M.TECH. THESIS ABSTRACT 2014

Power & Control

Signal Processing, Communications & Networks

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Microelectronics, VLSI & Display Technology

RF Microwaves & Photonics

Title : *Coherency Based Dynamic Equivalencing of Electric Power System*

Author(s) : *Chittora Shikha*
Roll No : *12104077*
Supervisor(s) : *Singh Sri Niwas*

Abstract:

The power system networks all over the world have been constantly increasing in size and complexity due to several interconnections and high load. Although modern computers can handle large amount of data, it is necessary to reduce the size of power system network for the reasons like fast processing, unavailability of data, security issues and to reduce the complexity of network. Sometimes it is completely unnecessary to model the entire network to see the behaviour of certain part of the system because parts of the system far away from the disturbance have a little effect on the system dynamics and therefore the least affected portion from the network can be eliminated. There are many methods to obtain a dynamic equivalent of network. The basic idea of these techniques and their comparative study are presented. Coherency based equivalencing technique is selected for this research due to its advantages. Various software are available nowadays with network reduction tool but they are not able to provide the correct dynamic equivalent. This thesis provides a procedure to obtain a dynamic equivalent in PSS/E program and the results are compared with different software. Modern power systems contain several HVDC links in the interconnected grid. The study of HVDC link is new evolving field of research. For the analysis of HVDC networks, it is required to build the entire network on HVDC simulator. But due to the limited capacity of simulator, network reduction is mandatory. The procedure is applied to reduce the network having HVDC link and the results are compared with the original network. New England 39-bus system is used for verifying the method.

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Title	***:***	***Design and Implementation of a Three Phase High Frequency Inverter with Superior Dynamic Performance***
Author(s)	***:***	***Gupta Nalin Lochan***
Roll No	***:***	***12104045***
Supervisor(s)	***:***	***Mishra Santanu&Joshi Avinash***

Abstract:

This thesis discusses the design, implementation, and application of a stand-alone, three phase inverter with 1 kHz operating frequency. The inverter is designed for critical loads which require a supply that has a small size and which can exhibit superior dynamic performance. The proposed inverter is capable of maintaining balanced and regulated voltage output under (a) Delta or star type loads with or without star point accessibility, (b) Balanced, unbalanced or severely unbalanced loading, (c) Passive loads with non-unity power factor, and (d) Non-Linear (Rectifier) loads. A completely analog design is chosen for the controller implementation with a switching frequency of 100 kHz. Analog implementation of the control circuit results in cost reduction, better reliability even under extreme working conditions, elimination of ADC and DAC circuits, and reduction in isolation requirements for feedback between power stage and low power control circuitry. Design of reference source, compensators, PWM controllers, and power stage implementation of the inverter is described in detail. The proposed design is validated using a lab prototype with 125V DC input and an output of 36V, 1 kHz, 250 VA. Superior dynamics of the design are experimentally validated for large-signal transients in input voltage, load, and reference. As an application, the basic single phase version of the proposed inverter is used as an amplifier for conducting a Power Hardware-in-Loop (PHIL) simulation. Design aspects of the amplifier along with complete details for PHIL simulation environment are described. Experimental results prove the effectiveness of this design as a power amplifier with excellent dynamic response when applied to PHIL simulations.

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Title	***:***	***Improved Control Scheme for Grid Integration of PV System with Dual DC Bus Fed Three Level Neutral Point Clamped Inverter***
Author(s)	***:***	***V Mahesh***
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Supervisor(s)	***:***	***Das Shyama Prasad***

Abstract

Worldwide harnessing of renewable energy sources has proliferated since the end of the year 2004, when global warming was recognized as a major threat to the environment and ecology. Renewable energy sources which are pollution free have been effective in reducing carbon footprints, in contrast to fossil fuels. Generating power through these sources also help in gaining carbon credits as they are excellent methods to control greenhouse gases in the atmosphere. One efficient way to utilize these renewable power sources is by connecting them to the utility grid. In order to interface renewable power sources to utility grid, power electronic converters are employed. The roles of these converters include efficient synchronization, unity power factor grid current injection and maximum power point tracking of sources. The injected grid current may have lower order harmonics due to various non-idealities like grid voltage harmonics (THD values in rural India are extremely high), ripple in dc link voltages - for which expensive high value of capacitors should be used, dead time in PWM, and uneven switch voltage drops. Normally grid-side filters are not designed to attenuate the lower order harmonics present in current. These harmonics in current may further distort the utility grid, and therefore they have to be actively attenuated through the grid converter. In this work, lower order harmonic elimination techniques are proposed and applied to a three level Neutral Point Clamped (NPC) converter that integrates a dual dc renewable bus to utility grid. Generally, these renewable sources are connected to grid at distribution voltage level, which are more prone to become unbalanced because of single phase loads. When these power sources are connected to an unbalanced grid, oscillations in injected power with double the grid frequency are generated because of the interaction between opposite sequence voltages and currents. A modified control strategy is proposed to eliminate the power oscillations, while interfacing renewables to an unbalanced utility grid

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Title : *Towards a Visually Guided Autonomous Quadrotor: Design, Control and Applications*

Author(s) : *Vempati Anurag Sai*
Roll No : *Y9227645*
Supervisor(s) : *Behera Laxmidhar*

Abstract

Modelling and control of Unmanned Aerial Vehicles is a challenging problem owing to the inherent non-linearity. They demand ideal control for generating precise motion. This work aims at designing and building a light-weight quadrotor with improved on-board computational power and a diverse set of applications. A complete dynamic modelling is presented along with the system's parameter extraction. We briefly describe the functionality of various hardware components used in the fabrication process. Our work also describes dynamics of the system and state-space formulation for the controller design. We discuss two control strategies and evaluate their performance: (i) a simple PID controller and (ii) an Integral back-stepping controller. We rigorously tested our algorithms on a Simulator and also on the test-bed. We also incorporated vision based localization using a simple monochrome camera output which is used for position control. In the end, we describe the future work and the possible applications of our system. All the simulation and the field test results are shown where and when they are necessary. This work is more of a developmental project where we tried to bring together the best of available resources. But we also made significant improvements wherever we could.

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Title : ***Robot Learning from a Human Expert through Modified Kinesthetic Teaching***

Author(s) : ***Ghoshal Debarshi Patanjali***

Roll No : ***12104019***

Supervisor(s) : ***Behera Laxmidhar***

Abstract

Teaching new motor tasks to robots through physical interactions is an important goal for both robotics and machine learning. Most monolithic machine learning approaches fail to scale when going beyond basic skills. In this work we present a simple framework for teaching the robot (to hit the ball) through direct physical interaction with a human teacher (i.e. Kinesthetic Teaching). Current popular established method of kinesthetic teaching generally uses a two-stage approach: First, a library of motor primitives is generated through direct physical manipulation of the robot. In second stage, a reinforced learning ("reward" stage) is implemented to dynamically adjust the policy of choosing from motor primitive library. In this work, we modify the Kinesthetic Teaching by incorporating the domain experience of the human teacher through repeated teachings, instead of relying on the "reward" stage. This approach has advantage: One potential problem with the "reward" learning phase is that there may be subjective difference of what is a "good" shot from the kinesthetic teaching and from the bystander viewpoint (later in "reward" stage). Even a little difference in this regard will result in a confusing feedback ("reward"), and hence it would be difficult to correctly figure out which library training samples should be reassigned what weight values. Our approach eliminates this problem altogether

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Title : *Estimation of the Rotor Angle of Synchronous Generator using PMU Measurements*

Author(s) : *Jha Manish*
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Supervisor(s) : *Chakrabarti Saikat*

Abstract

Power system is the most complex, biggest, and interconnected system in the world. Due to increasing demand and limitation on the power supply, synchronous generators are forced to operate near their stability limit, which make them vulnerable to the power system disturbances/fault. Hence, it becomes very important to access stability of synchronous generator, the internal rotor angle should be known. To access the angular stability, the rotor angle should be constantly monitored in real time. The proposed work develops a methodology for the rotor angle estimation during power system transients. With the advent of Phasor Measurement Units (PMUs), this task of estimating the internal rotor angle in real time, has been possible. PMU placed at the generator bus measures bus voltage and current phasors. These measurements along with the field voltage and current measurements are used for estimation of rotor angle. 7th order state space dynamical model had been used for the present purpose. A damper winding observer has been developed for observing the non-measurable damper currents. The electrical torque is then calculated on the basis of observed damper currents, and the swing equation is solved for getting the updated rotor angle of the synchronous generator. This work also proposes a parameter estimation technique for the synchronous generator. The reactances of synchronous generator vary as the level of flux changes and hence, these parameters are needed to be estimated during transients. Application of the proposed methods on test system shows promising results

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Title : *Auto-Summarization of Sanskrit Documents*
Author(s) : *Patel Akashdeep*
Roll No : *9227052*
Supervisor(s) : *Behera Laxmidhar*

Abstract

Summarization is a crucial information retrieval task in today's information centric world. A summary provides the main ideas in a document or a set of documents in a short and readable paragraph. In this work, we have focussed on developing algorithms for the automated summarization of Sanskrit documents. Before employing the summarization algorithm it is pre-processed. Pre-processing involves mainly sandhi splitting of combined words, stemming to get root words and removing stop-words. This improves `bag-of-words' model of the document . In the existing graph-based approach, sentences are ranked by mutual voting for each other. A vote in this case is the similarity value between two sentences. Cosine similarity is employed for its measurement in the `vector space model' representation of document (sentence). While computing similarity using this approach, every term in the document is assumed to be independent of other terms. We propose to utilize the lexical association between terms to improve upon this assumption by predicting weights of non-matching terms in two sentences. Thus enhanced similarity replaces the cosine similarity in the existing graph-based method. Experiments con rm an improvement in the quality of the system generated summary. A summary is supposed to resemble the document and thus, we build a hypothesis that the probability distribution of summary and that of the document should be as close as possible. We utilize this hypothesis to extract sentences for incremental summarization of the document. In this approach, among all the sentences, the sentence which generates summary having a probability distribution closest to the document, is chosen at every step. During the experiments, it was observed that the presence of context words in a sentence makes it a preferable candidate to be included in the summary. Thus, the distribution of context words is more likely to match between the summary and document, and not the distribution of all the terms, which also include the terms, which do not carry the content. Therefore, we measured the discrimination taking into account only the context words. Experiments show that this gives much better sentence selection and produces better summary. For the evaluation of our algorithms, we collected the corpus of Sr mad Bh agavatm from the Web. The corpus was pre-processed using the Sanskrit Heritage Reader interface. We also created manual gold-standard summaries for 15 documents from the corpus for the evaluation of our algorithms. It was found that graph method with enhanced similarity improves about 15% and the 2nd approach does about 18% over the baseline case.

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Title : *Neural Network based Forecasting of Hourly Solar Radiation*
Author(s) : *Yadav Ajay Pratap*
Roll No : *12104005*
Supervisor(s) : *Behera Laxmidhar*

Abstract

Forecasting of solar irradiation is significant for planning the operations of solar based power plants. The recent trend towards a low-carbon society has accelerated the rapid introduction of Photovoltaic (PV) systems for power generation. In response to this, electric utilities need to predict the output power of PV systems. The generation forecast, particularly the short term forecast, is a challenging task for the PV power system as its power output varies largely with the external conditions like sunshine, temperature, etc. Therefore, the focus of this work will be to perform solar radiation forecasting with special emphasis to short term forecasting. In the first part our work, the problem of local minima is addressed with respect to neural networks training. A Lyapunov function based training algorithm is explored for better training of feed forward networks. Later, a new tunneling based Lyapunov function weight update law is proposed to counter the problem of local minima in neural networks. The proposed weight update law is tested on some standard benchmark functions such as Shubert function and Breast Cancer classification problem. The developed training algorithm is used for making solar radiation forecasting. The forecasting is made for 7 days on hourly basis for Daily Normal Irradiation (DNI), Global Horizontal Irradiation (GHI) and Diffused Horizontal Irradiation (DHI). Three different forecasting model is developed for summer, winter and rainy seasons. The developed forecaster is compared against persistence model and standard neural networks model trained by back propagation algorithm. Finally, a hybrid forecasting model is developed which uses Wavelet Transform and adaptive learning based Recurrent Neural Network(RNN). The hybrid model is shown to improve the performance of forecasting model when the weather data is fluctuating. Finally, the scope and future work of our work is discussed.

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Title : *Learning To Grasp and Programming By Demonstration Using a 7-DOF Barrett Arm*

Author(s) : *Das Niladri*
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Supervisor(s) : *Behera Laxmidhar*

Abstract

Robot programming has become a tough and complex task, which requires knowledge of a robot expert. From elderly care to automotive industry robots are playing an ever increasing role in our society. The complexity with robots is not limited to the industrial robots but even more with the household robots. The robots built to operate in a home, facing the cost constraint needs to be programmed in a much easier way. The paradigm of Programming by Demonstration or PbD addresses the issue of ease of programmability satisfying the cost constraints. In this paradigm the user of the robot, himself will be programming the robot in a way that satisfied his/her needs. This is because it is the user who best knows about the task and also the way it needs to be accomplished. Now, it is not obvious for all the robot user to be an expert in robot programming. Hence the robot needs to posses certain intuitive as well as user friendly interface for programming. Instead of programming the robots using logical blocks of complex programming statements, in PbD the user would be capable of building this logical blocks into the robot by just performing the task i.e. giving demonstration(s) of the task. This thesis is about our attempt to create a framework for a robot to learn a task through human demonstration. For the experimentation with the learning framework we have used is Barrett Technology‘s WAM which is a 7-DoF arm. Microsoft‘s Kinect has been used for its vision feedback. For successful object manipulation the robot end-effector needs to have a desired position and orientation defined with respect to the camera frame. This problem is addressed by a two step process. First, the frame transformation parameters are determined. Then we have implemented an analytical based (not closed form) Inverse Kinematic solution. We have used a 3 fingered hand for object grasping in our experiment. Since a robot often needs to manipulate objects it has never seen before, it should be able to predict grasping region(s) for such objects. To address this problem we have used a deep learning based grasp region detection algorithm. Once the robot acquires the capability to grasp a unknown object in its workspace, it should be able to manipulate those objects for a specific task just as the user wants it to do. For teaching the robot object manipulation tasks, we have implemented a PbD technique called Symbolic Encoding. The robot learns to decide the goal states which includes intermediate goal states to attain the final goal state, through several demonstration

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Title : *Output Power Leveling of DFIG using Battery Energy Storage System*

Author(s) : *Sharma Shatakshi*
Roll No : *12104075*
Supervisor(s) : *Singh Sri Niwas&Anand Sandeep*

Abstract

Wind energy has been harnessed for hundreds of years by humans. The first wind mill that appeared in twelfth century for pumping water has been well improved over ages and is today used for producing electricity. Wind power is a popular form of renewable energy with minor environmental impact as compared to traditional energy sources. It consumes no fuel, and emits no air pollution, unlike fossil fuel power sources. Wind farms can supplement the base power generated by thermal, nuclear or hydro plants. However, due to its intermittent nature, wind power scheduling and integration with grid has many technical and economic limitations. The work presented here utilizes sixth order mathematical model of doubly fed induction generator connected to grid. Conventional vector control techniques have been used for control of the converters. The response of DFIG to varying wind speeds has been simulated and presented. The results have shown that the Active Power Output of the generator is solely dependent on wind speed i.e. it can't be controlled externally. However, Reactive Power Output is controllable through the current reference of converters. Further, modifications in the DFIG model to equip it with BESS (Battery Energy Storage System) have been proposed. The simulation results have been illustrated to show that using BESS, the active power output of DFIG can be controlled. It also helps in minimizing the effect of sudden wind gusts. The control scheme presented has been used to reduce the error in power generation (with respect to scheduled power) from up to 60% to 30%. This saves cost of penalty imposed on generators and justifies the use BESS in wind farms.

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Title	***:***	***Measurement Based Recursive Methods for Monitoring of Power System Oscillations***
Author(s)	***:***	***Porwal Prabhankar***
Roll No	***:***	***12104053***
Supervisor(s)	***:***	***Verma, Nishchal K&Chakrabarti Saikat***

Abstract

Power system is the most complex man made system. The demand of electric power is increasing day by day. At the same time, the tolerance to interruption in the power supply is decreasing. The deregulated market structure along with distributed generation has pushed the system to operate under the circumstances for which it was not designed. In a stressed system, a small disturbance can create a large oscillations. It is important to detect it as quickly as possible to take proper remedial action. Traditionally these dominant oscillating modes of the system are found using linearized state equations of the system. This method is complex and time consuming as it requires complete system modeling. To overcome these limitations, measurement based methods were developed to estimate these modes. System response was utilized to estimate the modes for such methods. For real time oscillation monitoring of power systems, measurements are required at faster rate. With the advent of Phasor Measurement Units (PMUs), which provide measurements at faster rate, wide area oscillation monitoring of power systems has become feasible. The work reported in this thesis concentrates on traditional measurement based methodologies such as Prony analysis and Matrix Pencil, and recursive versions of these methodologies to estimate the dominant modes of system. The concept of popular rank-one update was incorporated in the traditional methods to extend them to recursive methods. These measurement based methods utilize transient response having observable oscillations, obtained from PMUs. These methods were applied on signals obtained from various test systems, built in Matlab Simulink. A performance study has been made on traditional measurement based methods such as Prony analysis and matrix pencil method, and recursive versions of these methodologies

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Title : ***Source Diagnosis of Grid Connected Solar Photovoltaic Systems***

Author(s) : ***Kuchibhatla Bala Subrahmanyam***

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Supervisor(s) : ***Sensarma Parthasarathi***

Abstract

Rapid growth in energy demand accompanied by global warming concerns has accelerated the development of technology featuring naturally occurring renewable sources. Renewable energy sources(RES) while being pollution free, need not be centralized unlike their thermal counterparts. The intermittent availability of RES in small quantities has given rise to distributed generation. Distributed generation involves generating energy from various available resources in an area and excess energy available beyond the local consumption, being transmitted to the grid. Abundant availability of sunlight makes solar photovoltaic(SPV) an attractive option for distributed generation. In recent time share of PV installations in total renewable source based energy generations is in rise. To encourage the electricity producers to undertake PV installation solar PV specific incentives are provided. Currently subsidies are one of the driving forces behind rapid growth of PV installations. In incentive based financial environment it is of interest to have a real time verification mechanism whether the source of power supply is a genuine PV. To achieve the objective characteristics of PV source are extracted by varying the input voltage over a wide range. A digital controller approach is used to achieve wide range control of PV array voltage. Obtained characteristics are processed further and based on features unique to PV source, a mechanism to distinguish PV source from a non PV sources is developed. The developed diagnosis scheme is to be performed at non deterministic instants of time and procedure to achieve it is discussed. Mathematical modelling of the PV system that includes PV array and power converter along with its control is performed. Developed models are simulated in MATLAB/Simulink. Real time implementation of the proposed scheme is done on a laboratory prototype. The control mechanisms and source diagnosis algorithm are programmed in Digital Signal Processor(DSP). Experimental results obtained are in conformation with the analytic formulations, there by verifying the robustness of the scheme proposed

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Title : *Development of Email Security Threat Mitigation System*
Author(s) : *Seervi Teja Ram*
Roll No : *12104087*
Supervisor(s) : *Singh Yatindra Nath&Roy Amitabha*

Abstract

Messaging using email has become defacto standard of communication in the current world of internet. At the same time, email became the most widely exploited vector for malware injection, social engineering, spoofing and data leaking. In many attack scenarios, the first step adopted by hackers is to send an email containing malicious content or attachment and later use that pay load to expand the virus infection, data leaking, etc. Unlike internet access, email service penetrates right into intranet and private networks of an organization there by giving attackers a chance to deploy their tools deep into organization network. Another growing threat for organizations is the possibility of trapdoors in commercial appliances, third party developed software and embedded systems that can use email as channel for leaking sensitive information. Threat perception from insiders, collaboration partners and extended parts of organization network are other major security concern. Although virus and spam controls are able to prevent known attacks originating from internet, risk due to zero day vulnerabilities, third party software/appliances and insider attacks still remain as major threats and are required to be taken care of. In view of the aforesaid threat perceptions in email messaging system and their significance to organizations like BARC (Bhabha Atomic Research Centre) , a need is felt to have an Email Security Threat Mitigation System". As BARC has a policy of using open architecture systems and minimize commercial solutions for security systems, it is decided to develop the system in house. The core of the project is to develop a security engine that supports email fire-walling based on SMTP protocol entities, email messaging fields and email content combination. The scope of the project involves study of email based security threats and mitigation approaches, options available for building email firewall system and integrating it with email infrastructure, development of firewall algorithm with extensive configuration features, implementation and testing of firewall system and performance measurements

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Title : *Entire Frame Image Display Employing Monotonic Convergent Non-negative Matrix Factorization*

Author(s) : *Soniwal Yogesh Kumar*
Roll No : *Y9227672*
Supervisor(s) : *Venkatesh K S&Mitra Amit*

Abstract

Diminution of diode lifespan in display devices is an acute problem and is of much interest to researchers since displays are integrated part of most of electronics devices. While the material science industry is working on manufacturing diodes with increased lifespan, several algorithmic solutions have also been proposed in the past to solve this problem. Pixel addressing in an organic light emitting diode (OLED) display (or any other display) is a governing factor for diode (or display) lifespan. Traditional addressing schemes for displays work row by row. While one row is addressed, others remain idle. If a decent frame rate is required on a display with a large number of rows, the time available per row is very short indeed. In the short duration available, to brighten a pixel, a very large current has to be supplied momentarily, at the diode corresponding to this particular pixel, if the pixel intensity is high. This imposes severe stresses on diode lifespan. In this work, we propose a new approach to drive an entire frame of display, all at once. An image is expressed as a converging series of matrices called sub-frames of full image size (not just one row), but individually of rank one, employing sequential Monotonic non-negative matrix factorization (NNMF) on the target image and on subsequent residues remaining after each NNMF, such that the sum of sub-frames is equal to the brightness of the original image. The factors of sub-frames, i.e. column and row vectors are applied at horizontal and vertical drivers of the display respectively. Hence the entire frame is driven in each sub-frame. This amounts to distribution over a much longer time interval of the current being supplied at a particular diode in each sub-frame. This culminates to a significant improvement in driving time and lifespan of diodes in OLED displays. We have invented Monotonic NNMF algorithm and shown it to be more efficient and less time complex compared to existing NNMF algorithms. We further obtain an even faster converging series with a randomized version of Monotonic NNMF. The proposed approach of entire frame image display is demonstrated on a wide variety of images. An attempt to obtain matrix series representation (MSR) of any matrix using Monotonic NNMF is also shown.

