SURGE

Summer Undergraduate Research Grant for Excellence

Annual Report 2006

Office of Dean, Resource Planning & Generation
Indian Institute of Technology Kanpur
Kanpur 208016
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Executive Summary

In a bid to push the agenda of undergraduate research and promote a culture of research and interdisciplinary education among the new generation, an undergraduate research initiative was formally launched at the Indian Institute of Technology Kanpur during the summer of 2006. For this purpose, active help was sought from California Institute of Technology, USA (Caltech), a pioneer in undergraduate research.

The Summer Undergraduate Research Grant for Excellence (SURGE) program of IIT Kanpur holds the following vision:

> *Undergraduate research fosters collegiality and welcomes students into the community of researchers and scholars. It promotes self-discovery, helps to bridge the gap between class-room and real world, and leads to social, professional and educational development of the student. Undergraduate research at IIT Kanpur must present opportunities for students to do research under the mentorship of senior researchers at the frontiers of engineering and science.*

In its inaugural year, SURGE Program selected students from within the Institute, ten National Institutes of Technology (NITs), and the California Institute of Technology (USA). The program duration was ten weeks starting May 2006. Guidelines and markers were laid down well before the start of the program to give participating students and mentors a lead into their research before they began their work in May 2006. The Office of the Dean, Resource Planning and Generation facilitated the required coordination and infrastructure.

The program was received very well by both students and mentors. The students experienced a new non-competitive, challenging and exciting method of learning, which encompassed multiple levels of educational experience. The mentors from IIT Kanpur were impressed with the enthusiasm displayed and the rigor adopted by the young researchers. By the end of the program, favorable number of these young minds showed inclination towards seeking research and development as their career, and almost all students experienced enhanced and holistic learning as opposed to the "*chalk and talk method*".

Acknowledgements

The support and participation of the following is gratefully acknowledged:

- Generous donors who made contributions to support the program.
- Ms. Carolyn Ash, Director, Student-Faculty Programs, Caltech (USA), for providing guidance to the Institute in developing an undergraduate research program at IIT Kanpur.
- Dr. Siddharth Dasgupta, Associate Director, NSF Center for Science and Engineering of Materials, Caltech and an alumnus of IIT Kanpur for relationship building between IIT Kanpur and Caltech, and for raising funds for the program.
- Members of the Advisory Committee and Implementation Committee of SURGE.
- Professor C. V. R. Murty, and Dr. Vibha Tripathi as the Coordinators of the SURGE Program.
- The staff of the Office of the Dean, Resource Planning and Generation for support and assistance in conduct of the SURGE program.
- The faculty mentors at IIT Kanpur and the SURGE students for their enthusiastic participation.

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1. Introduction

Indian Institute of Technology Kanpur took yet another initiative: this time towards *developing a culture of research amongst the undergraduate student*. On 08 May 2006, the first batch of participants in the newly launched *Summer Undergraduate Research Grant for Excellence (SURGE) Program* started their 10 week research sojourn. The program aims to promote a culture of research amongst undergraduate students of not just IIT Kanpur but also at select other academic institutes in the country. This program was launched in collaboration with the *California Institute of Technology (USA)*, which has been running the highly acclaimed *Summer Undergraduate Research Fellowship (SURF)* program for over 25 years (www.surf.caltech.edu).

SURGE programme at IIT Kanpur has been developed to present opportunities for students to do research under the mentorship of senior researchers at the frontiers of engineering and science. Undergraduate research fosters collegiality and welcomes students into the community of researchers and scholars. It promotes self-discovery, helps to bridge the gap between class-room and real world, and leads to social, professional and educational development of the student.

2. Inception and Timeline of SURGE program

The concept of summer undergraduate research program emerged through various discussions in February 2005 between Professor Sudhir K. Jain (Dean Resource Planning & Generation, IIT Kanpur), Ms. Carolyn Ash (Director, Student-Faculty Program, Caltech), and Dr. Siddharth Dasgupta (an alumnus of IITK and Associate Director, NSF Center for Science and Engineering of materials, Caltech). This concept was developed further through e-mail discussions and subsequent visit of Professor Jain to Caltech in the summer of 2005. A memorandum of understanding was signed in October 2005 between Caltech and IIT Kanpur under which Caltech agreed to help IIT Kanpur in jumpstarting an undergraduate research program. Caltech and IIT Kanpur also agreed to exchange three students each for undergraduate research.

In fall 2005, the concept of SURGE was debated and finalized at IIT Kanpur. Applications were invited from students of IIT Kanpur desirous of participating in Caltech's 2006 SURF Program. A rigorous procedure of selection was put in place. The applications from students of all 17 National Institutes of Technology in the country and IIT Kanpur were invited in December 2005. The selection criteria included that the best applicant should be taken even at the cost of not having an equitable distribution across different NITs and across different specializations.

Ms. Carolyn Ash visited IIT Kanpur in the late January 2006. She enriched the campus community by sharing her invaluable experiences towards undergraduate research through a lecture and several group discussions. Also, she helped IIT Kanpur to develop its vision on undergraduate research that will guide our intent and actions in the years to come. Ms. Ash also interacted with IIT Kanpur

students who had been selected to participate in SURF at Caltech and in inaugural SURGE program.

IIT Kanpur's SURGE program was inaugurated on 8 May 2006 by Professor Sanjay G. Dhande, the Director. It was 10 weeks full of academic and non-academic activities for the SURGE students. On 14 July 2006, the first batch of 21 IIT Kanpur and NIT students completed their 10-week rendezvous with *research methodology*, *research tools* and *research attitude*. The program culminated with two-day seminar where the students presented their work undertaken as part of the SURGE Program.

The three students from Caltech, who joined the SURGE program on 17 June 2006, completed their 10-week summer research in August 2006. Their program concluded after one-day seminar in mid-August. Meanwhile, the three IIT Kanpur students, who went to Caltech in early May 2006 returned back by the end of July 2006. They had inspiring stories to tell about Caltech's SURF program.

Many of these short duration research efforts by the students produced high yield research outputs, and the students carried back lasting impressions on their impressionable minds at an early age.

3. The SURGE Program

Under the new Summer Undergraduate Research Grant for Excellence (SURGE) program, second and third year undergraduate students (including those in the Dual Degree programs) undertake short duration, but focused research projects and push their intellectual abilities beyond those driven by the classroom. The duration is 10 weeks from early-May to end-July of each year. Selected students receive a stipend of Rs.10,000 for the entire 10-week duration; an additional Rs.10,000 Award plus a commendation certificate will be given to those SURGE students who produce exceptional quality research during the 10 weeks.

As the SURGE program incorporates four different groups of students, the selection criteria differ slightly for all. However, all the candidates for all programs are selected on the basis of their academic record, involvement in extra-curricular technical activities, recognition at the national student level competitions, and their technical proposal for the research to be undertaken during the SURGE Program. The applications are scrutinized by two faculty members from the concerned departments, the Implementation Committee and Program Coordinators. Details of the information to be sought from the aspiring students in their applications are given on the SURGE website (www.iitk.ac.in/surge).

