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Prof V Ramgopal Rao from IIT Bombay has been appointed as the Director of IIT Delhi with effect from April 13, 2016. He is also the Chairman FITT… *(Ex- Officio)*

Smt S Z Irani, Minister of HRD laid the foundation stone of the Science and Research Park at IITD, April 29

Rebooting FITT

FITT has trudged along for over two decades and admirably shouldered the heavy responsibility of strengthening technology transfer in a comprehensive manner at IIT Delhi. Yes, much more could have been done. However, to move on with a renewed zeal on a rising trajectory, it is prudent to reorient strategies going forward while evaluating the hits and misses in this journey. In our experience, knowledge transfer from the academia is a facile phenomenon if confined to spillovers like movement of students and scientists, contract research and consulting assignments but, becomes challenging if the goal is to extract fuller value from information and innovations embedded in the research resultants. The mind space of a mature Technology Transfer Office is, thus, primarily occupied with the objectives of building capacity and capability, scaling-up licensing deals, enabling research spin-offs or for devising innovative models of outreach and sustained industry engagement. In short, it's about moving ahead with impactful social and economic footprints. FITT broadly aligns its priorities with the Institute (IIT Delhi) vision. Numerous internal discussions and brainstorming give a sense of purpose. There is no denying the Institute's current strong focus on innovation and entrepreneurship that is consistent with the national development themes. The thinking at FITT hovers around strengthening the existing robust platforms which, since inception, are perfectly aligned in the direction espoused nationally. Concurrently, the next phase of growth and development shall veer around the establishment of Research Parks that would serve as hotbeds of technical collaborations, creative programs and venture creation. FITT has jumped the whole hog into pursuing the Research Park initiative. The renewed focus and energy towards creating partnerships and capturing value from these is getting all around emphasis and importance. Many segments of the economic activity have been liberalized. Institutional formats like FITT are coming into the foreground. And, to articulate an ever active and dynamic profile with an eagerness to lounge forward, FITT has adopted a new logo which reflects the crucial role of deeper stakeholder engagement, effective mechanisms for knowledge transfer and a vibrant start-up platform at academia.

Dr A Wali

Tech Tales

Leadership Communication: Why Does It Matter?

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Leadership is a well-researched and discussed topic in business studies. A range of theories have been proposed to investigate the nature, development and effectiveness of leadership. At its core, leadership is about *influence*. As Hogan, Curphy & Hogan (1994, pp 493) propose, "leadership involves persuading other people to set aside for a period of time their individual concerns and to pursue a common goal that is important for the responsibilities and welfare of a group". Fry, Vitucci & Cedillo (2005, pp 837) endorse the view by defining leadership as "the art of mobilizing others to want to struggle for shared aspirations". This art of mobilizing requires the person occupying the leadership position to have a range of skills and traits that can generate trust, credibility and authority among the followers. Effective communication is one such skill.

Focus of leadership communication

Communication from a leader's perspective goes beyond simply making effective presentations or conducting effective meetings. Leadership communication requires leaders to create and manage meaning for both, internal and external stakeholders. Leadership communication needs to focus on:

A. Building organizational identity and image: Organizational identity refers to the distinctive features / attributes of an organization which are relatively stable over time. Organizational image is the perception of organizational identity. Different stakeholders can perceive an organization differently; therefore, image can vary from one stakeholder to another. Leaders need to expend considerable effort to reduce the gap between image and identity. Organizational vision (image of a compelling future) and strategy are often used to bridge this gap and to create synergy between the stakeholders. Leaders need to be able to formulate a compelling vision and highlight to its stakeholder's how it incorporates their interests. In order to generate a sense of inclusivity and participation, leaders need to create opportunities for dialogue and discussion between and among different stakeholders.

Shaping organizational culture: Organizational culture can be simply understood as the norms that guide attitude and behavior in organizations. Edgar Schein's (1984) popular conceptualization of culture highlights that it is more than the physical artifacts (e.g. logos, physical layout, uniform, building structure, etc.) that meet the eye. Culture comprises of (and in turn reflects) the values espoused by the organization and the assumptions that underlie these values. The underlying assumptions are often deep rooted and difficult to change immediately. Organizational culture therefore, is formed over time and is relatively stable in nature.

Leaders can shape organizational culture through their communication. A leader's 'vision' for the organization is shared with other members of the group through formal and informal channels. What the leader measures, notices, comments on and reacts to affects how the organization conducts itself. The very choice of medium for communication affects culture by creating impressions about the leader and the kind of culture he / she desires to create. For instance, when announcing an organization's new vision statement a leader may use company-wide videos or mass emails to reach out to all its employees. Other leaders may choose to interact personally through town hall meetings and workshops. If a leader chooses face-to face conversations for sharing crucial information and seeking employee feedback, he / she may be considered more accessible as compared to a leader who chooses a written format (e.g. email or feed back box).

Leaders are regularly evaluated for not only what they say, but what they imply through their gestures, tone and overall body language. A positive tone and body language enhance a leader's likeability; thereby, reducing the negative biases that may hinder effective communication. 'Authentic' leaders attract more followership and are better able to influence others. Authentic leaders are seen to be those whose attitudes, values and behaviors are in sync with each other (See Avolio & Gardner, 2005 for detailed discussion). Authenticity of leadership communication is often judged by the passion and consistency of a leader's communicative behaviors.

B. Conducting / managing difficult conversations: An important aspect of leadership communication pertains to conducting and managing difficult conversations. Difficult conversations can range from introducing organizational level transformations to addressing individual concerns pertaining to job security or relationship with supervisor / co-workers. Leadership role requires sensitive handling of such conversations, for they can have several repercussions (including on organizational culture). Take for instance a disgruntled employee who seeks an appointment with the Business Head to discuss the issues that he / she is facing

with their immediate supervisor. The Business Head will need to exert caution when listening to the grievance and refrain from giving an opinion, till he / she has heard both sides of the issue. In handling this situation, the business head is likely to create a precedent, which can be used in future in the organization. If for example, the business head decides to reprimand the employee for over stepping the supervisor, he / she is likely to send out a message to its employees that the organization has a formal and traditional culture, where hierarchy is valued. On the other hand, if the Business Head chooses to listen to the grievance and discuss it with the employee's supervisor separately, he / she conveys an open culture where everyone's experiences and feelings matter.

Once issues have been resolved or decisions made, leaders are faced with the important task of announcing / declaring the decision. Neutral decisions or messages (which means they are not likely to evoke an emotional response from the recipient, despite being relevant to them) or positive decisions or messages (which means they are likely to evoke a pleasant response from the recipient) are easier to deliver when compared to negative decisions or messages (which are likely to instigate the recipient to respond in a defensive manner). Based on the message type, the message structure needs to be decided upon.

Neutral and positive messages (e.g. thank you messages or notes of appreciation) are best delivered through a direct structure, wherein the key point is highlighted first, followed by the reasons for it. Direct structures are easier to understand and facilitate better recall. Once the recipient encounters the key message at the outset, he / she is better able to make sense of the rationale for it. In case of a positive message, when the recipient encounters the good news first, it puts him / her in a pleasant frame of mind to receive the remaining message positively. The example below uses a direct structure to frame a thank you note.

