Department of Electrical Communication Engineering, IISc

November 2015

Coding for Big Data

by **Birenjith Sasidharan, PhD Student, ECE**

FEATURED LAB STORY

Given the explosive growth in the amount of data generated and mined today, large data centres have sprung up around the world to store this data. These data centres can store over a billion gigabytes, consume over a hundred megawatts of power, millions of gallons of cooling water and occupy more than a million square feet, Fig. 1 shows a data centre in Bengaluru.

Fig 1a: Bengaluru's Tulip Data City data centre is estimated to be the third largest data centre in the world at 900,000 square feet (Photo courtesy: http://www.forbes.com/pictures/eimh45mddm/tulip-data-center/).

Of paramount importance in a data centre is ensuring immediate and reliable access to data. Storage devices within a data centre are prone to malfunction, need regular maintenance or could simply be busy serving other requests. To combat this, data pertaining to a single file is dispersed across nodes where each node corresponds to a storage device. Some form of error correction is used and data is often replicated. Error-correcting codes employ redundancy to combat errors and have long been used to ensure reliability while transmitting data across a communication channel or else during the storage and retrieval of data. In the setting up of a data centre, apart from reliability, error-correcting codes ensure that the amount of redundancy or storage overhead added is kept to a low level.

An important and new consideration that arises in a data centre is the need for efficient node repair from the usage of error-correcting codes, to the partial recovery of data. The importance of node repair was recognized and highlighted by a UC Berkeley team including Professor Kannan Ramchandran and then PhD student Alex Dimakis. This team came up with the definition of an entirely new class of codes, termed as regenerating codes, which were required to not only ensure the reliable and distributed retrieval of data, but also enable the efficient repair of a failed node in terms of minimizing the amount of data download needed to repair the failed node. This represented a paradigm shift in the way one viewed error correcting codes and was brilliant since till now, it was not even clear that it was possible to construct codes that would permit partial data recovery.

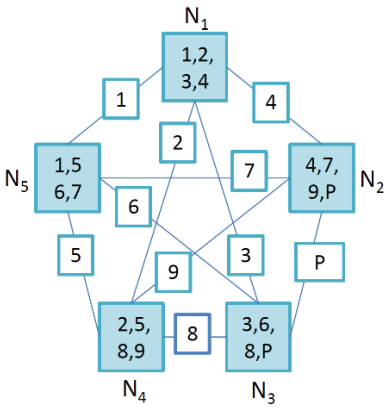
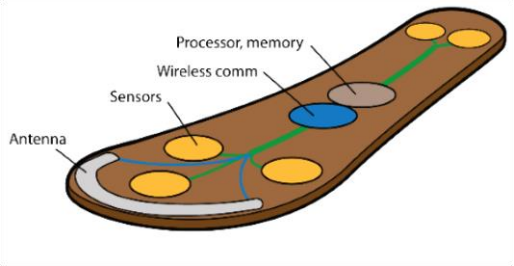


Fig 1b: The pentagon code.

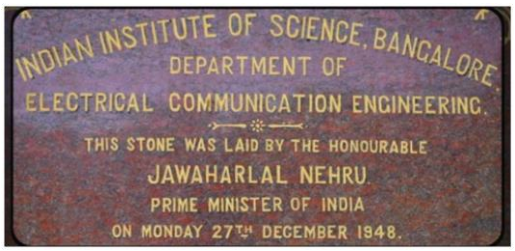
IN THIS ISSUE



Catching up with Peter Handel

Peter Handel is a Professor and Head of the Department of Signal Processing, Royal Institute of Technology, Stockholm, Sweden. He visited the Department recently where the Newsletter team was able to catch up with him and get a glimpse of the ongoing collaborative research.

Page 6



History of ECE

The Department of Electrical and Communication Engineering, Indian Institute of Science, is steeped in history, just as its parent institute. We trace the journey of the Department in this article.

Page 5

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From the Chairperson's Desk

by Prof. KVS Hari

Welcome!