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Title : *Acoustic Echo Cancellation using Non Negative Tensor Factorizations*

Author(s) : *Agrawal Suman*
Roll No : *12104110*
Supervisor(s) : *Hegde Rajesh M*

Abstract

There has been a paradigm shift in the technology from hand-held systems to hands-free systems, providing full-duplex speech communication. It permits the speakers to carry out wireless communication even without holding the device physically. This boom in technology brings with it the problem of acoustic echo which needs to be addressed for clean speech communication. Human auditory systems is able to isolate speech and echo seamlessly. However echo cancellation in hands free speech communication systems is challenging. In this thesis a method of acoustic echo cancellation based on Non-Negative Tensor Factorisation(NTF) is proposed. The NTF method utilizes Modulation Spectrogram and is able to group the redundant patterns in frequency with similar features. Synthesis is carried out using the Wiener filtering method from the generated tensors. Echo Cancellation experiments are performed on the GRID Database to evaluate the performance of this method. Reasonable improvements in performance are obtained using using Non-Negative Tensor Factorisation method when compared to Non-Negative Matrix Factorisation method and other conventional methods in literature

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Title : *Sparse Reconstruction Methods for Source Localization using Partial Dictionaries over a Spherical Microphone Array*

Author(s) : *Singhal Kushagra*
Roll No : *Y9227304*
Supervisor(s) : *Hegde Rajesh M*

Abstract

Source localization is an important problem which finds wide applications including source separation, Electroencephalography (EEG), radar systems, and tracking. On the other hand sparse reconstruction methods have been extensively applied to image processing problems but its applications to source localization in the spherical harmonics domain is limited. In this thesis, a source localization method is proposed which is based on sparse reconstruction using a spherical microphone array. The source localization method proposed in this work addresses two important research issues. It formulates the source localization problem in the spherical harmonics domain as a sparse reconstruction problem. Subsequently, a low complexity method to estimate the direction of arrival (DOA) of multiple sources is also proposed by using partial elevation angle dictionaries. The method is also modified to handle uncorrelated sources in noise. The use of such dictionaries reduces the complexity of the search involved in the two dimensional DOA estimation. Experiments are performed on various datasets at different SNRs and source separations to evaluate the performance of the proposed method. The results are compared with the existing methods in terms of robustness and probability of resolution for correlated and uncorrelated sources. The proposed method outperforms the other methods at low SNRs and has comparable performance at high SNRs. Time complexity analysis is presented along with experimental results which prove that the proposed method has much lower time complexity compared to standard sparse reconstruction methods. An application of source localization is also considered wherein a narrow band source tracking experiment is conducted. The proposed algorithm is able to track the source with high accuracy indicating the efficiency of the method

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Title : Segmentation Directed Inpainting
Author(s) : Nanduri Manoj Kumar
Roll No : Y8127310
Supervisor(s) : Venkatesh K S

Abstract

Abstract: Segmentation Directed Inpainting Inpainting is the art of synthesizing large portions of images using the background information. Most commonly used inpainting techniques fill the target region or hole in concentric layers from outside inward by sampling values from the background block by block. In each iteration, decisions are made in a greedy fashion taking into account only the local information on the gradient and isophote changes which might lead to irregular extensions of region boundaries inside the hole degrading the global visual appearance. To overcome this, we impose constraints on the search space for source-exemplars by segmenting the image and coupling the regions that have a tendency to connect through hole and interpolating their boundaries inside the hole using Bézier interpolations. The aim of hole-partitioning is to inpaint each sub-hole separately by constraining the search space to one or two regions adjacent to that particular sub-hole. A new confidence update rule is proposed which tries to measure the amount of faith in a block by looking at how anomalous the block is compared to other blocks in the corresponding search space. Most inpainting algorithms choose a fixed block size which is set before the algorithm starts. Using the additional information provided by our hole-partitioning algorithm, we choose block sizes separately for each sub-hole. Block size for a sub-hole is determined by mining the region characteristics of the corresponding search space by segmenting it at multiple scales. Proposed method is tested on several images and satisfactory results were obtained in most cases.

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Title : ***Robust Sensor Node Localization and Tracking using Extended Kalman Filtering***

Author(s) : ***Tripathi Sabha Kant***

Roll No : ***12104107***

Supervisor(s) : ***Hegde Rajesh M***

Abstract

The need for sensor node location estimation in mobile wireless sensor networks is perhaps the most important. Common location estimation techniques that are widely adopted in practice assume that there are some fixed nodes that know their location which are called anchors. These anchor nodes sends signal to mobile sensor node and by utilizing Receive Signal Strength (RSS), the sensor node can estimate distance between them and anchor nodes. Consequently, Node position is then determined by transforming signal measurements into position estimates by using algebraic methods. The contribution of the thesis is two fold. The first part presents a detailed analysis of sensor node localization using algebraic methods based on RSS along with a discussion on a real time implementation of the same. The second part of the thesis discusses the development of a method for sensor node tracking using an extended Kalman filter (EKF). It is demonstrated that better tracking results are obtained when the EKF is used even under noisy and unreliable RSS observation scenarios. Experiments are conducted on an indoor WSN lab test bed using NI nodes and gateways. The test bed consisted of three anchor nodes and one mobile node which also acts as a gateway. Several tracking experiments are performed over a network dimension of twenty five square meters. Nodes are assumed to travel randomly with constant velocity. An average tracking error of 0.1256 square metres is obtained with the EKF, which is reasonably better than other tracking methods that use the Kalman filtering techniques.

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Title : *Acoustic Echo and Noise Cancellation using Kalman Filter in a Modified GSC Framework*

Author(s) : *Tanan Subhash Chand*
Roll No : *Y9227598*
Supervisor(s) : *Hegde Rajesh M*

Abstract

Speech communication systems are often affected by acoustic echo. The perceptual quality of speech significantly degrades due to acoustic echo. It also affects the recognition performance of speech based applications. In practical applications speech signals also get affected with background noise in addition with acoustic echo. In this context, a method for joint acoustic echo and noise cancellation is required. A novel method for joint acoustic echo and noise cancellation in a generalized sidelobe canceler framework is developed in this thesis. The primary contribution of this thesis is the development of multi-channel adaptive Kalman filter (MCAKF) in a modified generalized sidelobe canceler (MGSC) framework. Additionally, in this work both the near end speech signal and noise is assumed to be unknown. In the proposed method speech acquired by a microphone array is processed through acoustic echo canceler. The output of acoustic echo canceler is subject to adaptive beamforming using MVDR method. On the other hand a coherence blocking matrix filter is used to attenuate the near end speech signal while passing both the noise and residual echo. A MCAKF is developed in this context to also estimate the noise and residual echo. Hence, a difference of MCAKF output and the adaptive beamformer (ABF) output gives an estimate of the near end speech signal. The performance of proposed method is evaluated using subjective and objective measures on the ARCTIC database. Distant speech recognition experiments are also conducted on the ARCTIC database. The proposed method provides reasonable improvements both in terms of perceptual evaluation and distant speech recognition when compared with other methods for joint acoustic echo and noise cancellation available in literature.

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Title : *Anti-Jamming Hybrid Transmitter Diversity Joint Time-Frequency Spreaded Multi-Carrier CDMA in Jamming and Fading Environment*

Author(s) : *Dewangan Maneesh Kumar*
Roll No : *12104103*
Supervisor(s) : *Sharma Govind*

Abstract

MC-CDMA is an elegant technique for wide-band communication in frequency selective fading and jamming environment. It combines the benefit of OFDM and CDMA, provides better BER performance than OFDM and CDMA due to its inherent ability to collect symbol energy scattered in frequency domain to gain frequency diversity. Joint-time-frequency spreaded MC-CDMA further enhances the robustness against partial-band partial-time jammer by spreading in both time and frequency domain. Multi antenna spatial diversity schemes can be combined with `joint-time-frequency MC-CDMA' to gain frequency diversity, spatial diversity and enhanced anti-jamming performance. In this thesis, two multi-antenna transmit diversity schemes, `2 antenna Alamouti joint time-frequency MC-CDMA' and `4 antenna Hybrid joint time-frequency MC-CDMA' are proposed. The performance of proposed schemes are investigated in frequency selective fading channel and partial-band partial-time jamming scenario. BER performance of proposed schemes are compared with MC-CDMA, 2D-MC-CDMA, joint-time-frequency MC-CDMA, Alamouti MC-CDMA, CDD joint time-frequency MC-CDMA. Simulation results show that proposed schemes outperform existing schemes, under the condition of identical data rate, transmitted power and occupied bandwidth. For multi-user down-link transmission, only a subset of Walsh-Hadamard codes are used to achieve zero Multiple Access Interference (MAI) over frequency selective fading channel, achieving the single user performance with limited number of users. Proposed systems performance is also investigated by applying rate-1/2, constraint length 3 convolutional coding as FEC. The proposed coded systems are shown to have tremendous BER improvement over proposed uncoded schemes. In down-link multi-user scenario, the number of users that can be supported will be increased significantly to full load condition.

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Title : *Observational Learning of Rules of Games*
Author(s) : *Dwibedi Debidatta*
Roll No : *Y9227188*
Supervisor(s) : *Mukerjee Amitabha&Venkatesh K S*

Abstract

People can learn to play games by observing others play. In the past, systems that attempted to discover game rules have used considerable background knowledge (e.g. game states, goals). In this work we use depth sensing technologies (RGBD), together with unsupervised transitions via Semantic Graphs to discover states and rules for games. The system is based on our own multiple-object tracking method based on an octree overlap metric. It uses the Hungarian algorithm for the assignment problem to assign object labels from one frame to the next. Each frame is represented as a Semantic Graph whose nodes represent the objects and the edges encode spatial relationships. The changes in the structure of these graphs reveal typical moves in the game. We perform automatic discovery of board states by clustering game piece locations. Knowledge from these states and the semantic graphs is mapped to First-Order Logic descriptions of the states and transitions. Based on this, an Inductive Logic Programming (ILP) system is able to infer the valid moves and other rules of the game. Starting with no game-specific knowledge, induced rules are demonstrated for Towers of Hanoi (e.g. higher pegs must be smaller) and 1D Peg Solitaire (moves may be 1 square or two).

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Title	***:***	***Collaborative Multi Camera Network Surveillance With Automated Agent Tracking Under Complex Occlusion***
Author(s)	***:***	***Chechani Shubham***
Roll No	***:***	***Y9227566***
Supervisor(s)	***:***	***Venkatesh K S***

Abstract

The advent of cheaper sensors and faster computing technologies has stimulated the development of new vision-based interpretive applications leading to the evolution of visions systems from traditionally passive to pervasive and intelligent. Multicamera vision systems have gained special attention in recent years with some of their applications including smart homes, crowd ux estimation, security and surveillance through environment monitoring, interactive mobile and robotic networks, tra c management, and virtual reality systems. We have presented our e orts towards an intelligent multi-camera surveillance system that uses a distributed network of image sensors, each capable of onboard processing and automatic intrusion detection and tracking. We have used an automated tracking approach which is able to track multiple agents in a scene by using a reasoning scheme for detecting the surveillance event primitives. We have also presented a technique to handle the cases of complete and partial occlusions. In a multi-camera network scenario, where multiple locations are to be monitored simultaneously, communication of data, i.e., event primitives detected by each network camera through the data of their respective eld of views, between the cameras is necessary. Our work presents an e ective approach for data communication between cameras for collaborative interpretation of events of interest by exploiting the communication redundancies in the process. The proposed approach of has been tested on a number of data sets and the results have been demonstrated.

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Title : *Fast Video Stabilization*
Author(s) : *Tiwari Abhishek*
Roll No : *Y9227034*
Supervisor(s) : *Venkatesh K S*

Abstract

Digital video stabilization is a very important tool to remove jitter and unwanted motion, captured in the video sequences caused by any relative motion between digital camcorder and the subject. Given an unstabilized video sequence, the objective of this thesis is to synthesize a new sequence as seen from a stabilized camera trajectory. A fast and real-time solution to digital video stabilization is presented in this thesis. The algorithm is based on two-dimensional feature based motion estimation. The method tracks a small set of features and estimates the movement of camera between consecutive frames. An affine camera motion model is used to determine the parameters of translation and rotation between images. Trajectory of computed affine parameters is temporally smoothed by using moving average filter to remove high frequency jitter and motion compensation is performed based on smoothed trajectory resulting in improved quality of video. The proposed algorithm stabilizes horizontal/vertical panning and rotations and is suitable for variety of applications such as handheld camcorder video, camera mounted on car video, cellphone camera video, etc. The algorithm adaptively selects feature points detector threshold as per video frame size to save significant computational costs and appropriate mask width to eliminate unreliable feature points which cannot be used for estimating frame-to-frame motion. Our algorithm features novel CPU-GPU parallel computation framework in which both GPU and CPU cores work in parallel and novel pipeline implementation of OpenCV routines to bring computational cost down to allow real-time rates for 720p video sequences. In addition to GPU, parallel computation capabilities of multi-core processors was exploited to implement the OpenCV routines pipeline leading to sizeable reduction in computational costs. The minimal computational cost of this fast algorithm gives 73 FPS for VGA video and 32 FPS for 720p video sequences. The proposed solution has been tested on a number of video sequences and results have been demonstrated.

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Title : *Robotic Vehicle Tracking in the Presence of Obstacles Using Non-Degenerate Particle Filter*

Author(s) : *Ranjan Rajeev*
Roll No : *12104113*
Supervisor(s) : *Hegde Rajesh M*

Abstract

Robotic vehicle tracking using randomly located active beacons without information on the initial location of the vehicle is challenging. The Kalman filter and its extended version require the initial position of the vehicle for proper convergence. Additionally, when the system model and the measurement model is non-linear, the Kalman filter fails to converge and accurate tracking cannot be realized. Particle filters can be used to alleviate this problem since it can estimate the position of the robotic vehicle even in the absence of the initial position of the vehicle and also provides a good trade of between robustness and accuracy. But a particle filter suffers from degeneracy problem. This degeneracy results in the selection of samples whose contribution to the posterior density is zero. A particular non-degenerate particle filter for robotic vehicle tracking is implemented in this thesis. The map of the areas with obstacles is assumed to be known in this work and motion planning is implemented using A* algorithm. Experiments are performed on the tracking of robotic vehicle with different path by varying the number of particles and compared to standard particle filter tracking methods. The tracking methods discussed in this thesis gives reasonable reduction in terms of RMS error of tracking

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Title : *Multi-resolution Non-Negative Matrix Factorization for Acoustic echo cancellation*

Author(s) : *Bansal Anshul*
Roll No : *Y9227107*
Supervisor(s) : *Hegde Rajesh M*

Abstract

Acoustic Echo Cancellation is very important in modern day communication owing to the ubiquitous spread of hands free telephony and voice over internet protocol systems. In this thesis, a multi resolution non negative matrix factorization (NMF) based acoustic echo cancellation method is proposed. The acoustic echo cancellation technique proposed in this thesis addresses two important research issues. Unlike conventional filter based algorithms for acoustic echo cancellation, which suffers from poor tracking of time varying loudspeaker-microphone enclosure(LEM), this method cancel acoustic echo without estimating the LEM. So it is more robust for both double-talk and single talk scenarios. Second, the NMF based acoustic echo cancellation method suffers degeneration of speech signal due to fixed time frequency resolution. The use of adaptive multi-resolutions reduces the degeneration and provides a better estimate of near end speech signal. Experiments on acoustic echo cancellation are performed on CMU ARCTIC database with several datasets at different values of echo to near end signal ratio(ENR). The optimal parameters like number of basis vectors for the proposed method are found through simulations. The experimental results are compared with existing state of the art echo cancellation methods using both perceptual and objective quality evaluations. The proposed method performs reasonably better than other methods motivating its use in practical acoustic echo cancellation

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Title : Parallel Simulation of Cache Hierarchy on CPU-GPU Heterogeneous Platforms

Author(s) : Aggarwal Kavish
Roll No : Y9227278
Supervisor(s) : Chaudhuri Mainak

Abstract

Accurate simulation of multi-level cache hierarchy is a lengthy process and the simulation time increases significantly with the current industry trend of deep cache hierarchies and multi-core processors that exercise these hierarchies. It is well-known that different sets of a cache can be modeled independently if the cache exercises a local replacement policy which uses local state information available within a set to arrive at a replacement decision. However, global replacement policies have gained in importance over the last decade due to the better quality of replacement victims that such policies offer. Due to the inherent dependence on global information, simulation of such policies does not offer much parallelism. We propose a parallel simulation model that can trade simulation accuracy for simulation speed in a controlled fashion for single-core as well as multi-core cache hierarchies exercising global replacement policies. Our parallelization model continues to map each cache set to a thread of execution, but allows them to synchronize only at regular epoch boundaries, the interval of which is a simulation parameter. In essence, our parallelization model converts a global replacement policy to a local replacement policy for the length of each epoch. We evaluate this parallelization model on modern graphics processing units (GPU) that offer few hundreds of hardware thread contexts and many thousands of ready thread contexts. We map the sets of different levels of the cache hierarchy that require communication to the same GPU thread block so that these threads can enjoy fast communication through the shared memory. For example, in our three-level cache hierarchy simulation, a group of L1 cache sets and the corresponding group of L2 cache sets are mapped to the same GPU thread block. However, the L3 cache sets are allocated in the global memory due to typically large sizes of the L3 cache. Event-driven queues are used to communicate between different levels of the cache hierarchy. This simple parallelization model can suffer from load imbalance because several applications exhibit non-uniform access volume to different cache sets, primarily resulting from cache-oblivious run-time virtual to physical address mapping. We adopt an already proposed technique to resolve this problem. Given that the host CPU pipeline is designed to efficiently execute sequential threads, we dynamically ship the simulation of the heavily loaded cache sets to the CPU, while the rest of the sets are simulated on the GPU. On every epoch boundary such a partitioning decision can be taken based on the observed set-wise load distribution of the last simulated epoch. Additionally, the fraction of the sets shipped to the CPU is configurable in the simulator. We evaluate this proposal on one local replacement policy (least-recently-used) and four recently proposed global replacement policies. Our empirical evaluation on four SPEC 2006 benchmark applications shows that our parallel simulator achieves at least 10% speedup over traditional CPU-based sequential implementations while experiencing very low simulation error in most cases. The performance scales well with the increasing number of simulated processor cores.