EXAMPLE OF A DIRECT MESSAGE STRUCTURE TO FRAME A THANK YOU NOTE

Thank you for the opportunity to deliver the key note address at the CEO's conference yesterday. The eminent guests and participants of the conference made it an enriching experience to share my ideas around sustainable organizations. Sustainability has long been a matter of concern, but the conference provided an opportunity to bring together key stakeholders, integrate different perspectives and generate innovative and practical ideas. I am sure this effort will go a long way in enlisting support from these key stakeholders.

Look forward to being a part of this journey.

Indirect structure begins with the rationale / reason behind the message before arriving at the main point. Indirect structures are harder to understand and should only be used when the messages are sensitive (e.g. breaking bad news or persuading someone to act in a way that they otherwise may not) and likely to evoke a strong reaction from the recipient. When it is expected that the recipient may filter out whatever is said after the key message has been delivered, an indirect structure should be used. On most other occasions, a direct structure works well where the key point is delivered first to avoid losing receiver's interest in the message.

EXAMPLE OF AN INDIRECT MESSAGE STRUCTURE TO FRAME AN ORGANIZATION WIDE ANNOUNCEMENT

As you are aware, we regularly gather customer feedback on the products and services we offer. The recent customer feedback was less than satisfactory. Majority of customers reported long wait times and below average support from floor staff as key points of dissatisfaction. We undertook a detailed exercise to diagnose the underlying issues causing these delays and negative customer experiences. Inadequate training of the floor staff emerged as a prominent factor leading to poor customer interaction.

The leadership team has decided to identify individuals needing more training. These individuals will be taken off the floor for some time and enrolled into different training programs. Your supervisor will be getting in touch with you, in case you are one the identified employees.

Do feel free to discuss this in detail with your supervisor and seek clarification, if any. You could also contact the undersigned for more information.

C. **Building high performance teams:** Most tasks in an organization require team formation and management for effective completion. Teams, unlike groups, are formed to work towards a specific goal for a specified period of time. Teams usually go through different stages before they are able to perform as a unit. Psychologist Bruce Tuckman in 1965 first identified the different stages that a team goes through: forming, storming, norming, performing, adjourning. In every stage, leadership (particularly communication) plays a crucial role in helping the team move from one stage to the other. Leadership communication at each stage has a distinctive role:

- **Forming:** This is the first stage where the members begin to interact with each other. Members are usually cooperative as there is little familiarity with each other, there is limited clarity over the team objectives and specific roles and responsibilities. Leadership communication in this phase needs to be directed towards clarifying the purpose of the team and the specific roles that individual members are expected to undertake for efficient task completion.

- **Storming:** In this stage, conflicts begin to emerge among the members as ideas and ways of working begin to clash. Leadership communication in this stage needs to focus on managing the conflict and facilitating the team's move towards the next stage of norming.

- **Norming:** In this stage, members begin to resolve their issues and conflicts. Members develop norms of interaction and performance to help the team achieve its objectives. Leadership communication in this stage needs to be facilitative and participative. Leaders need to ensure that different ideas are incorporated and all the members feel respected. Verbal and non-verbal communication must be used to show respect for divergent ideas and members.

- **Performing:** In this stage the teams begin to perform and accomplish tasks. Leadership communication in this stage becomes celebratory and developmental. Leaders need to identify members who are performing well and those who need more input and support. High performing members need to be acknowledged both, formally and informally. Members not being able to perform need coaching and support. Leaders need to interact with the key (if not all) members to gather their feedback and offer support, whenever required.

- **Adjourning:** In this final stage teams are disbanded / adjourned after accomplishing the objectives they had set out to achieve. Leadership communication in this stage should focus on thanking and appreciating its members for their hard work. Adjourning a team on a positive note not only makes the members feel pleasant about the experience of working with the team, but increases the chances of choosing to work with some of its members (including the leader) at a future time.

Concluding remarks

Leadership communication is crucial for an organization's success. The intent, content and tone of leadership communication affects the way members of the organization feel, think and behave. Leadership communication is about making and managing meaning for the key stakeholders so they align themselves to the organization's interests and aims. Communication from a leader's perspective therefore, needs to focus on building the organization's vision, strategy, culture, identity and image. Leaders need to think strategically about communication and need to work out a meaningful and focused communication strategy (Argenti, 2007: 21).

Since leader's likeability and acceptability affects the effectiveness of communication, leaders need to work towards building credibility and trust among other members. Authentic leaders are more aware of their preferences, strengths and weaknesses and tend to generate greater trust and credibility. From a communication perspective, these leaders are more cognizant of the verbal and the non-verbal cues that they give to others while communicating and the impressions that others form of them.

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Imaging of Optical Phase

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1. Introduction

Imaging systems have a widespread presence in diverse application areas such as healthcare, security, education, agriculture, and day-to-day consumer products. Further, several current developments in basic sciences today are closely linked to how well we can image an object or phenomenon of interest. When a source of light illuminates an object, the scattered light waves encode information about the object in the form of space-time variations of intensity, phase, polarization, spectrum, coherence. Most common imaging systems like cameras, microscopes and telescopes directly provide us information

about the intensity (and to some extent spectrum) of the light fields at their sensor plane, often completely ignoring the other physical parameters.

It is well known in the optics literature for quite some time that the phase of light waves contains far richer information compared to intensity [1]. Measuring or imaging the phase is however not so straightforward, as all visible light detectors (like the CMOS array sensor in a cell phone camera) only respond to the energy or intensity of light waves. Phase can only be inferred computationally from the recorded intensity data and the new information obtained is valuable for multiple applications as we will discuss in this article. Phase is a parameter that is meaningful when dealing with coherent radiation such as that from a laser and it plays an important role in how light propagates in free space or through material media. For example, lenses that are used in optical imaging devices can actually be considered as phase correctors that allow image formation under certain configurations.

2. Interferometric Phase Imaging

We will first see how modulation of fringes in an interference experiment allows us to image phase. Let us consider a microscope as shown in Figure 1 (a) that can be set up easily in laboratory with a low cost diode laser, microscope objectives, some optics and a CMOS camera connected to a computer. This is an interferometric microscope where in addition to a beam illuminating the sample slide, there is an additional reference beam derived from the same laser source by means of a beam splitter. While a usual microscope provides a raw image of a blood cell sample as shown in Figure1(b), in the interferometric microscope the beam that has interacted with the object interferes with the reference beam that has travelled nominally same optical path to produce a fringe pattern as shown in Figure1(c). What do these fringes tell us? Note that wherever there is a blood cell in the sample, the fringes curve around or bend. This is because the laser light passing through the cells travelled through some extra material with different optical thickness as compared to the reference beam. The beam therefore has additional phase given by $\phi(x,y) = (2\pi/\lambda)(n-1)L$ at point (x,y). Here λ is the wavelength of laser illumination, n(x,y) and L(x,y) are the refractive index and thickness of the cell sample at location (x,y) in the image. The raw recorded data is therefore not directly meaningful visually but with additional computation using our knowledge of light propagation, we can associate a numerical value of phase at each point (x,y) in the image as shown in a 3D rendered phase image of the cells in Figure 1(d).Why is this additional information useful? Well now one can possibly use this information to classify types of cells for diagnostic or other applications. For example in Figure 2 we show phase images for fresh blood cells vs. old blood cells that have been stored for a month. The fresh blood cells have a flat disc like shape with a small dip in the middle but the old cells are seen to have much more prominent dip and a donut-like shape. When looking under ordinary microscope this depth information is not available and the above classification cannot be performed by an image based technique as here. Interferometric imaging shows up in various forms, applications and basic science investigations. For example the recent detection of gravitational waves [2] depended on capability of measuring small phase changes in a giant interferometer spread over several kilometers. There are several other systems like Optical Coherence Tomography, interferometric antenna arrays for astronomical imaging, optical surface profilers, synthetic aperture imagers, laser speckle radars and others that critically depend on phase detection from interference patterns.