- An IITK student wishing to apply for Caltech's SURF program is first shortlisted on the basis of his/her application. He/She is then asked to give a small presentation highlighting his/her area of interest and his proposed research. The names of short-listed students are sent to Caltech where these students are matched with appropriate faculty mentors of Caltech. IITK students then need to fill the SURF on-line form which includes a proposal specifying their plan of research.

- An IIT Kanpur student wishing to be accepted for the SURGE program in the campus is required to identify an IITK faculty member who may be her/his potential research mentor, discuss with her/him the research work to be undertaken (clearly outlining the scope), and submit an application along with the research proposal. Short-listed students are called for a presentation. The final candidates are chosen on the basis of the clarity and coherence of their project proposal. They are required to submit a further revised four page research proposal before commencement of the program.

- An interested NIT student is required to submit an application along with a research proposal of his choice and names of possible mentors from IIT Kanpur. The short-listed students are matched with mentors in their chosen area by the SURGE Coordinators. These students are then invited to correspond with their mentors and submit a quality four page proposal before the commencement of the program.

- The students from Caltech are chosen by the Caltech SURF Office based on an interview. The applications and areas of interest of the selected students are received from Caltech. The SURGE Coordinators then match appropriate mentors and invite the Caltech students to correspond with them.

The SURGE participants are required to submit a mid term report after four weeks, and make a presentation to a small review committee consisting of a group of academic staff members on the work accomplished till then. The candidates prepare a *final technical report* at the end of 10 weeks. The culmination of the summer research is the *oral presentation* and feedback of student experiences in SURGE.

Care is taken to ensure that SURGE programme focuses not only on "research" but also on multifaceted personality development of the student. Thus, weekly social and cultural activities are interlaced with the research program. While these meetings allow the students to socialize and share their enthusiasm with each other, they help SURGE Coordinators to group mentor the students and get regular feedback. As a bonus, these activities win strong loyalty from the students for the program.

4. The Inaugural 2006 Programme

In the inaugural 2006 SURGE Program, 21 undergraduate students (10 from IIT Kanpur and 11 from National Institutes of Technology across India), who completed II/III year of undergraduate program of any branch of engineering and sciences, were chosen based on a very competitive national search for their strong academic background and aptitude to do high quality research. These young researchers spent 10-weeks of their summer vacation at IIT Kanpur to do research at the frontiers of engineering and science under the mentorship of IIT Kanpur faculty members. Please see Tables 1 and 2 for the details of these students and their summer research work. Further, three students from Caltech participated in the 2006 SURGE Program, and likewise, three IIT Kanpur students participated in

the 2006 SURF Program of Caltech. Please see Tables 4 and 5 for details of these students and their summer research work.

Keeping in mind the non-academic facets of the research-based program to ensure high morale of the students, the students were introduced to Kanpur city and its history in several well planned visits. A variety of extra-curricular activities was organized during evenings. One of the particularly memorable activities was a game of "Ultimate Frisbee" introduced by faculty coordinator, Dr. CVR Murty. The students were frequently joined by their mentors for these non-academic programs. This *teacher-student relation* was rated as one of the high-points of 2006 SURGE Program.

Abstracts of the research undertaken by the students during 2006 are given in Appendix A and Appendix B.

5. Feedback of Mentors and Students of 2006 SURGE Program

5.1 Mentor Feedback

The statistics of the responses to the quantitative questions of the *Mentor Feedback* form are given in Table 5. Some of the salient points that emerged from the qualitative responses to the other questions of the *Mentor Feedback* form are:

(a) All the mentors very much appreciated the idea as well as organization of the Program.
(b) Many mentors felt that 10 weeks in summer was too short a time for meaningful research; they plan to invite the student again to wind up the work.
(c) It was suggested that another informal research program should be run for IIT Kanpur students during the regular semesters.
(d) It was also suggested that the number of students be increased, in particular from the NITs.

5.2 Student Feedback

The statistics of the responses to the quantitative questions of the *Student Feedback* form are given in Table 6. The salient points from the qualitative responses to the other questions of the *Student Feedback* form are:

(a) Students were very thankful for the opportunity that IIT Kanpur presented them with. Almost 80% of them showed interest in continuing in research.
(b) The atmosphere provided by IIT Kanpur to the SURGE students was appreciated. Many students felt that the time was too short for them to tie up the project properly, though enough for them to taste flavor of research.
(c) A number of students felt that mid-term report was done when they were still inadequately prepared. They suggested that mid-term report may be replaced by informal discussions.
(d) On the lighter side, trip to JK Temple and Frisbee games were the most favored extra-curricular activities.

Table 1: IIT Kanpur students in 2006 SURGE Programme

No.	Name	Project Title	Mentor(s)
1	Paritosh Singh *B.Tech/EE/II Yr*	Influence of Varying Anodizing Conditions on Anodized Aluminum Oxide Nanopore Arrays	Satyendra Kumar *Physics* S. S. K. Iyer *Electrical Engineering*
2	Shubham Gupta *B.Tech/EE/II Yr*	Numerical Simulation of Electrical Properties for Bilayer Organic Light-Emitting Diodes and its Applications	B. Mazhari *Electrical Engineering*
3	Rahul Kanodia *B.Tech/CHE(Dual)/II Yr*	Phase Coexistence and Interfacial Properties of Lennard Jones Fluids Confined In Disordered Porous Material	Jayant K. Singh and Ashutosh Sharma *Chemical Engineering*
4	Ankit Sharma *B.Tech/CSE/II Yr*	Mobile-to-ATM Secure Wireless Communication using Cryptographic Key Management	Rajat Moona *Computer Science & Engineering*
5	Jasmit Singh Gujral *B.Tech/MME/II Yr*	Development of Particulate Reinforced Soldering Materials	R. Balasubramaniam and M. N. Mungole *Materials & Metallurgical Engineering*
6	Sidhant Dash *M Sc.(Intg.)/Maths/II Yr*	A Neuro-Evolutionary Approach to Time Series Forecasting	Amit Mitra *Mathematics & Statistics*
7	Gaurav Kumar *B.Tech/AE/III Yr*	Flow Past Two Circular Cylinders in Tandem Arrangement	Tapan K. Sengupta *Aerospace Engineering*
8	Vikram Pagaria *B.Tech/BSBE/II Yr*	Analysis of Codon Usage-Finding Regularities of Codon Bias and Its Implications in Human Disorders	S. Ganesh *Biological Sciences & Bio-Engineering*
9	Mayur Dixit *B.Tech/ME/II Yr*	Coating of Carbon Nanotubes on The Surface of Silicon Carbide Cutting Tools to Improve its Performance	K. K. Kar *Mechanical Engineering*
10	Purushottam Kar *B.Tech/CSE/II Yr*	INGIT: A Limited- Domain Formulaic Translation System for Indian Sign Language	Achla Raina *Humanities & Social Sciences* Amitabh Mukherjee *Computer Science & Engineering*