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Title : *Energy Efficient Heterogeneity Aware Routing Algorithm for Wireless Sensor Network*

Author(s) : *Rastogi Anshul*
Roll No : *12104012*
Supervisor(s) : *Singh Yatindra Nath*

Abstract

One of the main objectives of wireless sensor network is developing an energy efficient routing algorithm which has a significant impact on the lifetime and stability of the sensor network. One of the significant methods used in wireless sensor network is clustering method. LEACH was one of the clustering algorithms for homogeneous wireless sensor network which minimizes the energy consumption. The main objective of the thesis is to investigate the mechanism to conserve and balance the energy consumption in heterogeneous wireless sensor network. In this thesis, the impact of heterogeneity in terms of initial energy of node is considered and LEACH algorithm in presence of such node heterogeneity is discussed which gives poor performance in terms of network lifetime and reliability. A new Heterogeneity aware algorithm is proposed in which cluster-heads are selected on the basis of weighted election probabilities of nodes and this algorithm gives better performance in comparison to LEACH with heterogeneity. Also, a new Heterogeneity aware algorithm with energy balancing has been discussed which balances the energy consumption of every sensor node in a heterogeneous wireless sensor network. In this algorithm, the eligibility of cluster-head is decided by number of nodes supported in last round. The performance of the proposed heterogeneity aware algorithm with energy balancing is better in terms of network lifetime and reliability as the lifetime of the sensor network is increased by 13.38 % as compared with LEACH algorithm and it also gives smaller instability period.

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Title : *Edge Distortion Removal in Disparity Maps Using Alpha Matting*

Author(s) : *Ghatkesar Aarti*
Roll No : *12104001*
Supervisor(s) : *Venkatesh K S*

Abstract

Disparity refers to the shift in location of corresponding points in stereo images. Disparity and depth are inversely related and hence we can estimate the 3D coordinates of a scene given the stereo image pair of the scene. Disparity maps are also used in 3D rendering, aperture synthesis, special effects generation etc. These applications require high accuracy disparity maps, however the disparity maps obtained by a correspondence algorithm suffer from many inaccuracies, one of them being edge distortion. It is highly important to have good edges in a disparity map since during 3D reconstruction the human eye is more sensitive to the edges. As it happens, usually, due to distorted edges in the disparity map, the reconstruction of the scene looks artificial, which cripples the goal of augmented and virtual reality. This thesis aims at removal of edge distortions in a disparity map, one of the deterrents to accurate depth calculation and thus reconstruction of a scene. The problem with disparity maps estimated by various methods is that the disparity edges and the RGB edges do not align properly and also the edges of the disparity maps are not as sharp as the edges in the colour image. We tackle this by using Alpha matting and Exemplar Inpainting which is a new way of addressing the above problem. Alpha matting is a method of extracting a foreground from a background in an image. This requires user interaction wherein the user specifies what foreground to extract. However our method is completely algorithmic and does not require any user interaction. Matting gives us the advantage that we extract the objects from the RGB image and hence we are inherently extracting the edges in an RGB image to modify our disparity map. Since the edges of disparity maps do not align with RGB edges we are faced with a task of filling those disparities with appropriate disparity values at those pixels which earlier belonged to a different object. This task is achieved by Exemplar Inpainting. Inpainting is the process of removing objects and filling them with objects from the background such that the change is undetectable. Exemplar Inpainting is advantageous since it does not introduce blurring effects. The proposed algorithm yields promising results and improvement of an enormous magnitude

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Title : *Performance Analysis Of MIMO-STBC Based Decode-And-Forward Cooperative Relay Networks*

Author(s) : *Amalladinne Vamsi Krishna*
Roll No : *12104006*
Supervisor(s) : *Jagannatham Aditya Kiran*

Abstract

The performance of decode-and-forward (DF) relaying based multiple-input multipleoutput (MIMO) space-time block coded (STBC) cooperative communication systems has been studied in this thesis. Closed form expressions have been derived for the end-to-end pairwise error probability (PEP) of coded block detection at the destination node for single/ multiple relay nodes. For the multiple relay scenario, two different relaying protocols based on two-phase and multi-phase communication have been considered. Based on the closed form expressions derived, high SNR asymptotic approximations for PEP at the destination have also been derived which give insights into the achievable diversity order of the system and also used to formulate the optimization problem for optimal source-relay power allocation towards end-to-end PEP minimization. It is also shown that these schemes lead to a performance improvement compared to the schemes available in existing literature. Further, the ergodic capacity analysis of a transmission path selection based single relay DF MIMO-STBC cooperative wireless system has also been presented in this thesis. Closed form expressions have been derived for the ergodic capacity considering the availability of full as well as partial channel state information (CSI) at the source required for path selection. Simulation results have been presented to demonstrate the performance of the MIMO-STBC DF cooperative relaying system and verify the analytical expressions derived.

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Title : *Optimal Power Allocation And Precoder Design For Orthogonal MAC Based Wireless Sensor Network*

Author(s) : *Shevkani Lalit Asandas*
Roll No : *12104033*
Supervisor(s) : *JagannathamAditya K*

Abstract

In this work we consider distributed estimation of an unknown vector parameter when the sensor network is power constrained. Sensor observations are available at fusion center for joint estimation of parameter. Linear precoding at sensors and linear receive ltering at fusion center are applied in context of decentralized estimation. Various MSE and SINR criteria are considered for performance evaluation. Design of optimal precoders is carried out when the channels between sensors and fusion center are orthogonal, which is shown to be a NP hard problem in general. We use Majorization theory to reduce a complex matrix valued non-convex problem to a scalarized problem which can then be solved under the powerful framework of convex optimization theory. Precoder design is carried out for two cases - noiseless and noisy sensors. We show that our schemes achieve Bayesian Cramer Rao Bound (BCRB) for noiseless sensor case and we use inequalities to approximate MSE expression and power consrtaint for noisy sensor case and show that our scheme achieves benchmark MSE obtained when all the sensor observations are directly available at the fusion center.

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Title : ***SBL Based Channel Estimation And Detection For Wireless Communications***

Author(s) : ***Pal Arnab***

Roll No : ***12104014***

Supervisor(s) : ***Jagannatham Aditya K***

Abstract

A novel scheme for joint sparse channel estimation and data detection is proposed using SBL algorithm for spatially sparse MIMO STTC systems. We consider a sparse multipath MIMO channel matrix which comprises of overcomplete dictionary of basis spatial signature matrices corresponding to directional cosines at receive and transmit antenna arrays. Pilot based estimation techniques based on sparse bayesian learning algorithm is developed to get the channel estimate and updated hyperparameters. Also, a data detection based on space time trellis decoding is performed in the M-step to improve the channel estimation accuracy. Simulation results has demonstrated that the data-aided technique has superior performance in terms of mean squared error and Bit Error Rate (BER). This new scheme is compared with existing L1 norm minimization technique. Further a novel technique of spectrum sensing in OFDM based cognitive radio scenario has been developed for temporally sparse tapped multipath channel. We estimate the sparse channel coe cients based on SBL algorithm and utilizing these estimated value in generalized likelihood ratio test (GLRT) statistics for detection purpose. Also, we demonstrate that the proposed SBL based GLRT detection paradigm perform closely with the ideal known sparsity based GLRT detection technique

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Title : *Optimal Power Allocation and DownLink Beamforming in MIMO-OFDM Cognitive Radio Systems*

Author(s) : *Varshney Pulkit*
Roll No : *12104056*
Supervisor(s) : *Jagannatham Aditya K*

Abstract

In this thesis, we present optimal power allocation strategies for single user and multi-user MIMO-OFDM based underlay Cognitive Radio (CR) systems. Taking into consideration the spatial interference constraints, the proposed power allocation schemes maximize the throughput of the congnitive radio users. We begin by developing optimal downlink power allocation schemes for point-to-point MIMO-OFDM cognitive radio system with a predefined interference threshold to primary users. It is demonstrated that in the absence of channel state information (CSI), the rate maximization with isotropic interference constraints can be formulated as a convex semi-definite program (SDP), while in the presence of CSI, it is shown to reduce to a linear interference constraints based convex optimization framework. Closed form power allocation expressions are derived for the secondary user rate maximization. Subsequently, the rate maximization problem is also solved under CSI uncertainty framework employing the stochastic and worst case uncertainty models. We also present optimal beamforming schemes for a single receive antenna multi-user CR scenario, considering also the effect of a regularization parameter. A Karush Kuhn Tucker (KKT) based optimization framework is also presented to compute the optimal value of the regularization parameter

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Title : *Signal Detection and BER Performance of Hybrid DSSS and FHSS System in various Wireless Channel Scenarios*

Author(s) : *Mittal Sajal*
Roll No : *12104070*
Supervisor(s) : *Jagannatham Aditya K*

Abstract

In this work, we present a spectrally efficient design for the hybrid direct sequence spread spectrum (DSSS) and frequency hopping spread spectrum (FHSS) system. We address some key issues relating to the spectral efficiency, Bit Error Rate (BER) performance in AWGN and Rayleigh fading channels, signal detection and synchronization in various wireless channel scenarios. The proposed system employs the Gaussian Minimum Shift Keying (GMSK) based pass- band modulation to improve the spectral efficiency. We investigate the joint signal detection and synchronization performance of the system by employing a PN sequence based pilot symbol for unknown arrival time and unknown carrier frequency in AWGN channel and without the channel state information at the receiver for the single-input single-output (SISO) and multiple-input multiple-output (MIMO) systems in Rayleigh fading channels. Analytical expressions for the probability of joint signal detection and synchronization PD and the probability of false alarm PFA are derived. The detection performance is therefore visualized by plotting PD versus SNR for a fixed value of probability of false alarm PFA. In addition, the use of spatial diversity is explored to enhance the BER performance of the proposed system. At the transmitter end, a special class of space time block codes called alamouti codes are employed in the system to achieve transmit antenna diversity in MISO system. Similarly, receive antenna diversity is also exploited by using the multiple antennas at the receiver for Rayleigh fading channels to improve the BER performance. Thereafter, a multiple-input multiple-output (MIMO) structure is employed to exploit multi antenna diversity for Rayleigh fading environments to improve the BER performance of the system. Theoretical expressions for BER are derived for each of the said configuration under different wireless channel conditions.

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Title	***:***	***Sensing Throughput Tradeoff in Cognitive Radio with Random Arrival and Departure of Multiple Primary Users***
Author(s)	***:***	***Pradhan Hrusikesha***
Roll No	***:***	***12104025***
Supervisor(s)	***:***	***Banerjee Adrish***

Abstract

Cognitive Radio is a technology unfolded in recent times to solve the problem of the radio frequency spectrum deficiency by adjusting its transmission and reception parameters based on the surrounding radio frequency environment for the opportunistic utilization of spectrum. Cognitive Radio adapts to the changes in the environment and dynamically uses the spectrum when it is not used by the user who is licensed to use the channel. There exists tradeoff between sensing and throughput of the secondary user. Most of the works describe the throughput of primary and secondary user of Cognitive Radio Networks assuming that the state of the primary user remains constant during the total sensing period but in reality this is not the case. The primary user frame is not synchronized with the secondary user frame hence the primary user may arrive or depart at anytime it wants and this condition is considered in our analysis. The effect of this random arrival and departure of multiple primary users is considered for the study of sensing and throughput of the secondary user. It is assumed that both the idle and the busy periods are exponentially distributed and the primary user can change its status at most once during the secondary user frame. Numerical results show that sensing quality improves with the increase in the number of primary users occupying the channel, but with the increase in the number of primary users, the throughput of the secondary user and the optimal sensing time decreases, thus showing better sensing performance but with fewer transmission opportunities. The idle and busy periods mea- sure the primary traffic intensity and its randomness in using the channel. The decrease in throughput of the secondary user and the sensing quality depends upon the traffic intensity of the primary user, Signal to Noise Ratio of the primary user, number of primary users and the frame duration of the secondary user

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Title : ***Linear Decentralized Tracking in Power-Constrained Wireless Sensor Networks***

Author(s) : ***Singh Rahul Rajesh***

Roll No : ***12104080***

Supervisor(s) : ***Rajawat Ketan***

Abstract

Wireless sensor networks (WSN) are spatially distributed systems consisting of several low-cost, resource-constrained sensors reporting to a fusion center. Availability of cost-effective electronic devices have made WSNs ubiquitous in applications such as environment monitoring, surveillance, search and rescue, disaster relief, and target tracking. This thesis considers the problem of decentralized parameter estimation and tracking. The sensor nodes observe a vector source and perform linear precoding on the observations, before coherently transmitting them to the fusion center. The fusion center then decodes the source vector by linearly filtering the received observations. The proposed parameter estimator is both, adaptive and sequential, and can track a possibly time-varying source vector. Compared to existing approaches, the tracking requirement is significantly more challenging since it necessitates a time-varying optimal precoder and filter design. A low-complexity block-coordinate descent-based algorithm is proposed for the same, that allows for local and global power constraints at the sensor nodes. A novel online algorithm is also proposed that provides time-varying updates for the precoding and decoding matrices using simple, low-complexity update rules. Interestingly, the proposed algorithm can be linked with the popular recursive least squares (RLS) filter, allowing us to establish asymptotic properties such as unbiasedness and convergence. The link is also utilized to propose a provably convergent, extended-RLS-like version of the online algorithm that can incorporate a state-space model of the parameter vector, if available. Simulation results corroborate the performance enhancements provided by the proposed approach

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Title : Localization using Velocity Multidimensional Scaling (VMDS
Author(s) : Kumar Raju
Roll No : 12104063
Supervisor(s) : Rajawat Ketan

Abstract

Localization of sensor nodes is a fundamental problem in wireless sensor and ad hoc networks. For instance, sensor networks observing geographical and environmental phenomena, often require absolute or relative coordinates to be associated with the corresponding sensor readings. Sensor networks deployed for intrusion or event detection applications also need to report the origin of the detected event. Location awareness also simplifies several higher layer tasks such as neighbor discovery, routing, ascertaining coverage holes, and group querying of sensors. This thesis considers localization of mobile sensor networks within the framework of multidimensional scaling (MDS). Given inter-node distances, the MDS algorithm estimates the relative coordinates of the sensor nodes. In this thesis, we extend the classical MDS framework to also incorporate relative velocity information available from Doppler sensors at mobile nodes. The resulting optimization problem is solved in a distributed fashion using iterative majorization. The proposed vMDS algorithm can not only handle noisy distance and velocity measurements, but also continue functioning in the presence of missing measurements and high node velocities. The algorithm is provably convergent, has low implementation complexity, and provides significant performance gains over the state-of-the-art approach utilizing an extended Kalman filter.

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Title : ***Queuing Analysis of Multiple-Antenna Cognitive Radio Systems***

Author(s) : ***Agrawal Shivani***

Roll No : ***Y9227554***

Supervisor(s) : ***Jagannatham Aditya K***

Abstract

We present an analysis of the queuing performance of a multiple antenna cognitive radio system employing downlink beamforming. The paradigm of multi-user MIMO zero-forcing (ZF) beamforming is employed to null the interference at the primary user, thus achieving high SINR for our cognitive user. A closed form expression is derived for the probability density of successful packet transmission time followed by results for the average waiting and transmission times in an M/G/1 secondary user queuing system. We also derive the results for the case of multiple primary users where interference to all the primary users is made zero using zero-forcing beamforming. Further, this framework and the results are also extended to a more practical scenario with partial channel state information (CSI) at the secondary transmitter. We also derive closed form expression for queuing parameters considering interference from primary users. Numerical simulation results are presented to validate the theoretical performance analysis

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Title : *Optimal Transceiver Design for Downlink of MIMO-OFDM Cognitive Radio Systems*

Author(s) : *Garg Pulkit*
Roll No : *Y9227442*
Supervisor(s) : *Jagannatham Aditya*

Abstrac

With spectrum scarcity emerging as a huge problem, cognitive radio (CR) has emerged as a useful solution. In this thesis, we present optimal transceiver design strategies for point-to-point and multiuser MIMO-OFDM based underlay cognitive radio networks. Minimization of mean square error (MSE) has been considered as a metric to measure the system performance. The design is constrained by spatial interference at the primary user (PU). We start by designing the optimal receive beamformer which turns out to be the standard Wiener filter. For the transmitter design we begin by considering the point-to-point CR system. Different scenarios of PU channel state information (CSI) are considered and it is observed that the optimal transmitter design problem turns out to be non-convex. But using majorization theory framework the problem is converted to a simpler convex problem and thus a closed form solution for the optimal transmitter is obtained using the standard KKT framework. Then we consider the optimal transmitter design for the multiuser MIMO-OFDM cognitive radio systems. In multiuser scenario a user selection algorithm is presented to select a subset of secondary users (SU) from a large pool of active users. The transmitter design for these selected users is done similar to the point-to-point case to obtain a closed form solution

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Title : ***Cyclic Frequency Beamforming Based Spectrum Sensing in Cognitive Radio systems***

Author(s) : ***Kota Anusha***

Roll No : ***12104031***

Supervisor(s) : ***Jagannatham Aditya***

Abstrac

A novel Cyclic Frequency Beamforming (CFB) based spectrum sensing in cognitive radio systems has been proposed in this thesis. Towards this end, we demonstrate the Cyclic Conjugate Correlation (CCC) based cyclostationarity feature of narrowband digital communication signals. This property is then used to derive the optimal cyclic beamforming based combiner and test statistic for primary user detection in cognitive radio systems. It is demonstrated that while the optimal detector can be derived based on the Generalized Likelihood Ratio Test (GLRT) for an AWGN channel scenario. Theoretical bounds in terms of Receiver Operating Characteristics (ROC) have been derived for the proposed CFB detector. Also, we derive the optimal detector for a scenario with unknown carrier frequency and delay, corresponding performance bounds have been derived. Further, we have extended the proposed CFB detector to sequential hypothesis testing framework. Sequential Probability Ratio Test (SPRT) based decision rule and the expression for average number of blocks/symbols required to achieve performance criterion have been derived. Simulation results are presented to illustrate the performance of the proposed detection schemes and verify the derived analytical results.

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Title : *Modeling of Pinna Spectral Notches using Spherical Microphone array for rendering 3D Audio*

Author(s) : *SOHNI ANKIT*
Roll No : *12104010*
Supervisor(s) : *Hegde Rajesh M*

Abstrac

A wide variety of contemporary engineering applications in the areas of defense and entertainment require three dimensional audio rendering. Binaural audio rendering is receiving attention of researchers due to the advent of newer array processing methods in the spherical harmonics domain. However rendering person specific spatial audio requires extraction of pinna spectral notches for modelling of the human ear. In this thesis, a fast method for the extraction of pinna spectral notches (PSN) in the median plane of a virtual spherical microphone array is discussed. In general, PSN can be extracted from the Head Related Impulse Response (HRIR) measured by a spherical array of microphones. However, the PSN extracted herein are computationally complex and also not accurate at lower elevation angles. Hence a novel approach is proposed herein to reconstruct the HRIR using microphones over the median plane of a virtual spherical array. The virtual spherical array itself is simulated using the Fourier Bessel series (FBS). Subsequently, these HRIRs are used to extract the PSN. This method is computationally efficient since it is done over the median plane rather than over the complete sphere. On the other hand, it is also accurate due to the utilization of the Fourier Bessel series in the extraction of the PSN. Experimental results obtained on the CIPIC database indicate a high degree of resemblance to the actual pinna walls, even at the lower elevation angles. The results are motivating enough for the method to be considered for resolving elevation ambiguity in 3D audio. Suggestions for incorporating this method into 3D audio systems is also provided in the thesis.

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Title : *EXIT Charts for Turbo Decoding in Fading MIMO Wireless Systems*

Author(s) : *Sapra Rajat*
Roll No : *12104061*
Supervisor(s) : *Jagannatham Aditya K*

Abstrac

Turbo codes are being extensively used in 3G/4G mobile telephony standards such as 3rd Generation Partnership Project (3GPP), Long Term Evolution (LTE) which motivates us to study the Bit Error Rate (BER) performance of turbo coded multi-antenna wireless systems. One major drawback in studying the performance of such iterative coded systems is that we need to perform extensive simulations. In this thesis, we develop a framework which employs the Extrinsic Information Transfer (EXIT) chart to characterize the performance of turbo coded systems. Based on this EXIT chart analysis, we derive the closed form BER expressions for turbo decoding in various receive processing schemes such as Maximum Ratio Combining (MRC), MIMO Zero Forcing (ZF), MIMO Vertical-Bell Laboratories Layered Space-Time (V-BLAST) and MIMO Maximal Ratio Transmission (MRT). Further, we also present the BER expressions for wireless scenarios with antenna selection diversity and ordered subcarrier based multicarrier orthogonal frequency-division multiplexing (OFDM) transmission. This proposed framework thus enables BER prediction for turbo codes with arbitrary number of antennas and decoding iterations at a given SNR, without the need for extensive simulations, while also providing valuable insights into the convergence properties of the recursive turbo decoder

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Title : ModelScanner: Scanning 3D Human Model
Author(s) : Tripathi Pragyanandesh Narayan
Roll No : Y9227417
Supervisor(s) : Venkatesh K S

Abstrac

With the advent of 3D sensors like Kinect, Xtion or Tango by Google, major focus has been driven towards solving the problem of accurate 3D reconstruction of environments, objects and human beings with a particular pertinence to Virtual Reality and Robotics applications. ModelScanner is a system to create 3D models of people using Kinect sensor. To achieve this we have programmed a faster implementation of Kinect Fusion algorithm. Our implementation has proved to be around 2X faster than current implementation of Kinect Fusion in Microsoft SDK or in PCL library. It enables tracking and reconstruction of human model using the depth sensor. It receives a depth stream from the camera and tracks 6DOF camera pose using Iterative Closest Point (ICP) [2] algorithm. This camera pose is then used to integrate the new depth frame into a volume of voxels [3], resulting in an accurate and robust 3D reconstruction. We ll each voxel with signed distance function to represent the scanned model. It is updated and visualized as the frames are captured for immediate feedback. Our implementation automatically lls small holes that arise from self-occlusions. Our system is implemented mainly on K20 Kepler GPU, enabling very fast parallel computations of enormous amount of data.

