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NERD

Notes on Engineering Research and Development

An IIT Kanpur Students' Publication

Special Edition on ICARUS

ICARUS

Celebrating Undergraduate Research

Interview with Dr. Barbara Liskov

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Musings from the Editor's Desk

Hello everybody, you hold in your hands the issue which commemorates the third year of NERD. A very happy anniversary to NERD and all the NERDs!

The idea which began two years back now has solid roots and strong branches in form of many project initiatives which are growing and being appreciated. NERD lecture series plans to conduct many talks by eminent science communicators and journalists this year too.

We also took an online feedback over various aspects of NERD, and 72% of them preferred hard copy over soft version. We thank you to all those who participated in the process.

Peek into the issue and you will find ICARUS 2010 (Indian Conference for Academic Research by Undergraduate Research) in limelight. Yes! This is a special issue on ICARUS. There are articles by the winners of ICARUS 2010, talks by eminent dignitaries—Dr. R. Chidambaram (Principle Scientific Advisor to the Prime Minister), Dr. Roddam Narasimha (foremost fluid dynamicist and aerospace engineer of the country), Dr. K L Chopra (former Director, IIT Kharagpur and recipient of Shanti Swarup Bhatnagar Award) and Dr. Vijay Singh (Coordinator, National Initiative on Undergraduate Sciences), a little bit of this and a little bit of that.

Suddenly you notice there is a lot of ruckus everywhere regarding undergraduate research. It is a matter of pride that IIT Kanpur was the first to talk about it! But WHAT IS UNDERGRADUATE RESEARCH?

Now, we won't bear upon you with my layman-understanding and rather convey what Dr. Muralidhar, Dean Research and Development IIT Kanpur has to say on the subject - 'While talking of research by UG students, the interpretation of research is not about and only restrained to scholarly research. Research, from a much broader perspective, can be described as originality and design. For example, in JUGNU, students are putting together already designed technologies, but they are doing it for the first time themselves as well as probably for the first time in the field itself. I would classify this as research. UG research is all about throwing up ideas - they may be prophetic as well. Also, not only publications but also patents and technical entrepreneurship are basically research ideas that have germinated in minds of UG students.'

As for me, I would just say if there is so much hullabaloo about undergraduate research, why not try it out? Let's elope to the libraries, go through online journals and popular science articles, talk to our seniors – the resources are immense. The time is to realize that you don't need an apple to hit you to bring out the Newton within! There are many apples laying around already, just identify the most ripe one for you!

And one more thing, we are looking for students in the first year to fill the void of their successors. Come forwards and be a part of this initiative! We have something for everyone.

Regards,
Bhuvnesh, Pranjal and Utsav

(Editors, NERD)

CREATE, COMMUNICATE, CONTRIBUTE!!

The Protein Man

Bhuvnesh Goyal and Mohit Kumar Jolly

Dr. T P Singh

Dr. T.P. Singh *is an eminent Indian scientist who has made novel contributions to the structural studies of proteins and implemented a strong programme on rational structure based drug design. His laboratory has submitted more than 300 sets of protein structures to the Protein Data Bank (PDB) - the highest by any scientist in India and the third all across the world. He has been honored by Department of Biotechnology (DBT) as a Distinguished Biotechnologist and received the GN Ramachandran Gold Medal for excellence in Science and Technology. He has been the Head of Department of Biophysics at All India Institute of Medical Sciences (AIIMS) for two decades. NERD members had the privilege to talk to him and learn some concepts behind protein structures and the role they play in governing diseases and various other biological functions all across. Here are some of the excerpts of our conversation with 'The Protein Man':*

NERD: You have been with AIIMS for more than two decades now. What, in your view, is the most distinguishing feature of the institute?

Dr. Singh: I have been with AIIMS for 25 years now. AIIMS is different from other medical institutes because it gives equal emphasis on medical education, research and patient care. It has much more publications than any other medical institute in the country and the second largest number of publications among all institutes in the country. High quality research and development is necessary for growth of any country, and that gets neglected in other Indian medical institutes, where hospital business gets the most emphasis.

"We determine a large number of protein structures, then why can't and shouldn't the maximum no. of entries in PDB be by an Indian?"

NERD: You were appointed as the Head, Department of Biophysics at AIIMS in 1986 and you remained at the position till 2006. Please tell us about major research interests of the department.

Dr. Singh: Our main goal has been to determine a large number of protein structures, particularly those important for drug targets, and then design peptide based ligands (ligand is a substance that can bind to a bio-molecule and forms a complex with it to serve a specific biological function.)

We have also been working on drug discovery. Drugs generally function by binding to their targets that are mostly proteins. The binding characteristics of a protein are unique. Every protein has a different stereochemical binding site and hence only specific ligands can bind to that site. While discovering drug for a particular disease, one needs to know the details of the binding site and process to regulate/affect the function of the protein (or polypeptide) involved in that disease, and then design peptide (short polymers of amino acids) based molecules.

NERD: Proteins perform all diverse and vital functions of the cell such as metabolism, cell signaling, providing structural stability to cell etc., and you have been working in area of protein structure determination since your doctoral days. Can, you, in simple words, explain us the importance of structure determination of a protein?

Dr. Singh: Proteins are not ordinary compounds and their reactions are not ordinary chemical reactions. They function very specifically and bind to only those molecules having a complementary binding site. If you want to know and modify the function of a protein, you need to know its function or mechanism of action. Once you know its structure, you can enhance its stability etc.

NERD: Once we know the three dimensional structure of a protein, what can we say about its function? Is the structure necessary and sufficient for predicting the function?

Dr. Singh: Biochemical means are also used to determine the function of a protein, but they fail to provide any insight into the mechanism of action. Many times a protein is involved in more than one specific function. Structure determination is essen-

tial to learn about its function, but not sufficient. Many other biochemical and kinetics studies are required as well to predict its function.

NERD: NMR spectroscopy and X-ray diffraction are used to determine the protein structure. How do we know which method to use when?
Dr. Singh: X-ray diffraction is an accurate method to determine protein structure. It works on the diffraction of incident X-rays by atoms in the crystal, but through this technique, you can determine the structures of only those proteins that can crystallize. It can't be used when the crystallization step becomes the rate limiting one or perfect protein crystals are not obtained. NMR spectroscopy gives the statistical structure with limited accuracy; however, it is generally used for small proteins only because structure determination through NMR becomes a problem for larger proteins.

"Our biotech industry needs to exploit its highest potential not only for welfare of mankind, but also for contributing to the growth of Indian economy."

NERD: You introduced strong rational structure based drug design. Please tell us more about it. How does determination of protein structure help in drug design?
Dr. Singh: Initially drugs were made by observation, i.e. systematic chemical combinatorial approach, where a large number of molecules were synthesized by producing large variations in the lead (initial) molecule. This conventional method was very common among all pharmaceuticals companies, which invested a lot, but had only limited success after many trial and error iterations.
Structure based drug design is designing drugs on basis of what will fit in a binding site with known shape and chemical properties. Initially, we possessed a limited knowledge of which protein is critical for a particular disease; but with improving PDB (Protein Database) now, this method shall only improve and eventually become the method to obtain new drugs.

NERD: Kindly elaborate on the rules of peptide design you have developed. How shall these help better drug design?
Dr. Singh: Peptides offer a very interesting thing- we can modify the amino acids to say dehydro amino acids. By changing the positions of these dehydro amino acids, different peptide folds can be obtained and they can be tried to fit in different binding sites, and once you know the shape and chemical nature of the target binding sites, it obviously helps in better drug design.

NERD: How do you determine which proteins are expressed in which patho-physiological (diseased) condition? Do you need to determine structures of all expressed proteins before you start drug design?
Dr. Singh: When a disease occurs, the concentration of some proteins increase while that of some others decrease. We need to know and understand the concentrations of these proteins. By observing the difference in concentration of the proteins in normal and diseased state, we can identify the proteins whose concentrations change as a result of the disease. Having characterized these proteins, they can be used as biomarkers or drug targets.

NERD: We have heard that the combination of structure based drug design combined with clinical proteomics and bioinformatics is leading a big way in modern drug discovery. Please explain us more about the interaction between these fields.
Dr. Singh: Bioinformatics is an integral part of every modern biological research. It contains useful biological information and lot of software support. While correctness of a structure has to come from experiment, proteomics tells us which the important proteins are. These days the approach is problem wise, not method wise- bioinformatics, X-ray diffraction etc. are not disjoint today. You can feel the enjoyment and excitement in research only after you get into it.

NERD: You have more than 300 papers in international research journals and your lab has contributed more than 300 structure coordinates to Protein Data Base (PDB). What, according to you, has been your most significant contribution to your field?
Dr. Singh: Science has to be on frontline. We determine a large number of protein structures, then why can't and shouldn't the maximum no. of entries in PDB be by an Indian?
We have shown that LPO (lactoperoxidase- an enzyme present in milk) can be used as a drug against tuberculosis, as it can convert INH (isoniazid) to a radical that kills the bacteria *Myobacterium tuberculosis* that is responsible for the disease. These bacteria develop resistance towards drugs in course of time, and hence are able to spread diseases, but we have been able to overcome this resistance and contributed a significant step against diseases caused by them.

NERD: You have been awarded the Distinguished Biotechnologist Award by Department of Biotechnology (DBT), India and GN Ramachandran Award by Center for Scientific and Industrial Research (CSIR). Where do you see India in biotechnology industry map of the world in 2020? What major challenges do you see in front of Indian Biotech in-

dustry?
Dr. Singh: Indian biotechnology industry has a growth rate of 46%. It is a human resource dependent industry and I have hopes from it. India has a great chance in biotechnology and pharmaceuticals. Development of new drugs is a major challenge before the industry. If you have very potent drugs, you no longer need vaccines. Good quality research and development has to be much faster because the turnover will increase only when knowledge improves. Our biotech industry needs to exploit its highest potential not only for welfare of mankind, but also for contributing to the growth of Indian economy. Without research, no country has any future.

NERD: Please tell us something about your student days. Were you always sure to pursue research as your career?
Dr. Singh: I was a very weird student in class XII. I decided to pursue research just after my school, and I joined Allahabad University for my B.Sc. and M.Sc. I obtained my Ph.D. from Indian Institute of Science Bangalore in 1977 and worked as a post doctoral fellow with Dr. Robert Huber, who later received the Nobel Prize in 1988. Since 1984, I have been at AIIMS.

NERD: How would you describe Dr. T. P. Singh in one line?
Dr. Singh: I believe that it's only the work done by person that matters and creates a difference, not the person himself/herself. A scientist should never think of recognition.

NERD: What final message would you like to give to students?
Dr. Singh: Raw material at IITs have always been good, and hence the product. The academic ambience and professionalism obtained in IITs is worthy of praise, but IITs have yet to go high at the research front, and show the way in this direction too to all other technical institutes.

Bhuvnesh Goyal (bhuvnesh@iitk.ac.in) is a third year undergraduate in the department of Computer Science and Engineering at IIT Kanpur. He is very interested in science journalism and communication and sociology. He is a member of Core-coordination committee, NERD.

Mohit Kumar Jolly (mkjolly@iitk.ac.in) is a first year M.Tech. student at IIT Kanpur. He is interested in science journalism and communication, and is one of the founders of NERD.

Zonked!!

Piyush Srivastava

Weird games

It was, very recently, sports time at the Roadland Institute of Technology. Being the Geek Games coordinator, ChowTow came up with the following rather weird game: 5 people are randomly chosen from a crowd and are numbered 1 to 5. ChowTow then asks person I to write a positive integer p_i on a piece of paper (without communicating with the others). She calls the 5-tuple (p_1, p_2, p_3, p_4, p_5) so obtained their response tuple. The team of 5 then wins a jackpot if the sum of the reciprocals of the integers in their response tuple is 1.

ChowTow also has the following questions ready in case somebody comes along calling her game pointless: Can you show that if the number of winning response tuples is finite, then it must be odd? Is this number finite?

(Based on a problem in INMO 2005).

Send in your answers to nerd@iitk.ac.in latest by 30th September, 2010 and you can win a cash prize of Rs.1000!!

Piyush Srivastava graduated from IIT Kanpur with a B. Tech. in Computer Science and Engineering, and he is now a graduate student at the University of California, Berkeley, studying Theoretical Computer Science. At some point in time, he would like to know and understand all the Mathematics he wants to know and understand: and presently this wish looks very far from being fulfilled.

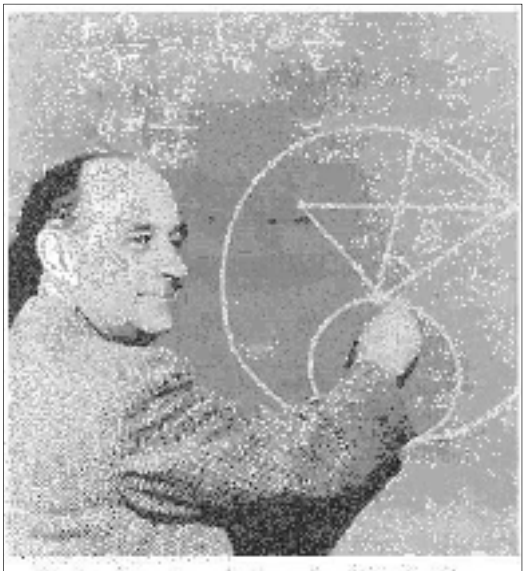
Go Nuclear or Kaboom!

Nuclear Energy: the Good, the Bad, and the Facts

Manish Kumar

Introduction

The exploration of natural sources for generation of electricity has been an evolutionary process. Over the years, it has progressed from tapping the potential of falling water to burning fossil fuels. The discovery of fission and the promise of abundance which nuclear energy came to hold subsequently, turned man's attention to utilise the potential of this source.



Enrico Fermi, an Italian physicist, led the team of scientists who created the first self-sustaining nuclear chain reaction.

History

It is human nature to test, to observe, and to dream. The history of nuclear energy is the story of a centuries-old dream becoming a reality.

In the years just before and during World War II, nuclear research focused mainly on the development of defense weapons. Later, scientists concentrated on peaceful applications of nuclear technology.