Table 2: National Institutes of Technology students in 2006 SURGE Programme

No.	Name	Project Title	Mentor(s)
1	Shruthi Viswanath *B.Tech./IT/II Yr* *NIT, Surathkal*	Remote Homologs of Pharmaceutically Important Membrane Proteins	R. Sankararamakrishnan *Biological Sciences & Bio-Engineering*
2	Vikas Singh *B.Tech./ECE/II Yr* *MNNIT, Allahabad*	Data Acquisition with Compact RIO	N. S. Vyas *Mechanical Engineering*
3	Pallavika Ramaswamy *B.Tech./ChE/II Yr* *NIT, Surathkal*	Hückel Calculations and Aromacity in Two and Three Dimensions	N. Sathyamurthy *Chemistry*
4	Abhishek Verma *B.Tech./CS/II Yr* *NIT, Tiruchirappalli*	Solver for Sparse Symmetric Positive Definite System of Linear Equations	Phalguni Gupta *Computer Science & Engineering*
5	Gaurav Vijay *B.Tech./CE/II Yr* *NIT, Surat*	Effect of Structural Wall Area on Seismic Performance of Open Ground Storey Buildings	C. V. R. Murty *Civil Engineering*

6	Rajasunath G. *B.Tech./MME/III Yr* *NIT, Warangal*	Nano-Hydroxyapatite-Alumina High Density Polyethylene Nanocomposites for Bimedical Applications	Bikramjit Basu *Materials & Metallurgical Engineering*
7	Prakhar Mehrotra *B.Tech./ME/III Yr* *NIT, Tiruchirappalli*	Effect of 'Slip' Splitter Plate on Vortex Shedding at Low Reynolds Number	Sanjay Mittal *Aerospace Engineering*
8	Swetaleena Mishra *B.Tech./ME/III Yr* *NIT, Rourkela*	Modelling of an Electrostatic Precipitator	V. Eswaran *Mechanical Engineering*
9	Manas Garg *B.Tech./CS/III Yr* *NIT, Tiruchirappalli*	Design and Development of an Interactive Code Optimizer	Sanjeev Aggarwal *Computer Science & Engineering*
10	Abhay Singh *B.Tech./ECE/III Yr* *MNNIT, Allahabad*	Speckle Removal, Segmentation & Classification of Synthetic Aperture Radar Images	Onkar Dixit *Civil Engineering*
11	Manpreet Kaur Saini *B.Tech./ECE/III Yr* *Dr. B.R. Ambedkar NIT, Jalandhar*	Design of Broadband RF Feed for Giant Meter Wave Radio Telescope Antenna	A. R. Harish *Electrical Engineering*

Table 3: California Institute of Technology (USA) students in 2006 SURGE Programme

No.	Name	Project Title	Mentor(s)
1.	Geoff M. Galgon *B.Sc/Maths/I Yr* *Caltech (USA)*	A Study of Smokeless Stove Implementation and Policy in Uttar Pradesh, India	A. K. Sharma *Humanities & Social Sciences*
2.	Sukhmani K. Singh *B.Sc/Chemistry/II Yr* *Caltech (USA)*	Ordered Assembly of Short Peptides	Sandeep Verma *Chemistry*
3.	Sarah A Stokes, *B.Sc/Physics/II Yr* *Caltech (USA)*	Self Interacting Dark Matter in the Solar System	Pankaj Jain *Physics*

Table 4: IIT Kanpur students in 2006 SURF Programme of Caltech (USA)

No.	Name	Project Title	Mentor(s)
1.	Ravi Teja Sukhavasi *B.Tech/EE/III Yr*	Application of Network Coding Ideas for FPGA Routing	Tracey C. Ho *Assistant Professor of Electrical Engineering and Computer Science*
2.	Sriramkumar Venugopalan *B.Tech/EE/II Yr*	Gas Sensors in Microfluidic Chip	Axel Scherer *Bernard Neches Professor of Electrical Engineering, Applied Physics, and Physics*
3.	Karan Malhotra *M.Sc(Intg)/PHY/III Yr*	Quantum State Estimation	John P. Preskill *John D. MacArthur Professor of Theoretical Physics*

Table 5: Quantitative responses in *Mentor Feedback* to 2006 SURGE Programme

#	Question	Average Score
Student		
3	Did the student measure up to your expectations? (1: Well below expectations; 5: Beyond expectations)	4.25
4	How much supervision did the student require? (1: A lot; 5: Not much)	3.35
5	Did the student work when you expected him/her to? (1: Never; 5: Always)	4.70
6	Did the student observe guidelines you set forth? (1: Never; 5: Always)	4.85
7	Did the student work well with your research group? (1: No; 5: Yes)	4.63
8	Did the student participate in department seminars or discussion groups? (1: No; 5: Yes)	3.50
9	How well suited was the student for the research in terms of: (1: Low; 3: Medium; 5: High) (a) Enthusiasm for the work (b) Preparatory Coursework (c) Skills or abilities, etc. (d) Background knowledge	 4.75 4.00 4.55 3.90
10	Would you recommend this student for the 2007 SURGE Program? (1: No; 5: Yes)	4.94
11	Would you like to work with this student again? (1: No; 5: Yes)	4.89
12	If your student was a non-IIT Kanpur student, would you consider taking him/her on as a graduate student? (1: No; 5: Yes)	4.91
13	Please give us your overall evaluation of the student. (1: Poor; 5: Excellent)	4.72
Research		
14	Did the research you expected from the SURGE research project get done in the 10 weeks? (1: No; 5: Yes)	3.88
15	Is the work worth publishing in a refereed Journal? (1: No; 5: Yes)	4.21
Overall		
16	Were you satisfied with the assistance and administrative support provided by the Office of the DRPG hosting the SURGE Program? (1: Poor; 5: Excellent)	4.71

Table 6: Quantitative responses in *Student Feedback* to 2006 SURGE Programme

#	Question	Average Score
Research		
3	On an average, how many hours per week did you interact with your Mentor and/or Co-Mentor? (1: 25 hours or more; 5: 5 hours or less)	3.25
4	Did you get the required equipment & facilities needed to carry out your research? (1: No; 5: Yes)	4.10
5	Did you attend research group meetings or participate in discussions with your research group members? (1: No; 5: Yes)	3.85
6	Did you feel comfortable asking questions to your Mentors and Co-Mentors? (1: No; 5: Yes)	
	(a) Mentor	4.48
	(b) Co-Mentor	4.08
7	What was the benefit you received from your summer research experience in terms of (1: Low; 3: Medium; 5: High)	
	(a) Clarification of career path	3.95
	(b) Skill in interpretation of results	4.52
	(c) Tolerance for obstacles faced in research process	4.19
	(d) Readiness for more demanding research	4.30
	(e) Understanding how knowledge is constructed	4.19
	(f) Understanding of the research process in your field	4.10
	(g) Ability to integrate theory and practice	4.00
	(h) Learning ethical conduct in your field	3.38
	(i) Learning laboratory techniques	4.14
	(j) Skill in how to give an effective oral presentation	4.14
	(k) Skill in science writing	4.33
	(l) Self-confidence	4.38
	(m) Learning to work independently	4.75
8	How does your undergraduate research experience compare to the expectations you held before you began your project? (1: Well below expectations; 5: Well above expectations)	4.00
9	Evaluate the overall performance of your Mentor or Co-Mentor: (1: Poor; 5: Excellent)	
	(a) Mentor	3.95
	(b) Co-Mentor	3.73
Overview		
10	Please comment on the effectiveness of the following: (1: Low; 3: Medium; 5: High)	
	(a) Writing the research proposal or project plan before coming to IIT Kanpur	3.33
	(b) Oral presentations	4.05
	(c) Writing your final technical paper	4.52