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Title : *Digitization and Visualization of Apparel*
Author(s) : *Maheshwari Rishabh*
Roll No : *Y9227484*
Supervisor(s) : *Venkatesh K S*

Abstrac

Recent years have seen an increasing interest in digitization of garments from data available from apparel industry. The apparel industry is focusing on digitization of garments so that they can be better visualized on online platforms. On the other hand, graphic designers are looking forward to utilize this already available huge garment data in designing clothes for characters used in animations, movies etc. In general, designing clothes in computer graphics involves making a three dimensional cloth, say shirt, around a three dimensional model, say human, and simulate the two. However such an approach cannot be directly utilised for digitization of garments as the data available from apparel industry is in the form of two dimensional panels, which form the complete garment after sewing in three dimensional space. Our research presents a complete pipeline that takes in input model data and garment data to give final cloth simulated over the model as output. The cloth is taken as Design file and Size file and model is taken as three dimensional mesh file. Design file is a simple image file containing texture information, whereas size file is a CAD file or mesh file containing size information of cloth in the form of two dimensional cloth panels. Our pipeline facilitates user to easily provide the sewing information of these panels in three dimensional space. It then sews these cloth mesh panels over model to provide virtual sewing. After sewing simulation, we get final cloth rendered over the model. Once all this is done, one can readily change Design or Size file without any further inputs. The algorithms in this thesis study include barycentric quad mesh subdivision technique, cloth simulation based on mass-spring model, cloth and static body collision, cloth self-collision and sewing of cloth through generic \textit{sewing springs}. The pipeline is facilitated with texture mapping at all stages. The results include rendered clothes over three dimensional models with a comparison of simulation time vs. visual appeal based on degree of cloth meshing. Comparisons between various sizes of cloth on the input model are also provided.

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Title : *2d Shape Classification In Tangent Space*
Author(s) : *S Silpa K*
Roll No : *12104079*
Supervisor(s) : *Venkatesh K S*

Abstrac

Shape analysis is a major problem in the fields of visual information systems, pattern recognition, computer vision, robotics, and many other fields. The major aspects in a shape analysis system are shape representation, description and comparison. This thesis aims at the representation of both closed and open 2D curves using a shape descriptor robust to similarity transformations and noise with a less number of shape features. Then, we propose the description of the curves in tangent space using a modified tangent space representation, which enables us to compare between curves. The 2D curves are approximated using significant points on the curve called as dominant points and the approximated polylines are used for tangent space(TS) representation. The TS representation gives a clear picture of the shape of the curve. Also, we have defined a distance measure to compare between two shapes from their TS representations by comparing the peaks and valleys in the midpoint curves obtained from TS representations. Towards the end of the thesis, we have also proposed a simple shape retrieval system on MPEG-7 shape-I data set based on our distance measure. With significant reduction in the shape features for description, the representation of 2D curves in tangent space as well as the shape classification based on the distance measure defined on TS representations gives a computationally efficient shape retrieval system

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Title : *Geographically Aware Overlay and Routing For Improved Peer-To-Peer Resource Sharing And Query Resolution in MANETs*

Author(s) : *Sharma Anuresh*
Roll No : *12104098*
Supervisor(s) : *Singh YN*

Abstrac

Mobile Ad hoc Networks (MANETs) and Peer-to-Peer (P2P) network s hold similarities concerning their routing and network management principles. The common goal is to provide networking functionalities in a completely unmanaged and decentralized environment. However, P2P and MANETs are established on a different basis. P2P is based on a static IP network and MANET on a mobile radio network. Hence, adoption of the P2P paradigm to share resources and resolve queries in a MANET scenario gives rise to challenging problems due to the fundamental mismatch of the two overlays. The advantage of DHT for resource sharing and query resolution along with bandwidth saving has yet not been fully exploited in MANET. Coupled with mobility, there is a drastic reduction in the resource sharing and query resolution performance. In this thesis, a novel way of integrating both the overlays has been designed and implemented by utilizing geographic awareness. Geographic Hash Table (GHT) in conjunction with Modified Geographic Routing (MGR) has been integrated to solve the problem of mismatch. The design has been implemented by constructing necessary algorithms along with listing the requisite data structures. Proof-of-Concept simulation results show that the algorithm works satisfactorily even for nodes with high mobility

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Title : *OFDM System in Aeronautical Channel*
Author(s) : *Tomar Vivek Kumar Singh*
Roll No : *12104092*
Supervisor(s) : *Rajawat Ketan*

Abstrac

Conventional communication methods between aircraft are not robust to time-varying channel conditions during flight, especially at supersonic speeds. This thesis advocates the use of an OFDM-based digital communication system for high data rate communication on the aeronautical channel. The proposed design is not only bandwidth efficient, but also resilient to multipath impediments. Interestingly, the aeronautical channel is not stationary, and its statistical characteristics depend on aircraft's relative position with respect to the ground and its velocity. Broadly, the channel conditions can be classified based on whether the aircraft is enroute, arriving or taking off, and parking or taxiing. The enroute and parking channels are particularly interesting due to the presence of high Doppler shift and large scatterers, respectively. The proposed OFDM design works for all channel conditions, without requiring manual intervention. Due to dynamic nature of aeronautical channel , training based approach is used for channel parameters estimation. Joint maximum likelihood estimation is used for estimating doppler shift, channel, and timing offset. Semi blind approach using same estimation algorithm is proposed in good channel conditions to enhance performance. Percentage and placement of training are optimized with respect to low bit error rate and high information rate. Varying rate convolution coding is done to exchange information rate for lower bit error rate. Bit error rate in all channel conditions are calculated with received snr and coding rate

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Title : *Distributed Asynchronous Localization in Wireless Sensor Networks*

Author(s) : *Tyagi Ritesh*
Roll No : *12104067*
Supervisor(s) : *Rajawat Ketan*

Abstrac

This thesis considers the problem of localization of wireless sensor networks. In contrast to the widely used range measurement based localization approaches, this thesis advocates fast algorithms based on squared range measurements. Generalizing the low complexity and asymptotically efficient squared range measurement based source localization algorithms, this thesis proposes a network localization algorithm that minimizes the squared-range least square (SR-LS) criterion. The global non-convex problem is split into several local subproblems that, although non-convex, can still be solved using bisection at each node. The overall distributed algorithm is flexible enough to incorporate range measurement constraints, bandwidth limitations, GPS positioning errors, and network delays. Indeed, a modified asynchronous version of the algorithm is proposed that can tolerate delayed updates from nodes. The algorithm converges faster than the state-of-the-art weighted distributed MDS algorithm, and achieves the Cramer-Rao Lower Bound (CRLB) performance.

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Title : *UAV: 3D Pose Estimation*
Author(s) : *Abhishek Anand*
Roll No : *12104008*
Supervisor(s) : *Venkatesh K S*

Abstrac

Nowadays the Unmanned aerial vehicle (UAV) are widely used in commercial and military sectors. The ability of these systems to take on dirty, dull and dangerous tasks which were formerly done by humans is encouraging their rapid adoption. They are usually deployed for military purposes and civil applications, such as policing, surveillance, sports, disaster relief, aerial photography, scientific research. UAVs are mostly dependent on an Inertial Measurement Unit (IMU) for navi- gation. But IMU errors grow with time, thus defeating the purposes of reliable and accurate navigation. So we have presented an approach to estimate the states of an UAV using only onboard camera which can be either used alone or assimilated with the IMU output to enable reliable, accurate and robust navigation. Presented here is a solution to the problem of estimating UAV state (its position, orientation and velocity) using only video from onboard camera. The state is estimated using three different approaches. Assuming a pinhole camera model and perspective projection, the first approach is based on optical flow and horizon detection. In the second method, the craft state is estimated using differential and discrete epipolar constraint assuming the scene is slowly moving. In the last approach, an Implicit Extended Kalman Filter is used on implicit measurements on nonlinear homography manifold space. The state estimation has inherent nonlinearity so both linear least square and nonlinear least square minimization has been explored to get optimal results. This dissertation also investigates how to find pitch and roll in the absence of a horizon contrary to existing techniques which depend on the presence of visual horizon in the image.

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Title : *Peer To Peer Offline Messaging System For Brihaspati -4 LMS Using The Jxta Framework*

Author(s) : *Ganguli Prithwish*
Roll No : *12104105*
Supervisor(s) : *Singh Yatindra Nath*

Abstrac

Generally it has been seen that in communication networks, Peer to Peer based architecture is faster than the centralized Client Server model. Therefore, there has been a momentum gaining in the development of the Peer to Peer communication systems. There is also an added advantage in P2P based systems that there is a certain inherent flexibility and scalability to implement the protocols for information sharing. The basic aim of this thesis is to design a reliable offline message delivery system for the Brihaspati 4: Learning Management System (LMS) for the Peer to Peer based architecture. This LMS is planned to replace the centralized Client Server based Brihaspati 3. This LMS is used as a learning platform for a number of universities spread over a wide geographical area. This is a platform which is used to conduct E- learning courses across or within universities and share course content and messages online. This thesis aims to provide the Brihaspati LMS with a module of messaging system within peers and peer groups which may be created on the basis of courses being offered or otherwise. This unique messaging system is supposed to work even when peers are offline, due to the novel concept of storage of messages within the peers themselves. This application acts as hybrid of a chat application and e-mail. The key feature of this messaging system is that it stores the instant messages in active nodes/peers and delivers them whenever the intended peers comes online

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Title : *Future and Past Encounter Based DTN Routing in Airborne Networks*

Author(s) : *Premi Abhishek*

Roll No : *12104097*

Supervisor(s) : *Singh Yatindra Nath*

Abstrac

Airborne networks are utilized for military purposes of information gathering, area surveillance, and rescue missions and also for non-military purposes such as rescue missions and real time environment monitoring. The data collected through these airborne platforms is generally available for analysis after the aircraft land back to the base. This leads to long time gap between the sensor (aircraft) and central decision body which can be avoided with real time transmission of data as and when available. As the airborne nodes are highly mobile, the link between the nodes becomes intermittent. This makes the utilisation of the TCP/IP based routing schemes unviable for data transmission as instantaneous end to end path between the sender and the destination is not available and there are long round trip delays. Hence, Data routing in airborne networks becomes a challenging issue in this dynamic topology. Airborne networks can be considered as Delay Tolerant Networks (DTN) which forms an overlay over the underlying network and provides for routing using ‘store and forward’ or hop by hop approach at the intermediate nodes. The routing is such network is based on opportunistic contacts and limited knowledge of the immediate neighbours. The challenge is to design a routing algorithm that will maximise the delivery ratio and minimise the delay or latency and redundancy of messages in this scenario. In this thesis, a novel scheme of integrating both past and the future encounter times of pairwise nodes for next hop estimation has been proposed. The proposed routing along with the available DTN routing schemes such as multi-copy routing, single copy routing are simulated and compared. The proposed scheme performs better than the existing schemes in terms of delivery ratio, delay and repeated messages

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Title : *Incorporating Short Messaging And Command Queue In Ieee 802.11e For Inter Vehicle Communication In Battlefield Environment*

Author(s) : *Kumar Rakesh*
Roll No : *12104106*
Supervisor(s) : *Singh Yatindra Nath*

Abstrac

Smart phones, tablets, high-speed wireless networks and other sophisticated communications technologies are rapidly changing the way people access, use and exchange information. The military is embracing the communications revolution, turning to a new generation of sophisticated systems to enable faster, richer, less costly and more flexible communications. However, as communication options multiply, so does the problem of getting disparate technologies to work together efficiently and securely. In this backdrop, adapting the current MAC protocols, designed for civilian applications, as it is, for military use may not fit the requirements. A study of the existing MAC protocols for Mobile Adhoc Networks in battlefield environment has been carried out. The priority queue mechanism of IEEE 802.11e which supports 4 priority queues can be utilized for wireless access in battlefield environment, which is characterized by rapid manoeuvres and mobile wireless clients. However, the priority queues have been proposed as per civilian applications and voice has been given the highest priority followed by video, best effort and background in that order. Battlefield communication is characterized by short messages which need to be handled at highest priority and priority pre-emption, implying prioritized access of the channel to a Military Commander. A short messaging and command queue of highest priority for emergency messages has been incorporated into the IEEE 802.11e protocol and its impact on the performance of other queues in terms of throughput and MAC delay has been studied.

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Title **:** ***Alternate Layer Sparsity and Intermediate Fine-tuning for Deep Autoencoders***

Author(s) **:** ***Bhutani Ankit***

Roll No **:** ***Y9227094***

Supervisor(s) **:** ***Mukerjee Amitabha&Venkatesh K S***

Abstrac

In this work, we present two new strategies to improve dimensionality reduction using deep autoencoders. It is shown that by enforcing sparsity and bottleneck constraints on alternate layers of a deep autoencoder, the performance of deterministic auto associative pre-training models like shallow autoencoders can be made comparable to, and in some cases even better than, stochastic models like Restricted Boltzmann Machines (RBMs). We also introduce a new technique called intermediate fine-tuning which improves the performance of all deep autoencoder models which employ stackable modules like RBMs for pre-training. The improvement in performance is demonstrated for the benchmark MNIST dataset as well as some synthetic datasets for which the intrinsic dimensionality is explicitly known.

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Title : *Time Synchronization in Wireless Sensor networks*
Author(s) : *Singh Sudhir Kumar*
Roll No : *12104109*
Supervisor(s) : *Singh Yatindra Nath*

Abstrac

The wireless sensor systems are employed for many applications. A number of algorithms exist for time synchronization in sensor networks. Time synchronization requires a number of messages to be transmitted by synchronization master, peer or child node depending upon the synchronization scheme used. There are three basic schemes used for time synchronization in the wireless sensor networks. These are sender receiver sender (SRS), receiver -receiver and receiver only synchronization (ROS); nodes use any one of the above to get synchronize. The energy consumed in transmission of single message is much more than that of its reception. ROS requires only two way timing message exchange between a pair of nodes to achieve synchronization of a group of nodes which can receive messages from broadcasting pairs. Thus, ROS is highly energy efficient as compared to other synchronization schemes. In this thesis we have proposed two topology based algorithms which allows large number of nodes to synchronize by ROS. We also investigate the accuracy of the algorithm as number of levels of ROS increases. The simulation results show that the accuracy of clock offset and skew at different node levels increases as the number of observations increase. The nodes close to the root node have better synchronization accuracy compared to higher level nodes.

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Title **:** ***Joint Carrier and Channel Estimation in Turbo Coded OFDM Systems***

Author(s) **:** ***Ummer Rashid***
Roll No **:** ***12104065***
Supervisor(s) **:** ***Vasudevan Kasturi***

Abstrac

Orthogonal Frequency Division Multiplexing (OFDM) is a widely adopted multicarrier modulation technique for high-data-rate communication systems over frequency selective channels. One major drawback of OFDM is that it is sensitive to synchronization errors. The performance of OFDM systems are mainly dependent on the carrier frequency offset and timing synchronization errors which results in inter-carrier interference (ICI) and inter symbol interference (ISI) respectively. Therefore, synchronization is of vital importance to OFDM systems. Moreover, estimation of multipath Rayleigh fading channel coefficients is necessary before the demodulation of OFDM signals. There exist different methods in the literature for estimating start of frame (SoF), carrier frequency offset (CFO) and channel coefficients either separately or jointly. In this thesis, we propose a new two stage joint estimation of SoF, CFO and channel coefficients. The frame structure of OFDM consists of a known preamble, cyclic prefix and data. The SoF and coarse frequency offset are first estimated jointly using a filter matched to the known preamble. Next, the multipath channel coefficients and fine frequency offset are estimated jointly using scaled unscented transform method. The bit-error-rate performance of OFDM is improved using turbo coding.

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Title : *Sparse channel estimation techniques for OFDM systems based on compressive sensing and subspace methods*

Author(s) : *Sarkar Abhinandan*
Roll No : *12104099*
Supervisor(s) : *Vasudevan Kasturi*

Abstrac

Sparse channels are typically encountered in many communication systems like under water acoustic channels, communications in a hilly terrain etc. Conventional channel estimation techniques like the Least Squares approach and interpolation based methods do not work well in this case, because these techniques do not exploit the sparse structure of the channel. In this thesis, we first present a comparative study of the existing sparse channel estimation techniques based on Matching Pursuit (MP), Orthogonal Matching Pursuit(OMP) and Basis Pursuit(BP) with respect to the mean squared error (MSE) and bit error rate (BER). Then we introduce the novel Compressive Sampling Matching Pursuit (CoSaMP) algorithm and demonstrate its superior performance with respect to the previously mentioned schemes. The channel estimation techniques are compared taking Cramer-Rao lower bound(CRLB) as the reference. Secondly, considering a different scenario, we introduce the subspace based methods of Multiple Signal Classification (MUSIC) and Estimation of Signal Parameters via Rotational Invariance Techniques (ESPRIT) algorithm when the channel is constant for a few OFDM frames within the coherence time. We propose a new method for ESPRIT based channel estimation as calculation of the ESPRIT MMSE estimator proposed in the literature is prohibitively complex and involves two matrix inversions per iteration. Simulation results show that the proposed ESPRIT estimator slightly outperforms the ESPRIT MMSE estimator in terms of bit error rate over a wide range of SNR's and that too with a reduced computational complexity. Finally the performance of these subspace based estimators have been comprehensively quantified for many different test cases.

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Title : *Spatio-Temporal Opportunity Detction with Multiple Primary Users*

Author(s) : *Pandey Puneet*

Roll No : *12104057*

Supervisor(s) : *Rajawat Ketan*

Abstrac

Spectrum sensing is an important area of research in the context of cognitive radio networks. This thesis considers the problem of identifying spectral opportunities from the perspective of detection theory. In particular, we design a distributed spatio-temporal opportunity detector for CR networks with multiple primary users. Unlike existing approaches, the detector capitalizes on the spatial and temporal correlation between the energy received at different secondary users (SUs). The problem becomes challenging in the presence of multiple primary users (PUs), where channel impairments may often hide one or more transmitting PUs. We propose a novel spatio-temporal test statistic that incorporates channel diversity and PU activity patterns through collaboration between neighboring SUs. Closed form expressions are derived for the probability of false alarm and probability of detection. Numerical tests confirm the efficacy of the proposed scheme over competing detectors

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Title : *A Study on Rate Compatible Turbo Product Codes*
Author(s) : *Kumar Shailendra*
Roll No : *12104108*
Supervisor(s) : *Banerjee Adrish*

Abstrac

In modern communication systems, detection and correction of errors are major challenges. As solution to detection and correction of channel errors, various coding schemes have been developed. It started with algebraic hard decoding schemes, and reached at an era of iterative soft decoding schemes. With the increasing demand of high data rate and low power consumption devices, coding schemes are needed, which give performance close to Shannon limit. The very popular coding schemes fulfilling the needs, are turbo convolutional codes, turbo product codes, LPDC codes, etc. The turbo product codes became popular because of its high performance, even at high code rate, with flexibility of trade off between performance and decoding complexity. Turbo product code is basically a coding scheme with set of fixed code rates. In the various applications like digital video broadcasting, satellite mobile radio communication, etc, there are requirements of variable information rates in real time environment. These variable information rates leads to the demand of rate compatible coding schemes. \par In this thesis, our aim is to develop rate compatible coding scheme, using Turbo Product code. The rate compatibility in turbo product code, is achieved by using various code modification schemes, such as shortening and puncturing. The efforts have been made towards the development and performance evaluation of turbo product code in AWGN environment with SISO (soft in soft out) decoding or Chase-Pyndiah decoding algorithm. Later, the rate compatibility in turbo product codes is developed and performance evaluations in AWGN channel environment has been done with various code rates

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Title	***:***	***Dynamic Robust Spectrum Sensing and Malicious user Tracking in Cognitive Radio Network***
Author(s)	***:***	***Kapoor Gaurav***
Roll No	***:***	***12104100***
Supervisor(s)	***:***	***Rajawat Ketan***

Abstrac

Spectrum sensing is the first and most important activity in a Cognitive Radio Network. Many external factors like the channel fading and shadowing may cause erroneous decisions if performed by a single node. This problem is easily handled by using spatially distributed cognitive radio nodes who collaborate to produce the final spectrum sensing decision. Cooperative spectrum sensing is capable of improving the spectrum sensing performance and distributing the computational load. There are potential malicious cognitive radio nodes who may modify the results of spectrum sensing for some gains. This results in deteriorating the performance gains achieved due to cooperation. The main objective of the thesis is to develop a scheme which can make robust decision in the presence of these malicious nodes and in an environment where the malicious users are slowly changing. Making use of the property that malicious users are sparsely distributed the problem of robustfication is converted into a constrained convex optimization problem. The performance metrics for such a system have been identified and simulations have been performed to study the performance. Online methods are used to handle sequential data in real time. This helps in tracking the malicious user and reducing the computational load.