It is a pleasure to share the excitement about the activities of the Department through this newsletter. This quarterly news digest would highlight the research activities, achievements of faculty, students and project staff, carried out in the Department and new initiatives.

In this world of ephemeral attention, it is imperative that a crisp delineation of scientific and engineering progress by active researchers be shared with the fraternity at regular intervals of time.

This newsletter is one small step in that direction.

We hope you will join us in celebrating our journey towards excellence.

Prof. KVS Hari

Chairperson

November 2015

PROF. KVS HARI
Chairperson, Department of ECE

CALLING ALUMNI

We would like to extend a special invitation for all our alumni to connect with us. We would like to stay connected and explore synergy for research and other engagements.

Prof. Navakant Bhat was on air live on FM 102.9 (All India Radio's FM Channel for Bengaluru) on 26th February between 5 PM to 6 PM.

Featured Outreach Activity

As a pre-cursor to Science Day and Open Day at IISc, the Science Media Center at IISc had facilitated a one hour interaction of IISc faculty where Prof. Navakant Bhat from ECE and CeNSE participated. This was aired live on FM 102.9 (All India Radio's FM Channel for Bengaluru) on 26th February between 5 PM to 6 PM.

This one hour interaction was received very well by the audience. During the program itself, there were phone calls seeking for more details about the research being carried out at IISc, and after the program too, many listeners wrote letters to AIR commending them for the interaction.

FEATURED STORY

Coding for Big Data (Contd.)

In December 2008, in connection with the hundredth anniversary celebration of IISc, Professor Ramchandran on a chance visit to Professor P. Vijay Kumar's Codes and Signal Design Lab in the ECE Department, explained the philosophy behind the new class of codes and noted that while they had a few handcrafted examples, general methods of construction were lacking. Professor Kumar then passed on the challenge to two promising and creative ME students, Nihar Shah and K V Rashmi, who in the space of a few months came up with several approaches to the construction, two of which led to general families of such codes. In this article, we explain by way of an example, the first and simpler of these constructions.

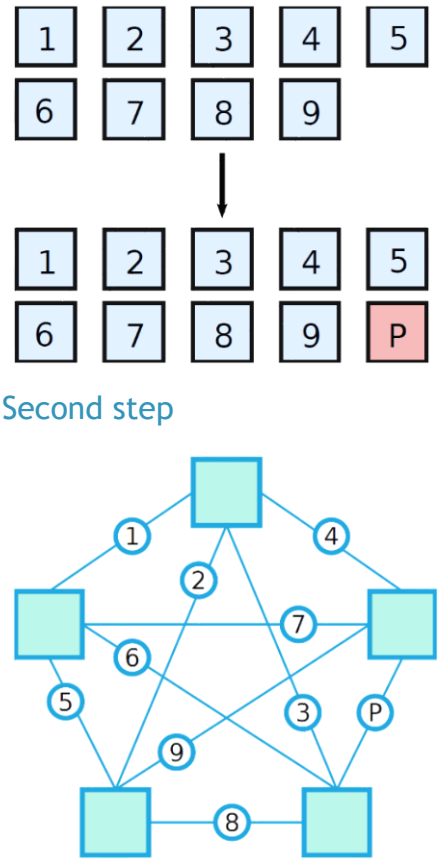


Fig 2: Construction of pentagon code depicted as in three steps.

The second construction, termed as the product-matrix (PM) construction [1], is more general and has received wide attention among the research and industry communities and fetched the authors the 2011/2012 IEEE Data Storage Best Paper Award.

There is interest in putting the product matrix codes to work in practice. In December 2014, a group of researchers from Technicolor, France reported that an optimized version of PM codes can permit encoding speed up to 790 megabits per second [2]. For lack of space however, we do not discuss this code further in this overview.

An Example Construction - The Simple Pentagon Code

In this construction, each data file is comprised of a set of 9 data blocks, labeled 1 through 9, with each data block corresponding to a string of binary symbols. Information pertaining to this file will be stored across 5 storage nodes with each node storing 4 data blocks in such a manner that the entire data file can be retrieved by connecting to any three nodes and repair of a failed node is accomplished simply through data transfer, no computation is needed.