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Appendix A

Abstracts of 2006 SURGE Research Projects

2006/1

Secure Wireless Communication between a Mobile Phone and an ATM using Cryptographic Key Management

Ankit Sharma, Computer Science & Engineering, IIT Kanpur
Mentor: *Rajat Moona, Department of Computer Science & Engineering*

This project attempts to establish a secure wireless communication between a mobile and an ATM using cryptographic key management. Cryptographic key management is a technique to establish authentication and secure transfer of information. In cryptographic key management, information is encrypted and decrypted using the key. Security implies reducing the chances of unauthorized access to sensitive information and to minimize harmful effects of eavesdropping. Authentication helps to ensure that information is reaching the person whom it is intended for. In this project, a theoretical model has been constructed assuming the fact that both the ATM and the user trust the bank. Using public and private key cryptography and signature of the bank, this model is able to authenticate the ATM to the user and vice-versa. After successful authentication, further communication is carried out encrypted using a session key. The implementation of this theoretical model has been successful to the extent of establishing a wireless communication between the ATM and the user using Bluetooth. However, the authentication part which involves public-private key cryptography could not be implemented due to technological restraints such as the GSM SIM, which has been used here as a security element, does not support public-private key cryptography.

2006/2

Flow Past Two Circular Cylinders in Tandem Arrangement

Gaurav Kumar, Aerospace Engineering, IIT Kanpur
Mentor: *T. K. Sengupta, Department of Aerospace Engineering*

The shedding of vortices and patterns of flow around two identical circular cylinders (where both of them can be given time dependent, independent rotary oscillations) in tandem arrangement have been investigated numerically here. Finite difference method is used in the simulation and the flow is assumed to be two-dimensional and incompressible. The instability and transition for such a flow regime is studied. Calculation of pressure and forces (lift coefficient, drag coefficient, moment coefficient) for both the cylinders is done here including cases where the front cylinder can execute rotary oscillation. Computations are carried out for various values of Reynolds number (Re), gap-to-diameter ratio (l/D) and rotary oscillation amplitudes (Ω_1). Direct simulation is used for present computations which involves using high accuracy compact schemes for spatial discretization and four stage Runge-Kutta method for temporal discretization. Over-set grid method is used for grid generation and chimera technique for domain decomposition. The dependence of lift and drag coefficients of the front and the rear cylinders on Re and l/D has been reported. The rear cylinder experiences a thrust and negative lift in some cases. Fast Fourier Transforms of the lift and drag coefficients of the front and rear cylinder have been obtained for different cases that show the behavior of vortex shedding for the front and the rear cylinder. Vorticity dynamics of the flow is also discussed. Proper orthogonal decomposition (POD) of the flow field is done in order to study the contribution of various eigen-modes to the enstrophy/energy of the flow. Effects of providing rotary oscillation to the front cylinder is studied that reveals that both drag and lift experienced by the front as well as the rear cylinder increases when rotary oscillation is provided to the front cylinder.

2006/3

Development of Particulate-Reinforced Soldering Materials

Jasmeet Singh Gujral, Materials and Metallurgical Engineering, IIT Kanpur
Mentor: *R. Balasubramaniam, Department of Materials & Metallurgical Engineering*

Solder is a common fusible metal alloy (usually Sn-Pb) with melting point below 450 degree Celsius. It is melted to join metallic surfaces, and widely used especially in a field of electronics and other engineering applications, in a process called soldering. The low melting point of a solder is a result of near eutectic composition of the material. The most common composition used is Pb-33%

and Sn-67%. Metallic contamination in small amount considerably affects the microstructure of a soldering joint. The microstructure of solders is important for different reasons. Within the temperature range of common applications, the microstructures of solder are constantly changing thus resulting in variation in mechanical properties and bonding strength. We studied the ancient text of Varhmihra's Brhatsamhita and tried to introduce the iron-oxide as mentioned by it to contemporary solder and thus studied its effect on various properties.

2006/4

Coating of Carbon Nanotubes on the surface of silicon carbide cutting tool to improve its performance

Mayur Dixit, Mechanical Engineering, IIT Kanpur
Mentor: *K. K. Kar, Department of Mechanical Engineering*

The performance of cutting tools depends mainly on the properties of the tool material and the work material. The objective of this investigation is to evaluate the performance of silicon carbide cutting tool by coating carbon nanotubes on its surface because of the outstanding properties of CNT i.e., Young's modulus of ~1.25 TPa, tensile strength of ~100 GPa, thermal conductivity of 3000 W/mk at 25^{o}C, etc. Special pretreatments like etching with HF and/or washing with acetone were carried out to remove the foreign materials from the tool surface and to get a good coating of nickel on the substrate. Nickel coating was carried out by electroless dip coating and thermal treatment in which various parameters like temperature, time, pH and concentration were varied to find their optimum values for the process. Chemical vapour deposition (CVD) method was used to crack the Ni-coating into nanoparticles which act as catalyst for growing CNTs in nitrogen atmosphere. Hydrogen was used as a reducing gas. Carbon nanotubes were grown by using CVD in which acetylene gas was used as the source of carbon. The nickel and carbon nanotube coated cutting tools were characterized by XRD (X-ray diffraction), SEM (Scanning electron microscope) and EDAX (X-ray energy dispersive spectrum) techniques. The suitable values of processing parameters were found by analyzing and observing the extent of CNT coating on the surface of cutting tools. Some interesting features like Y-junction, zig-zag CNT and carbon rods were also observed. Finally, the performance characteristics of cutting tool were evaluated by surface roughness.

2006/5

Influence of Varying Anodizing Conditions on Anodized Aluminum Oxide Nanopore Arrays

Paritosh Singh, Electrical Engineering, IIT Kanpur
Mentor: *Satyendra Kumar, Department of Physics*

The fabrication of anodized aluminum oxide (AAO) nanopore arrays is done by simple electrochemical processes like electropolishing and electrolysis using inexpensive and readily available equipments. The parameters of nanopore like their diameter, the spacing between them and their orderedness very much depend on the anodizing conditions. So, by varying the anodizing conditions the variation in the nanopore parameters can be studied. Now a day, the AAO nanopores have attracted the attention of lots of people since the process of their fabrication is quite inexpensive. And, they can be used in various applications like making nanowires and nanotubes. Also, as they offer structures in the nanometer scale which can be used in applications for magnetic storage , solar cells , catalysts and as substrates for artificial lipid membranes. Thus, a lot of research in going on in this field to study their dependence on the anodizing conditions so that more and more well-ordered nanopores can be fabricated. As a part of this project the conditions for the self-organized formation of ordered hexagonal structures in anodic alumina are investigated for oxalic and sulphuric acid as an electrolyte. First of all, fabricating the nanopores is quite challenging in itself. After a satisfactory sample containing nanopores is fabricated, the pore diameter and spacing are varied by changing the anodization conditions. The samples are obtained under different anodizing condition to study the affect of different parameters like type of electrolyte, time of anodization, etc. The surface of the samples obtained is analyzed using the AFM technique.