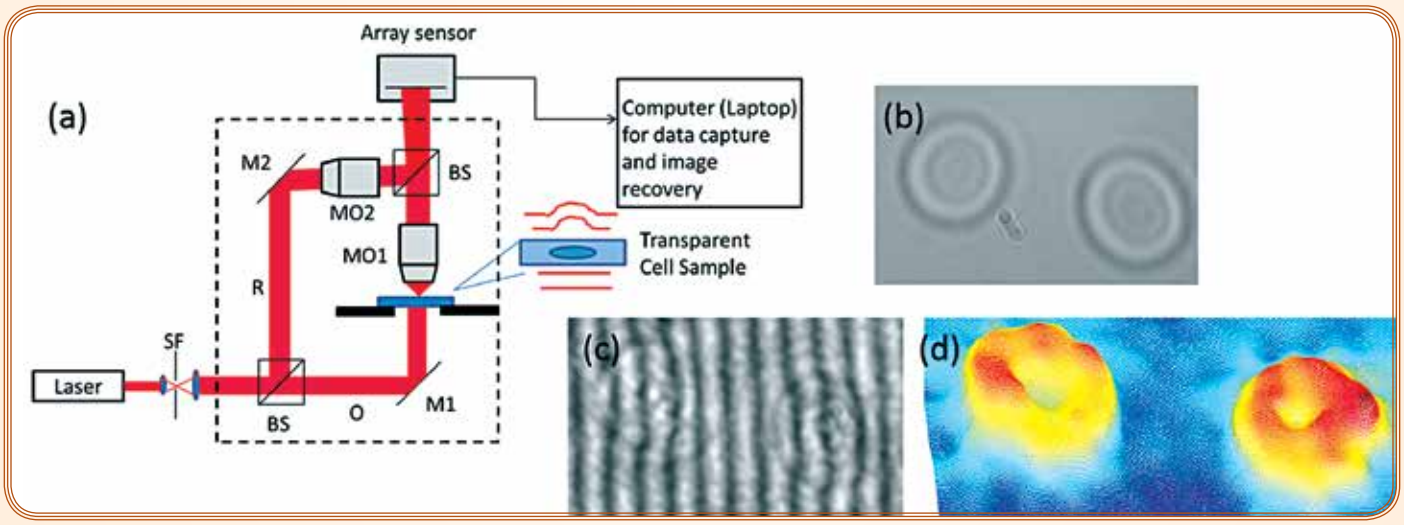

Figure 1: (a) Interferometric microscope system, (b) Usual brightfield image of blood cells, (c) Interferometric record of the same cells, (d) Phase image rendered as a 3D cell profile.

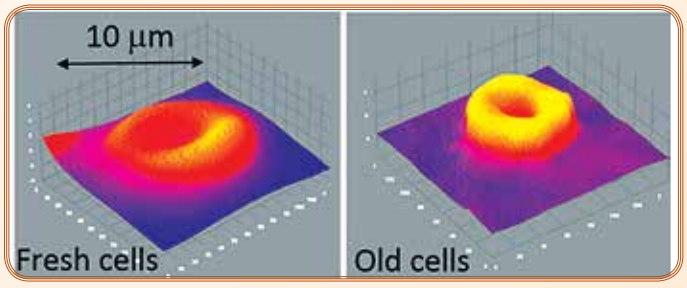

Figure 2: Classification of cells based on phase images. Fresh and old blood cells show different 3D morphology.

3. Non-interferometric Phase Imaging

The interferometer system shown in Figure 1(a) requires a reference beam and further needs high mechanical stability as the two optical paths have to stay matched with wavelength scale accuracy. Any vibration can disturb this stability and cause fringe shift. Further there are practical situations where it is not convenient to have a reference beam. For example when imaging through random media like turbulent atmosphere. Can relative phase across an optical beam be measured without a reference beam? The problem almost seems intractable and in principle there could be infinite number solutions to the phase problem. However using our knowledge of how light propagates and suitable modelling of constraints can give us a physically meaningful solution for the unknown phase. In Figure 3 we show phase imaging for an "IITD" phase object from direct diffraction intensity measurement. Non-interferometric phase imaging systems can be used in multiple applications in Optics, X-ray diffraction or electron microscopy. Recently allied phase retrieval ideas have found interesting use in portable cell phone based microscopes [3].

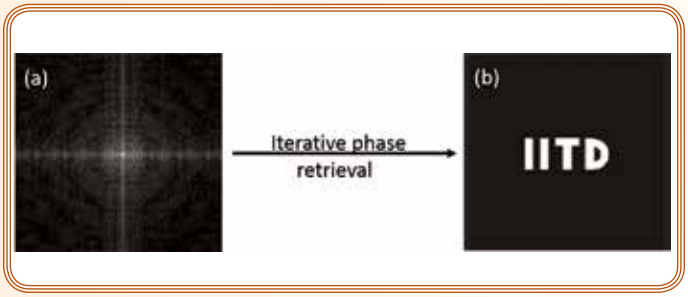

Figure 3: (a) Diffraction intensity pattern for a phase object (b) Recovery of phase function with sparsity assisted phase retrieval algorithm developed in house.

4. Recent developments at IIT Delhi

In recent years our research group at IIT Delhi has performed several basic investigations on recoverability of phase information from interferometric and non-interferometric data. This has led to overcoming of some long held limits in resolution and noise performance for phase imaging systems [4, 5, 6]. A patent on a high resolution phase microscopy system is now granted to IIT Delhi [7]. A prototype phase microscope system has been built in our laboratory and is being used regularly for investigating diagnostic applications of the phase imaging of cell samples in collaboration with AIIMS via a BIRAC incubation effort.

5. Future opportunities

Exploring multiple degrees of freedom in scattered light waves offers far richer information compared to usual intensity based photography. Further with the ready availability of computational power, there are interesting unconventional ways to look at information recovery using imaging devices that combine optics hardware and solution of large scale inverse problems for image reconstruction. The results obtained go much beyond traditional optical design or image processing treated in a stand-alone manner and in the process we can question several fundamental "text-book" limits on performance of imaging systems. The basic investigations can also be readily converted into low cost imaging devices with superior capabilities. Imaging research is highly interdisciplinary in nature and can bring together experts from diverse areas together for solving high impact problems. Exposure to this activity can also be greatly beneficial to Science and Technology students.