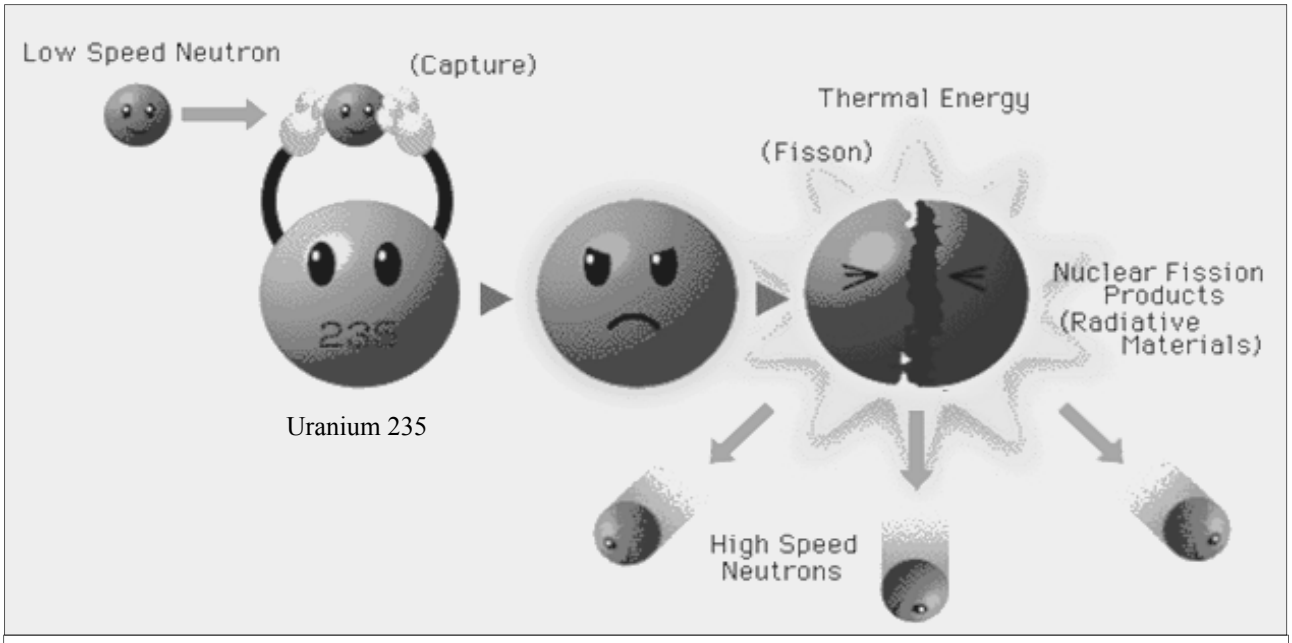
Ernest Rutherford was called the father of nuclear science because of his contribution to the theory of atomic structure. In 1904 he wrote:

"If it were ever possible to control at will the rate of disintegration of the radio-elements, an enormous amount of energy could be obtained from a small amount of matter".

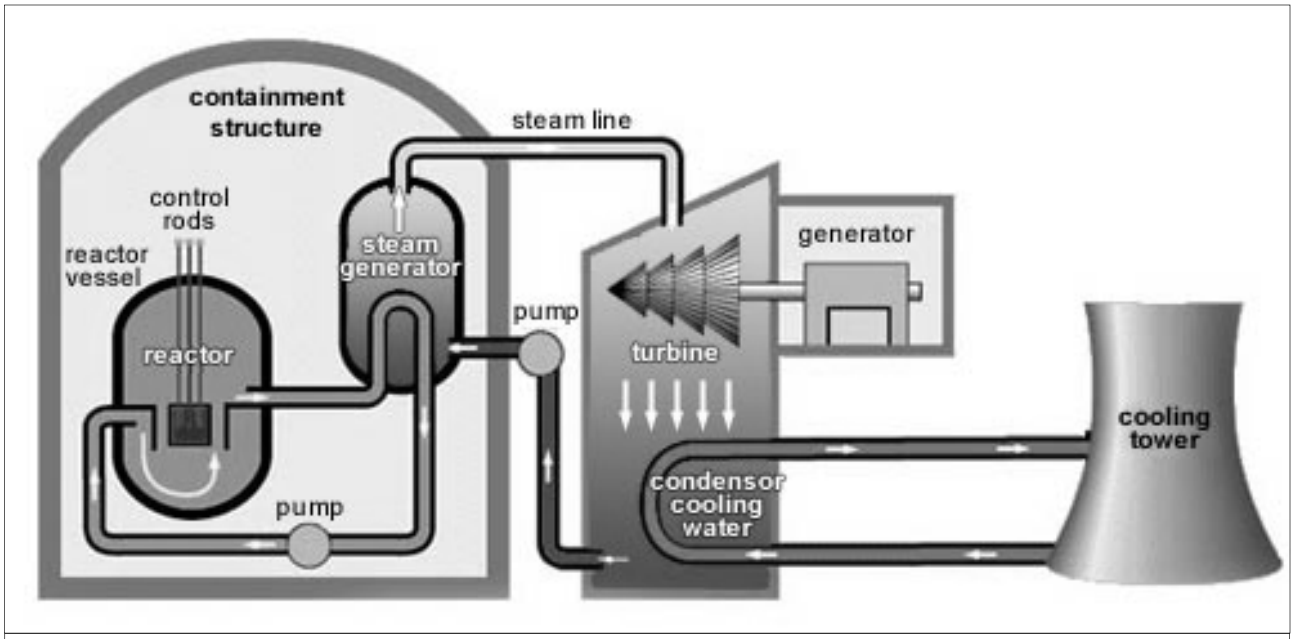
Albert Einstien developed his theory of the relationship between mass and energy. The mathematical formula is $E=mc^2$, or "energy equals mass times the speed of light squared". It took almost 35 years for someone to prove Einstien's theory.

The Discovery of Fission

In 1934, physicist Enrico Fermi conducted experi-



(Source: http://atropos.as.arizona.edu/aiz/teaching/nats102/images/nuclear_fission.gif)

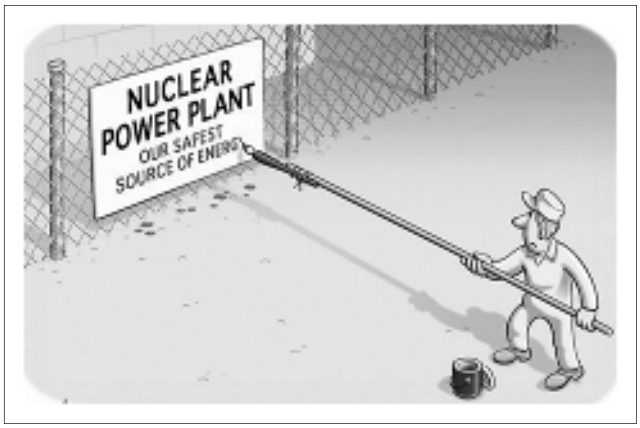


(Source: Basic working of a nuclear plant— http://www.me.utexas.edu/~ans/info/pwr.gif)

ments in Rome that showed neutrons could split many kinds of atoms (the results surprised even Fermi himself!). When he bombarded uranium with neutrons, he did not get elements he expected (the elements were much lighter than uranium). This splitting of uranium was called fission.

During fission, U-235 (an isotope of uranium that is used as fuel in nuclear power plants) absorbs neutrons. This causes U-235 to become unstable and split into two light atoms called fission products.

The combined mass of fission products is less than that of the original U-235. This is due to change of some matter into energy, as heat. Two or three neutrons are also released along with this heat. These neutrons may hit other atoms, causing more fission. A series of fissions is called a chain reaction.



Nuclear power plants (NPP) generate electricity like any other steam-electric plant: water is heated and steam from the boiling water turns the turbine and generates electricity. The main difference is the heat source. Heat from the self sustaining chain reaction boils the water in a NPP (coal, oil or gas is burned in other power plants to heat the water).

World's First Nuclear Reactor

Early in 1942, a group of scientists led by Fermi gathered at the University of Chicago to develop their theories. By November 1942, they were ready for construction to begin on the World's first nuclear reactor, which became known as Chicago Pile-1. The pile was erected on the floor of a squash court beneath the University of Chicago's athletic stadium. In addition to uranium and graphite, it contained control rods made of cadmium (cadmium is a metallic element that absorbs neutrons). When the rods were in the pile, there were fewer neutrons to fission uranium atoms. When the rods were pulled out, more neutrons were available to split atoms. As a result, the chain reaction sped up.

On the morning of December 2, 1942, the scientists were ready to begin a demonstration of Chicago Pile -1. Fermi ordered the control rods to be withdrawn a few inches at a time during the next several hours. Finally, at around 3:25 p.m., Chicago time, the nuclear reaction became self-sustaining. Fermi and his group had successfully transformed scientific theory into technological reality. The world had entered the nuclear age.

Current Nuclear Energy Scenario - Worldwide

Today, nuclear energy produces one-sixth of the world's electricity and could produce far more. Recognizing this potential, India and China, have begun major expansions of nuclear energy infrastructure.

Worldwide, there are around 440 nuclear power reactors (in addition 232 nuclear power stations are either under construction or proposed), with 372 GWe of total capacity. They provide about 16% of

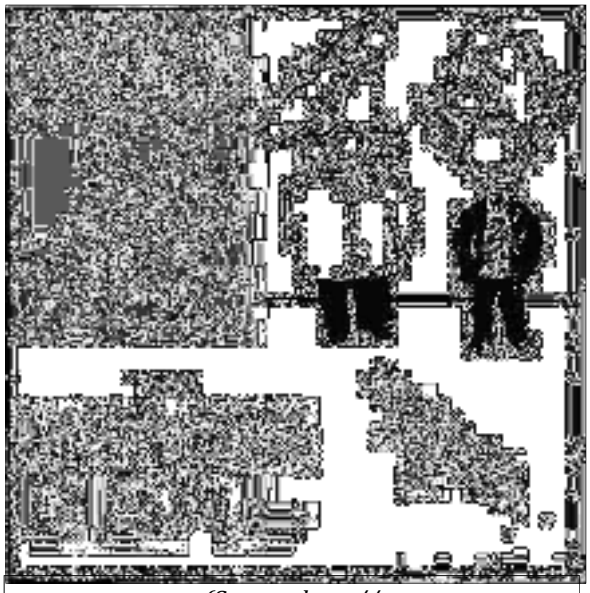
the world's electricity.

Nuclear Power in India

Nuclear Power was ushered in India in 1969 with the Tarapur Atomic Power Station, comprising of two boiling water reactors. The station was set up on a turnkey basis by General Electric Company, USA.

Nuclear power is the fourth-largest source of electricity in India (after thermal, hydro and renewable sources). India stands 9th in the world in terms of number of operational nuclear power reactors.

At the end of year 2009, Nuclear Power Corporation of India Limited was operating 18 reactors with a total capacity of about 4340 MWe. With the completion of other five projects under construction - two 220 MWe pressurised heavy water reactors (PHWRs), two 1000 MWe VVER pressurised water reactors, and the 500 MWe Prototype Fast Breeder Reactor, the nuclear capacity will be 7280 MWe by 2012. Eight 700-MWe PHWRs are also planned.



(Source: http://bellurramki18.files.wordpress.com/2008/07/rwbnucleardealcartoon_110708.jpg)

Focusing on the Future

India has a flourishing and largely indigenous nuclear power program and expects to have 20 GWe nuclear capacity by 2020 and 63 GWe by 2032. It aims to supply 25% of electricity from nuclear power by 2050.

The shortage of uranium reserves in the country has slowed down India's nuclear power program. The lack of uranium resources in India is driving the country's long term plan of developing the thorium fuel cycle (thorium is three times as abundant in the Earth's crust as uranium).

Uranium Production

Uranium is a metal approximately as common as tin or zinc, and it is a constituent of most rocks and even of the sea. Commercially, uranium is presently produced in 19 countries, although less than half produce significant quantities.

The two largest producers, Canada and Australia, alone account for more than 50% of world uranium production.

In India, uranium has been produced at the Jaduguda mine in the eastern state of Bihar since 1967. Mining is also expected to start in Bhima river belt of Karnataka.

Three-Stage Nuclear Power Program

The long term goal for India's nuclear energy program is to achieve energy independence using its vast reserves of thorium. To this end, India is implementing a three-stage program to develop fast breeder reactors that convert thorium into nuclear fuel. Most fast breeder technology has been centred on inputs of uranium and plutonium isotopes, but India does not have the reserves of uranium needed to achieve energy independence using these methods.

Most existing nuclear programs use an open fuel cycle, which means that more fuel has to be mined and processed to feed the reactors, and spent fuel has to be disposed of as high level nuclear waste. The thorium-based fast breeder reactor technology that India is developing uses a closed fuel cycle which reduces the need to transport radioactive fuel because the fuel is made in the reactor itself. Thorium-232 is not fissile*, but inside the reactor is converted to uranium-233 which is used as the breeder fuel.

The first stage of the program was the development of pressurized heavy water reactors. The spent fuel from these reactors contains unused uranium, plutonium, and other fissile materials. Rather than disposing of this as waste, the spent fuel is reprocessed and used in the development of fast breeder reactors in the program's second stage to keep with the commitment of maintaining a closed fuel cycle and to feed the third stage of the program. The third stage includes the development of thorium-based fast breeder reactors, which is being advanced currently with the Advanced Heavy Water Reactor.

Disposal of Nuclear Waste

More and more countries are now accepting nuclear energy as it is a cleaner and more efficient source of energy. But like any other method, there are drawbacks associated with it. One main issue is the problem of nuclear waste disposal.

Nuclear waste can be generally classified as either "low level" radioactive waste or "high level" radioactive waste.

Low level radioactive waste: It includes material used to handle the highly radioactive parts of nuclear reactors (i.e. cooling water pipes and radiation suits) and waste from medical procedures involving radioactive treatments or x-rays. Low level waste is comparatively easy to dispose off. The level of radioactivity in low level waste is relatively small. Storing the waste for a period of 10 to 50 years will allow most of the radioactive isotopes in low level waste to decay, at which point the waste can be easily disposed off.

High level radioactive waste: It includes material from the core of the nuclear reactor or nuclear weapon. This waste includes uranium, plutonium, and other highly radioactive elements made during fission. Most of the radioactive isotopes in high level waste emit large amounts of radiation and have extremely long half-lives, creating long time periods before the waste will settle to safe levels of radioactivity.

Why is Nuclear Waste an Issue?
Nuclear waste is a cause for concern because it is not bio-degradable (it does not decompose naturally under the affect of the atmosphere). Secondly, it causes a number of health hazards for anyone who comes into contact with the radiation from this waste.

Harmful radioactive emissions can cause skin cancer and genetically alter the DNA of people coming into contact with them, the effects of which will be passed on to the descendants of these victims for many generations to come.

The Indo-U.S. Nuclear Deal - An Overview
The Indo-U.S. civilian nuclear agreement, known also as the Indo-U.S. nuclear deal, refers to a bilateral accord on civil nuclear cooperation between the United States of America and the Republic of India. The framework for this agreement was a July 18, 2005 joint statement by Indian Prime Minister Manmohan Singh and the U.S. President George W. Bush, under which India agreed to separate its civil and military nuclear facilities and place all its civil nuclear facilities under International Atomic Energy Agency (IAEA) safeguards and, in exchange, the United States agreed to work toward full civil nuclear cooperation with India.

Following are the key aspects of the Indo-US civil nuclear deal:

1. The agreement not to hinder or interfere with India's nuclear programme for military purposes.
2. US will help India negotiate with the IAEA for an India-specific fuel supply agreement.
3. India and the US agree to transfer nuclear material, non-nuclear material, equipment and components.
4. The US will have the right to seek return of nuclear fuel and technology but it will compensate for the costs incurred as a consequence of such removal.
5. India can develop strategic reserve of nuclear fuel to guard against any disruption of supply over the lifetime of its reactors.
6. Provision for one-year notice period before termination of the agreement.
7. The US to engage Nuclear Suppliers Group to help India obtain full access to the international fuel market, including reliable, uninterrupted and continual access to fuel supplies from firms in several nations.
8. The agreement grants prior consent to reprocess spent fuel.

Nuclear Phobia - Myths and Facts
Myth: Radiation is unnatural, little understood, ever-growing threat to the natural earth. We're fouling our nest by continually adding to the earth's radioactivity.