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Title : *Hand Gesture Recognition from 3D and 2D Sensor Data*
Author(s) : *Kurmi Vinod Kumar*
Roll No : *12104091*
Supervisor(s) : *Venkatesh K S*

Abstrac

In the present era of technology, human computer interface(HCI) is not limited by physical contact with the devices. It has the potential to change the way users interact with computers and appliances, by eliminating input devices such as joysticks, mice and keyboards, and allowing the unencumbered body to give signals to the computer through gestures. This dissertation aims to emulate this mechanism in human– machine communication systems, specifically for hand gesture recognition with low complexity algorithms. We present efficient algorithms to detect the gestures of the hand from 3D and 2D sensor data. The main goal is to detect hand gestures in varying light conditions, irrespective of neighbouring clutter. In the first part, we proceed with hand segmentation with the assistance of depth histograms. Further, the fingertips of the hand are used to form a distinctive constellation of points, which is highly specific to the human hand and cannot be easily encountered in other objects. This constellation yields the position and orientation of the hand and fingertips, thus enabling us to design various gestures. The system is able to reject invalid gestures and works in the dark as well, on account of primarily depending on the depth information. For the same reason, the background clutter does not hamper the working of the algorithm. The algorithm has been used to design a few specific gestures. This involves tracking the change in position of the hand or change in its orientation or change in its state(open/close). Gestures have also been designed for two hands used simultaneously, keeping a track of their positions with respect to each other. We have worked with a commercially available depth sensor called Kinect sold by Microsoft. The system works in real time. The software used for the project is Computer Vision in Microsoft Visual Studio using C and C++.

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Title : *A New Full Rate Full Diversity Orthogonal Space-Time Block Code For Four Transmit And One Receive Antenna*

Author(s) : *Pavan Kumar G V V R*
Roll No : *12104050*
Supervisor(s) : *Vasudevan Kasturi*

Abstrac

In wireless communication system, fading is one of the major issues which has to be overcome for reliable communication. The major goals in a wireless communication system design are to avoid fading, reducing the error in communication, thereby increasing the throughput. Diversity technique reduces the error of the system considerably by sending multiple copies of same signal. Space Time Block Codes improves the performance of the communication system by exploiting both spatial and temporal diversity. We know that full rate and full diversity are not possible simultaneously for a system using complex symbols and having more than two transmit antennas. In this work we develop a Space Time Block Code which is not initially orthogonal, but becomes orthogonal after using Triple QPSK modulation technique for four transmit antennas. This STBC now achieves full rate and full diversity. The receiver decodes the symbols in pairs, there by reducing the computational complexity. Simulation results show that STBC using Triple QPSK modulation provides full transmission rate when compared to orthogonal STBC which provides transmission rate of only 3/4. Moreover, the bit error rate (BER) performance of STBC using Triple QPSK modulation is comparable to orthogonal STBC.

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Title : *Matched Filter Based Timing and Carrier Frequency Offset Estimation in OFDMA Uplink*

Author(s) : *Kumar Vijay*
Roll No : *12104111*
Supervisor(s) : *Vasudevan Kasturi*

Abstrac

In this thesis, we consider the problem of symbol timing and carrier frequency offset (CFO) estimation of all active users in quasi-synchronous Orthogonal Frequency Division Multiple Access (OFDMA) uplink scenario. We propose, a suboptimal, fast and practically implementable with low hardware complexity, data aided matched filter based timing and CFO estimation. The matched filter performs correlation operation between received signal and reference signal corresponding to each user. The reference signal is generated based on known training sequence and known subcarrier assignment structure. The time index corresponding to the correlation peak gives the timing estimate. The CFO estimation is done by computing the phase difference between two peaks which are obtained when the training sequence is repeated over two OFDMA symbol period. Performance of the CFO estimator is evaluated with respect to the mean squared error (MSE) and the performance of the timing estimator is evaluated in terms of probability of erasure

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Title : *An Iterative Tuning Strategy For Achieving Cramer Rao Bound Using Extended Kalman Filter For A Parameter Estimation Problem*

Author(s) : *Mohan Shyam Mohan*
Roll No : *12104078*
Supervisor(s) : *Naik Naren*

Abstrac

The Kalman filter (KF) is a powerful tool widely used to estimate quantities in the presence of noise, be it in the process or the measurement. The catch in the approach is the need to know the process and measurement noise statistics as well as the initial estimate and covariance of the states and parameters. The setting of these typically apriori-unknown quantities is called tuning of the KF. Tuning is typically done either manually or via adaptive estimation; however there is still a need for adaptive estimation of the unknown system parameters as well as the noise statistics, that yields accurate estimates and error covariances for the states as well as parameters. In our work an iterative tuning procedure is developed not only to estimate the parameters but also to achieve the Cramer Rao bound (CRB), thus making it an efficient estimator. A smoothing technique is used to solve the initial conditions for the state, and a new virtual measurement concept is introduced to initialize the filter for unknown parameters. The measurement noise matrix is estimated by the Myers and Tapley covariance matching scheme. A new method for estimating the process noise is introduced which uses the difference between the stochastic and deterministic trajectory. A tuning strategy is developed for both zero and non zero process noise case and many sensitivity studies are conducted on test problems to study the robustness of the algorithm, using a user friendly graphic user interface.

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Title : *Network Lifetime Improvement in Wireless Sensor Networks by Exploiting Sink Mobility*

Author(s) : *Singh Tarun Kunal*
Roll No : *12104086*
Supervisor(s) : *Singh Yatindra Nath*

Abstrac

Data gathering is a fundamental task of wireless sensor networks (WSNs). The task is to collect sensor readings from sensor nodes spread over the sensory fields at predefined single sink or multiple sinks (without aggregating at intermediate nodes i.e. relay nodes) for analysis and processing. Research has shown that energy expenditure at sensor nodes near sink is much greater than sensor nodes located away from sink. Therefore sensor nodes near sink deplete their battery faster than those away due to heavy overhead of relaying messages. The consumption of energy is therefore found to be non uniform, which causes degraded network performance and shortens network lifetime. In present work sink mobility has been exploited to reduce and balance the energy consumption rate. The effectiveness has been demonstrated by experiment study using Cooja simulator and RPL as a Routing protocol. It is found that the lifetime of sensor field is improved by exploiting sink mobility in comparison with stationary sink node. The proposed strategy moves the sink towards the nodes with highest residual energy. This approach does not need global knowledge; the residual energy information is available at each sensor site locally. This information is piggybacked with measurement data and reported to the sink. After getting this information by all leaf nodes of the network, the sink elects the node with greatest residual energy and moves towards that node. A special care is taken; sink is allowed to move only at instances when global DAG repair is made to mitigate the effect of large control message. The proposed algorithm is simulated using COOJA simulator of CONTIKI operating systems for sensor networks. The results have clearly shown that by exploiting sink mobility, the lifetime of sensor network can be greatly increased and premature failure (i.e. energy holes) can be avoided. The effectiveness of the proposed algorithm is more and more clear on large sensor networks.

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Title : *On the Performance of Quantum Error Correcting Codes in the Presence of Qubit Loss and Amplitude Damping*

Author(s) : *Gowda Manoj G*
Roll No : *12104038*
Supervisor(s) : *Banerjee Adrish&Kumar K Pradeep*

Abstrac

In quantum communications, photon losses are of primary concern in addition to noise. Quantum error correction is used to protect qubits from channel noise. Quantum error correction and quantum algorithms proposed so far work on the assumption that all qubits are present in the system during quantum operations. If some qubits of the codeword are lost, the surviving codeword belongs to a different Hilbert space and therefore lead to incorrect decoded qubit. Thus qubit losses will affect the performance of quantum codes. The proposed schemes in literature to combat losses make use of a significant number of qubits and are suitable for use in memory. At receiver quantum non-demolition counting of photons will indicate the loss of qubits. This information is fed back to the transmitter which, in the case of qubit loss, will resend the codeword. At first, we derive the channel fidelity when two channels in cascade are acting on the qubit. We then use the result to get channel fidelity under condition of qubit losses. The effect of combined amplitude damping and depolarizing channels on a qubit in considered. We show the non-commutativity between amplitude-damping and depolarizing channels. We propose a technique to transform codes for depolarizing channel into code for amplitude damping channel and combined amplitude damping and depolarizing channels. To combat qubit loss, we present a technique that uses feedback from receiver using non-demolition photon number counting. Expression for throughput and fidelity is derived. We also consider the case when feedback from receiver is erroneous and derive the throughput and fidelity in this scenario. We then present a scheme that uses the coding technique described in the literature and feedback to overcome losses. We derive throughput and channel fidelity for this case.

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Title : ***Coherent and Noncoherent Detection of CPM Signals using Viterbi Algorithm***

Author(s) : ***Nagaraju Jogu***

Roll No : ***11104062***

Supervisor(s) : ***Kasturi Vasudevan***

Abstrac

Continuous phase modulation (CPM) is widely used in wireless communication, Infact Global System for Mobile communications (GSM) networks use Gaussian minimum shift keying (GMSK) modulation. Coherent and non-coherent sequence estimation of CPM, signals use the Viterbi algorithm. In coherent detection the receiver knows the exact value of constellation points.Hence the Viterbi algorithm propagates real metrics. In noncoherent detection there is no synchronization between transmitter and receiver, which means the constellation points get rotated by some unknown phase angle. Here we use a technique called suboptimal noncoherent Viterbi algorithm (SNVA) in which complex metrics are propogated. The bit error rate performance of the conventional VA and SNVA is compared using computer simulations

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Title : *Impact of Carrier Frequency Offset on the performance of Universal Filtered Multicarrier*

Author(s) : *B Uday Kumar*
Roll No : *12104088*
Supervisor(s) : *Kasturi Vasudevan*

Abstrac

Universal filtered multicarrier (UFMC) is a recent multicarrier modulation technique which can be viewed as the generalization of Orthogonal frequency division multiplexing (OFDM) and filter bank based multicarrier (FBMC). UFMC has the potential to overcome the problem of OFDM which is sensitive to inter-carrier interference (ICI) which arises due to carrier frequency offset (CFO). In order to reduce side lobe levels, UFMC applies filtering operation to a collection of consecutive subcarriers, thus minimizing the ICI. It is a suitable technology for 5G wireless systems and it achieves this by combining the OFDM's simplicity with the benefits of FBMC. While UFMC's previous work used zero forcing equalizer for recovery of data signals, in this thesis, FFT based receiver is used for reception. FFT based receiver is employed due to its lower complexity. We examine the effect of CFO on the performance of UFMC with FFT based receiver and compare the results with the performance of cyclic prefixed OFDM (CP-OFDM) systems. Symbol error rate (SER) is considered as the measure of performance. Simulation results indicate that UFMC outperforms CP-OFDM. From the simulation results, we notice the robustness of UFMC to CFO effects.

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Title : *An Improved Extended Orthogonal Space-Time Block Code*
Author(s) : *Yalla Prasad*
Roll No : *12104094*
Supervisor(s) : *Kasturi Vasudevan*

Abstrac

In the recent years space-time block codes have been proposed for use in multiple transmit and receive antennas. Reliability of wireless systems can improve significantly by using space-time code design techniques. There has been considerable work on a variety of schemes which exploit multiple antennas at transmitter and receiver to obtain transmit and receive diversity and there by improve system reliability, for example orthogonal space-time block codes (OSTBC). However complex orthogonal space-time block codes with linear processing for greater than two transmit antennas cannot achieve full rate in multipleinput and multiple-output (MIMO) channels. However, at the expense of losing some degree of diversity advantage, it is possible to achieve full rate or even rates higher than one for any number of transmit antennas. In this thesis we work on a method to extend any space-time code constructed for n transmit antennas to 2n, 3n, 4n..... transmit antennas through Group-Coherent Codes (GCC). GCC design makes use of limited feedback from the receiver (as low as 1 bit). We start with designing the system model for MISO systems. Next, we generalize this process for arbitrary number of transmit and receive antennas. This method can be used for preserving full rate, full diversity and low complexity decoding with very limited feedback. We further employ a proper rotation at each branches of some OSTBCs to enhance system performance. We assume zero-delay in the feedback and prefect knowledge of the channels at both the transmitter and receiver.

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Title : ***A Unified Approach for Archival Film Restoration using Video Decomposition***

Author(s) : ***Yadav Ravindra***

Roll No : ***12104066***

Supervisor(s) : ***Gupta Sumana***

Abstrac

In this thesis we propose a unified approach for restoring video sequences affected by common degradations like blotches, scratches and partial color artifacts. The approach adopted is based on a novel principal component analysis technique. Principal component analysis is a widely used data analysis and dimensionality reduction technique describing the data with respect to a new set of uncorrelated variables or axes called principal components. One such principal component analysis technique is Low rank and sparse decomposition of a data matrix. It is based on the assumption the data lies near some low-dimensional subspace. There are various approaches for this decomposition, but the one we use is based on minimization of a weighted combination of the low rank (approximated by nuclear norm) and L1 norm (proxy for number non-zero components in a matrix). Since in a video shot the neighbouring frames are highly correlated, this makes the video a suitable candidate for low rank decomposition. Any artifact, on the other hand behaves as a sparse component. In this thesis we discuss how low and sparse decomposition approach can be used for video restoration applications that include removal of blotches, partial color artifacts and severely degraded large regions. Video restoration of degraded sequences essentially has two stages: first to detect the location of the artifacts using low rank and sparse decomposition, followed by filling up the artifacts using the characteristic properties of the particular artifact. Encouraging results have been achieved using the proposed approach.

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Title : *HDR Imaging Using Time Varying ND Filter*
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Roll No : *12104104*
Supervisor(s) : *Venkatesh KS*

Abstrac

In this thesis, we propose a Liquid Crystal Display (LCD) based time varying and adaptive neutral density (ND) filter to increase the dynamic range of conventional image capturing devices. Towards this end, an ND filter has been implemented us- ing an LCD based filter and this has been used as an attachment to the capturing device. Conventional methods of High Dynamic Range (HDR) imaging use exposure and aperture controls. In this work a novel idea is proposed; we capture a sequence of low dynamic range (LDR) images of the scene with shifted dynamic range at each capture. Next, we extract better illuminated portions from each capture and then they are fused together to get a high dynamic range (HDR) image. The proposed ND filter has a time-varying controlled passage of light, which enables the photographer to capture multiple images of the current scene automatically. This property of the proposed ND filter has improved the exibility in comparison to the manual selection of shutter speeds and aperture settings corresponding to each dynamic range. Also, the proposed system can be configured as an adaptive ND filter as the contrast of the LCD can be easily configured by reading the ambient light and using this incident light as a feedback to adjust the contrast of the LCD. The proposed system is a low cost solution with sufficiently good results.

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Title : *Modeling and Simulation of LDMOS and VDMOS FETs*
Author(s) : *Sahoo Jyoti Ranjan*
Roll No : *11104045*
Supervisor(s) : *Chauhan Yogesh Singh*

Abstract

In this era of automation, requirement of High-Voltage MOSFETs has increased manifold. Applications of these high voltage integrated circuits (HVICs) are enormous ranging from automotive and consumer applications like switch mode power supply (SMPS), DC converters, motor control, telecommunications and power amplifiers to smart power integrated circuits. In this thesis, an LDMOS device is generated and simulated in TCAD Sentaurus. The device properties like quasi-saturation effect, self-heating-effect, impact-ionisations and capacitance behaviour etc. are extensively studied. Here, we report high voltage MOSFET modelling using BSIM6 model. The proposed model has two components – intrinsic MOSFET channel of LDMOS modelled by BSIM6 and a drift region modelled by non-linear drift resistance. BSIM6 is the next generation bulk MOSFET model in BSIM family of models. It has already been approved as an industry standard model. It also has the model of Self Heating Effect (SHE) which is very important for high power devices like LDMOS. The drift-resistance model which is used to model the drift region of LDMOS includes effect like velocity saturation, self-heating and impact ionisation. All these effects have already been modelled in BSIM6. This model shows good behaviour over wide range of gate and drain bias conditions including convergence. The model also considers the capacitance behaviour of LDMOS device. We have validated this model on the simulated characteristics generated by TCAD and then, on the measured characteristics of an LDMOS device, where it shows excellent accuracy over entire bias range. This model also works very accurately for other high voltage structure like VDMOS, where scalability of the model has been demonstrated along with input and output characteristics of the device. We have also analyzed the effect of field plate on LDMOS device performances like break-down voltage and ON-resistance by simulating different LDMOS devices with different length of field plate in TCAD tool.