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To *Remember* or to *Think?* How about both...? Going Beyond *Von Neumann*

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If you were to choose one of the following two superpowers - (i) A brain with the best *thinking* prowess in all mankind (be it quantitative or qualitative) but with absolutely no *memory* or (ii) A brain with infinite memory (but absolutely no capability to *think or compute*), which one would you choose? Well, it turns out neither of the two exclusively are any good. To make use of *thoughts,* one needs at least some minimal *memory* to retain information for a finite duration of time. While an endless bank of memory with no ability to *think* is as good as an encyclopedia that can never be opened. Fortunately nature blessed mammals with generous proportions of *thought-capability* and *memory* simultaneously. For the sake of avoiding philosophical controversies, and the scope of this article, lets assume *'thinking' or 'thought-capability'* is an oversimplified synonym for *'computing' or 'computational-capability'.*

Present day digital computers and almost all computational platforms are based on *Von Neumann* architecture, named after the pioneering work of the legendary Austrian-Hungarian mathematician/physicist/

inventor Jon Von Neumann (1903-57). In systems based on *Von Neumann* architecture, there exist certain hardware blocks dedicated for the purpose of computation (example ALU, CPU etc) and separate blocks dedicated for storage (example RAM, ROM, Disk, etc). These two classes of blocks interact and communicate with each other (as and when required) through electrical wires. *Von Neumann* architecture has been the backbone of all digital computational systems since the very inception of computers and the electronic hardware based on it has scaled exceptionally well for several decades in accordance with the *Moore's* law. Thanks to the modular approach of Memory-Computation blocks in this architecture, engineers and scientists have been able to drive aggressive *Performance vs Cost roadmaps* of certain consumer electronics (desktops, laptops, smartphones, storage devices, etc) generation after generation (or node after node by scaling CMOS-logic and memory devices). However, like all dreams come to an end, the answer to future of computing doesn't lie in simply packaging more & more transistors or bits on a single die. Scaling cannot continue indefinitely due to-(i) physical microscopic factors (such as lithography limitations, fabrication and process control issues, leakage currents, nanodevice variability / stochasticity) and (ii) macroscopic system level trade-offs (such as memory wall, power wall, coding types, bandwidth, frequency etc.). The deterministic *Von Neumann* architecture in particular, is very sensitive to these nuances.

Apart from the aforementioned technical factors, there are also disruptive market forces and ever changing consumer behavior at play that creates more trouble for the *Von Neumann* architecture. Recent explosion of Cloud based services, social-media, e-commerce, data centers, Internet of Things (IoT), falling cost of sensors, smartphones / tabs etc. has led to generation of enormous troves of data. With this enormous data comes the need to develop more powerful and efficient hardware for *Big Data Analytics*. Not only is the volume of this data high but also its nature is highly asymmetric and asynchronous. Effective treatment of such data requires computational architectures and hardware that can efficiently handle complex tasks such as- pattern recognition, extraction, matching, classification, regression, autonomous unsupervised and supervised learning etc. The answer lies in looking at certain architectures that are fundamentally different from *Von Neumann* and better equipped to handle aforementioned applications.

Two promising beyond *Von Neumann* solutions are architectures inspired from-(i) *Neuroscience*, and principles of (ii) *Machine-Learning (ML)*. The key difference in both these architectures with reference to *Von Neumann* is that *Memory is Intelligent* for both of them. In other words, unlike *Von Neumann*, same pieces of hardware simultaneously share the functions of computation and storage. Coming back to the initial question of superpowers, memory and computation are not isolated anymore. Imagine if every bit in your 1 GB USB pen drive could perform even a simple computational task (like addition, comparison etc.) apart from just storing binary 1s or 0s! The pen drive would become a computational powerhouse.

Nature and in particular mammal brains are believed to work in similar ways. The human cerebral cortex is estimated to have about 10^{11} neurons and 10^{15} synapses(~ 10^{3-4} synapses/neuron) [1]. Training/ Learning/Stimuli lead to formation of different neural networks (ensemble of neurons & synapses working coherently) inside the brain to perform specific intelligent tasks such as vision, auditory perception etc. Formation of such networks can be attributed to the adaptable channels (also called as synapses) that connect multiple neurons. Owing to their plasticity, the synapses can change the strength of communication between two or more neurons in accordance with certain learning rules. In ML paradigms the synapses become synonymous to weights interconnecting different activation nodes (neurons). Weather we term them as Artificial Intelligence (AI), ML, Artificial Neural Nets(ANNs) or Hollywood style *Terminators,* software-implementation of such computational techniques on top of digital *Von Neumann* hardware has been around for a while. However, the full potential of these techniques in terms of low silicon footprint and low power dissipation can only be realized if the implementation is non-abstract and directly at the level of the hardware architectures, i.e. the hardware itself is adaptable, reconfigurable and wired according to the principles of computational-neuroscience or ML.

Part of my research at IIT-Delhi revolves around conceptualizing and building such nanoscale *neuromorphic* and ML hardware systems for efficient cognitive computation. It is a strongly interdisciplinary research activity involving elements of diverse areas such as nano electronic device fabrication, electrical characterization, modeling & simulation, development of programming schemes, design of hybrid CMOS circuits, computational neuroscience, learning rule optimization and system level applications. The strength of our approach lies in the fact that we use emerging non-volatile resistive memory devices (RRAM, also vaguely known as memristors) to enable synaptic or weight functionality, while advanced CMOS circuits to realize neurons, activation functions and peripheral learning/training circuits. The 2-terminal RRAM devices are similar to biological synapses in nature which make them a natural choice for building dense computational hardware with intelligent memory bits. We work with several different emerging RRAM technology families such as- phase change memory (PCM), conductive-bridge memory (CBRAM), Oxide based (OXRAM) and spin-transfer torque based (STT) memory. Figure1 shows Hafnium- and Titanium- oxide based nano scale OXRAM devices that we fabricated and tested for some hardware ML applications [2].

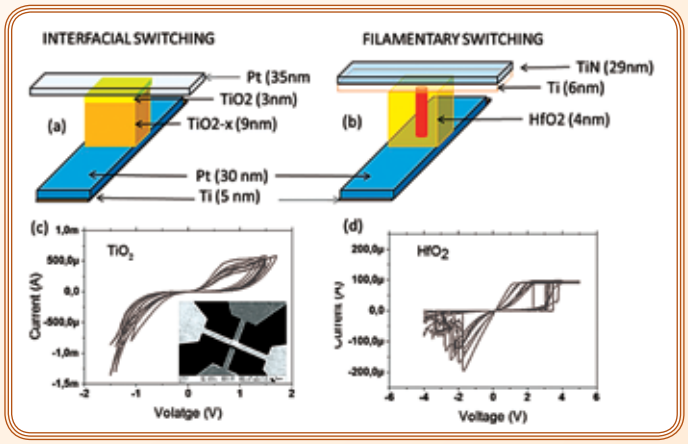

Figure1: Schematic of our fabricated nanoscale OxRAM devices for (a) TiO_2 and (b) HfO_2 stacks. (c) and (d) show corresponding IV curves with an Inset SEM image of the TiO_2 device [2].

At the level of algorithms or learning rules, we have successfully validated both spiking and non-spiking approaches. For spiking systems we exploited different flavors of a biological learning rule known as *Spike-Timing Dependent Plasticity* (STDP) [7], [8]. For the non-spiking ones we developed approaches such as hybrid CMOS-RRAM Extreme Learning Machines (ELMs) [2], [3] and *Restricted Boltzmann Machines* (RBMs) [5]. Some of our proposed techniques form the basis of specialized hardware for *deep learning*. Figure 2 shows our proposed OxRAM-ELM architecture. In all our designs we exploited undesired nano scale device attributes such as variability and stochasticity to our benefit [2], [3], [5]. This makes our systems resilient to unavoidable defects that arise out of aggressive scaling, an attribute unseen in conventional *Von Neumann* architectures.