Facts: Radiation has been with us since the dawn of time. Our soil, our water and our bodies are naturally radioactive. Radiation is best understood than most environmental challenges.

Myth: But we can't see or smell the radiation. We can't tell it's there until it's too late!

Facts: Radiation is detectable at the single atom level by a simple hand-held detector. No other hazard is so easily detected. Some physician wrote, "Humans and other animals have no organs for sensing ionising radiation, because they have no need for them". Natural radiation levels up to hundreds of times the levels now being regulated have proved to be harmless.

Myth: What about those huge waste tanks that have been leaking radioactivity into the ground for the years?

Facts: Those tanks at the Hanford site in the state of Washington were built during World War II, to build the atomic bomb. They have nothing to do with the commercial Nuclear Power Plants. If no Nuclear Power Plants had ever been built, the situation at Hanford would still exist. We have learned a lot since then, and there are no such tanks associated with the commercial Nuclear Plants. Hanford is now being cleaned up, and there is no evidence of danger to people or to any of the surrounding environment.

Myth: But what about the waste problem? The quantity of nuclear waste is so great and we don't know what to do with it!

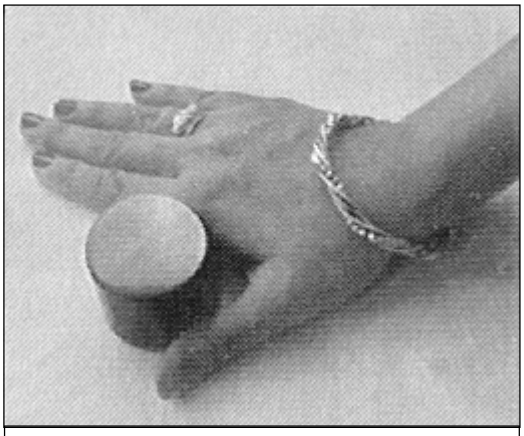
Facts: Not true! In every real sense, we handle the problem before it begins. Nuclear plants produce less than one-millionth the volume of waste from an equivalent coal-fired plant, so it can be put into sealed, stainless steel containers. We can put each person's lifetime of nuclear waste into a soda pop can (the corresponding waste from a coal fired plant is 140,000 pounds).

Myth: Nuclear waste is a long term hazard; it stays toxic for thousands of years.

Facts: All radioactive materials continually decrease in toxicity, whereas non-radioactive pollutants like mercury, lead, arsenic etc. maintain their toxicity undiminished forever. After a few hundred years, nuclear waste is no more toxic than the original ore. We make 10,000 times more lethal doses of chlorine each year and put it in our drinking water to kill germs.

Myth: The Chernobyl accident in 1986 killed thousands of people and disabled millions.

Facts: Not true. Fifty workers and fire-fighters at the plant were killed. A 20-year investigation by the U.N. and World Health Organization concluded that no members of the public were harmed. There were about 2,000 cases of childhood thyroid nodules, with 10 or 12 deaths resulting from this condition. The World Health Organization said that fear of radiation caused much more harm than radiation itself. It led to unnecessary long term evacuation of large population groups, 100,000 unwarranted "voluntary" abortions, unemployment, depression, alcoholism and suicides. The water cooled reactors of the kind now operating could not undergo the type of casualty that occurred at Chernobyl.



Solidified high level waste equivalent to power consumed by an average Indian family in 25 years, if all the power is from Nuclear Power Station.

Conclusion

In summary, nuclear fuel resources are plentiful and can meet future demand well into the future. Global primary uranium production capacity must increase substantially over the next two decades to make up for the declining contribution of civilian inventories and military sources and to meet additional demand.

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About the author

Manish Kumar Sharma (mksharma@iitk.ac.in) is an M.Tech student at IIT Kanpur, working in the field of Tomography under the guidance of Dr. Prabhat Munshi and Dr. M.S. Kalra in Department of Mechanical Engineering (Nuclear Engineering and Technology Programme).

Time to shoot!

We are looking for some really mouth-watering photographs that might help us design the first cover pages of upcoming issues of NERD.

The photograph maybe a very beautiful image of a bird or a tree or anything picturesque in the campus. So come forwards and contribute by sending in the photographs latest by 15th October, 2010 to nerd.iitk@gmail.com. If the photograph is selected for the cover page, you get certificate of appreciation. We require atleast two photographs per issue. Please keep in mind that the photographs should be original and may be modified using softwares like Coral draw, and Adobe Photoshop.

ICARUS 2010

Indian Conference for Academic Research by Undergraduate Students

ICARUS is the Indian Conference for Academic Research by Undergraduate Students. ICARUS is the first Indian conference that aims to capture the original work of undergraduate students from all disciplines of science and engineering. Its aim is to showcase and reward original thinking at any level of perfection.

ICARUS-2010 was conducted in March 2010 at IIT Kanpur as a part of its Golden Jubilee celebrations. Undergraduate students from around 200 institutions across the nation were invited to present their original research at any stage of completion. As many as 40 students from some of the best colleges of India were selected to present their work in the Paper Presentation session - 'Sanshleshan'. Of the order of 10 Undergraduate students presented their hands-on project work at the poster presentation - 'Adbhut'. At 'Joojho', a problem baffling the best minds in the industry was invited and around 20 UG Students were shortlisted for the brainstorming session to try to find a solution to the problem.

At 'Margdarshan', eminent personalities in Science and Technology ranging from Dr. R Chidambaram (The Principal Scientific Advisor to the Government of India and former Director of BARC.) to Prof. R Narasimha India's foremost Aerospace scientist and a world renowned fluid dynamicist to Prof K L Chopra (Former Director, IIT , Kharagpur and President, Society for Scientific Values) and Prof. Vijay Singh (National Coordinator, Science Olympiads at the HBCSE, Mumbai).

ICARUS 2010 successfully concluded with the participation of more than 200 Undergraduate students from more than 20 different institutions.

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ICARUS 2010

Intelligent Vehicles and Automated Highways

Deepthi Tammana, Keerty Praveena and Pallavi Kesarwani

Convoys of trucks moving along an automated highway, their distance from each other never varying, their speed never slacking, their course never wavering, despite fitful rain and heavy fog, the bus driver never peers uncertainly into the gloom but unhesitatingly follows road markers, avoids obstacles, maintains his lane and his speed, platoons of cars follows each other at regular intervals. But when the progress of one car is halted by an emergency, the others smoothly, swiftly, simultaneously shift lanes. Automatic braking lets even those with mobility impairments drive cars and intelligent parking systems conveying the violations directly to the enforcement cell. That's the world of Automated highway systems (AHS). And its coming soon.

Introduction

The present system of roads and highways with manually operated cars and trucks has provided means of transportation, serving both, individual and group needs, a costly expansion of system capacity will probably be required in the future to satisfy ever-increasing demand for transportation. As traffic has increased so has congestion, and the response of adding more lanes is in many areas is becoming undesirable and impractical. Other approaches have included expanding mass transit facilities and promoting car and van pooling. These techniques have had varying degrees of success in limiting the number of vehicles using the highways because they tend to be effective only when applied to situations where there are substantial numbers of users who have common origins, destinations, and travel times. Applying automation techniques to vehicles and roadways will increase the capacity and efficiency of existing facilities while retaining the advantages of Individualized mobility. Intelligent vehicles and automated highways is a new technology which will make a major change in highway transportation. Control, communication and computing technologies will be combined into an intelligent vehicles and automated highways system that can significantly increase the safety and highway capacity without new roads to be built.

IVHS

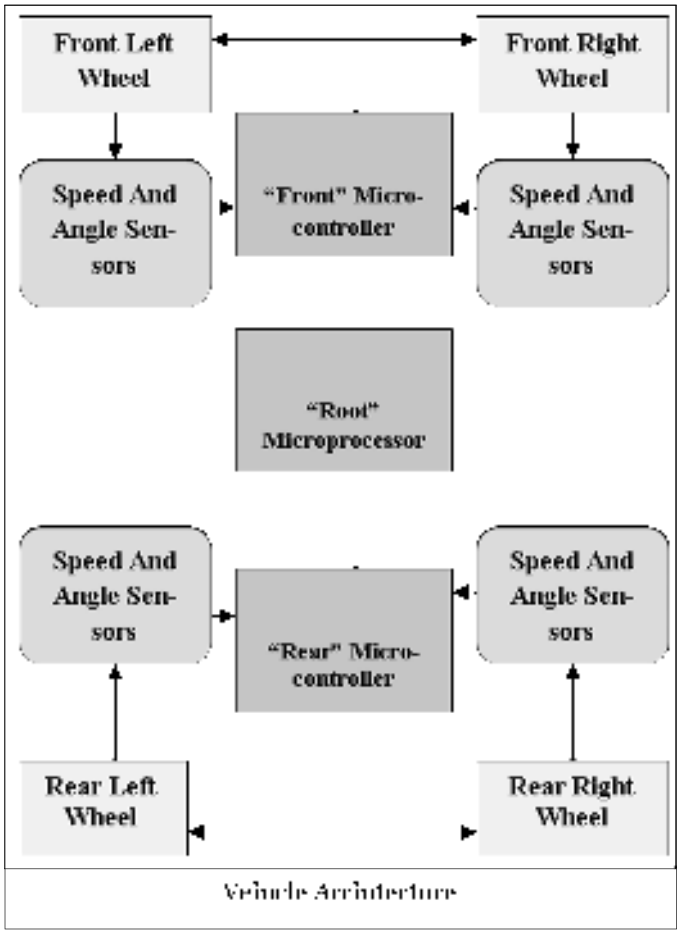
IVHS is the selected approach for addressing the needs, both present and future, of the nation's roadway complex. It involves the application of advanced systems-information processing/ display, communications, control, and sensing-to improve the effectiveness of this complex.IVHS is comprised of six interrelated areas:

1. Advanced Traffic Management Systems (ATMS)
2. Advanced Traveler Information Systems (ATIS)
3. Advanced Vehicle Control Systems (AVCS)
4. Commercial Vehicle Operations (CVO)
5. Advanced Public Transit Systems (APTS)
6. Advanced Rural Transportation Systems (ARTS)

IVHS-Goals Ahead

1. Capacity: An important goal of AHS is to provide capacity advantages compared to present highways. An increase in lane capacity is desirable as it means that AHS would provide a more efficient utilization of facilities and right-of-way (ROW) in both new highway construction and in the conversion of portions of existing highways. It is also desirable that the AHS provide less expensive highway capacity than conventional highways.
2. Safety: An automated system that eliminates many of the opportunities for "improper driving" situations will not only eliminate many fatalities and injuries, but reduce property damage as well. Further, the system effectively eliminates the possibility for head-on and angle collisions where the closing speed of the vehicles contributes to their severity, as well as the run-off-the road accidents. Thus, improved highway safety is an important and achievable AHS goal.
3. Energy: AHS had the goal of making a positive contribution to the Efficient and rational management of our energy future through the reduction of the absolute consumption of energy as compared to the conventional highway and also the reduction of the consumption of petroleum-based energy. The AHS can decrease consumption because if effectively eliminates congestion and allows a smooth flow of vehicles at a constant velocity.
4. Environment and Community Impacts: Environmental goals of an AHS include those related to noise and air pollution, community disruption, and user acceptance. These issues are currently

of great concern in the process of expanding the capacity of existing highways, particularly in intensely developed urban areas. AHS presents the opportunity to reduce the noise and air pollution of an existing highway facility as well as reduce the total land requirements while significantly increasing the capacity of existing highways.



Vehicle Architecture

Implementation Strategy Development

The criteria employed in the evaluation included the following:

1. Level of investment required by individual user& system owner,
2. Degree of inter-agency cooperation required,
3. Risks assumed by user, operator & owner
4. Cost to user,
5. Cost to general public,
6. Size of potential market,
7. Disruption to non-AHS users during construction,
8. Disruption to non-AHS user during operation, and
9. Political feasibility.

Conclusion

The Automated Highways Systems (AHS) places a maximum proportion of required control and communications on each vehicle. Such a system of passive guide way and largely self-sufficient vehicles is the logical technological and institutional successor to the current freeway system. Capacities per lane will approach twice that of conventional highways, and the cost of providing capacity will be well below the cost of conventional highways.

In the AHS program, what initially appeared to be a futuristic concept has been carried to a point where all indications are that it is technologically ready for development, and that it will become a cost effective alternative to conventional methods in providing for constantly increasing demands on our transportation system. There seem to be no insurmountable problems, but a substantial development of technologies is needed to support the high-speed close-headway highly reliable and safe operations that provide the main advantages of AHS. This study has gone to a sufficient level of detail that it can be predicted with some confidence that the end result of an orderly development program will be a system that is cost effective and a step forward in the application of transportation methods. However, the final form of this system will not necessarily be as predicted here since, in the development process, evolutionary changes will arise in response to new technologies or as applications develop. Study results show AHS to be, first, a cost-effective way to provide needed highway capacity increases with minimal impact in terms of new ROW requirements; next, a highly effective technique for improving highway safety and convenience; and finally, a way to make the electrification of the personal vehicle practical and competitive with no need for battery -technology breakthrough.

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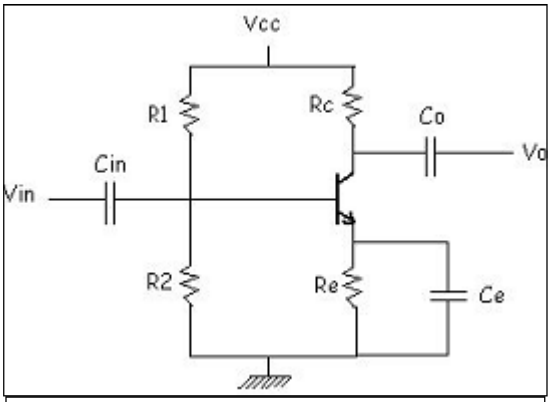
ICARUS 2010

An Open source Analog Amplifier Design Tool

Om Prasad Patri and K Sanmukh Rao

This correspondence presents an open-source tool AutoAmp developed at the Indian Institute of Technology, Guwahati. It is available at http://sourceforge.net/projects/autoamp-iitg/. This tool helps the user to design different types of electronic amplifiers, using solid state devices, for a given specification. It can handle several types of designs namely common-emitter BJT amplifier (single and two-stage), operational amplifiers (inverting and non-inverting) and power amplifier. Not only does it design the amplifier, but also simulates the designed amplifier using SPICE simulator and displays the performance curves. This tool is deemed to be valuable in undergraduate teaching and labs. Especially in electronics-design related laboratories, the student need not design the amplifiers which are mostly the heart of many electronic designs.



Single stage BJT CE amplifier

What is AutoAmp?

Almost everyone who has done a first year undergraduate course in electronics will recognise this as the widely used BJT CE amplifier circuit. And most of these people would have dealt with the woes of finding appropriate circuit parameters (e.g. resistance values) for their purpose. It was precisely this (and our laziness to solve equations) which motivated us to work on an automatic software tool for finding circuit parameters of a few common amplifier circuits used in our undergraduate labs. Thus came AutoAmp.