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Title : *Performance Analysis of Germanane Nanoribbon Based Transistors by Atomistic Simulation*

Author(s) : *Chokhra Saurabh*
Roll No : *Y9227525*
Supervisor(s) : *Ghosh Bahniman*

Abstract

A single-atom thick sheets of stable graphene(two dimension material) were made from crystalline solids and exhibited remarkable electronic and structural properties ,fundamentally different from its parent material and its potential use in growing electronic devices. Hence it attracted researchers attention to identify and extract new two dimensional materials and calculate their electronic properties and apply those in building effective devices. In this direction, MX2, Si, Ge type of material has been extracted and intensive research work is going on in the direction of manufacturing efficient devices out of these material properties. In this work, I built bilayer germanane armchair nano ribbon and complete hydrogen passivatedgermanae zigzag nano ribbon MOSFETs and studied the effect of various defects (wrap, ripple, twist) and deformations (rough edge, vacancy), Uniaxial strain, biaxial strain, Uniaxial compression and biaxial compression on device electronic and transport properties. I analyzed the current voltage characteristics, conductance, transmission spectrum due to application of defects, deformation and strain in Atomistic tools kit and recorded changes in peak current, negative differential region, peak to valley ratio with very small amount of disturbance. Till now, Only hydrogen passivatedgermanane can be synthesized, hence i studied the effect of strain, width on the nano ribbon band structure and plotted the graph with decreasing width to the bandgap. Strain engineering can be applied to open the bandgap as per device requirements. These results will be useful in the miniaturization of memory cells, solar cells and a lot more devices. Additionally these results can be used as a sensor to calculate mechanical deformations in particular device

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Title : *Spin Torque Induced Microwave Dynamics In Magnetic Tunneling Junction Based Devices*

Author(s) : *Khokhar Prashant*
Roll No : *Y9227427*
Supervisor(s) : *Ghosh Bahniman*

Abstract

It is found that spin polarized currents can transfer magnetic moment from one magnetic layer to another. Spin Torque Nano Oscillator or STNO is a device based on Magnetic Tunneling Junction (MTJ) geometry which uses this phenomenon to convert dc current into microwave frequency signals. STNO has a wide current and magnetic field tunability and hence, is highly promising for fields like micro-wireless communications, nanosensors, chip clocks for VLSI applications, etc. However, certain challenges such as low output power and high applied magnetic fields limit its usability. Consequently, further improvements are required before their widespread application is possible. This thesis is dedicated to theoretical study and micro-magnetic simulations of such an oscillator using MTJ geometry and perpendicular magnetic anisotropy. We observe oscillator operation in the absence of applied external fields and. moreover, as a first principle investigation of STNO based on perpendicular polarizer configuration, we run simulations to find the dependence of oscillator frequency on free layer thickness, input current and oxide thickness. Additionally, we try test our proposed geometries on some common ferromagnetic materials. Finally, we manipulate the material anisotropy using electric field to directly control the oscillation driving spin transfer torque (STT). This will enable us to drastically decrease the power consumption, and at the same time increase the frequency range of our oscillators. This problem has direct applicability in CMOS compatible VCOs. This thesis will be useful to understand and improve upon existing STNOs, in order to work out their present impediments for commercial applications

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Title : *Voltage Controlled Magnetic Anisotropy in Spintronic Devices*

Author(s) : *Solanki Gaurav*
Roll No : *Y9227231*
Supervisor(s) : *Ghosh Bahniman*

Abstract

Magnetic memories like Race-track memories (RTM) and Spin transfer Torque RAM (STT-RAM), are the most promising candidates for the future world of memories. They are non-volatile, provide extremely high memory density, have extremely fast access and don‘t require any standby power. These features make magnetic memories the best option for the bold idea of having a universal memory. Now, any sort of memory in the modern world requires an oscillator for proper command and data hand-shake with the other machine (the one which is using it). And, if an oscillator could be embedded with the memory itself it‘s a win-win situation. Now, Spin-Transfer Nano-Oscillators (STNOs) are nano-scale oscillators that could be controlled and tuned by current and/or magnetic field. They are the smallest microwave oscillators yet developed, are easy to fabricate in large quantities, they work in a broad temperature range, are thoroughly tunable, and are compatible with the existing silicon technology. And if these devices come together as anticipated next memory revolution isn’t far away. However, there‘re certain challenges that need to be overcome before any of the above stated device could rule out the existing ones. For RTM the high current density requirement is the main hurdle in the path; secondly, we want to make it as fast as possible; and thirdly, we want to have a better control over the device. We have investigated these issues in Chapter 2 and 3 of this thesis, where we tried to reduce the power requirement, and tried to improve upon the control by adding up voltage control on the device. In chapter 3 we investigated domain wall motion (DWM) driven by spin waves, i.e. a different way of implementing DWM with a very little current requirement. Similarly, for STNOs there are certain challenges like higher output power and better control over the output frequency of the STNO. In chapter 4 we studied STNO and tried to fix the second problem of controlling the STNO, by using voltage controlled magnetic anisotropy. Finally, in the last chapter, we studied a different class of oscillators namely domain wall (DW) oscillators. These oscillators are better than STNOs in terms of design. We also a proposed a novel design for DW oscillator in the end and discussed nuances in these oscillators

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Title : *Switching Current Reduction Techniques For Magnetic Tunneling Junctions Based Mrams*

Author(s) : *Dwivedi Kshitij*
Roll No : *Y9227289*
Supervisor(s) : *Ghosh Bahniman*

Abstract

Spin transfer torque (STT) based magnetoresistive random access memory (MRAM) has shown enormous promise among the next generation of non-volatile memories due to its scalability, high operation speed and unlimited endurance. A Magnetic Tunnel junction (MTJ) is the basic building block of a STT-MRAM. When current flows through the MTJ, the FM absorbs angular momentum from the electrons and a torque is generated which flips the magnetization of the free layer. Logical value of memory bit is stored by the spin orientation of the free layer. However, the challenge with STT-MRAM is that the current required for switching are relatively large (107-108 A/cm2) and hence relatively large transistors are required to drive them and power consumption is also high, thus limiting the information storage density in this technology. Thermal stability and critical switching current density have a tradeoff relationship and when switching currents get reduced the thermal stability of the STT-MRAM bit also gets reduced leading to reduction in shelf-life. In this thesis, we investigate various strategies and try to employ them for switching current reduction without compromising the stability of the MTJ. First strategy uses the concept of perpendicular anisotropy, synthetic antiferromagnetic coupled free layers and double barriers with opposite magnetization direction in fixed layers. All three of them are reported to reduce switching current significantly and when we make use of all of them we observe a high reduction in current density. In second we use the concept of a cross shaped free layer which can be used to store two bits in a single MTJ and thus improve storage density. We use the system of coupled cross shaped free layers with double barriers to get more stable MTJ device. The third strategy employed make use of ferromagnetic materials which are reported to have less saturation magnetization Ms and damping coefficient α values. Since the spin transfer torque is inversely proportional to these terms we expect a significant reduction in current by using this strategy as well. For higher thermal stability we make use of the same device used initially with Cobalt based Heusler alloys as the material to fabricate free layers.

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Title : *Performance Improvement of Silicon Junctionless Tunnel FETs and the use of III-V materials in Junctionless Tunnel FETs*

Author(s) : *Basak Shibir*
Roll No : *12104076*
Supervisor(s) : *Ghosh Bahniman*

Abstract

Since the subthreshold swing of the MOSFET is not scalable below the theoretical minimum of 60mV/dec, a trend of substantial increase in leakage current is encountered. Therefore recent trends have shown diverse research interest in tunnel devices that have the potential to exhibit sub-60mV/dec subthreshold swing. Junctionless Tunnel FET (JLTFET) is a potential device with a silicon channel which is easier to fabricate and highly scalable due to the absence of p-n junction. In this work we suggest a Dynamic Threshold mode of operation of the JLTFET where the threshold voltage can be dynamically adjusted as per power requirement. A serious problem of leakage through the centre of the device for body thickness more than 20nm is reported and described for JLTFETs. Using a lightly doped source region the leakage current is reduced by 8 orders. The impact of acceptor trap states on the performance of the silicon JLTFET is observed quantitatively. The temperature dependence of the leakage current due to trap assisted tunneling is also observed. Forming a GaP-Si heterojunction below control gate, the average subthreshold swing is reduced to 45mV/dec from 65mV/dec in Si-JLTFET, consequently reducing the threshold voltage by 25%. Using narrow bandgap InAs as the source, and lattice matched III-V compound (GaSb) as a drain a significant improvement in drive current is established. ON-current in the order of 10mA/μm and an intrinsic delay close to 0.1ps is obtained for 0.5V supply voltage. The impact of Dual material gate on the performance of GaAs-Ge JLTFET is also observed. Process steps involving the fabrication of a Si nanowire Vertical-JLTFET is proposed. Simulation results show good performance of the projected vertical structure. Average subthreshold swing less than 60mV/dec and ON-current slightly less than 0.1μA/μm was achieved using a 10nm Si nanowire.

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Title : *Novel Device Structures Employing Junctionless Transistors*
Author(s) : *Asthana, Pranav Kumar*
Roll No : *12104054*
Supervisor(s) : *Ghosh Bahniman*

Abstract

Abstract Scaling of MOSFETs beyond sub 30nm technology brought challenges of device performance and doping gradient. Moreover, subthreshold slope swing was limited to 60mV/dec due to fermi-dirac distribution of energy. Failure of compatibility of MOSFETs resulted FINFETs and TFETs for 22nm technology and beyond. Conventional TFETs outstripped the limit of subthreshold slope of inversion mode devices however sharp junctions were still present with them. Our work attempts to provide potential solution to challenges faced in switching devices through Junctionless Transistors. We have chosen Junctionless Transistors mainly because of its scalability and therefore capability to uphold Moore's law. Additionally, it cuts process budget and provides fabrication ease. The thesis is broadly divided into two parts, one, focused on switching characteristics improvement of Junctionless Tunnel Field Effect Transistor (JLTFET) and second, Junctionless FETs. Chapter 2-7 are related to JLTFET while Chapter 8 and 9 are related to poly-Si Junctionless TFT and Channel All Around Junctionless FET respectively. JLTFET is potential candidate which can replace both of them because of scalibity, high speed and low power dissipation. We have innovated, Hetero-Structure of JLTFET(H-JLTFET), Intrinsic channel Single Gate TFET(iSG-TFET), Barrier Modulated TFT(BM-TFT) and Channel All Around(CAA) Junctionless FET which indicated tremendous improvement in performance of transistors. The focus of our simulation was to bring down the cost of fabrication process through various techniques, e.g. uniformly doped channel, intrinsic channel, single gate structure etc. Moreover, we have managed to get good transfer characteristics and suppressed short channel effects. Numerical simulation results indicated that it matches or surpasses standards of International Technology Roadmap for Semiconductors (ITRS)'s Low standby Power (LSTP) or High Performance (HP) depending on the application.

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Title : *Spin and charge transport in silicene and germanene*
Author(s) : *Chaudhary Pushkar*
Roll No : *Y9227445*
Supervisor(s) : *Ghosh Bahniman*

Abstract

Spin study has gained a huge interest in last one decade. Much of this is due to the fact that many of the proposed devices, to be used in future, are based on the spin of the electrons. After the first model structure of the spin based device, spinfet, was proposed, researchers started studying various effects in those models. In this work, magnon scattering in spinfet and the effects of stress and defects on the current-voltage characteristics of a silicene based device are studied. Magnon scattering becomes minimum in a mid-range of magnon energy. Tensile stress increases the bandgap whereas compressional stress decreases it.

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Title : *Study of switching speed in Magnetic Tunnelling Junction*
Author(s) : *Agrawal Shukant*
Roll No : *Y92275777*
Supervisor(s) *Ghosh Bahniman*

Abstract

Magnetic Tunnelling Junctions offers new promising technology for memory storage devices. They are gaining more and more attention because other technologies like CMOS technology is hitting quantum barriers. They offer a great alternative as they provide us with a non-volatile memory with a durability of up to 10 years, sub-nanosecond switching and no standby power consumption. In our work we majorly concentrate upon increasing the switching speed of magnetizations in MTJs. First we study many technologies independently and then we combine them to see their effect on switching periods of MTJ In our first chapter we study the basic CSV (Conventional Spin Value) MTJ by dividing its switching period in two parts. We study the basic MTJ so that we can compare it to the next technologies. Next we apply voltage to the CSV MTJ and study its effects. Then we apply a perpendicular polarizer layer to introduce a perpendicularly polarized current. We then combine these technologies to achieve ultrafast switching. Finally to increase the switching speed more we apply a temperature gradient to the OPSV VCMA MTJ. We see that our final design greatly outperforms the basic CSV MTJ in terms of switching speed

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Title : *Junctionless Tunnel Field Effect Transistor and its Optimization using III-V Semiconductors*

Author(s) : *Goswami Yogesh Puri*

Roll No : *12104096*

Supervisor(s) : *Ghosh Bahniman*

Abstract

The traditional MOSFET (Metal Oxide Semiconductor Field Effect Transistor) has an n-type source/drain doping in an otherwise p-type doped region and vice versa. This results in a doping concentration gradient near the junction between source/drain and the channel, the effects of which can be neglected for a long channel device. However, as the device size shrinks, an extremely acute gradient is essential whose fabrication becomes rigorous [1], in the dearth of which its performance deteriorates and it also ceases to purvey a sub-threshold slope of less than 60mV/decade. The notion of a junctionless field effect transistor (JLFET) originated so as to have a device without any metallurgical junction. However, the conventional JLFET fizzled to deliver a lower sub-threshold slope (<60 mV/decade) and the other devices were also proposed, most commonly were Tunnel Field Effect Transistor (TFET). TFETs has lower sub-threshold slope (<60 mV/decade) in comparison to MOSFETs but has low ON state current and it also has fabrication issues. The transistors that have the advantage of both JFET and Tunnel FET i.e. Junctionless Tunnel Field Effect Transistor (JL-TFET) were proposed. In this thesis, the performance of junctionless tunnel FET (JLTF ET) has been improvised using III-V semiconductors. In the first part, simulations of JLTFETs have been performed to demonstrate the effect of band gap energy of the channel material on the dc characteristics of a JLTFET. In the second part, we have suggested a way to improve the performance of device by lateral grading of doping concentration. In the third part, we have studied the dc and ac performance of a Gallium Arsenide based single gate JLTFET. In the final part, a hetero double gate JLTFET has been proposed and its dc and analog characteristics along with short channel performance is analysed

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Title : *Study of Charge Transport Properties of WS2 and WSe2 through First Principle Studies*

Author(s) : *Gupta Aayush*
Roll No : *Y9227008*
Supervisor(s) : *Ghosh Bahniman*

Abstract

After the discovery Graphene there has been a lot of interest towards other layered materials like Graphene. Materials of the general form MX2 which are called transition metal dichalcogenides are such materials. They can form nanoribbons like graphene and such nanoribbon have versatile electronic structures and can be metallic or semiconducting by changing the edges of the ribbon. The electronic properties of such materials are not fully understood till now. In this work we have investigated two such materials, Tungstenite (WS2) and WSe2. We have investigated the band-structure of the zigzag and the armchair nanoribbon. Also we have considered the affect of nanoribbon width, mechanical stress and defects such as vacancy, rough edge, ripple, wrap and twist on the bandstructure of WS2 and WSe2. We have also calculated the IV characteristics and identified the NDR region for the WS2 and WSe2 nanoribbons. Further we have introduced various defects and compared their effects on the NDR region and IV characteristics of the un-defected nanoribbon. Evaluation of such properties is done using the non-equilibrium Green`s function density functional tight binding theory (DFTB-NEGF). Our study shows significant differences in peak current and the window of Negative Differential Resistance because of the impurities. Further we have included a small study on the effect of EE scattering on the spin relaxation length of monolayer Silicene and Germanene

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Title : *Investigation of Electron Transport Properties of WTe2 and MoTe2 through ab initio calculations*

Author(s) : *Gupta Abhishek*
Roll No : *Y9227027*
Supervisor(s) : *Ghosh Bahniman*

Abstract

Recently, two dimensional materials have garnered a lot of attention after the discovery of graphene owing to the mass less charge carriers. Due to this success, the researchers have started to investigate other materials which are two dimensional and have thickness equal to one atom. Some of the materials with such properties are of type MX2 (where M is a transition metal and X represents chalcogen) and are transition metal dichalcogenides. WTe2 and MoTe2 belong to this class of materials. In this work we have studied the transport and electronic characteristics of WTe2 and MoTe2 armchair nanoribbon and analyzed the results by introducing several defects such as vacancy and rough edge, deformations such as wrap, twist and ripple and uniaxial and biaxial tensile strain. To analyze the model, we have used the ab initio density functional tight binding theory and the non-equilibrium Green's function approach to study the impact of defects on the abovementioned properties of a 6nm WTe2 and MoTe2 armchair nanoribbon. We have also done a brief study of spin relaxation length in bilayer armchair graphene nanoribbons. Electron-Electron scattering has been incorporated to study their effect on the spin relaxation mechanism in graphene nanoribbon. We have also investigated the effect of width variation on the spin relaxation length in the nanoribbon. Semi classical Monte Carlo method is employed to study the scattering mechanisms and spin relaxation mechanism is studied at different temperatures.

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Title : *A Unified Drain Current Model of Double-Gate Junctionless Field-Effect Transistors Including Short Channel Effec*

Author(s) : *Ram Raksha*
Roll No : *12104064*
Supervisor(s) : *Dutta Aloke*

Abstract

As the conventional Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs) scale down to the nano domain, ultra-sharp source and drain (S/D) junctions are required, in order to ensure lesser diffusion of S/D dopants into the channel, which causes an increase in the junction leakage. More advanced lithography and annealing processes have to be used to achieve ultra-sharp S/D junctions, thus leading to an increase in the overall cost. To alleviate these problems, Junctionless Field-Effect Transistors (JLFETs) have been proposed in the literature, having the same doping throughout the source, drain, and the channel region, thus doing away with the need of having S/D junctions. JLFETs require fewer processing steps and provide better short channel characteristics, as compared to conventional MOSFETs. At the same time, modeling of this device is more challenging than that of conventional MOSFETs due to its different working principle. In this work, a unified model for the drain current of a symmetric Double-Gate JLFET (DG-JLFET) is presented. The model is physics based and uses a simplified one-dimensional approach. It is first developed separately for the different regions of operation for long channel DG-JLFETs, and then the unification of these models is done by combining the models of the different regions, using suitable interpolation functions. Also, in this work, the surface conduction mechanism, taking into account the mobility degradation effect due to the transverse electric field, has been successfully incorporated, which was hitherto missing in the earlier models reported in the literature. In addition, analytical expressions for the short channel effects, viz. Drain Induced Barrier Lowering (DIBL) and Subthreshold Swing (SS) degradation are obtained from the Gauss' law, using the same approach as that developed for conventional MOSFETs. After incorporating these, the model proposed yields a unified current-voltage expression for DG-JLFETs, valid for both long and short channel devices. The results of the model have been successfully validated with the 2D Silvaco (ATLAS) simulation data, which incorporates the Lombardi model for effective mobility. In addition, the subthreshold current behaviour of a short channel JLFET is compared with the measured data reported in the literature, and an excellent match is observed. Thus, our model can be perceived to be a successful attempt in the area of JLFET device modeling.

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Title : *A Unified Drain Current Model for Laterally Double Diffused MOS (LDMOS)*

Author(s) : *Chowdhury Nupur*
Roll No : *12104048*
Supervisor(s) : *Dutta Aloke*

Abstract

High voltage MOSFETs (HV-MOS) have gained increased importance of late because of their ability to integrate with other circuit modules. This has led to development of lighter and more compact devices. Their applications includes amplifiers, rectifiers, switches, etc. In this work, we present a purely physics based model to interpret the behaviour of high voltage MOSFETs (Laterally Double Diffused MOS (LDMOS), in particular). Taking a surface potential based model (Hiroshima-University STARC IGFET Model (HiSIM)) as the base, our model is developed by dividing the structure into three regions, namely the intrinsic MOSFET region, the overlap region, and the purely drift region, in series and modeling each region separately. A novel approach has been proposed to minimize the number of iterations needed to evaluate the surface potentials at the source and the intrinsic drain ends. The three models are then combined together to a unified model by ensuring current continuity among the three regions, and by using suitable interpolation functions. The results of the model developed in this work, using the above approach, are validated with the 2-D simulation data obtained from Silvaco and with the measured data of the 40 V SOI-LDMOS (Silicon-over-Insulator LDMOS) transistor from I2T100 (The Intelligent Interface Technology for 100 V MOSFETs) developed by the AMI Semiconductor company. The DC output and the transfer characteristics of the device as depicted by our model have closely matched with both the data. Also, with regards to the small-signal model performance, the parameters g_{m} and g_{DS} have also shown quite close match with both the data. This proves that the model developed in our work is correct to a large extent

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Title : Noise Modeling in High Electron Mobility Transistors
Author(s) : Dasgupta Avirup
Roll No : Y9227159
Supervisor(s) : Chauhan Yogesh Singh

Abstract

High Electron Mobility Transistors, initially developed for high frequency operation, have shown a huge improvement in power density over conventional devices due to its high breakdown voltage and high current carrying capabilities. These transistors allow high power operations at much higher frequencies than conventional LDMOS FETs, which were widely used in the cellular base stations. Apart from this HEMTs have shown very low noise values as compared to the conventional devices and have thus gained importance in markets with low noise tolerant applications (Eg: Airborne RADAR, ship RADAR and missile seekers for military use; and base station drivers, multipoint video distribution systems and satellite communication systems for commercial applications). With the development of the HEMT technology, the need for improved models which capture all the nuances of this particular device and are accurate and robust enough, has grown. Especially with the emphasis on low noise characteristics of HEMTs, an accurate and flexible HEMT noise model has become the necessity. This thesis deals with the two most important and major noise sources: Thermal noise and Flicker Noise, in HEMTs. A flexible and robust drain current flicker noise power spectral density model, which takes into account both the mobility and carrier number fluctuations, and a model for drain current thermal noise power spectral density has been presented. These models have been validated extensively with TCAD simulations as well as measured data and have proven themselves to be quite accurate and also tunable to fit different device geometries and constructions

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Title : *Fast Low Power ROM-Embedded SRAM*
Author(s) : *Koneru Abhishek*
Roll No : *Y9227286*
Supervisor(s) : *Qureshi Shafi*

Abstract

Implementations of Math function evaluators and digital signal processors can be faster and simpler if we have large on-chip look-up tables stored as read-only memories (ROMs). In this thesis, a fast low power ROM-embedded SRAM memory has been designed. The proposed memory operates in two modes: SRAM mode and ROM mode. When the memory is operating in SRAM mode, ROM data cannot be retrieved. A special two step process is applied on the memory to retrieve ROM data. We use a modified version of the conventional SRAM bit cell to embed ROM data without any area overhead or performance degradation on the bit cell. We use a technique called hierarchical bit line and local sense amplifiers to reduce the active power consumption of the SRAM, which constitutes a major portion of the total power consumption. A 8Kb prototype of the above proposed SRAM has been designed in UMC 180nm technology using CADENCE. Post-layout simulations were performed on the prototype that was desiged and the various performance parameters were evaluated. In the ROM mode, the time needed for ROM data access is 2.4 ns. ROM data stored as look-up tables in external memory has access times of the order of ms – μs. The power consumption during the ROM data access cycle is 27.956 mW. In the SRAM mode, the read and write access times are 850ps and 700ps respectively. In comparison to previous work, the read access time has improved by 31% and 18% improvement has been achieved in write access time. The average power consumption of the memory in SRAM mode is 26.352 mW. In comparison to previous work, 34% saving has been achieved in the total chip area.