In the first step of the construction, an extra parity block P is constructed which is simply the XOR of all the 9 data blocks. Next, the 5 storage nodes are pictorially represented as a fully-connected graph having 5 vertices and $\binom{5}{2} = 10$ edges. We will refer to this fully-connected graph as a pentagon. In the second step, each data block is placed on a unique edge of the pentagon and replicated, with one copy being stored in the two vertices that are at either end of that edge. In this way, each node stores 4 data blocks as shown in Fig. 2 making for a total of 20 data blocks.

Node repair is accomplished simply by transferring to the failed node, the data shared by other nodes in common with the failed node. For the purposes of data recovery, it suffices to connect to any 3 nodes since collectively, any set of 3 nodes contain 9 distinct data blocks. These are either the desired set of 9 data blocks or set of 9 blocks with one data block replaced by a parity block. The parity can then be used to recover the missing block. This construction can be shown to have a generalization to any number of nodes, and is optimal in terms of the amount of the storage overhead given the code's data retrieval and repair capabilities.

The Microsoft Approach to Node Repair

Around the same time, based on their experience in the context of node repair, a group of researchers at Microsoft Research pointed out the importance of reducing the number of helper nodes contacted in the repair process. With this in mind, they introduced a second class of codes designed for large data storage which go by the name '**codes with locality**'. We illustrate with an example.

In Fig. 3, there are 14 data symbols $\{(X_i)_{i=1}^{7}, (Y_i)_{i=1}^{7}\}$ and four parity symbols P_x, P_y, P_1, P_2 stored across 18 nodes. Together the 18 symbols form an error-correcting code having 14 data symbols and 4 parity symbols. However, contained with this overall code are two smaller, local codes comprised of $\{(X_i)_{i=1}^{7}, P_x\}$ and $\{(Y_i)_{i=1}^{7}, P_y\}$ respectively.

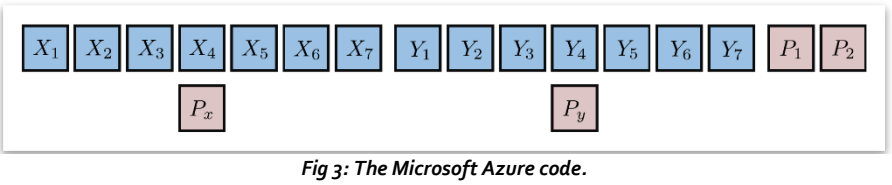


Fig 3: The Microsoft Azure code.

FAST FACTS

20%

Data center infrastructure management can lead to energy savings that reduce a data center's total operating expenses by up to 20 percent.

If a node storing one of these 8 + 8 = 16 symbols fails, this node can be repaired simply by downloading data from the remaining 7 nodes within the local code. If there are two erasures within the same local code, then the local code is overwhelmed and cannot repair itself.

However, all is not lost at this stage. Two global parities P_1, P_2 in conjunction with the remaining non-erased symbols can come to the rescue and restore both the erased symbols. The overhead associated with this code is 18/14 or 129%. A Reed-Solomon code that is somewhat comparable in terms of level of reliability delivered and the number of nodes contacted to repair a failed node would store 6 data symbols and 3 parity nodes for an overall overhead of 9/6=150%. This reduced overhead has reportedly saved Microsoft millions of dollars [3].

Codes with Local Regeneration

Professor Kumar and his lab then asked themselves if it were not possible to combine the advantages of both classes of codes into a single code that provides savings both in terms of data download as well as number of helper nodes contacted. This led them to come up with a new class of codes, termed as '**codes with local regeneration'**. An example of this class of codes appear in Fig. 4.