Analog amplifiers are the building blocks of many electronic circuits. Different types of analog electronic amplifiers are commonly used in radio and television transmitters and receivers, high fidelity (hi-fi) stereo equipment, micro computers and other electronic equipment. Transistor amplifiers are among the most commonly used kinds of amplifiers. Most common active devices used in transistor based amplifiers are bipolar junction transistors (BJTs) and metal oxide semiconductor field-effect transistors (MOSFETs), with BJTs being a preferred choice for lab level circuit-design. An operational amplifier(op-amp) is an amplifier circuit with very high open loop gain and differential inputs which employs external negative feedback for control of its transfer function and gain. These attributes form the basis for op-amp applications in integrated circuits and its extensive study and use in experimental circuits.

We have developed a simple open-source amplifier design tool, named AutoAmp, for the following types of amplifiers, given some design specifications:

1) Single Stage BJT Common Emitter (CE) Amplifier
2) Two-Stage BJT CE Amplifier
3) Operational Amplifier: Inverting/Non-Inverting
4) Op-Amp Difference Amplifier
5) Class-A Power Amplifier

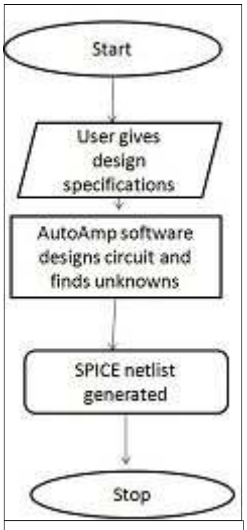
For each type of design the software requires minimum design specifications assuming the lab working environment. The assumptions can however be modified in the source code as per requirements. Net voltage gain is the key design parameter that the software uses across most amplifier types. However, few designs require more specific information like the maximum available resistance in the case of operational amplifier design. Given the choice of type followed by minimum design specifications, the software generates a netlist file to be opened in LTSpice for necessary circuit analysis. AutoAmp is open-source and can be run on both Windows and Linux-based systems. The necessary adaptations for the OS are mentioned in the AutoAmp website. Autoamp is available for free (along with the source code) at http://sourceforge.net/projects/autoamp-iitg/

Why AutoAmp?

There are not many free tools which automatically design basic amplifier circuits given the design specifications. It is expected that industries may be maintaining customized circuit design tools to solve their purpose. However use of such commercial

tools for academic purposes is likely to be prohibitively expensive. Basic amplifier-circuit design along with its analysis is required in any complex circuit in electronics. Thus availability of such a tool will be a boon for teachers and students alike. There is particularly no open-source design tool available for designing amplifier circuits with BJT amplifiers and class-A power amplifiers. Most importantly, none of the available tools have a provision for the analysis of the circuit generated. We aim to provide an interface where the user can get the design of the circuit in LTSpice after providing certain design specifications. Such a tool will be very useful in classrooms and for other non-industrial purposes where such circuit design is warranted. The commercial tools come with a whole package of electronic design automation tools with lot of circuit-options, which makes them complicated. For learning or teaching a basic course in analog electronics, only a few numbers of these circuits are required. Further, addition or deletion of components and changing the source according to individual requirements is a preferred feature.

Our design tool tries to overcome most of these problems. It is a simple and user-freindly tool. AutoAmp is easy to operate, takes minimum input and generates an LTSpice netlist which can be used to design the circuit in LTSpice directly. Being open-source, customized changes can be easily made to the source code to give the desired results; components can be easily added or removed by writing some extra functions in the source code.



Black Box diagram for AutoAmp

Design Approach

This section describes our design approach of the tool in detail. A blackbox representation of the tool is given by Fig. 2.

A. Software Design Methodology The tool is a command line software designed in the C++ programming language. The user is asked for the name of the input file, to select an amplifier of her choice in a menu based environment and finally to enter voltage gain and other parameters based on the type of amplifier chosen. Based on user's choice the respective functions are called which compute the values of components which are used to create the netlist of the respective type of amplifier into the file specified by the user in the beginning.

B. Circuit Design Approach

1) Single Stage BJT CE Amplifier: We have designed a small-signal voltage amplifier operating in the audio frequency range. We have used an n-p-n transistor, namely, 2N2222. Two port h-parameters are used for circuit analysis. Maximum, minimum, and typical values as required, of the h-parameters are obtained from the transistor datasheet. These values along with the other known values are used by the software to get optimized values of the circuit components, i.e., resistances and capacitors.
2) Two Stage BJT CE Amplifier: This design consists of two CE amplifier stages in cascade. Two amplifying stages thus give us a higher overall gain. The design methodology remains the same as in single stage CE amplifier but is applicable over two stages in this case.
3) Operating Amplifiers: This is the simplest ampifier designing strategy in which we are using the inverting and non-inverting configurations of the ideal We assume an ideal op amp with infinite openloop gain. Now to avoid the loss of signal strength, voltage amplifiers are required to have high input resistance. In the case of the inverting op-amp confguration we are studying, this could cause the resistance value to become impratically large (e.g. greater than a few megaohms). Hence in our design we use a different feedback mechanism by which the circuit is able to realize a large voltage gain without using large resistances in the feedback path.
4) Op-amp Difference Amplifier: In this design, we implement a difference amplifier that responds to the difference between the two signals applied at its input and ideally rejects signals that are common to the two inputs.
5) Class-A Power Amplifier: Here we have designed a power amplifier by simply implementing a CE BJT amplifier with a high power output stage for which a transformer is used.

Conclusion

This paper presents a simple open-source design tool using C++ which can help in designing and analyzing an amplifier given some design specifications. The software is able to demonstrate five design spec -combinations. The complete package is deemed to be of utility to circuit designers and instructors, especially in a technical college environment. Future work relevant to the project can include standardization of resistances and capacitors and external voltages. We would also like to extend our design to MOSFETs, include variable frequency range amplifiers and also try other classes of amplifiers. Writing more isn't really going to help, so we suggest you move to the website and start exploring if you looking for a tool to design amplfier circuits automatically.

About the Authors

Om Prasad Patri is a final year undergraduate student in Computer Science and Engineering at IIT Guwahati. His research interests lie in pattern recognition, machine learning and data mining.

K Sanmukh Rao is a final year undergraduate student in Computer Science and Engineering at the IIT Guwahati. He is interested in working on issues in Networks on Chip and Operating Systems.

Note: This work was done as a term project in our Analog Electronics course and was supervised by Dr. Amit Kumar Mishra, Assistant Professor, Department of Electronics and Communication Engineering, IIT Guwahati.

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Detecting Cancer

Early Scattering for Early Cancer Detection

Jaidip Jagtap

Today more than 25 lakhs cancer affected cases present in India & death rate is 4 lakhs per year. Cancer is second largest cause of death in India & increasing with the rate of 11% per year. Every day 2000 people get affected by mouth cancer.

Lungs & liver cancer in men while breast & cervical tissue cancer in women rate is higher. More than 85% of all cancers originate in the epithelium. These are treatable provided they are diagnosed in one of the preinvasive stages. The new Optical-probe technique based on light-scattering spectroscopy is able to detect precancerous and early cancerous changes in cell-rich epithelia. Human Papilloma Virus is main cause for cervical tissue cancer in females. HPV (16, 18) vaccines are available in market but few of the normal patients died after taking the vaccine. The reason might be the side effects of the vaccine which is still to be resolved. Also there have been cases in the recent past which has created doubt regarding the effectiveness of HPV vaccine in curing the disease.

Among the life-threatening diseases, cancer has been one of the deadliest. It can develop in almost all parts of the human body. Some common types of cancer are bladder, breast, colon & rectal, endometrial, kidney, leukemia, lung, melanoma, pancreatic, prostate, skin, thyroid etc. The early detection and subsequent prevention of cancer have been a challenging task for researchers all over the world. Some of the conventional techniques used for the diagnosis of cancer are mammography, ultrasonography, MRI, positron emission tomography (PET) and histopathology. However, each of these techniques has certain limitations of being slow, invasive or expensive. In order to overcome these limitations, researchers have been looking for optical techniques which can be noninvasive (or minimally invasive) and cost effective as well.

In recent years, spectroscopy and imaging are being developed as powerful techniques for the early and quick diagnosis of cancer. Inelastic scattering such as Fluorescence, Raman and Elastic scattering spectroscopy are being used as spectroscopic tools while Polarization-gated, Time-gated imaging techniques, Optical Coherence Tomography (OCT) imaging techniques are being developed. The increase in number & size of nuclei results in varying elastic scattering. Research in our Biomedical Optics and Spectroscopy Laboratory focuses on the use of some of these tools for cancer diagnosis. Here Elastic scattering is briefly described with Polarization Gated Imaging & Mueller Matrix Imaging.

Polarization Gated Imaging

Fundamental studies to understand the effect of size and refractive index on polarized light interacting with tissues had been studied by making turbid medium of polystyrene & silica of different sizes scatterer having different refractive indices which reflects tissue medium. In polarization gated imaging technique Images have been recorded for linearly and circularly polarized light. When linearly polar-

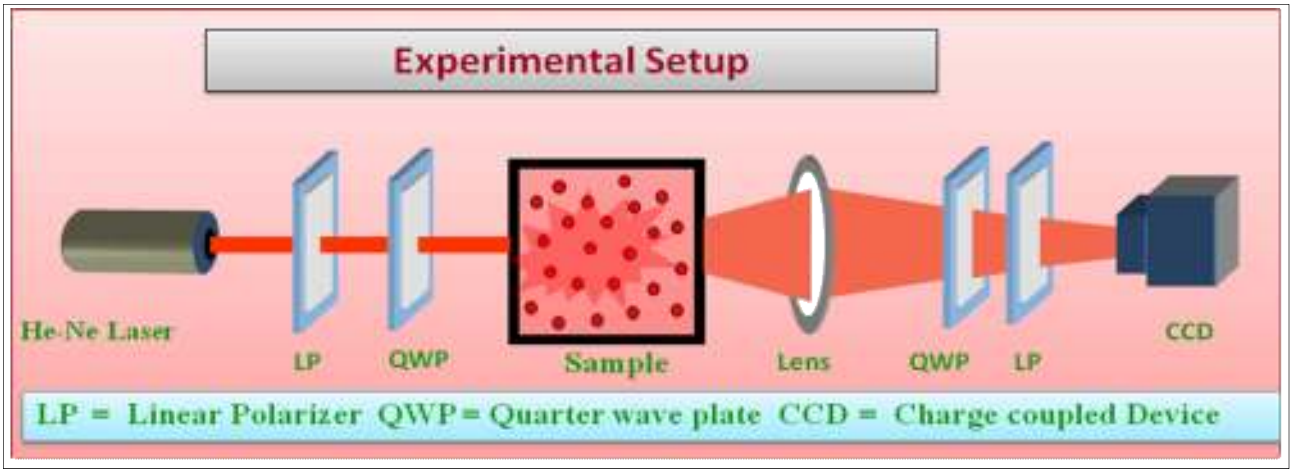


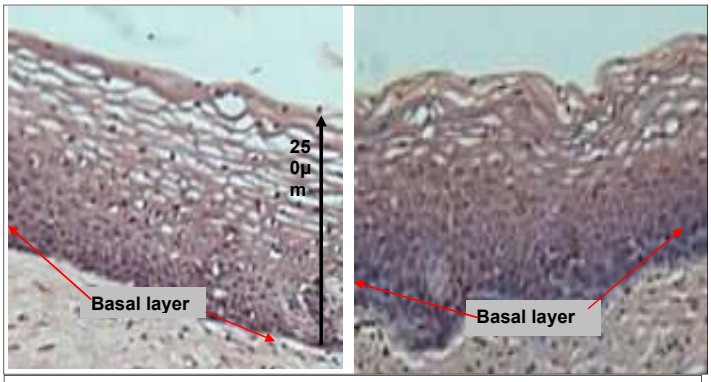
Figure 1

ized light was incident on the sample, transmitted intensity with polarization parallel ($I_{||}$) and perpendicular ($I_{\perp}$) to the incident state of polarization by orienting the axis of an analyzer either parallel or perpendicular to the incident direction of polarization, the degree of linear and circular polarization was calculated. The differential polarization gated images were obtained by subtracting the cross – polarized signal from the co – polarized signal for either linear or circular polarization state of the incident light. The qualities of the images were evaluated by quantifying the resolution and contrast of the images obtained at different polarization channels from individual scattering samples. The experimental setup is as shown in fig.1.

$$I = \langle E_{||}E_{||}^{*} + E_{\perp}E_{\perp}^{*} \rangle$$
$$Q = \langle E_{||}E_{||}^{*} - E_{\perp}E_{\perp}^{*} \rangle$$
$$U = \langle E_{||}E_{\perp}^{*} + E_{\perp}E_{||}^{*} \rangle$$
$$V = i\langle E_{||}E_{\perp}^{*} - E_{\perp}E_{||}^{*} \rangle$$

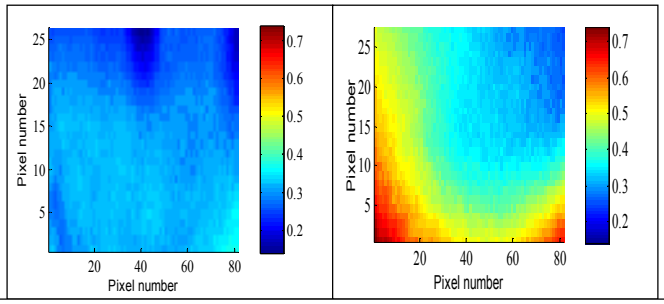
$$M = \begin{bmatrix} \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \end{bmatrix}$$

(1) and (2) respectively



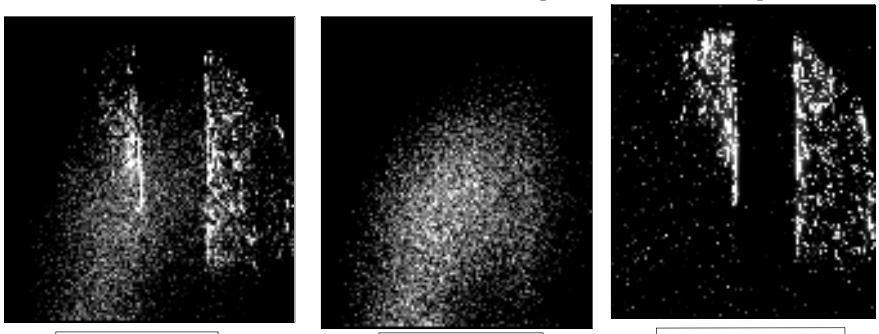
Microscopic Images of human cervical tissue for normal & dysplastic tissue respectively.

It is found that monodispersed large size & higher refractive indices Polystyrene microspheres image quality is better for linearly polarized light. In contrast for mixture of small & large size polystyrene microspheres Image quality is better for circularly polarized light.



Depolarization power images for epithelial region of normal & abnormal human cervical tissue.

This result was exactly opposite to the scattering observed in tissue. So scatterer silica with small refractive index is used with small & large size. In case of silica microspheres of large, small as well as mixture of large & small size scatterer image quality is better for circularly polarized light.



a.Co-state **b. Cross** **(c) Co-Cross**

This result matches with the scattering observed from tissue. It helps to understand & study the structure of cell having different refractive indices scatterer like nuclei having 1.45 & lipids~1.51, cyroplasm~1.37.