2006/6

INGIT: A Limited Domain Formulaic Translation System for the Indian Sign Language

Purushottam Kar, Computer Science and Engineering, IIT Kanpur
Mentor: *Achla M Raina, Department of Humanities and Social Sciences*
Co-Mentor: *Amitabha Mukerjee, Department of Computer Science & Engineering*

Sign language research focuses primarily on the neuro-physiological and developmental aspects of this modality. Cross-modal processing of spoken and sign languages has not received enough attention. The present work reports INGIT, a limited domain formulaic translation system which translates spoken language utterances into Indian Sign Language (ISL) strings. The system is designed to aid communication between an official at a railway booking counter and the deaf customer. The output strings are tagged for various visual markers such as non-manual signs and deictics used in ISL and other sign languages. The ISL expressions thus generated can be fed into a graphical system to generate graphical signs. INGIT is based on the framework of Construction Grammars which use words as well as larger constituents as units of semantic analysis. An in depth investigation into the structure of ISL based on first hand data collected from native ISL users constitutes the ground work for INGIT. Representational and mapping issues specific to cross-modal translation are identified and implementable solutions are provided for some of them. Cross-modal representational issues point to the need for a semantically mediated translation procedure while the mapping issues motivate the choice of a formulaic approach. The approach pursued here builds upon a semantic module worked out for Hindi/ Hindi-English code-mixed variety and the ISL. The system supports compositional as well as formulaic translations.

2006/7

Phase Coexistence and Interfacial Properties of Lennard-Jones Fluid Confined in Disordered Porous Material

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Mentor: *Jayant K. Singh, Department of Chemical Engineering*
Co-Mentor: *Ashutosh Sharma, Department of Chemical Engineering*

The grand canonical transition-matrix Monte Carlo method is adapted for the simulation of the phase equilibrium of a Lennard-Jones (LJ) fluid confined in a disordered porous material. A systematic investigation is done to study the influence of confinement, strength of solid-fluid interaction, porosity, microstructure, system size on the phase behavior of the confined fluid. Extreme sensitivity of phase diagram of LJ fluid on microscopic structure of the porous samples of repulsive nature has been observed. However, for LJ fluid-matrix attraction at low porosity, phase behavior has been found to be insensitive to matrix realizations. This Report also describes an approach for determining the surface tension of a model system that is applicable over the entire liquid-vapor coexistence region. Finite-size scaling techniques are implemented to determine the infinite system size surface tension from a series of finite-size simulations of LJ fluid in disordered matrix of different nature. This report also presents the preliminary results of interfacial profiles of LJ fluid in a hard sphere matrix.

2006/8

Numerical Simulation of Electrical Properties for Bilayer Organic Light-emitting Diodes and its Applications

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Co-Mentor: *Y.N Mohapatra, Department of Physics*

Modeling and simulation of Organic Light Emitting Diodes (OLED) can aid in optimization of their performance and develop better device structure by providing insight into device operation that is either unavailable or difficult using experimental techniques. A simulator for Bilayer Organic light-emitting diodes has therefore been developed to study effects of various parameters on performance of a OLED in steady state. The set of partial differential equations consisting of Poisson equation, continuity equation, drift-diffusion equation and recombination equation have been simultaneously solved numerically to determine the device behaviour. Injection of carriers at the Organic- Organic interface and at electrodes have been modeled using models that are widely referred in literature. The mobility has been assumed to be field-dependent following universal Poole-Frenkel form. The simulator is able to provide spatial variation of electric field, recombination profile, hole and electron density along with current-voltage characteristics. These characteristics aid in having an insight into device behavior for different parameters. In the first method, the validity of simulator was confirmed by comparing results obtained from simulation for a single layer, single carrier device with analytical solution and found to match very well. In the second method the device simulation results were compared with simulation results presented in literature. In this case also a good qualitative agreement was obtained. To illustrate the usefulness of simulator, results are presented that demonstrate the impact of mobility and interfacial barrier height on recombination efficiency.

2006/9

A Neuro-Evolutionary Approach to Time Series Forecasting

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Mentor: *Amit Mitra, Department of Mathematics and Statistics*
Co-Mentor: *Neeraj Misra, Department of Mathematics and Statistics*

Time Series Forecasting is an extremely important problem that has received a lot of attention from many different quarters of science and engineering because of its intrinsic difficulties and practical applications. Many different techniques have been applied to the problem, and they have met with varying degrees of success. We present a Neuro-Evolutionary approach to time series forecasting, wherein we evolve neural network models to do time series prediction using an advanced evolutionary computation algorithm, called Neuro-Evolution using Augmenting Topologies. Changes in the original algorithm are implemented and to reach the high level of precision desired by time series forecasting, a novel ensembling method is also proposed and implemented. The algorithm's ability to evolve networks for a chaotic time series prediction task is tested by applying it to a benchmark series, the Mackey-Glass Time Series, and finally to test the proposed ensembling technique, the system is applied to predicting a complex currency exchange rate time series, that of the Yen-Dollar daily exchange rates. The results suggest that the system is robust, and when combined with the proposed ensembling technique, it is able to beat the predictions of the Random Walk model in the currency exchange rate prediction task. In the Mackey Glass test, the system successfully demonstrates its ability to evolve minimal structures to solve complex problems and multiple runs on the task confirm its ability to create diversity in terms of the architectures of the neural networks it produces.

2006/10

Analysis of Codon Usage - Finding Regularities of Codon Bias and its Implications in Human Disorders

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The question of whether synonymous codon choice is biased has been positively answered in many organisms but still no convincing answers and explanations have been found. It has been felt that the nucleotides surrounding the codon; the codon's context influences the choice of the codon from among a group of synonymous codons. In the human genome, the study has been more complicated due to the increased complexity of the genome as well as many regulatory bio-phenomena acting coherently. In this work, the relation between codon usage and its context is studied for twelve nucleotides on either side of the codon. This study is reinforcement to the fact that codon bias indeed exists and that there is a correlation between codon usage and its context at two independent levels although of different propensities- one effect that is dependent on the distance of the context from the codon while the other is independent of the distance from the codon. The former effect is stronger and more pronounced than the latter. The latter effect creates regularity in the pattern of context dependent codon bias. Here, the pattern obtained in the i^{th} nucleotide from the codon is similar to the pattern obtained in the $(i+3)^{th}$ or $(i-3)^{th}$ nucleotide. In addition, phenomena like amino acid bias, codon signature bias, dinucleotide bias, G+C content constancy in a species have also been addressed so as to coherently figure out the rationale behind codon bias. Codon bias and Context Dependent Codon Bias (CDCB) are particular manifestations of coding sequence non-randomness, which is utilized in many different cellular processes. It seems that codon bias as well as context dependent codon bias is ubiquitous for all organisms and that CDCB has distinct regularities. The CDCB regularities are also dependent on the nucleotide composition of a codon and, therefore, are in accordance with the codon bias regularities. The best known use is that of codon bias in achieving efficiency and accuracy in protein synthesis. Also, in eukaryotic cells, CDS non-randomness is utilized in the splicing process. The fact that codon usage is more strongly related expression level supports the notion, presented in a recent study, that codon choice may be related to the tRNA abundance in the tissue in which a gene is expressed.