As can be seen from the figure, data pertaining to a single file is spread across 15 nodes encompassing three pentagons, with each node storing 4 symbols. Repair of a failed node is accomplished by downloading a total of 4 symbols, one from each of the remaining nodes lying within the same pentagon. The three pentagons are coupled together by means of linear relations among the 9 data symbols encoded by each pentagon. Such coupling is needed to handle instances when the number of erasures is beyond the capability of the individual pentagons. It can be done in a manner that is optimal in terms of the number of additional erasures that can be handled. As an example, it is possible to configure these linear relations in such a manner that the code can store 25 symbols of data across the 15 nodes in such a way that the system can recover from the erasure of any 3 nodes.

Codes with Hierarchical Locality

In a code with locality, when there are two or more erasures within a local code, one is forced to contact all remaining non-erased symbols to accomplish node repair of all failed nodes. If the length of the overall code is large in comparison with the length of each local code, there is a steep jump in the number of helper nodes contacted between the cases when the local codes repair themselves and the cases when the overall code steps in to bailout an overwhelmed local code. When Professor Kumar delivered this lecture at a seminar at the University in Melbourne, it was pointed out that in this sense, the code construction was not scalable.

This observation led Professor Kumar and his lab to come up with a fix in the form of a class of codes termed as codes with hierarchical locality. An example appears in Fig. 5. The overall code here is of length 12 and is composed at the lowest level of 4 local codes each of block length 3. When the number of erasures is beyond the capability of these local codes, then there is a layer of intermediate codes of block length 6 which can step in to repair. It is only when these are also unable to handle the situation that one calls upon the entire, global code. As with all other code constructions described here, the code is optimal in terms of the number of erasures handled, given the number of data symbols protected.

Other Work

There have been many other contributions by Professor Kumar's Lab to this area which have not been described here, these have been described in the bibliography provided. Other students who have made strong contributions to the work in Professor Kumar's Lab include Prakash Narayanamoorthy, Lalitha Vadlamani, Birenjith Sasidharan, Nikhil Krishnan and S. Balaji.

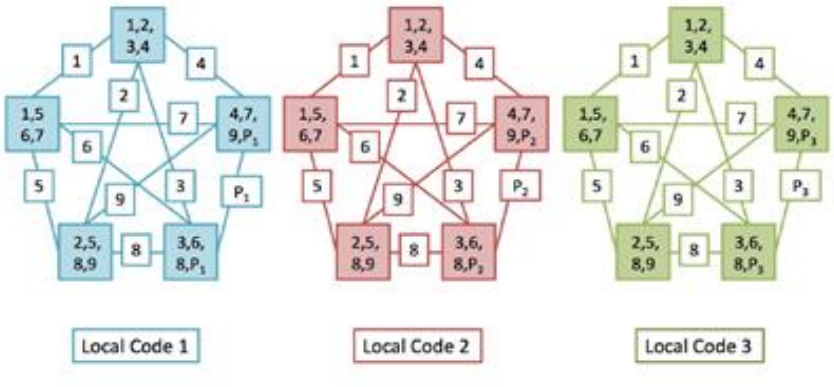


Fig 4: An example of a code with local regeneration developed at the lab in IISc.

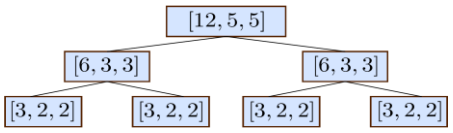


Fig 5: An example of a code with hierarchical locality developed at the lab in IISc.

Industrial Collaboration

The work on the product matrix code has been granted a US patent [4]. There has also been close interaction with the Advanced Technology Group of storage industry leader NetApp Inc. that led to a jointly co-authored paper presented at the USENIX Hot Storage workshop held in Philadelphia in June 2014. Our NetApp collaborators include Siddhartha Nandi, Srinivasan Narayanamurthy, Ranjit Kumar and Syed Hussain.

Further reading

For further reading and references, log on to the ECE Website or scan this QR code.

REFERENCES

[1] K. V. Rashmi, N. B. Shah, and P. V. Kumar, "Optimal exact-regenerating codes for distributed storage at the MSR and MBR points via a product-matrix construction," IEEE Trans. Inf. Theory, vol. 57, no. 8, Aug. 2011.