This technique also useful to identify, locate & diagnose tumors (invisible, rigid mass of different refractive indices) in tissues. But the disadvantage of this technique is that as absorber & scatterer concentration dependent. It's difficult to find the changes in turbid media as scatterer concentration decreases & it is been conformed by absorption spectra done on the medium of black Indian ink of concentration 0.16% of total volume of water. So Mueller Matrix imaging have advantage over polarization gated imaging & it's more sensitive technique for turbid media.

Mueller matrix imaging: Human cervical tissues

Mathematical formulation of polarized light:

Mathematically, a beam of arbitrary polarization, including partially polarized light, can be represented by a column vector called as Stokes vector which consist of a set of four quantities, called Stokes parameters. The Stokes parameters of a quasi-monochromatic beam are given by (1).

Here *I* refer to the irradiance or intensity of the light, *Q*, *U*, and *V* represent the extent of horizontal linear, 45degree linear, and circular polarization respec-

tively.

Mueller Matrices:

When any polarized beam interacts with scattering medium its state of polarization get changed. Let the Stokes vectors for incident and transmitted beams are S and S' respectively. Then we can write

$$S' = M \cdot S \quad (3)$$

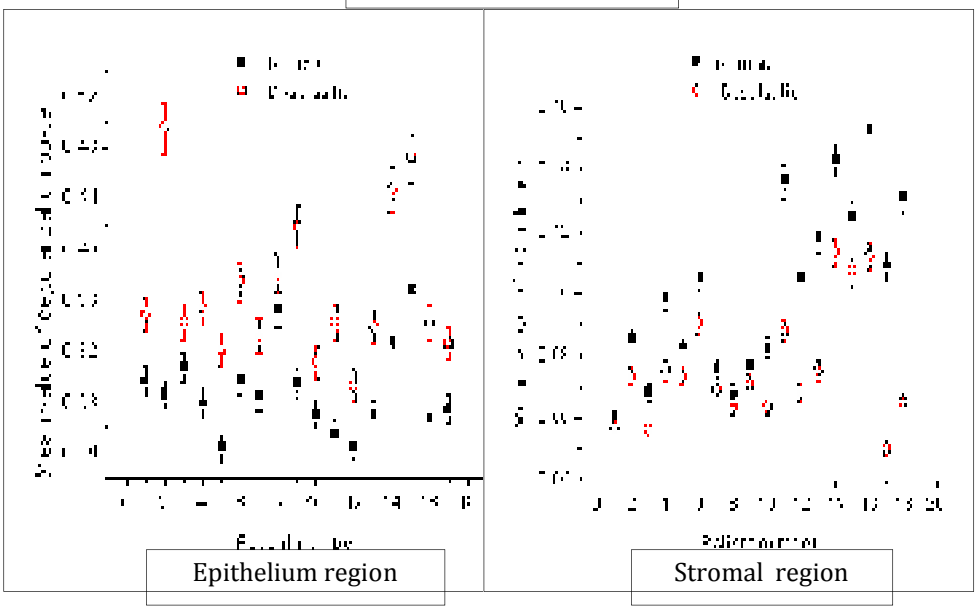
Where M is 4x4 matrix of given medium shown by (2).

This 4x4 matrix of the medium which relates the Stokes vector of incident beam to Stokes vector of transmitted beam is known as scattering matrix (Mueller matrix). The usefulness of the Mueller method is that, it gives us a simple means of determining the state of pose elements may be determined by merely multiplying their associated Mueller matrices. Using the setup shown in Fig.1 the Mueller matrix M is generated by taking 49 images of different combination of polarizer & analyzer states. Polar decomposition of Mueller matrix in depolarization, diattenuation & retardance is done by Lu & Chipman. Depolarization gives depolarizing ability of material for incident polarization state while diattenuation gives the attenuation of beam passing through the sample & retardance gives the birefringence & optical activity of material.

Mueller Matrix decomposition imaging in Human Cervical Tissues

Morphological and structural changes take place in biological tissue during the progression of disease like cancer. Our study involves imaging the elastically scattered light from tissue samples to probe the minute morphological changes that occur during the progress of disease. When a polarized light is incident on a highly scattering medium, it is scattered and there is reduction in polarization power. This loss in the polarization of scattered light reflects the morphological changes in medium. Mueller images for normal and dysplastic or early precancerous state of cervix tissue have revealed interesting changes which correlate well with microscopic tissue images as shown in figure below.

From 10 Samples



Epithelium region | Stromal region

The red color in depolarization image shows higher scattering due to number of increased nuclei as seen in corresponding microscopic image of abnormal tissue. No consistent change has been observed in diattenuation & retardance value. Also the stromal region shows consistent changes in retardance to discriminate normal & abnormal human cervical tissue. The mean value of depolarization & retardance for epithelial region & stromal layer are plotted respectively & this plot can be used for unknown sample slide to discriminate between normal & dysplastic (precancerous) cervical tissue after applying the Mueller matrix imaging method.

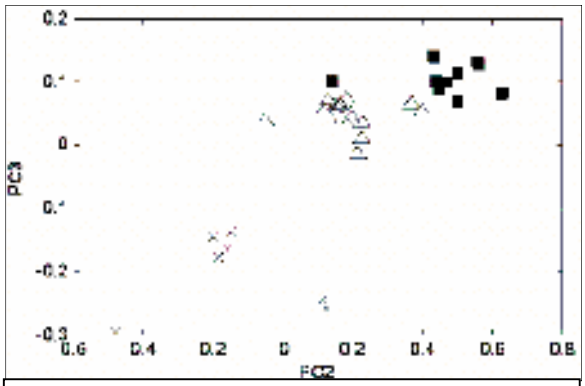


Fig. PC2 Vs PC3 Δ:- normal ; ×:- GD-1; ■ :- GD-2
From the graph PC2 vs PC3; Clear demarcation among various stages of dysplasia and normal tissues. Indicates the potential to use this

Principle Component Analysis:

To discriminate between different grades of dysplasia principle component analysis method is been used. So any unknown tissue slide after doing the experiment a PCA is done on the data extracted from depolarization power images. The PC3 vs PC2 plot well discriminate in dysplasia grades as shown below,

Conclusion:

Our study shows that Mueller decomposition images have a potential to reveal the structural and morphological changes in the dysplasia state of human cervix tissue efficiently. In the epithelium region depolarization power is sensitive to morphological changes during progression from normal to dysplastic state while diattenuation and retardance do not show any signifi-

cant change. However, it is the retardance which reveals the morphological changes around the stromal region. The changes in epithelium region are conventionally used for the diagnosis of dysplasia while the changes in the stromal section are generally not mentioned in the normal histopathology. However, with our observation of stromal changes through retardance images, one can strengthen the diagnostic technique. Additionally, we have shown that the mean values of depolarization power in epithelium region while that of retardance in stromal region show a significant change from normal to dysplastic tissue while diattenuation does not show consistent change. It can be summarized as: Mean value of depolarization power in epithelium < 0.32 indicates normal while mean value > 0.32 indicates dysplastic tissue. In stromal region Mean value of retardance >0.08 indicates normal while mean value <0.08 indicates dysplasia.

Our opinion is that this parameter which appears to show a cut-off in the depolarization power values can be taken as a benchmark for discriminating normal tissues against dysplastic one after performing a careful statistical analysis on a large number of samples.

References:

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Workshop on science communication and journalism

Workshops on Science Journalism and Communication were conducted by one of the founders of NERD, Mohit Kumar Jolly, during Techkriti'10 (Annual technical and entrepreneurship festival of IIT Kanpur), Tryst'10 (Annual technical festival of IIT Delhi) and IISER Pune. The workshop covered some basics of science/ technology journalism and communication

- What is science journalism and communication and what do science communicators do
- Various modes and means of effective science communication - interface of science and media
- Why is this field gaining importance in India and abroad
- What challenges exist and what are the career opportunities for science/engineering graduates in this field
- How can students get started into this field right away through freelancing or other means

Various modes of journalism/communication– print (magazines/newspapers/popular science books), video (documentaries/TV shows), audio (radio scripts), science cartoons, public debates shall be taken as examples to bring to light the need for different modes depending on the audience and the content.

"It is suicidal to create a society dependent upon science and technology in which hardly anybody knows anything about science and technology", Carl Sagan, the eminent science writer once said.

Today, with the rapid developments in science and technology impacting the society and environment we live in, science journalism and communication is growing as a specialist field of scientific expertise and as a creative and lucrative profession/career option for science/engineering graduates, but this field suffers from a paucity of talent all across the globe. For more details about the workshop and science communication and journalism, please contact Mohit: mkjolly.15@gmail.com or 9044274258.

ICARUS 2010

Multivariate Analysis

Apoorvaa Deshpande and Jyothsnaa S

Data representation has always been important in various fields and graphical representation is an indispensible aid in data analysis. In general, continuous variation of two or three variables can be represented by 2-d graphs or 3-d surfaces, but in a practical scenario the result is not influenced by 2 factors alone. We have tried to explore the feasibility of some of the possible methods of representation with respect to higher dimensions and 2-d representation.

Cartesian and polar systems, are the most widely used ways of plotting data today.

Apart from the aforementioned, scaled graphs are also used for specific requirements, eg: Semilog graphs. But when it comes to variation or interdependence on/of more than 2 parameters, there are not many methods of representation.

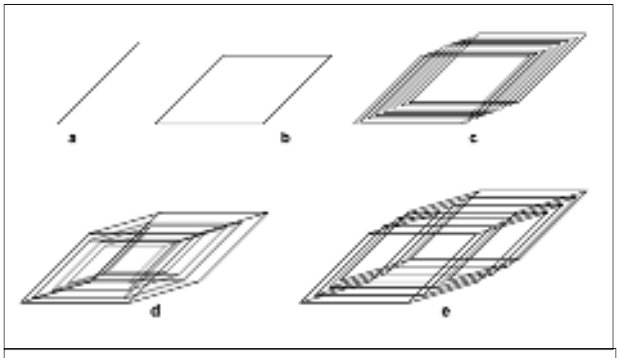

Figure 1: a, b, and d show the continual conversion from one lower dimension to a higher one. d and e are meant to distinguish between the representation of 4d objects as seen in 2d (which is d) and in

Use of four dimensional representation

Using analogies with the conversion of objects from one dimension to the next we deduce that as far as the 4th dimensional representation is concerned it can be carried out using identical objects displaced by infinitesimal units in three dimensional space (Analogy as drawn from the conversion of a point to a line then to a parallelogram and finally a parallel piped).

An example is shown in Figure 1.

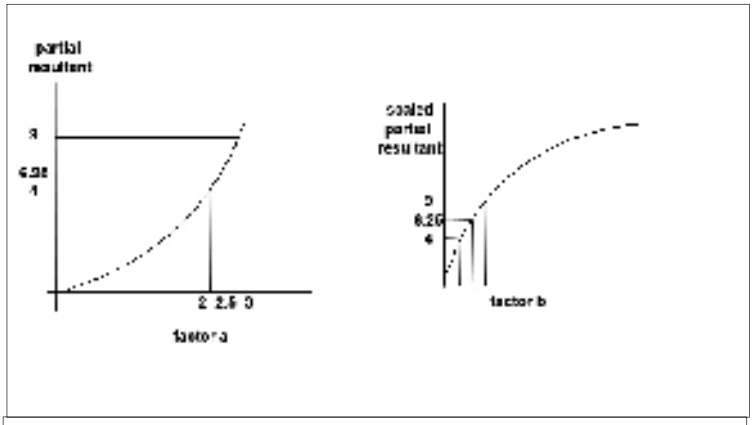

Figure 2: In the first graph we plot normally that is it is scaled normally as 1 unit against one unit of the function it self. Here we obtain the value of the function's partial derivatives at such intervals and replot by now considering unit variation as that shown by the new function.

Modifications to the current two dimensional graphing system

Multiple graphing

The section has again been divided into two subsections.

1. Consider a function R which depends on n different factors. We group these factors and plot them such that the graph of the individual effect of each of these factors on the R (that is the graph of the partial differential) is obtained. By using the appropriate and adequate number of values of these functions as obtained from the graph the differential line can now be treated as a factor by itself and be re-plotted by scaling appropriately. Example is as in Figure 2.
2. This section basically is an extension of the previous .However it is distinguished by its advantage of being modifiable to suit a scenario where the factors themselves are interdependent. Here however we will first consider the case where the factors are independent. Consider an R which depends on m factors. Unlike the previous method here we will plot the inverse of the partial differential function obtained. That is the variation of the factor with respect to R will be plotted.

Each of these is then used to produce a surface by rotation around the resultant axis(R). One application of is that it can be used to predict the number of overlapping risks in case of risk maps. It also has other similar applications.

Colour variate mapping

Heat maps use strips of different shades of a particular colour to indicate the quantity or co-ordinate of a factor or element. Our addition to this concept is that of super position.While considering the cumulative effect of two quantities on a resultant R, two strips of different shades can be used. The variation in shade may represent wither their relative degrees of importance or the appropriate quantification. We also need to remember that the resultant colour is infact obtained by predefined functions, and therefore the software used should pick the resultant shade depending on the required form. This method helps in quick and more intuitive analysis of data.

For instance: Say, colour represents the coordinate or quantification and the darkness of the shade the priority given to it (figure 3).

However this method can be used only in case of manual comparison and with respect to limited number of samples. Higher samples require software based implementation

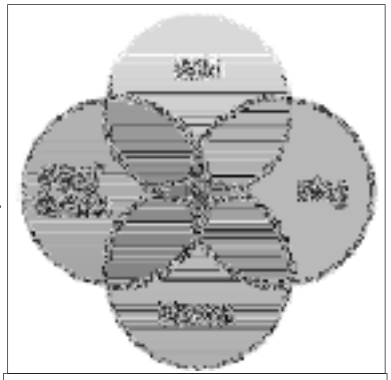

Figure 3: Let the number of people visiting both blogs and wiki be the same as represented by green, the brightness of blog indicates that blog readers bear more priority in the analysis.

Parallel coordinates

A backdrop containing n parallel lines, parallel and equally spaced are taken. A general point is represented as a polyline with vertices on parallel axis. The position of vertex on i-th axis corresponds to i-th coordinate of the point. However his method can be modified and exploited for representation of several higher dimensions.

To do this we use a method similar to that explained already in the multiple graphing section. The resultant (R) is plotted along the axis of say a cylinder. Having divided the complete 360 degrees into n/2 parts, each of these represent a corresponding half plane in the vertical dimension perpendicular to it. On each plane a spectrum is plotted showing the relative variation of R with the factor, similar to a parallel coordinate system.

This method can be used for several other interpretations and deductions. For instance, if we were to represent one

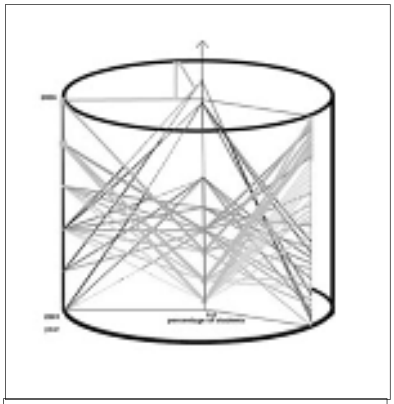

Figure 4: Here the leftmost plane of representation alone has been shown, the 360 degree angle is to be however equally divided among n or n/2 parameters as the case may be. In this graph the two factors are years and the variation in colours may be used to represent the different branches or variations in data itself for compari-

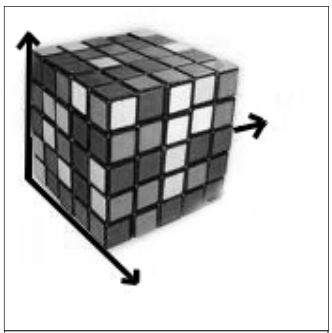

Figure 5: Cartesian axes as shown can be used to determine the required coordinate in terms of a cube.

to many functions by using a factor k (<1). Then the projection on the upper surface of the cylinder basically can be used to figure the relative importance or priority of each factor depending on the thickness of the projections.