2006/11

Speckle Removal & Segmentation of Synthetic Aperture Radar Images

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In the past two decades, many speckle reduction techniques have been developed for removing speckle and retaining edge details in Synthetic Aperture Radar (SAR) images. Most of the standard algorithms use a defined filter window to estimate the local noise variance of a speckle image and perform the individual unique filtering process. The result is generally a greatly reduced speckle level in areas that are homogeneous. But the image is either blurred or over smoothed due to losses in detail in non-homogenous areas like edges or lines. This creates a barrier for the use of SAR based remote sensing images to classify, interpret and analyze terrain accurately especially in sensitive applications like military and scientific research. The primary goal of speckle reduction is to remove the speckle without losing much detail contained in an image. This work aims at analyzing the performance of various Speckle Reduction Filters in terms of the output image statistics. Image segmentation is a process of dividing an image into different regions such that each region is, but the union of two different regions is not, homogeneous. In general, autonomous segmentation is one of the most challenging tasks in digital image processing. A rugged segmentation procedure brings the process a long way toward successful solution of image problems that requires objects to be identified individually. On the other hand, weak or erratic segmentation algorithms always guarantee eventful failure. In general, the more accurate the segmentation, the more likely recognition is to succeed.

2006/12

Effect of Area of RC Structural Walls on Seismic Performance of RC Buildings with Masonry Infills and Open Ground Storeys

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A large number of five storey RC Buildings built in the earthquake prone areas of the country have two undesirable features, namely the open ground storey where parking of vehicles is done and the slender columns (230mm wide) in the grounds storey. Such buildings have collapsed during recent earthquakes in the country. This study proposes RC structural walls to retrofit these buildings for seismic safety. The influence of structural wall area is studied on seismic response of the typical 5-storey RC frame buildings with brick masonry infills and open ground storey. Buildings with five different wall areas are analysed and designed for different load combinations as per Indian Standards. Seismic performances of these buildings are evaluated through displacement-based nonlinear static pushover analyses. Natural vibration characteristics are improved with addition of structural walls. A formal method is proposed for tuning buildings to have pure translational mode shapes in its fundamental modes. Study shows a need to add a floor slab at the plinth level of building to significantly reduce the lateral deformation of buildings in the ground storey. Seismic design of buildings with walls indicates reduction of steel consumption in RC columns when compared to that in conventional non-seismic design of open ground storey buildings. Study shows improved stiffness characteristics and flexural mode of failure in RC members with increasing area of walls. Length of structural wall contributes significantly to the lateral stiffness of buildings, than thickness. From this limited study, 2% structural wall area is seems sufficient (from economy and seismic performance points of view) for ensuring safety of open ground storey RC frame buildings during extreme earthquake shaking.

2006/13

Hydroxyapatite-Alumina-High Density Polyethylene Nanocomposites for Biomedical Applications: Processing and Characterization

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Hydroxyapatite has proved to be a widely accepted bioactive implant material. However important limitations, like brittleness and poor mechanical properties, HAp can not be used as a bulk load-bearing implant material. The higher stiffness (elastic modulus) of HAp than cortical bone results in bone resorption and leads to implant loosening. In this respect, the use of low-modulus materials such as biocompatible polymers appears to be an interesting approach. However their low strength associated with low modulus usually impairs their potential use. In this backdrop, the basic aim of the present work is to characterise the polymer-ceramic nanocomposite materials, which exhibits a desired combination of mechanical properties (E-modulus, hardness, fracture toughness) with good biocompatibility for implant application. For the present study, nanosized HAp and alumina particles (particle size <100nm), up to 40 vol%, have been incorporated in polyethylene (HDPE) matrix. Fretting wear studies of the composites were carried out against steel and zirconia counter bodies with

fretting parameters of 1,00,000 cycles, 10 Hz frequency, 10N load and 80µm stroke length in simulated body fluid (SBF) and in ambient conditions. The results indicated higher wear resistance (wear rate of 3.56X10-6mm3/Nm) and lower COF (˜0.057) with the S2 (40 vol% HAp) composite in SBF environment against zirconia counterbody. However, higher wear loss is measured in S1, (pure HDPE) wear rate of 25.2X10-6mm3/Nm, sample against steel in air. The wear resistance was higher in SBF environment than air in all the composites against both the counterbodies. Such lower wear rate in SBF environment is due to the lubricating effect provided by the SBF, similar to the effect of synovial fluid in the joints. Cytotoxicity tests involving the L929 fibroblast cells reveal preferential attachment and proliferation of cells onto S2 (40 vol% HAp) composite. This is attributed to the presence of the bioactive HAp particles in the composite.

2006/14

Design and Development of an Interactive Code Optimizer

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This project was aimed at developing an interactive system that would accept a program source code as its input and modify it in a way so as to keep the output same as the original program but to make it more efficient in terms of execution steps and memory consumption. This operation, called optimization, is usually incorporated with special kind of compilers called optimizing compilers. Though modern optimizing compilers do an excellent job at code optimization, they suffer from the major disadvantage of being black box solutions. The details of the optimization process are completely hidden from the end user. This project attempts at developing a code optimizer that would allow users to analyze all processes that take place in the course of optimization and also empower them to select which optimizations are applied to the input program. The result is a system that has multifaceted utility including that of a usual optimizer, a training tool to understand optimization process and concepts and also a training tool that allows programmers to analyze the changes the system suggests. The language used for implementing the system is Java and the program to be optimized should be in three address code. The project will be continued for enhancement even after the SURGE 2006 program.

2006/15

Design of a Broadband RF Feed for the Giant Meterwave Radio Telescope

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The Giant Meterwave Radio Telescope (GMRT), one of the largest radio telescopes operating in the meterwave frequencies, is situated near Pune, India. The telescope was designed to operate at frequencies centered around 50, 153, 233, 325, 610 and 1420 MHz. It is being planned to extend the range of operation of the telescope to cover the complete frequency band of 550 MHz to 1700 MHz. In this project, we propose one of the possible feed designs that covers the above frequency band. A log periodic array antenna has been proposed by Chalmers University of Technology for the US Square Kilometre Array (SKA). In this study, the Numerical Electromagnetics code has been used to compute the performance of the Chalmers feed for the US-SKA over an infinite as well as finite ground plane. A good agreement between the computed results and the published results has been observed. This project begins with the analysis of Chalmers feed for the US Square Kilometre Array. It has been demonstrated that Numerical Electromagnetic Code (NEC), a freeware, can be used to analyse this structure. Simulation of the array over an infinite ground plane is found to be quite straight forward. However, a finite ground plane posed an interesting challenge. Traditionally, a ground plane can be realized by a square wire grid. Making the grid size large resulted in incorrect results, and the computational resources posed a limit on the smallest grid that could be chosen for creating the ground plane. A log periodic mesh has been proposed to realize a finite ground plane. It has been demonstrated that this structure gives better suppression of the back lobe level over a wide range of frequencies while keeping the problem size relatively small. Apart from computational advantages, this structure can also be used to physically realize the ground plane. We are presently working on the ways to optimize the feed design for lower cross polar level and input reflection coefficient.