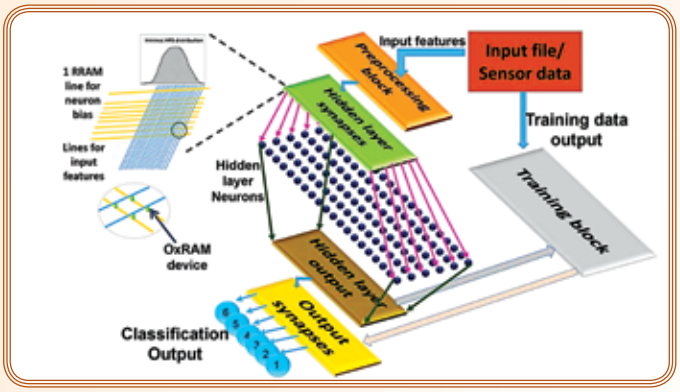

Figure 2: Our proposed hybrid CMOS-OxRAM ELM Architecture for multi-class classification [2].

At the application front, we have validated different applications such as auditory and visual pattern extraction, multi-class image classification, regression etc. We had successful proof-of-concept for diverse real world test cases such as- satellite imagery (see Figure 3) and healthcare diagnosis [2].

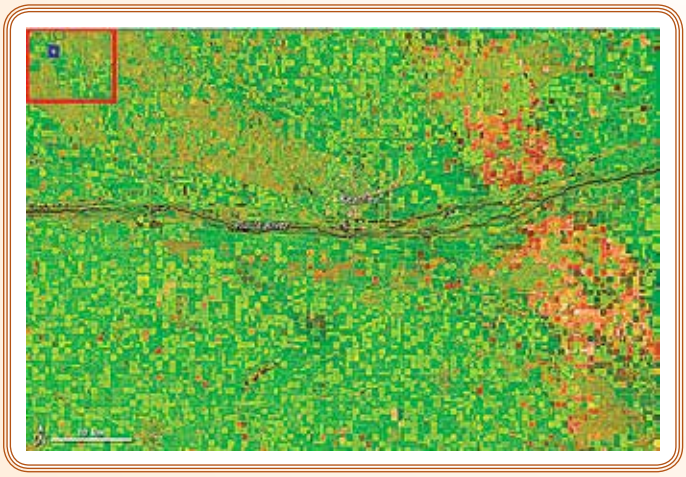

Figure3: LandSat image used for multi-class classification using our ELM architecture [2].

The infrastructure and test facilities that we are setting up at IIT-Delhi* for characterizing RRAM technology for such unconventional computing applications is at par with global state-of-the-art setups and of strong relevance for industrial applications.

Our pioneering work in the domain has been well recognized by the community through several awards and recognitions (example *Best Poster at NVMTS - China 2015, Laurent de These, Nanosciences Foundation – France – 2014)*. IBM recently used our patented work on the 2-PCM Synapse [9]. On a more industrially relevant note we are also looking at empowering some standard digital applications such as CMOS imaging [6] and NoC routers [4] exploiting RRAM devices.

Global semiconductor non-volatile memory (NVM) market was sized~USD 32 billion in 2012, and is bound to grow steadily through 2018 [10].RRAM related activity is expected to take up a significant portion of this market as the semiconductor industry fiercely pursues the future replacement of charge based NAND Flash storage. At the same time the global neuromorphic and ML hardware market is estimated to surpass a market size of USD 10 billion by 2020[11]. This makes it a very exciting time to work on the intersection of the R&D of unconventional computing and RRAM. Such rare cusp of interest for both industrial and academic R&D communities in the field significantly favors our end-to-end (from devices to circuits to applications) research methodology.

* Facilities partially supported by sponsored Extramural Research Project from Department of Science & Technology (DST), Government of India.

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Faculty Profiles

Prof Sushil
Department of Management Studies
IIT Delhi

Prof Sushil is the Abdulaziz Alsagar Chair Professor (Professor of Strategic, Flexible Systems and Technology Management), at the Department of Management Studies, Indian Institute of Technology Delhi. He was also the Deputy Director (Operations) from July 1, 2015 to June 30, 2016. He has served as Visiting Professor and delivered seminars in many leading universities, such as University of Minnesota, Minneapolis, MN, Stevens Institute of Technology, NJ, University of Lethbridge, Alberta, Université Paris 1 Panthéon-Sorbonne, Paris. He is an active researcher and has supervised more than 60 doctoral dissertations. He has twenty books to his credit in the areas of Flexibility, Strategy, Systems Thinking, and Technology Management and over 300 papers in various refereed journals and conferences. He is the Editor of Book Series on Flexible Systems Management published by Springer. He is the Founder Editor-in-chief of Global Journal of Flexible Systems Management and is also serving on the Editorial Boards of leading international journals.

He has pioneered the area of 'Flexible Systems Management' and made original contributions to the field of knowledge in the form of interpretive approaches in management such as SAP-LAP models/linkages, Total Interpretive Structural Modeling, and Interpretive Ranking Process. He has evolved the concept and framework of 'Flowing Stream Strategy' as strategic flexibility to manage continuity and change. He has also provided mantras for continuous organizational vitalization (LIFE), and models for strategic performance management (Flexible Strategy Game-card), sustainable enterprise (Star Model) and strategy execution (4A's Model).

Currently, Prof Sushil is serving as Independent Director on the Boards of RINL, HSCC, and River Engineering. He has acted as consultant to both governmental and industrial organizations; a few representative ones are Ford Foundation, APCTT, UN, Defense Research and Development Organization (DRDO), Wipro Infotech, LG Electronics, Rockwell International, Tata Consultancy Services, James Martin & Co, Gas Authority of India Ltd,Sona Koyo Steering Systems, NBCC, and DGS&D. He is the Founder President of the professional body, 'Global Institute of Flexible Systems Management'. He has been awarded 2014 AGBA Fellow (by Academy for Global Business Advancement, USA).

Prof A Mittal
Kusuma School of Biological Sciences
IIT Delhi

Aditya Mittal received his B Tech in Biochemical Engineering from Harcourt Butler Technological Institute (HBTI), Kanpur, India (1996). Through campus placements, he was recruited as a Management Trainee with Shaw Wallace & Co Ltd, a blue chip company in 1996 with an annual turnover of over 1200 Crores. Within three months of his stay in Mumbai (then called Bombay), he was deputed as a Brewer in the largest brewery (Skol breweries) of Shaw Wallace & Co at Uran (in the outskirts of Bombay, now a part of Navi Mumbai). There, he was a part of a team that launched the beer "Royal Challenge" in various parts of India – for few years immediately after its launch, Royal Challenge was one of the leading beers in India. The innovation of bottling a specific beer brand (Royal Challenge) in green bottles to prevent photo-oxidative degradation was introduced first at Skol breweries in India and is now a standard practice by all leading beer brands in India. In addition to reaching several milestones in

beer production (for the brands Royal Challenge, Haywards 5000 and Haywards 10000), he was instrumental in commissioning of state-of-the-art cleaning-in-place (CIP) and carbon dioxide recycling systems at Skol breweries. He also developed a method of making paper out of brewery waste, specifically from the lauter tun stage of the process – that waste was being utilized only as part of cattle feed at the time. Within eight months of his stay at Skol breweries, Aditya was made a part of a three-member Quality Assurance team to oversee beer production processes in all breweries operated in India by Shaw Wallace & Co Ltd at the time. He considers his experience at Shaw Wallace & Co Ltd both at the corporate and brewing shop floor levels, to be as important in his personal and professional growth as was his four year hostel stay at HBTI, Kanpur.