Also, this method combined with the concept of heat maps and intensity mapping provide a hole new spectrum for exploration.

Example is shown in Figure 4.

Coordinates within coordinates

In this method, it is possible to plot the variation of as many parameters as necessary. We initially locate regions and then the required point. But it is very useful and quick to get a general idea about the relative location of any data. This method is based on the principle of abstraction. First, we plot the required point in a three-dimensional coordinate system based on the magnitude of some three parameters. This point in turn will serve as another coordinate system with another 3 parametres. In this, again we can plot the required point and repeat this process of zooming in of the coordinate systems. Thus we keep on narrowing down the region of interest till it eventually reaches a point.

Example is shown in Figure 5.

Mulipartite matching

When we have discrete quantities involved, we can extend the idea of matching in graph theory and apply it as a convenient way of representation. Suppose for a quantity A_1, there are a_1 choices possible, for quantity A_2 there are a_2 choices and so on where $a_1 <= a_2 <= \ldots\ldots <= a_n$. So finding a perfect matching is equivalent to finding a minimum edge dominating set. In case there are priorities for each choice as in, a_1 prefers a choice 3 in a_2 over choice 6, we create a priority list for all quantities in a_1 for the other quantities in a_2, a_3, etc. Finding a matching for this case is equivalent to solving the stable marriage problem for which Galey-Shapley algorithm can be used.

The representation of multivariate data has a immense applications in almost

every field. We have tried to explore ways to accomplish the same. Our future work includes developing algorithms and softwares for all the methods.

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ICARUS 2010

Numerical Study on Natural Convection during Solidification in a Square Cavity

Venkatesh R L, Sindhuja S and K Kannan

Abstract

Solidification of metals is under great research due to the interest in solidification conditions necessary to eliminate macro-segregation and inter-cellular segregation in metals.

The other areas motivating this research are materials processing, purification of metals and metal casting. In this paper the role of natural convection during solidification of pure metal in a square cavity is studied numerically by developing a personal CFD code using MATLAB 7.5 (R2007b). Various discretisation schemes (Upwind, Hybrid, Central, Exponential, and Power) are employed for the discretisation of the governing equations individually and the accuracy of the solution of various differencing schemes are analyzed. The results obtained were compared with benchmark solution.

Introduction

Every man-made object involves melting and solidification at some stage. Solidification is a phase transformation process that is accompanied by release of thermal energy. The essential feature of the system undergoing solid-liquid phase change is a moving boundary that separates the two phases of differing thermophysical properties and at which thermal energy is liberated. Hence, solidification process is referred as moving or free boundary problem.

During solidification of a casting or an ingot the superheat in the melt and the latent heat of fusion liberated at the s/l interface are transferred across the solidified metal , the metal-mold interface, and the mold encountering at each one of these steps a certain thermal resistance. As the metal solidifies it shrinks, an air gap may form, and the metal may oxidize.

In addition, a lubricant may sometimes be used to facilitate removal of the solidified metal from the mold. The heat transfer process occurring across such a complex mold-metal contact is complex and not well understood (Ho and Pehlke, 1985; Golzan and Bamberger, 1987). The process of controlled heat addition and removal from a system undergoing phase transformation is an important issue and is beginning to receive fundamental research attention.

In this paper the effect of natural convection is studied during solidification of a liquid metal.

Physical problem

Consider a rectangular enclosure of width 2B, mold thickness d and height A. The enclosure is extended to infinity in the Z direction. Initially the mold is kept at a temperature T_c (502 K-cold wall temperature) which is slightly lower than the solidification temperature T_{sat} (505 K for Pure Tin). Then the melt at temperature T_h (506 K) is poured into the mold cavity at time t=0,hot wall maintained at this temperature.

Immediately a thin crust of solid is formed adjacent to the inner surface of the mold and an inward movement of solid front starts. Because of the thermal gradient setup in the melt, convection current starts in the melt. In the analysis the top and bottom wall of the enclosure are maintained adiabatic and the two vertical walls of the mold are maintained at constant temperature.

Mathematical model

Continuity Equation

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \quad (1)$$

Momentum Equation

In X direction:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\upsilon\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)$$

$$-\frac{1}{\rho}\frac{\partial p}{\partial x}-(1-fl)Cu \quad (2)$$

In Y direction:

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=g\beta(T-T_{sat})+v\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)$$

$$-\frac{1}{\rho}\frac{\partial p}{\partial y}-(1-fl)Cv$$

(3)

Energy Equation

$$\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\left(\frac{\partial^2 T_l}{\partial x^2}+\frac{\partial^2 T_l}{\partial y^2}\right)+Sp$$

(4)

$$Sp=-\frac{\partial(\rho\Delta H)}{\partial t}$$

Enthalpy Update Equation

$$(\Delta H_p)^{n+1}=\Delta H_p^{\,n}+\frac{a_p}{a_p^o}Cp\,(hrfu)(T_p^{\,n}-T_{sat})$$

(5)

$$(\Delta H_p)^n=0 if (\Delta H_p)^{n+1}<0$$

$$(\Delta H_p)^{n+!}=Lif\,(\Delta H_p)^{n+1}>L$$

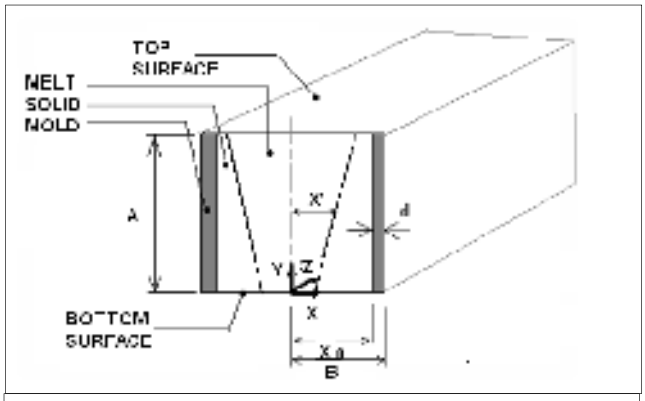

Figure 1: Rectangular enclosure, infinite in Z- direction

Initial and Boundary conditions

At x = 0, $\boxed{T=T_h}$

At x = B, $\boxed{T=T_c}$

y = 0, y=l, $\boxed{\frac{\partial T}{\partial y}=0}$ $\boxed{u=v=0}$

The flow is assumed to two dimensional, unsteady, and obeys the Navier-Stokes equations for incompressible Newtonian fluids written in Cartesian coordinates. The thermophysical properties are independent of temperature and are the same for both solid and liquid. The model also assumes that density remains with temperature. However the present simulations assume a Boussinesq approximation for density (density variations due to gravity are accounted for in buoyancy terms). The present formulation is a one-domain method wherein the same set of equations is used for both solid and liquid. The material in the cavity is regarded as a porous medium with porosity varying with liquid fraction through Carman- Kozenay's law.

The term – (1-fl) Cu is added to the source term of the momentum equation to account for the zero velocity when the liquid becomes solid. In full liquid state it has no effects and is zero. In totally solid elements the final large value of it will swamp all terms in the governing equations and force any velocity predictions effectively to zero. The value of C has to be assigned suitably. The linear relationship is assumed since its isothermal phase change for a pure metal.

The term Sp is a source term added to the energy equation accounts for the latent heat evolution. The present work applies enthalpy porosity approach technique.

Equation (5) is used to update ΔH value for the each time iteration loop. 'hrfu' is under-relaxation factor. This factor is introduced to compensate for the effect of neighboring control volume's change in temperature between two consecutive iterations, *n* and *n*+ 1

which is neglected while deriving the above equation. This assumption is not going to affect the final solution, as when the solution converges, temperature between two consecutive iterations remains same. The term a_p *is* the coefficient of the finite volume discrete equation. The above equation is derived based on the control volume analysis as in the present work the finite volume method is used to discretize the governing equation.

Here the nodal latent heat values are adjusted according to the difference between the nodal temperature predicted from the energy equation and the phase change temperature. The nodal latent heat value assigned to computational cells undergoing a phase change provides a heat source in the energy equation to account for latent heat evolution. This source expires when the latent heat content of the cell is exhausted. At this point ΔH =0 and the cell is totally solid. ΔH at each iteration in a given time step. To avoid overshooting and undershooting problem during computation, the value of ΔH is set to L if $\Delta H > L$ and is set to zero when $\Delta H < 0$. That is a control volume can be said to melt completely when, $\Delta H = L$ and is said to be solidified completely when $\Delta H = 0$.

Numerical method

A finite volume method is used to discritise non-dimensionalised governing equations with staggered grid arrangement. Time discretisation is fully implicit. Nonlinearity and coupling between the equations is handled by the SIMPLE algorithm of Patankar [12].

Grid generation

A non-uniform grid is generated. A fine grid is created near walls and a comparatively coarser grid is created

$$x_{staggered} = \frac{i-2}{ni-2} - \frac{1}{2\pi}\sin\left(2\pi\left(\frac{i-2}{ni-2}\right)\right)$$

$$y_{staggered} = \frac{j-2}{nj-2} - \frac{1}{2\pi}\sin\left(2\pi\left(\frac{j-2}{nj-2}\right)\right)$$

in the rest of the cavity domain. The non-uniform staggered grid is created using sine functions.

Later, non-staggered grid points are calculated by averaging successive staggered grid points. The fig.2 shows the grid generated for a square cavity.

A grid independent study was made with different grids of 30x30, 40x40 and 50x50. The grid size of 40x40 is found suitable and used here.

The non-dimensionalised governing equations, which are discritized, are solved using the SIMPLE algorithm. The MATLAB code was developed employing the procedure and TDMA procedure is used for the prediction of flow variables.

Properties	Symbol	Units
Specific Heat	Cp	242 J/kg K
Coefficient of Thermal Expansion	β	2.67E-4 K^{-1}
Kinematic Viscosity	ν	1.94025E-8m^2/s
Density	ρ	6793 Kg/m^3
Latent heat of fusion	L	6E4 J/Kg
Fusion Temperature	T_{sat} or T_f	505 K
Prandtl no	Pr	0.009

Table 1: Physical Parameter values

Physical Parameters

The value of metal properties used and the value of non dimensional parameters are shown in Table 1.

Results and discussion

The liquid-solid phase change at different time is studied and the following fig shows them. The solidification process is studied for different Rayliegh no and the role of convection is also studied. The figures shown here are for Ra= 2.5 x 10^5 and Ra=1.59x10^5. On observing the temperature profiles typical of natural convection in a square cavity, as the time increase, due to the increasing thermal resistance of the solid layer and thus reduced heat conduction. Heat transfer from the liquid pool to the solid-liquid interface by convection plays an important role in the local energy balance at the interface. The curved solidification front provides conclusive evidence of this phenomenon.

At early times, the solid-liquid interface is only slightly curved, indicating heat transfer is mainly due to conduction. As time progresses, buoyancy driven natural convection in the liquid metal influences the local heat transfer rate at the solid-liquid interface. The curved interfaces provide conclusive evidence of this effect. When the liquid tin reaches the top of the melt layer, it turns 90• and impinges at the solid-liquid interface.

The flow is deflected and descends along the interface while its temperature decreases. Due to the higher temperature of the liquid metal near the top of the interface, the local solidification rate is lowest in this region. By the time the liquid has reached the lower part of the cavity, it has been cooled down to nearly its fusion temperature. The melt turns 90• and flows back towards the hot wall. Since the heat transfer rate from the hot wall to the interface by conduction is reduced by the advective energy transport, the solidification

rate at the lower part of the interface is higher than one would expect for conduction

The study was performed for different set of non-dimensional parameters and their effect where studied. Following are the few plots obtained for the set of non-dimensional numbers. The darker portions indicate the solidified melt and the lighter portions indicates the molten metal with convection patterns.

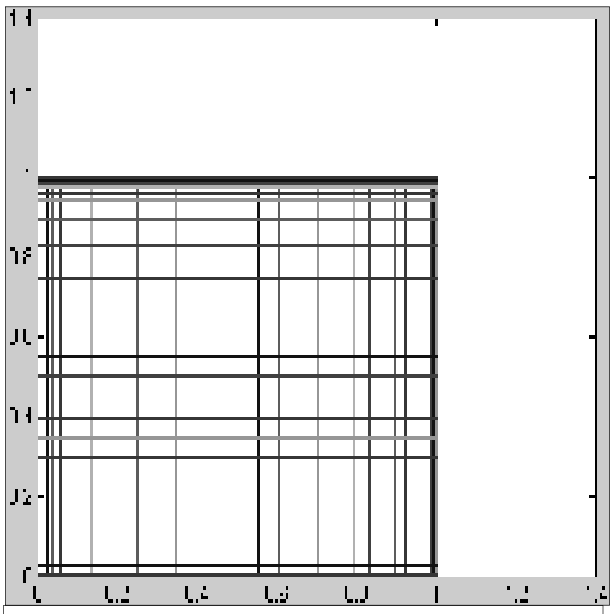

Figure 2: Grid generation for a square cavity

in the convergence. The usage of various discretisation schemes also matters in the prediction of solid liquid interface shape. Though there is not much significant variation the power law and hybrid schemes predicts better. The present work can be extended by applying different algorithm to solve the governing equations and different model to calculate enthalpy change. The further scope is to extend this work with the study of radiation effect along with convection and conduction.