2006/16

Hückel Calculations and Aromaticity in Two and Three Dimensions

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Co-Mentor: *C. N. Ramachandran, PhD Scholar, Department of Chemistry*

Aromaticity, one of the old concepts has been revisited many times giving the theories of chemical bonding, structure and stability. Although it is a concept, it has a deciding role on the properties of molecules. Earlier concept of aromaticity was restricted to two dimensional conjugated π systems and later extended to various types of three dimensional systems. Extensive ab initio calculations have been carried out for planar and non planar systems with and without π electrons. Calculations were performed with Hartree-Fock (HF) and Density functional theory (B3LYP functional) methods using 6-31G* basis sets. Aromaticity indices like Degree of aromaticity, Nucleus independent chemical shift (NICS) and Reactivity index were used in the present study. Hückel calculation, a simple but powerful approach toward explaining the stabilities, physical properties, and chemical reactivities have been performed for some three dimensional systems. Benzene and other conjugated systems were found to be aromatic based on the three indices mentioned. On protonation the aromaticity of benzene ring increases although there is an energy barrier. In Corranulene the criteria of planarity is lost but the system still behaves as aromatic. Water clusters were found to be slightly aromatic due to the delocalization of electrons through hydrogen bonding. Among fullerene derivatives it has been observed that aromaticity can change with the number of electrons, structural parameters as well as encapsulation. A remarkable change in aromaticity is observed for two dimensional graphene sheets on folding to three dimensional tubes.

2006/17

Effect of "Slip" Splitter Plate on Vortex Shedding from a Cylinder

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The objective of this work is to observe the effect of a 'slip' splitter plate on vortex shedding from a cylinder by placing the plate along the line of symmetry. The use of such a plate is a hypothetical one, it is used here as a tool for better understanding of the flow phenomena involved. The plate allows the slip of velocity along itself but prevents any flow normal to it. The present study aims to increase our understanding of vortex shedding by tracking down the region downstream the cylinder which needs to be constrained to suppress it completely. Computations for various configurations of the plate, for Re = 46.9, 50, 65 and 100 flow are carried out using finite element formulation. It is found that, there are many locations, where the splitter plate of appropriate length suppresses the vortex shedding. Also, at there exists a location for splitter plate inside the recirculation bubble where the time taken by the plate to suppress the shedding is minimum. The absolute and convective stability of the fluid system (both with and without the splitter plate) is determined by performing the Global Linear Stability Analysis. The critical length (Lcr) of the slip plate at each location and the corresponding Strouhal number, which suppress the vortex shedding is determined. Convective Stability Analysis is done, and it is found that the flow past a cylinder becomes convectively unstable at around Re = 5. This study establishes that the vortex shedding in the wake of a circular cylinder is due to an absolute instability of the flow in the wake.

2006/18

Remote Homologs of Pharmaceutically Important Membrane Proteins

Shruthi Viswanath, Information Technology, NIT, Surathkal

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G-protein coupled receptors are the largest family of proteins and they play an integral role in cell signaling. They are present in practically every organ and play a vital role in several physiological activities. Hence present a wide range of opportunities as drug targets. But these proteins pose problems for physical extraction. Hence there is a need for computationally determining structure and function of these proteins as a first step towards developing novel drug molecules. In this project, we try to identify possible relationships between the GPCR families. We postulate that some of the known or orphan GPCRs would have arisen due to exon shuffling and /or exon duplication. Here the strategy is to shuffle the transmembrane segments of the selected GPCRs and supply them as query sequences to the BLAST tool, which searches for similar sequences among the database of protein sequences. This can help us find novel relationships between the GPCRs i.e. instances of shuffled homologs or homologs arising out of exon duplication. In our study, we shuffled the transmembrane domains of seven Class A and Class B GPCRs and analyzed the output of the shuffled sequences. Our preliminary studies indicate that there are four instances of probable exon shuffling and eight instances of probable exon duplication among the Class A and Class B GPCRs.

2006/19

Modeling of an Electrostatic Precipitator

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Electrostatic Precipitators are one of the most common particulate control devices that can operate in a wide range of gas temperature and achieve high collection efficiency. Hence, prediction of the collection efficiency of an electrostatic precipitator is important in a wide range of industrial applications. Various methods for the prediction of efficiency are reported in the literature. Most of them focus on simple geometrical arrangements or are based on models developed over past years. The strategic aim of the work presented here is optimization of collection efficiency of an ESP at minimum cost. The effects of various non-dimensional parameters on the collection efficiency are studied which would help in predicting the values of various variables for optimum collection efficiency of the precipitator. A computational technique has been presented for the general solution of the governing equations of particle dynamics of an electrostatic precipitator from which the collection efficiency can be calculated. The equations are presented in their theoretical framework. The particle motion involves terms for effect of drag force, inertial force, and electrostatic forces. The methodology involves deriving the governing equation by modeling of the precipitator and then solving it assuming a given flow field, electric field, initial conditions and the boundary conditions using Mat lab, hence tracking the path of the particle in the precipitator. Once the path of particles is tracked it can be predicted that whether the particle will be collected in the plates or not. From this the efficiency may be known.

2006/20

Solver for Sparse Symmetric Positive Definite Linear Equations using Parallel Genetic ordering

Verma Abhishek, Computer Science, NIT, Tiruchirapalli
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Several direct methods have been devised for solving sparse symmetric and positive definite linear systems. Finding an ordering of the matrix to minimize the height of elimination tree is crucial for effectively computing the Cholesky factor on parallel systems. This problem is known to be NP-hard. The height of the elimination tree is an indication of the number of parallel elimination steps. Though many effective heuristics have been proposed, the problems of how good these heuristics are near optimal and how to further reduce the height of elimination tree remain unanswered. This project is an effort to this investigation. A parallel genetic algorithm customized to optimize this parallel ordering problem is devised. It is characterized by two novel genetic operators, adaptive merge crossover and tree rotation mutation. The genetic algorithm is parallelized in order to utilize high performance of clustered computing and tested on a three node Beowulf cluster. It has been observed that without seeding a heuristic, the population requires a large number of iterations to evolve into an optimal solution. There is no overhead involved for generating the heuristic. The overhead of generating the heuristic cannot be justified for the improvements achieved presently.