[2] N. L. Scouarnec, "Fast Product-Matrix Regenerating Codes," CoRR, vol. abs/1412.3022, 2014.

[3] C. Huang, H. Simitci, Y. Xu, A. Ogus, B. Calder, P. Gopalan, J. Li, and S. Yekhanin, "Erasure coding in windows azure storage," in Proceedings of the 2012 USENIX Conference on Annual Technical Conference, Berkeley, CA, USA, 2012.

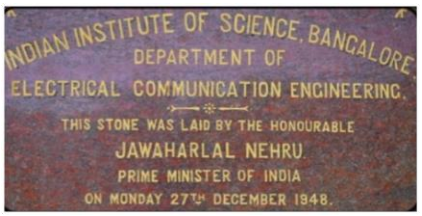
[4] K. V. Rashmi, N. B. Shah, and P. V. Kumar, "Methods and System for Replacing a Failed Node in a Distributed Storage Network," United States Patent 8,631,269, Granted January 14, 2014.

[5] P. V. Kumar, "Codes for Distributed Storage – Asking More of an Old Friend," Plenary Talk, IEEE International Symposium on Information Theory, 2014. [Online]. Available: http://media.itsoc.org/isit2014/Kumar.mp4

Tracing the History of ECE

by **Madhukara Putty, Science Media Center at IISc**

This is a first of the series of articles where we try to trace the history of ECE and its activities.



The Department of Electrical and Communication Engineering, Indian Institute of Science, is steeped in history, just as its parent institute. Though the department was formally conceived in 1946, its origins date back to the early days of the Institute itself. Since it is one of the first places to start training in electrical sciences and engineering in India, it has played a major role in the development of the field in the country. Over the years, the Department has provided quality training to the students, joined hands in numerous nationally important missions, and provided industry with reliable manpower.

Thanks to bold and visionary views of the founders of the Institute, Electrical Technology has been one of the focus areas since beginning. The Department of Electro Technics was set up in 1911, just a couple of years after the Institute was established. It was renamed Department of Electrical Technology in 1913. A decade later the Wireless Laboratory was set up, which was expanded to the Electrical Communication Engineering Section in 1928. Though these are important events on their own, one has to put them in the broader picture to fully appreciate their significance.

The first few decades of the twentieth century is studded by landmark improvements in science and technology, in general, and electronics in particular. In 1909, Robert Millikan measured the quantity of charge on an electron. Two years before this, Lee De Forest, an American engineer patented the vacuum tube, which heralded a new era in communication and dawned the age of computers. Back in India, there was a major thrust on electrical power generation. Country's first hydroelectric power project was taking shape near Shivanasamudra, a beautiful waterfall located about a hundred miles from IISc. The planners of IISc, who clearly foresaw the growing influence of electrical engineering, decided to establish the Department of Electro Technics as one of the first departments of the Institute.

Today, it is no coincidence that the Department takes lead in emerging areas like the Internet of Things 5G Wireless, mm-Wave Circuits, Valley Electronics, Massive MIMO, Big Data Analytics, RF Mems, Neuro Computing, Compressive Sampling, Network Coding, and strives to touch the lives of the people.

Prof Alfred Hay, one of the best electrical engineering teachers in England and the author of popular textbooks at that time, was the first head of the electrical communication and engineering (ECE) section. He launched the first electrical technology course in India - a post-BSc three year course leading to Certificate of Proficiency Award. He trained students through advanced level courses and research work, particularly in areas of DC/AC machines and electrical/magnetic materials. The strong foundation he laid was well appreciated by the review committee in 1921. Prof J K Catterson-Smith, successor of Prof Hay, set up India's first Wireless, and High Voltage Laboratories, founded the Electrical Engineering Society (1923), and launched its publication *Electro Technics* (1926). The high voltage laboratory assisted the growth of electrical industries in Bangalore area in the later years, and played an instrumental role in the establishment of the Government Porcelain Factory. After Prof Catterson-Smith went back to England in 1930, Prof F N Mowdawalla became the first Indian to head the section (June 1931 to July 1934). Prof Kenneth Aston from the University College, Cardiff was at the helm between 1935 and 1944. During his reign, Mahatma Gandhi paid a visit to the section (1936).