Owing to his interests in research from his B Tech days and some family observations regarding occupational hazards (e.g, regular consumption of ethanolic beverages) in spite of a very comfortable lifestyle, Aditya left Shaw Wallace & Co Ltd after over a year to pursue his PhD from Drexel University, Philadelphia, USA. In 2002, he earned his PhD in Biological Sciences (Membrane biophysics and exploration of viral fusion mechanisms) under the mentorship of Prof Joseph (Joe) Bentz. Additionally, at Drexel, he worked on drug transport by the multi-drug resistance protein MDR1 in collaboration with GlaxoSmithKline, and, was involved in synthesis of gold/silver nanoparticles and nanowires using a contact-less method called SCBE at the department of Chemistry. He then worked as a Visiting Fellow at the National Institutes of Health (NIH), Bethesda, MD, USA on remodeling of biological membranes with Dr Leonid Chernomordik. Subsequently, he joined IIT Delhi (2004) as an Assistant Professor where he set up his independent research program towards exploring kinetics and self-assembly in biological systems.

As an independent researcher, he chose to come out the shadows of his stalwart American mentors by initiating research activities that were not mere continuation (direct or indirect) of his doctoral or post-doctoral work. With a few undergraduate students and one doctoral student, he set-up real time video microscopy for measuring microbial cell movements and high-resolution fluorescence microscopy for live mammalian cells. Both were firsts for IIT Delhi. Simultaneously, he started developing rigorous analytical techniques for analyzing single cell data from the measurements. Being one of the pioneers in extracting information from real-time video microscopy (RTVM) data on cell-cell fusion, in 2007 he analyzed RTVM data of whole organisms resulting in a top cover article from India. Analytical methods indigenously developed by him are now routinely integrated in RTVM imaging software and formed the foundations of his further contributions in cell biophysics and computational biology. In late 2005, he started working on bacterial assembly of nano-magnets – a first from India. By 2006, he had become a part of a very selective group of researchers in the world who could culture nano-magnet synthesizing magnetotactic bacteria. Subsequent to his pioneering work on bacterial nano-magnets, which was also covered quite extensively by *Nature India* in 2007 and 2008, several research laboratories in India started working in this area.

In 2008, Aditya was approached to serve as one of the founding members of the School of Biological Sciences at IIT Delhi for popularizing modern biology amongst UG students, while developing vibrant post-graduate programs in biology. His efforts, with major assistance and contributions from his School colleagues, into spreading biological sciences education through newly designed courses were appreciated across the IIT Delhi community and led to formulation of a foundation 100-level core UG biology course for all incoming freshmen at IIT Delhi. Realizing the extreme challenges towards continuing his cutting-edge experimental research while setting-up a new academic entity at IIT Delhi, he started focusing on development and application of his analytical methods to basic biological problems at a molecular level. By 2010, his efforts resulted in opening of a completely fresh avenue in the area of protein folding. Based on analysis of thousands of 3D protein structures (the largest dataset analyzed till that time), in collaboration with B Jayaram at IIT Delhi, Aditya published a series of studies that added an altogether new dimension towards attempts at solving the "protein folding problem". This became popularly referred to as the "stoichiometry driven protein folding hypothesis". Even after more than six years and several critiques, his findings remain undisputed. This in itself is an admirable achievement in the rapidly evolving field of computational biology.

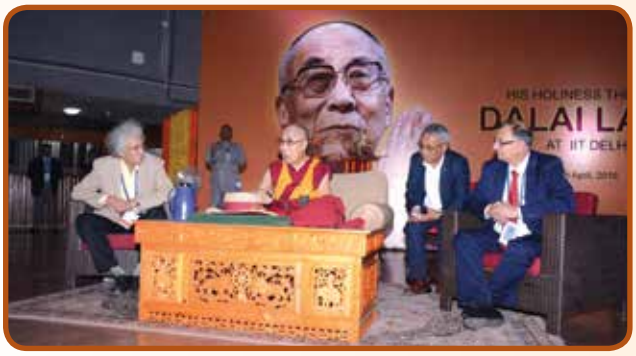
In 2012, Aditya became one of the youngest full Professors at IIT Delhi. His current research focuses on exploring origins of biological self-assembly at a molecular level. His independent research has resulted in four ***cover*** articles till date along with several recognitions. He was honored as an Associate of the Indian Academy of Sciences and featured in the cover story of a 2006 issue of *Chemical & Engineering News* (American Chemical Society) as "India's Young Blood". He was also designated "Asia21 Young Leader" by the Asia Society, New York, USA. He has served/serves as an Editor/Editorial Board Member for scientific journals in both applied and pure biological sciences, and serves as reviewer in several top multi-disciplinary journals. He has also Chaired/served-on several national and international committees on research and education. He has guided/supervised several post-graduate theses (doctoral and masters) and several under-graduate projects. For the work done under his mentorship, students have received several awards (of special note are two best M. Tech. theses at IIT Delhi and one doctoral thesis related American Society for Cell Biology award). He has served in various co- and extra-curricular capacities at IIT Delhi (of special note are faculty-in-charge/Chairman of NCC, the student Board for Recreational and Creative Activities and Tryst-the annual science and technology student festival of IIT Delhi, and, as the Contingent Leader of the staff sports team). Currently, he is serving as the Associate Dean of Student Affairs (Events). In 2015, a Teaching Excellence Award was conferred on him by IIT Delhi.

Having been nurtured by a single mother (Asha Mittal – retired as Mathematics faculty from Kirori Mal College, Delhi University), Aditya's upbringing included a solid appreciation for creating time towards holistic development and pursuing interests beyond the purely professional. He holds a diploma in Indian classical music from the Prayag Sangeet Samiti for playing the Tabla. He has also remained active in sports from his school days. Since joining IIT Delhi, he has won several medals in the Inter-IIT staff sports meets held at different IITs (gold for Badminton-2008 & Chess-2009, silver for Badminton-2007, 2013, 2014, bronze for Badminton-2006, 2009, 2012). An avid hiker, he has covered parts of the Appalachian Trail in the USA. Every year, he disappears with his wife (Shweta Mittal) and son (Siddhant Mittal) into the wilderness in India for about two weeks exploring isolated and less traveled parts. Some of his travels include staying in a tent on a white sandy beach next to the jungles of Adaman islands for more than a week, a few days in the Bomdila Monastery, and hikes up to Hatu Peak (~11000 feet, it was not motorable then), Sandakphu (~12000 feet) and Bum La Pass (~16000 feet).

Aditya aims to contribute to the growth of indigenous research while solving biological problems (of his interest) either on his own or in collaboration with his Indian colleagues. He wishes to be a representative of academics who are able to balance their outside-the-box research interests and strong teaching commitments, while creating time to enjoy non-professional interests also. Often referred to as "Addy" by his friends and ex-students, he is up for a scientific discussion any time, especially with the incentives of a fine brew (draughts are preferred) or the choicest single malts.