2006/21

Data Acquisition with CompactRIO

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Co-Mentor: *V. Raghuram, Department of Mechanical Engineering*

This study describes data acquisition with CompactRIO using LabVIEW (laboratory virtual instrument engineering workbench). It is a small rugged industrial control and acquisition system powered by reconfigurable I/O (RIO) FPGA technology for ultrahigh performance and customization. It incorporates a real-time processor and reconfigurable FPGA for reliable stand-alone embedded or distributed applications. The study includes the working with different switching sequences, full step and half step of stepper motor. The stand alone technology of CompactRIO is used to write the code to FPGA core and run the stepper motor with circuitry made stepper motor drives through digital outputs. It also includes working with the configuration of CompactRIO and developing the application code as host VI so that it can be operated through a wireless communication system. CompactRIO find its utility in "In Vehicle Data Acquisition", ABS Brake Test, Noise and Vibration Measurement and Air Conditioning ECU Prototyping that is why in future work these modules are going to be used in developing a communication system for railway safety.

2006/22

Self Interacting Dark Matter in the Solar System

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Mentor: *Professor Pankaj Jain, Department of Physics*

Weakly coupled, almost massless, spin 0 particles have been predicted by many extensions of the standard model of particle physics. Recently, the PVLAS group in Italy observed a rotation of polarization of electromagnetic waves in vacuum in the presence of transverse magnetic field. This phenomenon is best explained by the existence of a pseudoscalar particle (spin 0, negative parity) with a mass m≈1 meV and coupling to photons g≈2x10-6 GeV-1. However, this coupling is very strong in comparison to the conventional astrophysical limits. With this coupling, the sun would dissipate energy quickly and the lifetime of the sun would be much shorter than observed. In this paper, we consider a hypothetical pseudoscalar particle that interacts strongly with itself, but only weakly with visible matter. Hence this particle acts like a dark matter. Assuming that these pseudoscalars pervade the galaxy, we can evade the limits placed on the pseudoscalar-photon coupling from the sun. Using the collisionless Boltzmann equation, we show that the pseudoscalars follow a distribution that fits all astrophysical limits placed on the solar dark matter for a range of parameters.

2006/23

A Study of Smokeless Stove Implementation and Policy in Uttar Pradesh, India

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Mentor: *Professor A. K. Sharma, Department of Humanities & Social Sciences*

The smoke from traditional stoves is a major health hazard in parts of rural India, leading to the deaths of nearly half a million women and children each year. There are several technologies that aim to combat this issue, but the only one that may be implemented at an acceptable cost is the so-called "smokeless stove." The principal components of its construction are a chimney, to redirect smoke, and a redesigned interior, to increase fuel efficiency. Our analysis aims to answer the question of why smokeless stoves have been adopted by so few, despite the existence of numerous government programs, operating for over two decades, designed to popularize and subsidize their construction. We carry out village surveys, focusing primarily on four villages in the Kanpur district of Uttar Pradesh, India's most populous state, to determine the attitudes of people, especially women, regarding smokeless stoves. Focus-group discussions among women, in-depth interviews, and talks with village leaders are conducted. A study is then undertaken of the state's smokeless stove promotion policies, involving officials at the village, block, and district levels.

2006/24

Ordered Assembly of Short Peptides

Sukhmani Kaur Singh, Undergraduate Student (Chemistry), California Institute of Technology, Pasadena, CA, USA

Mentor: *Professor Sandeep Verma, Department of Chemistry*

This study deals with synthesis and morphological studies of a self-assembling short peptide sequence derived from antimicrobial indolicidin peptide. This truncated peptide sequence was especially chosen for its unique structural qualities and its potential to organize into ordered structures in solution based on our preliminary studies. Mutant peptide A was synthesized using conventional solution phase methods and fully characterized for purity. Optical and fluorescence microscopic images indicated that the peptide adopted a uniform circular structure upon aging in solution. Scanning electron microscope (SEM) images showed the formation of spherical shells which was further confirmed by the appearance of flat circular patterns in transmission electron micrographs. It is believed that rapid aggregative propensity of this mutant peptide may lead to new design paradigm affording uniformly spherical soft matter amenable to advanced nano(bio)technological applications.

Appendix B

Abstracts :: 2006 SURF Research Projects

2006/25

Quantum State Estimation

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Different quantum state estimation procedures were compared for various simulated experimental conditions and show that Bayesian mean estimation (BME) with the correct prior has a lower divergence than the rest. Also, the performance of BME with an incorrect prior was examined, and compared with the several procedures using different metrics such as trace norm, Kullback Leibler distance, fidelity, and 2-norm. The maximum likelihood estimation (MLE) is indicated to be unreliable – it typically yields estimates with zero eigenvalues. Such a result implies absolute certainty that some event will never occur – a certainty that is unwarranted in the absence of infinitely much data. BME never reports zero eigenvalues and has a natural well defined variance. It is shown that the variance reported by MLE does not indicate the experimentalist's uncertainty in his estimate and is, at best, an indicator of the entropy of the estimate. Finally, a "quick and dirty" procedure is proposed, which removes the negativity of the tomographic estimate, and is computationally much easier than MLE. This procedure is shown to be better than MLE (by most metrics) in our numerical experiments.

2006/26

Application of Network Coding Ideas to FPGA Routing

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Mentor: *Professor Tracey Ho, Electrical Engineering and Computer Science, California Institute of Technology, Pasadena, CA (USA)*

Network Coding has been recently shown to improve performance compared to that of routing for multicasting information over wired and wireless networks. The subject of my project was to analyze the usefulness of introducing coding capability at intermediate nodes in FPGAs. Unlike in wired/wireless communication networks, computation in FPGAs can be very expensive in terms of the chip area. Hence, we have restricted coding only to a two/three input EXOR. Given a circuit segment of an FPGA in the form of a butterfly network, the number of wires crossing the bisection between the source and destination pairs can be decreased by use of a simple EXOR. On analyzing the commonly used FPGA benchmarks, it has been observed that there is scope for further optimization of the channel width by modifying the existing placement algorithms to search for template matches, the butterfly network being one such example. Further research in this topic should try to address the issues of finding a representation for FPGAs suitable for applying network coding tools and modifying the existing network coding algorithms to handle integer capacities.

2006/27

Gas Sensors for Microfluidic Chambers

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Co-Mentor: *Dr. Saurabh Vyawahare, Post-doctoral Scholar, Electrical Engineering, California Institute of Technology, Pasadena, CA (USA)*

The contributions of the field of microfluidics are becoming increasingly influential in biotechnological applications. These applications benefit potentially by integrated reduction in scale through lowered production and operating costs, via the specific dynamics of flowing liquids occurring at the micro-scale. A novel gas sensor design has been proposed for a microfluidic chip which provides a controlled atmosphere for bacterial growth. It comprises an inter-digitated array of platinum working electrode and silver/silver chloride reference electrode in contact with a solid, gas-permeable film of non-aqueous Poly-Vinyl Alcohol-gel electrolyte. The electrode pattern can be evaporated as well as screen

printed on a glass slide. The pre-polymer liquid containing dissolved electrolytic salts can be made to flow into micro-channels leading to a micro-chamber and cured in-situ. $NaHCO_3$ for CO_2 and KCl for O_2 have shown reversible response at room temperature. The impressions of temperature and relative humidity have to be studied too. Research on its sensitivity and specificity for characterization will be pursued by the nanofab group. Also in research are innovative ways to route the solution being monitored over the gas sensor to enhance sensitivity.

2006 SURGE Program

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