Conclusion

The role of convection in the solidification is studied. It is inferred that in the numerical modelling of phase change processes the selection of under-relaxation factor plays a major role

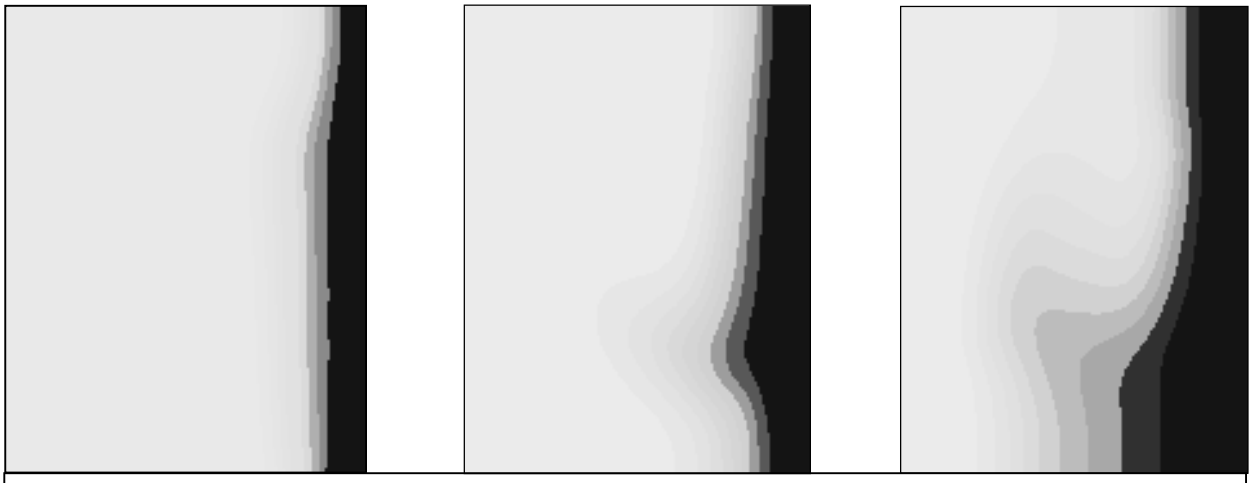

Figure 3 Solid-liquid interface at different timesteps Ra=2.5e5

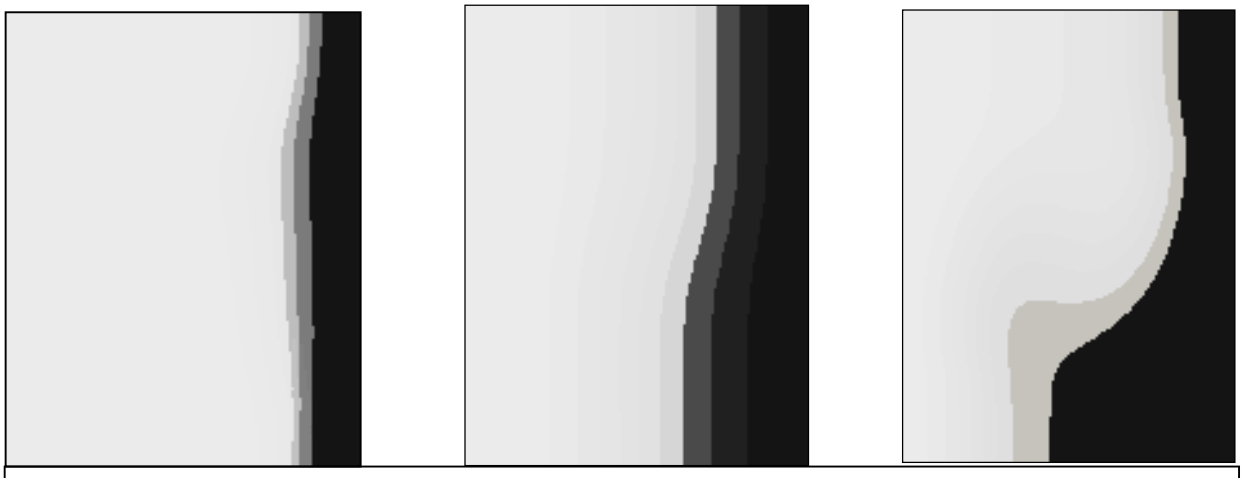

Figure 4 Solid-liquid interface at different timesteps Ra=1.59e5

Nomenclature

d	thickness of the mold [m]
B	width of the enclosure [m]
g	gravitation constant [m/s^2]
k	thermal conductivity [J/s m K]
A	height of the enclosure [m]
L_q	latent heat of solidification [J/kg]
P	pressure [N/m^2]
T	time [s]
T	temperature [K]
T_c	cold wall – (mold surface) temperature [K]
T_h	Hot wall temperature [K]
T_{sat}	solidification/saturation/Fusion temperature [K]
u	velocity in the x direction [m/s]
v	velocity in the y direction [m/s]
y	vertical coordinate measured from the bottom of the enclosure [m]
x	horizontal coordinate measured from the centre of the enclosure [m]
X'	half width of the melt region [m]
X_o	distance from the centre line to the solid-mold interface [m]
ΔH	latent enthalpy content [J/kg]
fl	liquid fraction

Greek symbols

a	thermal diffusivity [m^2/s]
β	temperature coefficient of cubical expansion [K^{-1}]
ν	kinematic viscosity $= \mu/\rho$ [m^2/s]

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About the Authors

Venkatesh R L (venkatesh.cfd@gmail.com) and Sindhuja S are the students of PSG College of Technology with their Bachelor's in Production Engineering (Sandwich) 2005-2010 batch. Their research interest is much related to the computational techniques and numerical algorithms used to solve the problems related to fluid and heat transfer. Presently, Venkatesh is a Technologist at General Electric Company and Sindhuja is a Graduate Engineer Trainee at Ashok Leyland. Their faculty guide is Dr K Kannan, Senior Lecturer, Dept of Production Engineering, PSG College of Technology, Coimbatore.

A whole bunch for you!

NERD had organized a few competitions in association with Takneek, which are :

1. Science meets poetry: Jot down a poem with science and technical flavour.
2. Scientoon making competition: Make a scientoon. Visit www.scientoon.com to see what it is and how it looks like.
3. Science fiction writing: The story should have some aspect of future science or technology as an integral to the plot. The science can be physical, sociological, psychological or some science that might not exist!

We are encouraged by the enthusiastic response that we received from you. We promise we'll come up with more such competitions in the future.

Please do come forwards and yield your pen to the scientific world! There is much to write about!

The Engineer Girl

Interview with Dr. Barbara Liskov

Bhuvnesh Goyal and Utsav Kesharwani

Dr. Barbara Liskov is currently the Institute Professor in the Department of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology. In 1968 Stanford University made her the first woman in the United States to be awarded a Ph.D. in computer science. She is a member of the National Academy of Engineering and a fellow of the American Academy of Arts and Sciences and fellow of the Association for Computing Machinery (ACM). She is also a recipient of John von Neumann Medal and the prestigious Turing Award for her contribution to the world of computing. She was in IIT Kanpur to deliver a lecture as a part of Golden Jubilee Program, IIT Kanpur. We got an opportunity of talking to her. Here are some excerpts from the interview:

NERD: Please elaborate on your research area.
Dr. Liskov: These days, I am working in distributed systems. I have been working in this area for quite a long time. I am particularly interested in online storage; that is instead of keeping your data on your personal machine, it is accessible over internet. The idea of online storage is very appealing as one doesn't have to worry about back-ups then. Of course more and more companies would like to do the same. I like to work on issues having to do with online storage, primarily security issues and performance issues. Security includes both making sure that the stored information is not lost and it is accessible when needed, and preserving the confidentiality and integrity of the data.

NERD: What would you like to say about the status of software engineering on a global level?
Dr. Liskov: Well, certainly things are much better today than they were when I started. The practice has greatly improved in the field. But still building software that works and delivers on time and on budget is still a very hard job.

NERD: What future can you see about the online data handling and security issues that you just talked about?
Dr. Liskov: A lot of problems are being encountered in the area of security and I am interested in technical ways of assisting. Also, I think that's an area of research that will go on for quite sometime seeing that we are nowhere near to the solution today.

NERD: The concept of data abstraction is one of the roots of your significant impact in easier construction of software. Would you please elaborate on this concept for our readers?
Dr. Liskov: The first kind of abstraction mechanism that people used when writing program were procedures or sub-routines, which are a method of computation. So you can talk about using a sort procedure and you don't have to worry about how it is implemented. Data abstraction does the same for data. You can talk about a set or stack, an array or string, or any other data structure, and at the level of the user is just the description of the behaviour, and under the covers is the implementation. You get the same benefits that you get from the procedures, but you are encapsulating something that's bigger, because data abstraction involves many procedures that are used to interact with the data and there can be very complicated representations underneath, where you decide exactly how to layout the objects in the primary and secondary storage.

NERD: First CLU, then Argus and more to come, what is your advice to young programming language scientists? Are there a set of principles that they should follow?
Dr. Liskov: I always talk about the four principles that you have to follow while designing a program language and these are -[1] you have to have enough expressive power, so the language expresses what needs to be expressed, [2] but it has to be simple so that people can understand it and use it effectively, [3] it has to be easy to use to do things that you want the people to do and finally, [4] it has to perform well enough. These principles not only apply to program language design but also to whole interface design in general. Everytime you design an interface, you are designing a simple programming language. Programming language constraints what people can do, when people write program in your language, that's all they depend on and if it doesn't have expressive power and is not sufficiently simple to use, then they don't have a very good tool.

NERD: Can a code be made to achieve the ideal state of being hack-proof?
Dr. Liskov: Well, certainly we can do a lot better

than C. You are talking about malicious attacks and hackers of that sort. It's a kind of a game that goes on. By using better programming languages we can get rid of certain kind of problems like many of the attacks related to buffer overruns, unchecked bounds, etc. So, to some extent you can solve the problem, but I think that people who are hacking are very clever and determined to hack anything that we make, so I don't know that we will find something that's hack-proof. One of the main problems is the complicacy of softwares and I think part of what is involved in making sure that hackers can't hack it is making sure that it really works which is quite a problem.

NERD: Your work on practical Byzantine fault tolerance has demonstrated that there are more efficient ways of dealing with arbitrary (Byzantine) failures. Please elaborate on Byzantine fault tolerance and your work related to the same.
Dr. Liskov: I worked on replication techniques which enable a group of "replicas", a group of machines to work together in such a way, that even if there is a Byzantine failure of a certain number of them, the group still performs correctly as a whole entity. This requires replication protocols, which in the case of Byzantine failures are pretty complicated, because Byzantine failures are arbitrary failures and you always have to assume that you are working against an adversary and the adversary is very clever and it's going to do the worst possible thing. An example of what can happen is - you have a storage system, it's got several replicas, one of them is Byzantine Fauly, now you send this node a request to say "modify"/do this modification, and it writes back and says," Ok, I have done it.", but it's a lie. So you have to expect that some nodes are lying, and you want the protocol as a whole to work correctly because you have enough number of replicas that are working properly, so the lying nodes are outnumbered. That is why, you have to invent protocols that use the group of replicas because you can trust the group of replicas, but you can't trust any individual member of the group.

NERD: You have a computing principle (Liskov Substitution Principle) named after you; can you please tell us more about it?
Dr. Liskov: It's a very simple principle that has to do with type hierarchy. It is in context to the languages like JAVA and C#, where you can define a type and a subtype. The principle says that objects of the subtype must behave like those of the supertype, when used in context when the supertype is expected. What this means is that if I write a program expecting a supertype and it's given an object belonging to the subtype, then this object behaves like an object of the supertype .A very fundamental principle of modern program construction is that you have to be able to write down your program by depending upon specifications. Supertype has a specification, that's a behaviour it is expected to have. If I write a program and it uses an object of the subtype, the Liskov Substitution Principle says that the subtype has to honour that specification and has to act accordingly.

NERD: Prof. John V. Guttag said that every modern program has ideas that can be traced back to you. What are your thoughts on the same?
Dr. Liskov: [Laughs!!] Well, I think that was very nice of him to say that. That sounds like a very tall order. He is probably talking about my work on data abstraction and modular program construction. The modern programs are written in a very modular way with strong interfaces and specifications. A very important principle is that you would be able to reason locally about the correctness of a module, that is, a region of code that implements an interface. So, if you have small module, you can reason with it, whether it's meeting with the specifications without having to worry about the rest of the program.

NERD: You have a string of awards to your name – ACM Turing Award, ACM SIGSOFT Impact Paper Award, ACM SIGPLAN Programming Languages Lifetime Achievement Award to name a few. What do you feel has been your most significant contribution to the scientific community in terms of your research area?
Dr. Liskov: I think my work on data abstraction and modularity is the most important of my contributions.

NERD: What has been your influence in the field of programming, the one John v. Guttag said about you changing the way people think?
Dr. Liskov: When I started working in this field, people didn't understand modularity well. The idea of data abstraction didn't exist. So, I invented that idea. There were other people working on similar ideas at that time, but I came up with the idea of abstract data-types and then I refined the idea further and did a lot of work on how do you specify them, how do you reason about them, how do you write modular programs, et cetera.

NERD: Tell us something about your childhood and early years. What were the expectations from you as a girl?
Dr. Liskov: I grew up in San Fransisco. I don't think there were any expectations. At that time in the United States, women typically would have a career as a secretary or a teacher. I was always very interested in Maths and Science and I just kept on working, though it wasn't considered a right thing for a girl to do. And one thing let to another [Smiles]. I went to college, I majored in maths. I went to look for a job. As a Mathematician, I couldn't get good one. Somehow, I got a job as a programmer, that's

how I got into computer science and discovered that I had an aptitude for it. After a while, I am back to school. So, I was just a meandering path. My parents expected me to do well in school but certainly not as a computer scientist.

NERD: You are one of the leading researchers in your field; did you ever think of being one when you were a student? What was your mindset about your future then?
Dr. Liskov: I certainly didn't think about it when I was an undergraduate or a graduate student. I was just pursuing my interests. I never thought about where I would end up. I just kept on going and finding things that I was interested in, and I did change fields. I started in Artificial Intelligence, then moved to the Systems, worked on Programming Languages, program methodology and then worked on distributed Systems. So, I have been pretty flexible about changing research directions as interesting things arose. I never really thought about what's the end going to be, I just thought about what's interesting, what's worth doing.

NERD: Did you face any challenges as a woman scientist?
Dr. Liskov: Well sure. When I got my PhD, I didn't have any reasonable job offers of a faculty position. I went to industry instead. By the time I went back to become professor in MIT, the climate had changed and people were beginning to look for women in faculty positions. If I hadn't been a woman, I would have gone directly into a faculty position after getting my PhD. But on the other hand, I always felt that I had more freedom, and after college I felt that I could do whatever I want to, whereas my male counterparts were very worried about their careers. I didn't have to think about my career;in that sense it was a benefit.

NERD: You are the first U.S. woman to earn a PhD from a computer science department. It is seen that the field of research and engineering that has a sex ratio favouring males. Why do you think it still prevails all over the world and what may be the possible solutions?
Dr. Liskov: Well, it seems to be universal, but it also differs from one country to another and same holds true for mathematics. By and large in the United States, girls don't do well in the top level of mathematics, but there are certain countries like Romania where they do a lot better. I think a lot of it is cultural. And I think there is something about an image of a computer hacker that's very unattractive to girls. So, many of them go in different directions. I really don't know what to do about it. It doesn't matter what people do as long as they find something that's interesting for them. What's bad is when they are deflected from what they might have been happiest doing, due to some external reasons. I think that there are a lot of women out there who might have a happy career as a computer scientist, but they went into a different direction for reasons that had more to do with how girls are raised and what society's like.

NERD: What is your take on Undergraduate Research?
Dr. Liskov: At MIT, we encourage undergraduate research. We have undergraduate research opportunities program that helps and encourages students to get involved in research projects. I think it's a wonderful opportunity for the students to see what research is like, so that when they finish school, they have a better idea about it, and might get interested in it.

NERD: Do you think that your contributions to the scientific society have been put to implications to their full extent?
Dr. Liskov: I have no idea [Laughs!!]. I think that there is a certain segment in the professional community that follows good programming practices. I am not sure it's done everywhere, I don't know.

NERD: Describe Dr. Barbara Liskov in one line.
Dr. Liskov: I have always been interested in doing what's interesting. My idea of a great job is where you find the work interesting, the things you do can make a difference, but I don't know how to describe myself.

NERD: What is your final message for the students/ readers?
Dr. Liskov: I think that the time when you are in college is the time to different things. What you want in the end is to have a career that you find interesting and that you can do well at. Not everybody can do well in everything. You have to recognize you strengths and limitations and learn to be flexible.