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Title : *Translating CILK programs to ZING models*
Author(s) : *Moona Pratik*
Roll No : *Y9227433*
Supervisor(s) : *Roy Subhajit&Iyer Sunder Kumar*

Abstract

Model Checking is an indispensable tool geared towards analysis of programs. With increasing complexity of computer software, it has become a necessity to automate the process of extracting models. This thesis attempts to solve this problem by developing a tool which can automatically extract models of concurrent programs written in the CILK language. It also sets up a feedback loop to isolate the execution path of the buggy run. We present efficient algorithms to translate constructs for concurrent programming to their equivalent models in the ZING model checking language

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Title : *Studies of Multi-Terminal Domain Wall Devices*
Author(s) : *Gupta Gaurav*
Roll No : *Y9227221*
Supervisor(s) : *Ghosh Bahniman*

Abstract

Magnetic tunnel junctions (MTJ) are the basic building blocks of one of the latest memory technology called Spin Transfer Torque Random Access Memory (STT-RAM). It offers various possibilities including sub-nanosecond bit switching, compatibility with existing bulk CMOS technology, high packing density and low standby power consumption. But there are tradeoffs in every area of technology. In terms of cost and efficiency STT-RAM lacks from existing technologies. For MTJ bits to switch current densities are required needs large transistors and high power consumption. Low current makes magnetization unstable which lead to switching delays. In this thesis, we talk about three different solutions to this problem. We optimized these technologies microwave assisted switching, voltage assisted switching and current injector assisted switching. We shows various parameters dependence of these technologies and in the end conclude our achievements.

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Title : *Hetero-junction Junction-less Tunnel FETS*
Author(s) : *Abhishek Anshu*
Roll No : *Y9227106*
Supervisor(s) : *Ghosh Bahniman*

Abstract

AS we scale down the metal oxide semiconductor field effect transistor (MOSFET) to sub -30 nm regime, it faces fundamental challenges and major difficulties in fabrication of sharp doping gradient at the source and drain junction and also its sub- threshold swing (SS) is still limited to 60mV/decade. Alternative transistors such as conventional TFET has better SS than inversion mode (IM) device but it has low ON current and fabrication becomes challenging in sub- 20nm region for both TFET and IM device. This practical challenges and roadblock in further optimisation of tunnel FET neutralises its advantages in case low power demand. So with decrease in technology node, there is a need of transistor without any junction. In the part of our thesis new device architecture named hetero-junction junctionless tunnel FET (JLTFET) has been proposed, which provides combined advantage of junctionless transistor proposed by lilienfeld's first transistor principle and tunnel FET. In the first part of our thesis we have worked on device simulations of hetero-junction junctionless transistors and we have suggested a way to improve the performance of device by using high band gap material at drain side. In the second part we have studied the basics concepts of HJLTFET and its performances are investigated by variation of device parameters. In the third part the performance of dual metal gate HJLTFET have been compared with that of conventional HJLTFET by keeping all simulation parameters same for both devices. Fourth part of our thesis deals with analog characteristic of HJLTFET and its performance advantages over HJLTFET

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Title : *Implementation of Organic Resistor and its Application as Temperature Sensor*

Author(s) : *Barjatya Amit*
Roll No : *Y9227070*
Supervisor(s) : *Mazhari Baquer*

Abstract

Organic electronic have obtained huge interest in the field of electronics and as sensing elements due to their wide range of application as low-cost, possibility of being manufactured on large area,as throw-away electronics on flexible substrates and wide range of available semiconductors with varied properties. Where Solar cells, LED's and TFTs have attracted larger attention, other important circuit elements like resistors have not attracted much interest from research community. In this work, we extend the work of a previously proposed resistor structure, in which the ohmic region in a diode is exploited and extended to higher voltages by stitching them in series, and also explore its possibilities of being used as an temperature sensor.Simulation results indicate that the proposed structure can be used to produce resistor with linearity better than 5% error, harmonic distortion less than 5% and also the temperature sensitivity of voltage of about 1.82mV/K when driven at a constant current of 250 µA and when we look at temperature sensitivity of resistance in ohmic region it stays to 0.006 K^{-1} but we can increase the operation to higher voltages and make sensitivity independent of voltage of operation by increasing number of segments. Experimental results on IT O/MoO 3/P 3HT/Gold are used to validate the results. Linearity error can be reduced from 50% to 12% for operation at 2V and harmonic distortion of less than 2% can be achieved. Impedance analysis showed the resistor can be modeled as frequency independent upto 1KHz at 2V.

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Title : Performance Analysis Of FinFETs
Author(s) : Pandey Harsh
Roll No : 12104024
Supervisor(s) : Chauhan Yogesh Singh

Abstract

Moore's Law has governed the scaling of CMOS technologies. As the device dimensions have reached the threshold of device scaling (i.e.22nm) several deleterious effects comes into picture of the decreasing gate length. Several short channel effects such as threshold voltage (V_{th}) roll off, drain induced barrier lowering (DIBL) and gate induced drain leakage (GIDL). Advanced structures such as Double Gate Field Effect Transistors(DGFETs) and Triple Gate Field Effect Transistors(TGFETs) have been explored. Several short channel effects can be effectively controlled by these advanced structures. FinFETs have caught a lot of attention s shown in the fabrication of SOI FinFET. FinFETs have a thin silicon fin around which a gate electrode is wrapped. One of the important parameters that determines a FinFET to be dual/tri gate, depending upon the thickness of the oxide at the top of the channel. The thesis in particular depicts the results of 3-D simulation of triple gate bulk FinFETs. In this work for SOI FinFET, process steps are mentioned in detail. Performance Analysis particularly Digital Figure of Merits are discussed for Bulk FinFET. Analog Figure of Merits have also been discussed in detail and their variation or dependence with respect to parameters have also been analyzed. Short channel effects, series resistance comparison are carried out. The spacer length is changed and its effect on characteristics have also been observed. Last but not the least, Aspect Ratio dependency is also studied. Finally the main conclusion of this work is summarized and the future scope in new directions have been proposed.

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Title	***:***	***Accelerating Critical Sections in Multithreaded Applications by Message Prioritization in On Chip Networks***
Author(s)	***:***	***Kulkarni Neeraj***
Roll No	***:***	***Y9227292***
Supervisor(s)	***:***	***Chaudhuri Mainak&Iyer S Sundar Kumar***

Abstract

In multi-threaded programs, critical sections form a major bottleneck as they tend to serialize the execution of threads. Load/store instructions that miss in the per- core private cache are almost entirely responsible for the stalls inside the critical sections observed in large-scale chip multi-processors. Accelerating the execution of load/stores can reduce the overall execution time of the critical sections. This can reduce the serialization time and offer overall performance gains. This thesis proposes acceleration of load/store requests from critical sections by prioritizing them in the switches of the on-chip network that connects the caches with the next level of shared cache. We propose algorithms to give different priorities to different categories of messages injected into the network. Due to the prioritiza- tion, the stall times of load/stores inside the critical sections are reduced releasing the locks earlier. Our evaluation of multi-threaded programs from the PARSEC, SPLASH-2 and a lock based version of the STAMP benchmark suites running on a simulated 128-core chip-multiprocessor shows reasonable performance gains com- pared to a baseline design employing FIFO message scheduling, round-robin port scheduling and deterministic dimension-order routing in the switches.

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Title : *Modelling of Gate Leakage Current in High-k MOSFETs*
Author(s) : *Chikara Ankur*
Roll No : *12104011*
Supervisor(s) : *Chauhan Yogesh*

Abstract

MOSFET scaling has been traditionally accomplished by scaling of horizontal and vertical dimensions (gate oxide thickness) as well, which was necessary to maintain the gate control of the channel. Till 65nm technology node, silicon dioxide, SiO2, was used as the gate insulator material. But at 65nm technology node the gate insulator, SiO2, was few atoms thick, that it was not possible to scale it further for lower technology nodes due to reliability and leakage current requirements. For going beyond 65nm technology node, Intel was first to introduce high-k dielectric as the gate insulator, to replace SiO2. In this work, the conduction mechanism of gate leakage current in MOSFET having high-k dielectric is investigated and a compact model is developed for the same

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Title : Analysis of UTBBSOI MOSFET using TCAD Simulation
Author(s) : Kumar Rahul
Roll No : 12104059
Supervisor(s) : Chauhan Yogesh

Abstract

The main objective of this thesis is to perform comprehensive simulation study of the different parameter variation in well scaled ultra-thin body and buried oxide (BOX) Silicon-on-insulator (SOI)(UTBBSOI) MOSFET. Traditional CMOS on bulk silicon is highly inefficient to meet the demands of Smart Mobile device beyond 22nm. This is because planar transistors have reached the physical limit in controlling leakage current and lack of ability to reduce the operating voltage without compromising performance, a major origin of wasted battery power. Consequently, UTBBSOI MOSFET has received a lot of attention in recent times. Back gate biasing below the BOX modulates the threshold voltage. This is an important feature of this technology. Intrinsic nature of silicon film thickness reduces the effect of process variation like random doping fluctuation (RDF). UTBSOI devices display superior suppression of short channel effects, improved current drive, low leakage current and better subthreshold slope and drain current, thus allowing further device scaling. The impact of gate length, silicon film thickness and BOX thickness scaling on DIBL, subthreshold slope, drive current and leakage current are analyzed. Multi-threshold voltage technique is also analyzed in this work. Low, standard and high threshold voltage Vt devices are achieved without degrading the good channel electrostatic control by doping the substrate region. This technology brings a significant improvement in terms of performance and power saving, complemented by an excellent responsiveness to power management design techniques for energy efficiency optimization. The symbiosis between design and process is a key in this achievement enabling to provide already at 28nm node a real differentiation in terms of flexibility, cost and energy efficiency with respect to any process available on the market

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Title : *Analysis of Photo-Response of Top Contact Organic Thin Film Transistor*

Author(s) : *Dash Anurag*
Roll No : *Y9227115*
Supervisor(s) : *Mazhari Baquer*

Abstract

Organic thin film devices are being actively developed due to the potential for implementing low cost flexible electronic systems using mass printing techniques. An organic photo-transistor combines the switching and amplifying property of a transistor with the light sensing capabilities of a photodetector thereby offering a device that can exhibit higher sensitivity and benefit from a simplified fabrication process. Although, the optical response of organic thin film transistors has been widely reported, there has been no systematic investigation of the detailed mechanism underlying the photo-response in these devices. This thesis uses 2D device simulations to investigate in detail the different possible mechanisms that can give rise to photo-sensitivity in a top contact organic thin film transistor. For devices, consisting of a single active semiconductor layer, the breakup of photo-generated excitons constitutes a key bottleneck especially when applied voltage is low in the linear mode of operation. In this case electric fields present are insufficient to break the excitons and photo-response is poor. In the saturation mode, when applied drain voltage is large and good source injecting contacts are used, a large field forms only within the pinchoff region next to drain and exciton breakup occurs and photo-response is strong. It is shown that current under illumination increases due to effective modulation of channel length and regions next to source and rest of channel region do not contribute to photo-responsivity. The effects of channel length, mobility and applied voltages are reported in detail. Further studies are conducted under conditions where separation of excitons is easier, i.e. in bulk hetero-junctions and with lower exciton binding energies. As against the previous case, a weaker injection from source was studied that provided large field in the source junction as well.

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Title : ***Light and Temperature Sensitivity Of High Injection Barrier Diodes***

Author(s) : ***Kumar Anupam***
Roll No : ***Y9227114***
Supervisor(s) : ***Mazhari Baquer***

Abstract

Organic semiconductor devices including light emitting diodes, solar cells, transistors, sensors etc are being actively developed due to potential for low cost fabrication on flexible substrates using printing techniques. Among sensors, temperature and light sensing devices are required for a wide range of applications. In order to maintain simplicity, two terminal devices, either resistors or diodes are commonly used for such applications. In the present work, a device consisting of an organic semiconductor sandwiched between metal electrodes from both sides is investigated. In order to obtain high light to dark current ratio, the potential barrier between the organic semiconductor and the metal is kept high. The dark current is limited by high injection barriers and is expected to be highly temperature sensitive as well. Device Simulation was used to evaluate the potential of the device for temperature and light sensing. The temperature coefficient of current and voltage are 4x10-2K-1and 4x10-2K-1 respectively. The device exhibits high light to dark current ratio of 885.9 at 5 V. A device structure (ITO/ZnO/P3HT/Al) using P3HT (Poly(3-hexylthiophene-2,5-diyl) was fabricated and temperature and light dependent measurements were done. The temperature coefficient of current and voltage are observedto be 6x10-3 K-1 and 1x10-3K-1 respectively. The device exhibits a high light to dark current ratio of 160 at 5 V.

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Title : *Organic Photodiode Array for Image Scanning*
Author(s) : *Naimatullah*
Roll No : *12104044*
Supervisor(s) : *Mazhari Baquer*

Abstract

Organic electronics technology is being actively developed worldwide because it allows low cost implementation of systems that have flexible form factor, are thin and light in weight. Among the interesting applications is a flexible sheet that can scan an image of a surface over which it is placed. The implementation of sheet scanners reported so far require integration of a photodiode with a thin film transistor in each pixel. This increases the process complexity and cost of the product. In the present work, the feasibility of using simply an array of photodiodes for image scanning is evaluated. Analyses along with device and circuit simulations are used to determine the photodiode characteristics that are required to minimize crosstalk between the pixels. Design of a photodiode that approximates these characteristics is presented. Organic photodiodes using the P3HT: PCBM as an active layer were fabricated and characterized to determine their feasibility for image scanning applications. Photodiodes with different characteristics were naturally obtained due to inherent process variations. Diodes which had better photovoltaic efficiency were found to be unsuitable for the application of interest while diodes that had 'poor' efficiency were determined to be more useful. For example, diodes with power conversion efficiency of 0.425 per cent were unable to yield any size of pixel array while diodes with very low efficiency of 4.8 x ⟦10⟧^(-5) per cent can be used to make pixel array of size as high as 183, which can scan an image in 50 grey levels.

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Title	***:***	***Temperature Dependent Current-Voltage Characteristics of Poly(3-hexylthiophene-2,5-diyl) Based Organic Diodes***
Author(s)	***:***	***Kumar Nitin***
Roll No	***:***	***12104047***
Supervisor(s)	***:***	***Mazhari Baquer***

Abstract

Organic semiconductor technology offers several advantages like easy and low cost processing techniques, availability of wide range of materials and monolithic integration on virtually a variety of substrate including flexible sheets of plastic, paper and steel. In this work, temperature sensitivity of organic diodes is investigated for their application in temperature sensors. Simulation of organic diodes is used to determine the temperature sensitivity of current, voltage and other parameters in different regions of operation. It is shown that there is a tradeoff between temperature coefficient and cross sensitivity of the diode to parameters such as mobility, thickness etc. A transition voltage marking the transition from exponential to power law current behavior offers a good compromise between these competing effects. An improved technique for extraction of built-in voltage is also proposed which utilizes temperature sensitivity of transition voltage. The temperature sensitivity arising from presence of traps is also described. Poly-3-hexylthiophene (P3HT) was used as a semiconductor material for fabrication of diodes owing to its high mobility, processability and solubility in common organic solvents. Also, an inverted structure with zinc oxide (ZnO) layer has been used, which reduces degradation in air. The inverted structure of ITO/ZnO/P3HT/Au was fabricated followed by characterization. The characterization results show that properties of P3HT changes as device is heated to more than 50 °C. Also, the device is not able to reproduce the earlier characteristics once it is cooled down to room temperature and characterized again

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Title : *An Elliptic Curve ASIP over GF(2m) for RFID Transponders*
Author(s) : *Hansdah Shirjon Shalku*
Roll No : *Y9227550*
Supervisor(s) : *Qureshi Shafi*

Abstract

RFID tags are small devices used widely for identification, tracking, and data storage and processing in new applications. Since, these devices are passively powered, the processing power is limited raising security and privacy concerns. A purely software implementation of computationally intensive encryption schemes under such constrained environments is widely believed to be infeasible to guarantee the security for data sensitive applications. In this dissertation we design an Application Specific Instruction Processor to achieve feasible security requiring 0.30 mm2 to 0.46 mm2 depending on the implementation characteristics. We investigate the implementation of Elliptic Curve Cryptography over Binary fields, GF(2m) in projective coordinates using additional multiply, reduce and accumulate units in a digit serial digit parallel manner. A prototype of the processor has been designed, verified and synthesized in 180 nm TSMC technology using Synopsys. Simulations were performed for binary field multiplications for 113, 163, 192 and 233 bit key sizes. Point multiplication and Finite field multiplication for the widely used 163 bit key size has a latency of the order of 90k-30k and 100-30 cycles respectively. The power consumption achieved during the Binary field operations is between 0.78 mW and 1.98 mW. The implementation in this dissertation make RFID tags suitable for applications requiring high security standards

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Title : *Study On Ultra-Thin Metamaterial Absorbers For Dual-Band And Wideband Applications*

Author(s) : *Yadunath K*
Roll No : *12104093*
Supervisor(s) : *Srivastava Kumar vaibhav*

Abstract

Microwave absorbers have several applications in commercial as well as military domain where high performance absorbing materials over a broad frequency band are required. However, the large thickness of the standard microwave absorbers is the limitation for using them in radar cross section (measure of detectability of an object with a radar) application in stealth technology. Recently, metamaterial absorbers provide major breakthrough in this area, where the ultra-thin structures comprising periodic unit cells in the sub-wavelength regime can be used to obtain near unity absorption. But the bottlenecks of such metamaterial absorbers are their structural asymmetry and narrow absorption bandwidth. This thesis discusses different types of metamaterial absorber designs to deal with the above shortcomings. Firstly, the absorption in metamaterial absorbers has been explained using destructive interference theory. The theory has been verified using a standard metamaterial absorber structure. Mathematical formulations have been derived to illustrate destructive interference theory. A polarization insensitive metamaterial absorber based on destructive interference theory has been explained. Using destructive interference theory and electromagnetic resonance mechanism, an ultra-thin wideband metamaterial absorber has been presented in microwave frequency region. The simulated response shows that the structure exhibits above 90% absorption in the frequency range 5:60-12:95 GHz under normal incidence. Unlike other multilayer wideband absorbers, the proposed single layer structure has been fabricated and experimentally verified with the numerical simulations. The absorptivity of the broadband absorber under oblique incidence for both TE and TM polarizations has also been investigated in light of destructive interference. The designed absorber is ultra-thin, having thickness of 3:8 mm and can be used in many potential applications. Lastly, the effective material parameters of the above discussed absorbers have been extracted using a parameter retrieval method
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Title : *Study on Metamaterial Inspired Multi-Band Planar Microstrip Antennas*

Author(s) : *Reddy VenkatramI*
Roll No : *12104072*
Supervisor(s) : *Srivastava Kumar vaibhav*

Abstract

Metamaterials are artificially engineered periodic structures where the unit cell size is kept much smaller compared to the operating wavelength. Recently, the use of metamaterials as a tool for enhancing the capability and achieving novel functions in antennas' design has led to a wider attention. The objective of this thesis work is to study on the design of metamaterial inspired multi-band planar microstrip antennas. First, planar inverted-F antennas (PIFAs) loaded with LC resonators are presented for multi-band operation . The electric and/or magnetic resonances induced by the LC resonators are re- sponsible for achieving multi-band characteristics in these antennas. When the conventional PIFA is loaded with single-band and dual-band LC structures, antennas with dual and triple-band char- acteristics are respectively obtained. Finally, a triple-band LC resonator is employed to achieve a tri-band PIFA with enhanced bandwidth of 36.8 % (27 % higher than reference PIFA bandwidth) at the upper resonant frequency. The design concepts are validated by fabrication and measure- ment of the proposed LC loaded antennas. Secondly, dual-band patch antennas loaded with Complementary Electric LC (CELC) res- onators in the ground plane of the patch are proposed for WLAN (5.725-5.85 GHz) and WiMAX (3.3-3.8 GHz) applications. Two antenna designs have been proposed. In the first design, one CELC is etched out from the ground plane of patch antenna which leads to generation of a lower order mode in addition to the conventional patch mode. In order to achieve better impedance bandwidth at the lower order resonant mode, two CELC resonators with closely spaced resonant frequencies are etched out from the ground plane of the patch in the second design. Finally, microstrip-fed monopole antennas loaded with Composite Right/Left Handed (CRLH) and Epsilon Negative (ENG) unit cells are presented for multi-band operation. When the monopole is loaded with CRLH unit cell(s) a number of lower order frequency bands, which is twice the number of unit cells, have been achieved in addition to the _=4 resonance of the monopole. The new operating frequencies are below the resonant frequency of the reference monopole and can be controlled easily by the unit cell dispersion relation. In ENG loaded monopoles, each added ENG unit cell produces one lower order mode in addition to the _=4 resonance of the monopole.