Events 2016

Defence Minister Shri M Parrikar addressed students and faculty members at IITD on the occasion of National Technology Day



Talk by His Holiness the 14th Dalai Lama on Ethics & Happiness @ IITD- April 9

SMITA Lab, IITD received National Award for commercialization of N9 Pure Silver- May 11

FITT signs an MoU with CCEI, Daegu Korea- June 13

Abbreviations

AM: Department of Applied Mechanics,
BSTTM: Bharti School of Telecommunication Technology and Management,
CARE: Centre for Applied Research in Electronics,
CAS: Centre for Atmospheric Sciences,
CBME: Centre for Biomedical Engineering,
CES: Centre for Energy Studies,
CRDT: Centre for Rural Development and Technology,
CPSE: Centre for Polymer Science and Engineering,
CE: Department of Civil Engineering,
ChemE: Department of Chemical Engineering,
Chy: Department of Chemistry,
CSE: Department of Computer Science and Engineering,
DBEB: Department of Biochemical Engineering and Biotechnology,
DMS: Department of Management Studies,
EE: Department of Electrical Engineering,
HUSS: Department of Humanities and Social Sciences,
IDDC: Instrument Design Development Centre,
ITMMEC: Industrial Tribology,
KSBS: Kusuma School of Biological Sciences,
ME: Department of Mechanical Engineering,
Phy: Department of Physics,
TT: Department of Textile Technology

Innovations

Opportunities for IP Licensing

S No	Title	PI/Dept/Centre
1	Cap Remover	Prof S N Singh, AM
2	System and method for protecting fragile objects	Prof S Mukherjee, ME
3	Water pumping system with solar photovoltaic array FED brushless DC motor and a method thereof	Prof B Singh, EE
4	An assay and kit for detection of endotoxin	Dr S Gupta, CHEME
5	Inter-connected carbon nano-sheets (ICNS) based electrode catalyst pase formulation for dye-sensitized solar cell (DSSC) and method of deposition of the same	Prof AN Bhaskarwar, CHEME
6	Process for conversion of sulfur trioxide and hydrogen production	Dr S Upadhyayula, CHEME
7	Catalyst composition for conversion of sulfur trioxide and hydrogen production process	Dr S Upadhyayula, CHEME
8	Method for monitoring of foulants present on chromatographic resins using fluorescence probe	Prof AS Rathore, CHEME
9	In-vitro engineered virus-like particles from flock house virus capsid proteins and uses thereof	Dr M Banerjee, KSBS
10	Formation of ester and amide bonds by enzymes in an aqeous media	Prof MN Gupta, DBEB
11	Triple-layer wound dressing material and method of preparation thereof	Prof V Koul, CBME
12	Circuit topology of Modular Multilevel Converter (MMC) from DC to AC power conversion applications	Dr A Das, EE
13	Membrane-less variable focus liquid lens with manual actuation	Dr SS Bahga, ME
14	System and device for measuring the compression properties of textiles	Prof SM Ishtiaque, TT
15	A grid interfaced smart charging station	Prof S Mishra,EE
16	Aluminosilicate based catalyst for conversion of natural gas to higher hydrocarbons and process thereof	Prof KK Pant, CHEME
17	Flexure based passive grippers	Dr J Prasad, ME
18	Concrete vibration energy harvester	Dr S Bhalla, CE
19	Twin/multiple rotor vertical axis wind turbine	Prof S Veeravalli, AM
20	Organelle-targeting peptide as nanocarrier for macromolecular delivery	Dr A Chugh, KSBS
21	Automatic strap mechanism for motorcycle helmet	Prof P Mahajan, AM
22	System and method for full resolution fourier domain OCT imaging	Dr K Khare, PHY
23	Classfying test data based on a maximum margin classifier	Prof Jayadeva, EE

Technology Profiles

Membrane-less variable focus liquid lens with manual actuation

Dr SS Bahga
Department of Mechanical Engineering
IIT Delhi

Liquid lenses with tunable focal length have seen significant interest over past decade due to their potential of replacing bulky lens assemblies consisting of fixed focal length lenses. Liquid lenses use liquids as the refracting media. Unlike conventional optical systems which require varying distance between fixed-focal length lenses, liquid lenses give same functionality by varying the curvature and eliminating relative movement between the lenses. Therefore, the compactness of liquid lenses makes them suitable for miniaturized optical systems, such as mobile phones and surveillance cameras.

One approach of varying the curvature of a liquid lens involves holding an optically clear liquid using a transparent elastic membrane and varying the volume or the pressure of lens liquid. However, mechanical fatigue and physical imperfections of the elastic membrane limit the lens performance. Moreover, membrane-type lenses are sensitive to the orientation as gravity effects can cause the lens to acquire asymmetric shape. Alternatively, the interface between two immiscible, optically clear liquids with different indices of refraction can be used as the deformable membrane. The liquid-liquid interface is such membrane-less liquid lenses is extremely smooth compared with an elastic membrane and is devoid of mechanical fatigue. Moreover, in membrane-less liquid lenses, the adverse effects of gravity can be eliminated by choosing two liquids with equal densities. The existing designs and actuation mechanisms of membrane-less liquid-liquid lenses involve either deformable lens walls, piezoelectric transducers, ferrofluids actuated by a magnetic field, or thermoresponsive hydrogels to apply pressure on the liquids. Consequently, these lens designs are relatively complex and expensive in construction, which preclude their integration with low-cost optical systems such as mobile phones.

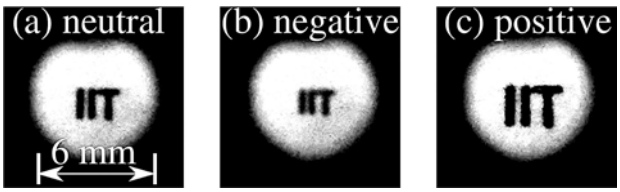


Figure 1: Images taken through the lens for different positions of the screw. The lens attains positive and negative power depending upon the screw position.

At IIT Delhi, we have developed a simple membrane-less liquid lens which can be actuated manually using a linear actuator such as screw or piston. Our design of the variable focus liquid lens retains the advantages of other membrane-less liquid lenses, such as high resolution and no-gravity affect, while simplifying the actuation mechanism and reducing the fabrication cost. Our liquid lens can operate both as positive (converging) or negative (diverging) lens depending upon the curvature of the liquid-liquid interface and the relative magnitude of the refractive index of the two liquids, as shown in Figure 1.

Processing ultrasound data in an ultrasound imaging system

Prof S Anand
Centre for Biomedical Engineering
IIT Delhi

Ultrasound Imaging Systems are used in non-invasive diagnosis of tumours. The quality of the tumour (benign or malignant) is differentiated based on its stiffness. Tissue elasticity of tumour is measured by calculating the velocity of orthogonally induced shear waves. This requires an ultra-fast ultrasound scanner working at 1000 fps to observe the inter-frame movement of wave propagation. In transmission section current technologies use group excitation of crystals (elements) for B-mode imaging and all crystals excitation simultaneously for operating at high frame rates. Delay and Sum (DAS) method is used in high frame rate ultrasound machines for parallel receive beam-forming. The main objective of this invention is to use novelties such as Alternate Crystal Excitation(ACE), Homogenous Channel Matrix Estimation (HCME), and Ethernet Interface.

Alternate Crystal Excitation(ACE)

All odd channels are used for transmission and even channels are used for reception, thereby eliminating the 3dB loss due to Transmit Receive switch. The frequency of operation is 2 to 8MHz and all the configurations are controlled through MATLAB program in GUI.

Homogenous Channel Matrix Estimation (HCME)

A calibration process used for channel estimation using a homogenous medium which is having a uniform attenuation like a smooth soft tissue or a tissue mimicking phantom. Using Multiple Input Multiple Output (MIMO) principle, wherein received signal in 'N x N' MIMO is given by, $Y = H * X$, $X = H^{-1} * Y$.