Bhuvnesh Goyal (bhuvnesh@iitk.ac.in) is a third year undergraduate in the department of Computer Science and Engineering at IIT Kanpur. He is very interested in science journalism and communication and sociology. He is a member of Core-coordination committee, NERD.

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DOG-EARED

Book review—Code Name: Ginger

Puneet Singh

Author: Steve Kemper
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Publisher: Harvard Business Press
Number of Pages: 336
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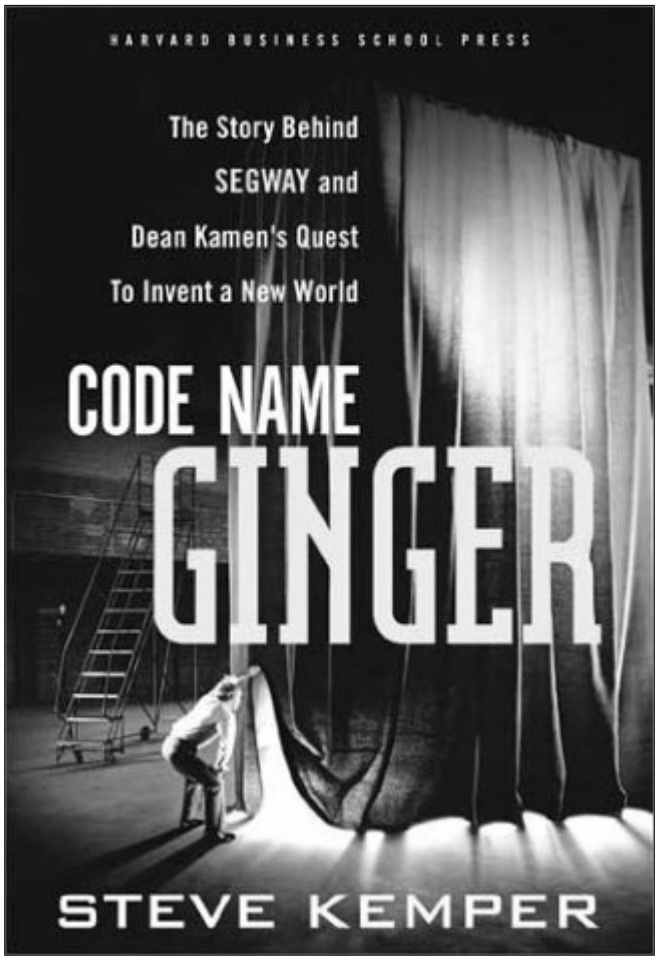
IIT Kanpur Book Club Availability: 1 Copy



Did you ever dream about being an inventor? Have an elaborate workshop of your own where you build gadgets and machines that solve the world's problems. Sounds like Dexter's Laboratory or the good old days, when Edison made the light bulb or when the Wright brothers built a flying machine in their bicycle shop. In today's world, we are more likely to hear about Steve Jobs, Bill Gates, Mark Zuckerberg, Jeff Bezos et al, the entrepreneurs who made it big. But its not the same as inventing a new thing, is it?

The name Dean Kamen may not strike any bells, but he is one person who has lived the inventor's dream. This book, "Code Name Ginger" by Steve Kemper, has the tagline: "The Story behind Segway and Dean Kamen's Quest to Invent a New World". The book is all about the personality of one of the world's most fascinating people, Dean Kamen. A self made millionaire from all his inventions and patents for wheelchairs, medical equipments to helicopters, he has his own island, private jets (which he flies himself) and even a few helicopters. Here is someone who wears jeans and a jacket all the time, whether he is meeting the President or in a dinner at a luxury restaurant. His pockets are filled with screwdrivers, spanners and tools, creating a nightmare for airport security. Hence he pilots his own jets, one of the very few people in the US who are allowed to fly without a co-pilot. But its not because he has the money, but because he has the skill. A down-to-earth person, who dreams big, and wants to change the world.

The book is an insiders account on the design and development of his most famous creation: the Segway Human Transporter which was kept under wraps as just 'Ginger' . It was a machine that was meant to change the world's transportation system. Launched nearly a decade back, despite its technological advances and unique abilities, the invention can today be called a commercial failure. But that does not make the story any less interesting.

It started off as an idea on which he began working in his free time, and became one of the best kept secret projects in the world. Partly, because of his paranoia (or good sense maybe) that the Asian giants like Honda, might get the idea of making a cheap, efficient personal transportation that would make automobiles in urban areas redundant. A lot of critics have claimed the Segway to be 'just a scooter'. But the magic of Segway is its engineering. It makes walking useless. Why walk, when you can stand on a Segway, go faster, have complete control by just adjusting your body weight, climb stairs, have a 'zero' turning radius! The book traces how the different features were put into the vehicle, starting from a large table with two wheels, on which one of his engineers sat and whizzed around the workshop (and crashed quite a few times).

To the readers with a technical bent of mind, this vehicle incorporates one of the most well known problem in Controls, balancing an inverted pendulum. But it is also much more than that, accelerating forward when the user shifts weight forward, turning, decreasing speed, not letting the user fall off and reading about it makes you realise the enormous complexity involved in our everyday activities. The dream Segway of Dean Kamen also incorporates a fuel cell, so you could be cleaning polluted water while you power your transportation! So you could solve the world's transportation and drinking water problems at one go. This has tremendous promise for the developing countries where water as well as roads are a huge problem. But till now these prototypes have not been released commercially.

The book is written by a journalist who was given insider's access by Kamen, who felt that such a great invention ought to be documented well. The whole process of developing a new product is captured extremely well. Reading it, you realise how Venture Capitalists work, how new companies are made, hiring of staff, promotions, work atmospheres, designs and manufacturing techniques are developed. It is not a book for business people or entrepreneurs alone. It is essential to be read by scientists and researchers as well, because it gives you an idea that whatever discovery or invention you make, it needs to be practical and be able to be implemented well. The problems involved in manufacturing are unique and the way they are solved are extremely ingenious. For example, when assembling a part, the workers are supposed to screw in the nuts at different places. Very often the wrong nut is put in the wrong place. The assembly has to be done again. So manufacturers use different right-handed and left-handed screws for different places. So even inadvertently it is not possible to make a mistake. Of course procurement is also another issue. A part of the book tells the immense conflict that went behind choosing the right supplier for the gyroscopic sensors in the machine. Buying a sensor worth a few dollars more could cost the company a million dollars.

Another insight that this book provides you with is the dynamics of the workplace. The personality of Dean Kamen was the driving force of the project. He was the anarchic ruler of all he surveyed. But not without reason. He had a lot of great engineers and designers each with his/her own personality quirk. How they got on with each other, how they fought, settled, worked together and finally came out with a great product is very elegantly documented in this book. At the end of it you realise that in a team with plenty of disputes, the love of an idea unites them and inspiration coupled with hard work surely gets you results.

There are bad moments as well, when bad decisions are made and they are covered up. The author seems to be extremely clearly pointing out what all went wrong with Segway, which does make the book seem a little less objective. The high profile meetings with the great businessmen of today's world tossing around millions of dollars to develop this machine is an incredible part of the book. And yet, Dean Kamen's absolute commitment is evident of his faith in the power of invention. The author has done a great job in describing all facets of Kamen's character and has not held back in pointing out where his idiosyncrasies led to the financial fallout for the machine. But it is not finger pointing but a well balanced view of the person.

The book is a must read for anyone who dreams of changing the world. There is a lot of work written about the beauty and aesthetics of pure sciences but a book such as this really promotes engineering itself to a greater height. How technology drives the world and how engineering drives technology is an extremely important issue for all young engineers and scientists in the world today. Segway might have been a failure, but the story behind it has a lot to teach and could guide a billion successes in the world tomorrow

Puneet Singh (punsingh@iitk.ac.in) is a third year undergraduate student in the department of Aerospace Engineering at IIT Kanpur. He is fond of all flying things, beast or machine. His research interests include Helicopters and Unmanned Aerial Vehicles. He spends his time doodling cartoons and reading.

ICARUS 2010

What THEY Said

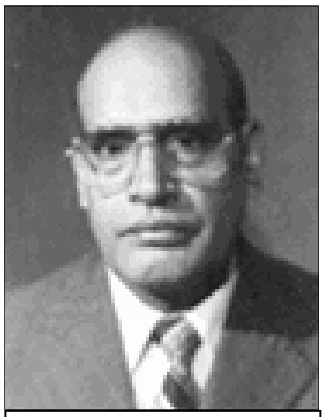
Dr. R. Chidambaram emphasized the need of motivation to make India a 'Developed country' in the fullest sense of the term and a 'Global Innovation Leader'. He quoted Peter Medawar's (Noble Prize winning Biologist) advice to young scientists – Always work on 'important' problems, 'important' to science and society.

Dr. R Chidambaram

He then talked about evolution of nuclear technology in India, importance of nuclear energy and generation of nuclear energy.

His message to the students - Your work should be directed towards "relevance or excellence, preferable both."

Dr. K L Chopra spoke at length about emergence of many ethical issues (relating to administration, practice and use of science) being the significant changes that the last five decades have seen in the structure and practice of science. He defined ethics, misconceptions related to the same and major ethical issues concerning academics, scientific values, scientific temper, research integrity, scientific misconduct, fabrication, falsification and plagiarism. He also said that inspite of all this, it must be realized that ethics aren't something that can be taught- they are something that need to be cultured, nurtured and inculcated right from the start, in the mind of a budding scientist, engineer, or human being, to make them grow up to become a responsible citizen of the society.



Dr. K L Chopra

Prof. Vijay Singh

Prof. Vijay Singh spoke about the NIUS program, a venture that has been set up to promote to status of Undergraduate research in India. The National Initiative on Undergraduate Science (NIUS), a major initiative of the education wing of TIFR (Tata Institute of Fundamental Research), HBCSE (Homi Bhabha Centre for Science Education) concerning tertiary science education in India was launched in the summer of 2004. At ICARUS, Professor Vijay Singh spoke about how NIUS is involved in initiating and guiding students over an extended period for proto-research, preparing and editing lecture notes, and promoting undergraduate research.

Dr. Roddam Narasimha gave the talk titled 'Evolution of Science and Engineering Education in India and its future'. The title is self explanatory of the nature of the talk. Some of the points he touched upon were related to his own student days in one form or the other. He talked at length on the importance of introductory courses in academic curriculum and what will happen if bachelor courses are introduced in the academic curriculum of an institute like IISc.

Dr. R Narasimha

He also enumerated on the contribution of institutes like IITs and IISc to the research scenario in India.

(Source of all images: www.icarus.org.in)

Acknowledgement: G Sriram (sriramg@iitk.ac.in)

OBITUARIES

Prof. Satish Dinkar Joglekar, born in 1949, obtained his Ph.D. in Theoretical Particle Physics from the State University of New York at Stony Brook in 1975. After that, he worked as a post-doctoral research associate at Fermilab, Institute for Advanced Study, Princeton and University of California at Berkeley. He joined IIT Kanpur as a faculty member in 1981.

Prof. Joglekar was one of our most distinquished theoretical physicists with a very deep understanding of Quantum Field Theory and Particle Physics and made many significant contributions. His research interests included Gauge Theories, Renormalization Theory, Cohomological Problems in Gauge Theories, Anomalies, Renormalization of theories with Scalar fields, energy-momentum tensor, Anomalies and Path Integral Formulations, Superspace Formulations of Gauge Theories, Nonlocal Theories, Axial/planar, Coulomb gauges; Proton Form-factor; Causality in non-local and non-commutative field theories and composite models.

He was a chaired Professor at our Institute. He was a Fellow of Maharashtra Academy of Sciences and National Academy of Sciences, India. He had been a member of Institute for Advanced Study, Princeton, American Physical Society, and New York

Dr. Vishwas Narhar Kulkarni joined the Department of Physics IIT Kanpur in 1986. He carried out his doctoral work in Nuclear Physics Division of the Bhabha Atomic Research Centre, Mumbai, and obtained his doctoral degree from Marathwada University Aurangabad, in 1981. He carried out postdoctoral research at the University of Padua, Italy. While being a visiting faculty at Centre for Superconductivity Research in University of Maryland, USA, he developed and supervised the research programs using the 1.7 MV Pelletron accelerators.

He was an excellent experimental physicist in the area of low energy particle accelerators and interdisciplinary research using energetic ion beams. His efforts transformed the Van De Graaf facility at IIT Kanpur as an eminent centre for Condensed Matter and Materials Science applications. He made many significant contributions to the use of ion beams in material modification and synthesis of useful non-equilibrium phases, and the physics of ion-beam mixing.

He has been one of the main architects in establishing the current world class facilities and research programmes at the Ion Beam Complex consisting of a 1.7 MV Tandetron accelerator, a state of art Focused Ion Beam system and other complementary facilities for modern and futuristic technology development. He had been working on surface engineering, prototype nano device and MEMS/NEMS fabrication by focused ion beams; plasma and ion beam-induced modifications of technologically important materials; ion-matter interaction and materials analysis using Rutherford backscattering, channelling and recoil spectroscopy. NERD team wishes that his departed soul may rest in peace.

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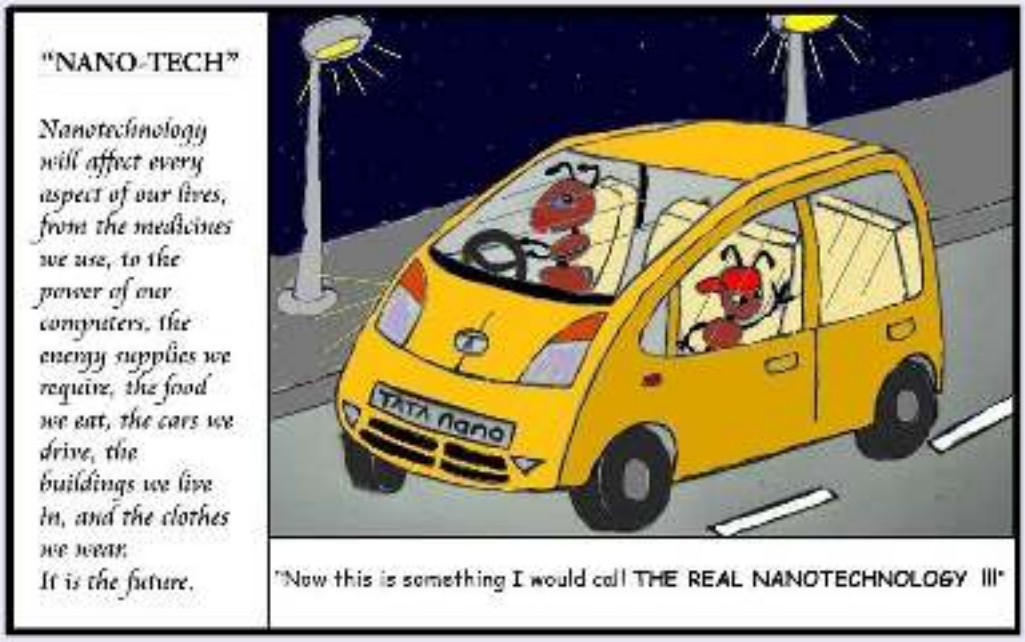

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