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Title : *Study on Metamaterial Inspired High Gain and Narrow Beamwidth Planar Antenna*

Author(s) : *Suthar Hemant*
Roll No : *12104026*
Supervisor(s) : *Srivastava Kumar Vaibhav*

Abstract

Currently great efforts are being made to design high performance antennas for wireless communication technology. The mobile radio, WLAN devices and satellite communication systems needs compact size, high gain with narrow beamwidth antenna. Planar microstrip antenna systems provide a number of attractive features such as low profile, conformability, compatibility to MMIC technology, mechanical robustness and ease of fabrication. But low gain and directivity have restricted their wide applications. Designing of high gain microstrip antennas is a very active and challenging field of research. Over the past decade, metamaterials have attracted the attention of scientific com- munity. Metamaterials are artificial electromagnetic structures realized from collection of sub-wavelength metal-dielectric circuits. Metamaterials have demonstrated the properties that do not appear in natural materials. One can design the material, whose permittivity and permeability values vary independently and can take desired positive and negative values over a certain frequency band. Since the experimental realization of metamaterials in the start of twenty first century, engineers are working on use of metamaterials to control the performance of microwave devices like antennas, filters and couplers. Zero index metamaterial (ZIM) is an interesting class of metamaterials, which can provide precise control over the radiation beamwidth of antenna. The aim of this thesis is to design high gain and directive microstrip antennas by incorporating ZIM unit cells. First, a compact ZIM unit cell is designed and characterized by effective medium theory. A superstrate layer consisting of an array of 7 x 7 unit cells is designed and used as lens over a reference patch antenna. A coax fed microstrip patch antenna with ZIM lens operating at WLAN (IEEE 802.11a) frequency band is proposed. It is observed that presence of ZIM lens considerably increases the gain and reduces the radiation beamwidth. Secondly, the Z shaped resonator as ZIM unit cells are embedded in wideband bow-tie dipole antenna (4.9 GHz-7.6 GHz) for gain enhancement. The ZIM unit cells are employed in planar geometry. The wideband nature is achieved by bow-tie dipoles, whereas the gain is improved by incorporation of ZIM unit cells. The design concepts are validated by fabrication and measurements.

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Title : *Study on Linearly and Circularly Polarized Printed Antennas Using Metamaterial Inspired Resonators*

Author(s) : *Singh Aditya*
Roll No : *12104003*
Supervisor(s) : *Srivastava Kumar Vaibhav*

Abstract

Modern day communication devices need to support multiple services in various bands like GPS, GLONASS, UMTS/WCDMA, Bluetooth, Wi-Fi along with many others. To serve such devices, miniaturized antennas capable of operating at multiple bands are required. In addition, the systems like satellite communication, RFID, GPS and GLONASS require circularly polarized antennas as they o er many advantages like reduction in multipath e ects, exibility in orientation of receiver and transmitter with reliable data transmission. As the requirement of present day communication systems are becoming more stringent, the design of antennas for such systems has become a challenging problem for researchers. Since the inception of metamaterials, many new methodologies incorporating metamaterials have been proposed for design of performance enhanced antennas. On the other hand, printed antennas o er many features which modern day radio and wireless communication systems demand, like low pro le, relatively inexpensive, compatibility with MMIC technology and ease of fabrication. The work in this thesis is based on design of printed linearly and circularly polarized multiband antennas using metamaterial inspired resonators. First, a printed linearly polarized quadband monopole antenna employing the complementary split ring resonator(CSRR) and interdigital capacitor(IDC) is presented. The sub-wavelength resonances of the CSRR and IDC are used to obtain multiband performance. The four bands of operation at 2.04 GHz, 2.12 GHz, 2.41 GHz and 2.93 GHz o er (S11 < -10dB) impedance bandwidth of 4.37%, 1.95%, 14.89% and 1.85% respectively. The radiation patterns at all operating bands are quasi-omnidirectional. Secondly, a printed circularly polarized crossed dipole antenna incorporating an IDC is proposed. Two bands one below and one above the /2 resonance of the dipole are induced by etching an IDC on each dipole arm. A triple band behavior is obtained with impedance bandwidth (S11 < -10 dB) of 80 MHz (1.37 - 1.45 GHz), 470 MHz (1.53 - 2.00 GHz) and 170 MHz (2.04 - 2.21 GHz). The 3 dB axial ratio bandwidth corresponding to the rst band is 30 MHz (1.37 - 1.40 GHz). For the second band, the axial ratio bandwidths are 170 MHz (1.56 - 1.73 GHz) and 20 MHz(1.98 - 2.00 GHz) while the third band does not o er optimum axial ratio.

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Title : Low Profile RFID Antennas using High Impedance Surfaces
Author(s) : Gupta Gaurangi
Roll No : 12104023
Supervisor(s) : Harish AR

Abstract

A perfect electric conductor (PEC) reflector kept at a quarter wavelengths away from an omnidirectional antenna is generally used to suppress radiation in one direction. At lower frequencies this spacing becomes very large, and thus becomes unacceptable in modern day technology which demands low profile, compact and mechanically robust antennas. As the antenna element is brought closer to the PEC reflector, the current induced on the PEC cancels out the antenna current, thus resulting in low input bandwidth and poor radiation efficiency. The solution to this can be a perfect magnetic conductor (PMC), as the current induced in a PMC reflector will be in phase with the antenna current element, thus the distance between the two can be significantly reduced without the antenna being shorted out. Due to unavailability of PMC in nature, artificial magnetic conductor (AMC) is used as a reflector for antennas. Metal patches with via is a popular method to obtain high impedance surface (HIS), which works like an AMC in a specific frequency range. However, the coupling between via elements and antenna feed results in an impedance mismatch and distorted radiation pattern. Attempts have been made to obtain high impedance characteristics using via less single layer structures. Obtaining miniaturization and high bandwidth demands reduction in space between elements leading to simulation and fabrication complexities. A two-layer high impedance surface is proposed in this thesis to alleviate both these problems. This structure reflects electromagnetic waves with no phase reversals and stops propagation of surface waves. The geometry consists of two layers of metal patches separated by a dielectric surface. This structure is backed by a metallic ground plane. Unit cell is designed and tested with periodic boundary conditions to obtain the PMC characteristics in the UHF RFID frequency range. A bow-tie dipole antenna is placed very close to the structure and the antenna-HIS combination is optimized to obtain the required matching and radiation characteristics. The symmetry of the high impedance surface is exploited to obtain both linear polarization and circular polarization. Thus, a low profile and compact structure is obtained with all the desired characteristics. Due to use of four dielectric layers in the structure it becomes a little bulky, thus an attempt has been made to replace the dielectric layers with air spacers. Replacing both dielectric layers between HIS and ground plane increases the back lobe especially for lesser number of unit cells in the structure. Similar problem is seen in basic high impedance surface structures as well. Thus, a metal cavity backed HIS surface has been proposed to solve the above problem. Generally circularly polarized antennas are preferred in RFID Technology to detect the linearly polarized tags irrespective of their relative orientation since power received is always constant. If linearly polarized antenna is used the tag can only be read when both tag and antenna are aligned. This property of the linearly polarized antenna has been exploited in this thesis to detect the orientation of the tagged object. The linearly polarized antenna is attached to the RFID Reader and the whole system is rotated about the axis of the antenna. Measured signal strength being a function of relative orientation is processed to determine the orientation of the tagged object. Knowledge of orientation is important in many industries like installation, packaging and shipping and this technology allows detecting objects which are physically inaccessible or even out of sight, thus giving it an extra edge over optical technology.

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Title : *Multipaction breakdown in dielectric loaded Rf structures*
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Roll No : *12104018*
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Abstract

The phenomena of multipactor can be defined as exponential growth of electrons in a microwave device at radio frequencies due to secondary emission of electrons. This phenomenon occurs in resonance with the applied RF field. One of the seed electron under influence of the electric and magnetic field strikes the structure generating secondary electrons, if during the time of generation of secondary electrons; phase reversal of electric field happens then these secondary emitted electron goes on to further collision with structure emitting more electrons. This model of exponential growth can be compared to avalanche breakdown. The avalanche breakdown in resonance with applied electric field leads to an uncontrolled growth of electrons into the system leading to vacuum breakdown. This process can cause severe irremediable damage to the structure. Objective of this work is to develop 3D codes to analyse multipactor in a device with or without dielectric walls. Two versions of 3D code have been written. The first version analyses the structure for multipactor based on macro particle approach leading to faster simulation results. The second version deals with each particle individually and hence this approach can be called as multi particle approach. Multi particle code, as it deals with many particles simultaneously, gives an insight into multipaction, while costing more simulation time as compared to macro particle approach. The knowledge of the maximum electric field the structure can handle, and the areas prone to multipaction is very useful in design of multipactor free structures. This work predicts the maximum electric field that a structure can handle and also the trajectories of electrons which can be used to identify the areas that are prone to multipactor breakdown

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Title : ***Study of Dielectric Resonator for Dual Applications as Filter and Antenna***

Author(s) : ***Jyani Ashok Kumar***

Roll No : ***12104015***

Supervisor(s) : ***Biswas Animesh***

Abstract

Dielectric Resonators have applications in the areas of microwave integrated circuits technology and antenna design. They possess features such as low loss and high quality factor which makes them an eff ective resonating elements suitable for shielding microwave circuits like filters and oscillators for satellite communication applications. However, when DRs with low permittivity are kept in an open environment, it will result in power loss in the form of radiating elds thereby reducing the radiation Q-factor of lowest order mode. This discovery has laid the foundation for using DRs as e ective antennas. The use of mobile communication is increasing. This development has put more demand for compact size and low energy consumption for the equipments. To reduce the size of RF modules, concept of multifunction has been introduced. We can use diff erent modes of a single Dielectric Resonator for di fferent applications, to bundle multiple components into a single module for compact and multifunctional wireless communication systems. This leads to the study of the dual function DR that simultaneously acts as an antenna (DRA) and a fi lter (DRF), commonly known as Dielectric Resonator Antenna and Filter (DRAF). In this thesis, two DRAF designs have been proposed. First structure consists of a cylindrical DR, loaded with a metallic disc, is utilized as the resonator for the antenna as well as bandpass fi lter for X band. Two different methods have been used to excite the antenna part of DRAF. In first method, a microstrip excites the antenna and then in second method a coaxial probe is used to reduce the coupling between DRA and DRF excitation. The proposed structure with microstrip excitation achieves a measured impedance bandwidth of 5.55% at operating frequency 8.82 GHz for DRA part. The resonance frequency for DRF part is 10.91 GHz. With coaxial excitation it achieves a simulated impedance bandwidth of 9.42% at operating frequency 8.15 GHz for DRA part. The resonance frequency of lter part is 11.19 GHz. In second DRAF a Multi Layer Multi Permittivity (MLMP) ring DR is used to achieve a wide band response for dielectric resonator antenna with an improved spurious-free window. The proposed structure achieves a measured impedance bandwidth of 38.06% covering frequency range 5 GHz to 7.35 GHz for DRA and measured 3dB bandwidth is 211 MHz covering frequency range 5.82 GHz to 6.03 GHz for DRF. The Measured resonance frequency for DRA is 5.38 GHz and for DRF it is 5.93 GHz Both DRAF are loaded with a circular metallic disc, to improve the insertion loss of the DRF and to tune the lter simultaneously

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Title : *Shared Aperture Array - A Study*
Author(s) : *NAIK HARISH*
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Abstract

The active phased arrays are increasingly in demand due to their multifunctional capabilities. In several applications the array has to provide simultaneous multiple beams which are controlled independently. The shared aperture which houses multiple sub arrays on a common aperture will be an versatile choice when the system speci fication requires frequency and polarization diversity, etc. The shared aperture arrays also reduces the overall size, weight and cost in an area constrained platforms. In this thesis a modular dual frequency orthogonal linearly polarized shared aperture design is proposed. In a multi-frequency shared aperture array consisting separate antennas for various operational bands, the choice of inter-element spacing is a major challenge. The spacing is optimized by interleaving the lower frequency elements along the grids formed for high frequency elements is commonly available in the literature. The approach complicates the design when the choice of frequencies are independent to each other. A novel design in shared aperture array is introduced in this thesis by proposing a common inter-element spacing for two frequency bands which may be independent to each other. This is of first kind in shared aperture design where a low frequency elements are closely placed and the array is designed under the influence of strong mutual coupling, and higher frequency array follows the traditional design process. The concept off ers modular, low pro file and low cost solution with signifi cant weight reduction for a large array environment. The work presented in this thesis delegates a techniques of array design in the presence of strong mutual coupling, matching electrically small antennas, inter-band coupling reduction and low power solutions for high power wireless and radar systems.

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Title : ***Design of Miniaturized Dual and Triple-band Bandpass filters using Split Ring Resonator***

Author(s) : ***Rathore Vaishali***

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Supervisor(s) : ***Biswas Animesh***

Abstract

In the era of wireless communication systems, bandpass filters play an important role. They have applications in the area of modern satellite and wireless technologies demanding more compact and efficient filters that could work in multiple frequency band. Planar filters have the additional advantage of being incorporated in a single chip along with other front end elements thus providing the scope of compact transceiver systems. This has been the motivation behind designing of miniaturized dual and triple band filters using Split Ring Resonators. The thesis presents the study of coupling properties of square Split Ring Resonators for different types of coupling and the variation of coupling coefficients with spacing between the resonators has been discussed. The dual band and triple band bandpass filters are designed using the coupling matrix approach which is obtained using frequency transformation and optimization and implemented using Split Ring Resonators. This methodology of designing filters proves advantageous as once the coupling matrix is derived, equipped with the knowledge of the range of coupling coefficients obtained for the SRR and the corresponding spacing between the resonators for the required value of coupling coefficient, SRR can then be set appropriately which makes the tuning process faster. It also gives a insight into the range of coupling coefficients that can be obtained using a particular type of SRR and likewise the coupling matrix can be chosen where the couplings lie within the desired range. The symmetrical dual and triple band bandpass filter designed using SRR have desired selectivity and return loss alongwith good match between the simulated and measured results. The filter dimensions are very small as SRR provides miniaturization. Triple band filter using SRR has not been reported till now.

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Title : *Design of Dual/Triple Bandlimited Filters using Dual Mode Dielectric Resonators*

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Abstract

With the rapid advancement in the sector of wireless communication, added with the scarcity of the frequency spectrum along with the need of simultaneous use of different wireless applications give rise to the need of multiband filters. For the modern day wireless and satellite communication systems require the least possible insertion loss. For less insertion loss, Q-factor must be high enough which makes the filter bulky and heavy like Waveguide Filters. The required size of the waveguide filter is reduced by replacing the hollow cavity with a dielectric loaded cavity. This is because of high permittivity of the Dielectric material. Also owing to the high Q of the Dielectric material the filter designed with dielectric loaded cavity have low insertion loss and good selectivity. In addition to this, multimode feature of the Dielectric Resonator can be used to get a manifold decrease in the size of the filter. Dielectric Resonators are used in satellite, wireless and base station application etc. especially where a very less insertion loss is required in a narrow band of frequency. In the recent years, different techniques for somehow reducing the size of the filters which are quite bulky (e.g. Waveguide filters, Dielectric Resonator filter) is under heavy investigation. This thesis presents various dual band filters using Dual mode in a Dielectric Resonator. In the presented work, two dual band bandpass filters are designed with different dual mode pair in chapter 4 and 6 with full dielectric resonator and half cut cylindrical dielectric resonator respectively. a dual band bandstop filter using half cut dielectric resonator is also designed which is presented in chapter 5. In the end of the thesis a Triple band bandpass filter using half cut cylindrical dielectric resonator is present in chapter 7. The advantage of designing a Dual mode filter provides 50% reduction in the size of the filter if would have been designed with single mode. With addition to this the dual mode of half cut cylindrical dielectric resonator have been used instead of full DR, this implies a direct cut down of cost by 50%. Hence dual mode filters using half cut dielectric resonator present manifold advantage to simple single mode dielectric resonator filter with full cylindrical dielectric resonator

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Title : *Multilayer Metamaterial Filters using Stacked Mushroom Structures*

Author(s) : *Arya Yogender Kumar*
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Supervisor(s) : *Biswas Animesh*

Abstract

The Filters find tremendous applications in present day wireless communication systems. The need for multiband filters that are small in size has increased drastically since the inception of mobile devices. The planar filters are thus very useful due to the small size and ability to be incorporated in small mobile devices. This thesis focuses on the usage of stacked mushroom structures as a resonator for the implementation of multiband filters. A figure of merit for bandpass filter is the insertion loss which is a direct impact of quality factor of the technology used. The mushroom structures have high Quality factor as compared to other metamaterial resonators . In the presented work, each band is attributed to each layer of stack. This has been successfully veri ed using dispersion relation for dual and triple layer Zeroth Order Resonator (ZOR) shielded mushroom structures. Using single cell of dual and triple layer stacked mushroom structure, dual and triple passbands were observed respectively which can be used for implementation for dual and triple band bandpass filters which are compact in size

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Title : *Antenna Performance Enhancement Using 3D Structures*
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Abstract

In this thesis, an attempt has been made to enhance the performance of a simple patch antenna, by introducing three dimensional metallic pillar structures on it. An increase in bandwidth can be obtained by increasing the effective current path which leads to increase in inductance. Here the effective current path has been increased using these metallic pillar structures. Three designs variations have been discussed here. In the first design, three dimensional metallic pillars are kept between two U-shaped patches, which lead to increase in bandwidth as well as antenna miniaturization compared to a simple microstrip patch antenna. It is observed that height and base dimension has an important role to play in affecting the bandwidth of the antenna as well as the resonant frequency. In comparison to a simple patch antenna the proposed structure gives a much wider bandwidth. Special emphasis is paid to ensure that the antenna gives desired results at a higher frequency of 24GHz ISM band the performance of the antenna is measured by placing it on an extended ground plane and varying the dimensions of the ground plane. The return loss and the radiation pattern of the antenna do not vary significantly with changing the ground plane size. In the second design, a variation of the first design is proposed by making an arbitrary cut on the base of the U-shaped patch and thereby creating two current paths in the antenna. Here we have obtained considerable miniaturization at the cost of reduced gain as the thickness of the substrate is not scaled suitably. In the third design, the height of the metallic boxes is kept fixed and bandwidth is tried to increase. These boxes are kept on top of a simple patch antenna which is shorted on three sides so that we can reduce the fringing field and obtain broadside radiation pattern. Two current paths making the antenna resonate in two different but nearby frequencies have been obtained by, connecting the boxes with metallic strips. When these two resonant frequencies are made to it results in increased bandwidth.

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Title : *Design of Metamaterial Loaded Tapered Slot Vivaldi Antenna for NDT and UWB Applications*

Author(s) : *Bhaskar Manoj*
Roll No : *12104037*
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Abstract

The Vivaldi antenna is well-known for its ultra wide band characteristics, and is quite often being used in pulsed radar, remote sensing, military mobile wireless system etc. The microwave imaging and non-destructive testing(NDT) is an emerging area which has a wide range of applications, e.g. airport security, aerial surveillance, through wall imaging etc. In order to achieve good spatial resolution and penetration of the EM waves into the object for various NDT applications, the required antenna should work at both lower frequency and higher frequency bands with a good directivity. The highly directive and UWB Vivaldi antenna can be used for the microwave imaging applications. In this work, a novel Vivaldi antenna operating quite effectively over 1-10 GHz with directivity of 2.1-7.2 dBi has been designed, fabricated and tested. A new type of anisotropic zero index metamaterial cell has been proposed for the gain enhancement of the tapered slot Vivaldi antenna. Measured results of the fabricated antenna are found to be in close agreement with the simulated results, which validates the design of the proposed antenna. The designed antenna has been successfully tested for the characterization of various samples, which shows its potential for microwave NDT applications. In the next step a complementary split ring resonator(CSRR) loaded band notch Vivaldi antenna for the UWB application has been proposed in the frequency range of 3.1 to 10.6 GHz, with the band notch frequency of 4.84 GHz. This antenna is mainly designed for wireless communication, as it minimizes the electromagnetic interference caused by IEEE 802.11 WLAN, HIPERLAN/2, WiMAX.

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