Adaptive beam-forming is achieved by applying varying weights w1, w2, w3 etc., for different channels. The weights are chosen such that the mean square error is minimized. So the weight matrix 'W' is given by

$$W = H^{-1}.$$

A non-square Matrix Hof order 'M x N' is given by,

$$W = (H^T H)^{-1} * H^T$$

In the calibration process, each channel is transmitted one by one through the homogenous medium to get the Receive Matrix. 'R' giving an estimate of H. Determination of 'R' completes the calibration process. The value of 'R' is stored for further image processing. The variants 'α' and β are multiplication factors for adjusting better image clarity.

$$R = \alpha * H + \beta * I$$

Ethernet Interface:

The maximum output from Gigabit Ethernet (GE) interfacing is~650Mbps. The GE interface to the laptop cannot process the entire data. Hence the captured data is processed for~20Mbps in multiple windows displaying in one ultrasound frame for realistic processing as Ethernet packets. Thus the ultrasound images are available at 1000fps in the laptop for the estimation of speed of shear waves.

Some examples of Development Project @ FITT

S No	Title	PI	Dept/Centre
1	Product development of liquid pour point depressant at sub 10 degree celsius	Dr V Singh	CHEME
2	Generic classification model and a learned classification model for invoices	Prof S Chaudhury	EE
3	City bus systems and emissions from in-use heavy duty vehicles	Prof G Tiwari	TRIPP
4	Determination of the maximum packing speed of the pouch packing machine (FFS Rotary Machine)	Dr PM Pandey	ME
5	Extensive characterization of supported metallic oxide catalyst and their stability in sulfuric acid decomposition section of I-S ccle for hydrogen production	Dr S Upadhyayula	CHEME
6	Multi modal natural interaction	Prof S Chaudhury	EE
7	Reducing contract shadow in surgical lights	Dr M Sarkar	EE
8	Development and deployment of integrated visual and acoustic sysem towards conservation efforts of Ganga river - (Phase-I)	Prof R Bahl	CARE
9	Development of low volume sampler for monitoring heavy metals in ambient air	Prof DS Mehta	PHY
10	Development of novel NMOF based sensors for volatile organic compounds for practical applications	Prof AN Bhaskarwar	CHEME
11	Design for automatic smart card recharger	Dr J Kumar	IDDC
12	Life Cycle of Assessment of Bottle Grade Poly Ethylene Terephthalate (LCA of PET)	Prof AK Nema	CE
13	Multivariate data analysis for biopharmaceutical engineering	Prof AS Rathore	CHEME
14	Consultancy and development in the area of CNN for computer vision applications	Dr B Lall	EE
15	Development of data analytics technology for mobile enterprises - (Phase-II)	Prof S Chaudhury	EE
16	Process design validation of circulating bed biofilm reactor (BioCask) for effluent treatment	Prof S Roy	CHEME
17	Technology development of aerated cement and concrete with solid-waste utilization	Prof AN Baskarwar	CHEME
18	Feasibility of geothermal energy in India using single well injection and production method	Dr J Phirani	CHEME
19	Catalyst loading and its impact on trickle bed reactors - (Phase-III)	Prof S Roy	CHEME
20	Consultancy and development in the area of CNN for computer vision applications	Dr B Lall	EE

Some technology transfers at FITT during 2016

1) An assay and kit for detection of endotoxin

2) Portable device and disposable chip for immunogenetic enrichment of target biomarkers

Snippets

Corporate membership of FITT

FITT invites the industry/industry associations/R&D organizations and financial institutions to become corporate members of FITT at a nominal annual subscription. A corporate client can participate in technology transfer and joint R&D programmes of the Institute on a priority basis with FITT providing the interface. Membership form can be downloaded from www.fitt-iitd.org

New Corporate Members:

1. JBM GROUP
2. Trivitron Healthcare Pvt Ltd
3. BASF India Ltd

Professional Candidate Registration Programme

Applications are invited from qualified professionals working in industry and research organizations for a unique knowledge augmentation and skill enhancement programmes at IIT Delhi. This involves a semester-long registration for a regular PG course. Course fees ranges from Rs. 15,000/- to Rs. 20,000/- (industry professionals) and Rs. 6,000/- to Rs. 8,000 (academic/government personnel) for a 42 hour lecture course. In the case of a few selected courses, on-site course delivery using the two way audio-video link can be considered. All major disciplines of Science and Engineering, and also relevant courses from the Humanities, Social Sciences and Management streams which are being conducted at IIT Delhi are covered. The course detail can be downloaded from FITT website www.fitt-iitd.org. Eligibility: Degree in Engineering or Masters Degree in Science, Management or any other Post Graduate Degree with relevant industry experience. The two semester sessions in the academic year starts in the month of July and January, the exact dates being notified in advance. Contact: uttamaswal@hotmail.com, kirityroy@yahoo.com

We value your feedback

FITT seeks to explore various avenues to enhance the quantum of interaction between industrial units/end-users and IIT Delhi. Therefore, we keenly look forward to your feedback and suggestions on various issues that can help meet our objectives. Write: mdfitt@gmail.com.

News and Views

Our product standards lack an IPR context

Over the last few years India and many countries have been witnessing increased litigations and debates on royalty payments and terms for licensing of standard essential patents, utilised in complex technology areas such as mobile telephony.

Indian jurisprudence in this regard, specially handling royalty issues, is at a nascent stage. There is an urgent need to address the issue in view of growing number mobile users in India and preference for the latest technologies… Source: The Business Line- March 7, 2016

Technology at display: 'Open House' at IIT Delhi to showcase 500 projects

From a device to protect the elderly from accidents to a project on smart campuses, a session on 3D printing and holograms to a detailed drainage master plan for the capital, the 12th edition of 'Open House' at IIT-Delhi will see students display more than 500 projects this year. The projects will be open for public viewing Saturday at the IIT campus from 10 am. Over 80 demo projects and 500 research projects will be on display at the Open House, while 4,000 school students are expected to visit the event… Source: The Indian Express- April 23, 2016

HRD minister Smriti Irani pays surprise visit to IIT Delhi hostels

NEW DELHI: Union HRD minister Smriti Irani on Friday made a surprise visit to two hostels of IIT Delhi to take stock of the conditions. Immediately after inaugurating a new lecture hall complex and the Unnat Bharat Abhiyan programme, Smriti Irani decided to visit the Shivalik and Kailash hostels.

At Shivalik, students complained to the minister about a single water cooler catering to all in the hostel, which currently has 375 students… Source: The Times of India- April 29, 2016

Cabinet approves country's first IPR policy

NEW DELHI: The Cabinet has approved the national intellectual property rights (IPR) policy with a view to promoting creativity, innovation and entrepreneurship.

The aim is to create awareness about economic, social and cultural benefits of IPRs among all sections of society, Finance Minister ArunJaitley today said while briefing reporters about yesterday's Cabinet decisions… Source: The Economic Times- May 13, 2016

BIRAC Announces **9th** Call for Proposals under the Biotechnology Ignition Grant (BIG) Scheme from **1st July to 16th August, 2016.**
For more details : http://www.birac.nic.in/

LEADERSHIP @ FITT

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2. Dr A Wali, Managing Director
3. Mr KK Roy, Chief Operating Officer

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