World War II (1939 – 1945), despite causing widespread destruction, also fuelled a lot of development in electrical communication and computing. Cognizant of this growth, the Institute leadership decided to upgrade the ECE section into a full-fledged department in 1946. This clearly shows the remarkable ability of the erstwhile leadership to foresee the trends in technology, and taking decisive steps to accordingly change the research ecosystem. Prof K Sreenivasan, an alumnus of the Institute, became the first Professor and Head of the ECE Department. He oversaw the planning and construction of a new building with functional laboratory, lecture halls, office rooms, workshop, stores and an auditorium. During his term (1946 – 1959), many new laboratories were set up, and researchers from different parts of the world visited the Department for short and long assignments. The Department also built close association with the newly set up public sector companies like Indian Telephone Industries Ltd (1948) and Bharat Electronics Ltd (1955). PREDA, the first analog computer in the country, was established in the Department also during Prof Sreenivasan's tenure. [To be continued in next issue.]

QUICK FACTS

- PREDA, the first analog computer in the country, was built in the Department in mid-50's.
- The Department has been working with the industry from as early as 1955.
- The Department has been working on projects related to national security since 1950s.
- India's first high voltage laboratory was set up in the 'ECE Section', which actually assisted the growth of electrical industries in Bangalore area in later years.
- The bust of Heinrich Hertz, installed in the foyer of the Department, is a gift from the Government of West Germany.
- 'ECE Section' of the Department of Electrical Technology became the Department of ECE in 1946.

Bust of Heinrich Hertz

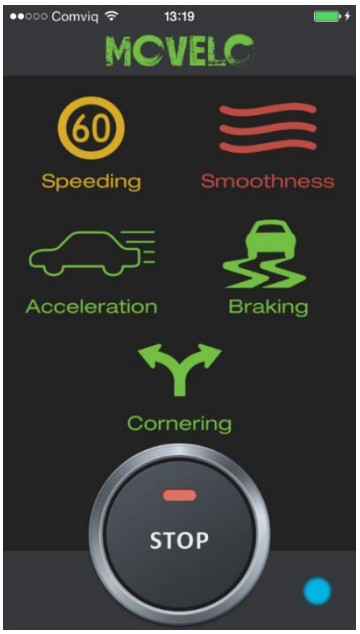
Catching up with Peter Handel

The Newsletter team managed to have a quick Q&A with Prof. Peter Handel who was visiting the Department during late September 2015. He collaborates with Prof. KVS Hari and Prof. Bharadwaj Amrutur at ECE.

Can you tell us a bit about your collaborative work with the Dept. of ECE in IISc?

At the moment we have an ongoing project targeting the elderly population. The project aims to develop technologies that can monitor the walking patterns of the elderly, and try to predict their risk to fall. The first part of the project is the development of a monitor using sensor technologies. The monitor will be embedded into shoes and will observe the walking pattern of the wearer. The second part is to design a smart walking stick with capabilities like fall detection, and the final part is the development of an exoskeleton. The project is jointly funded by Vinnova in Sweden and the Department of Science and Technology, India.

What does the monitor do?



This maps the trajectory of the shoe. It measures acceleration and rotation every millisecond and derives the position from them. Based on that, we condense the data into relevant information like change in length and height etc. All computations are done inside a small box that houses sensors, processors, battery, and the memory chip. It can run as a standalone unit or be connected to your smart phone to sense your walking pattern. The whole system is about looking for bio mechanical signatures to see if you are at a higher risk of tipping down.

The role of IISc

IISc is involved in the development of the technology and software related to the foot mounted sensor. Since the same sensor will also be used in the stick, IISc is taking care of the stick too.

Shoe mounted technology is a collaboration with IISc and KTH, and the stick mounted technology is between IISc and IIT-Kanpur. The exoskeleton is a collaboration between another Swedish university and IIT Kanpur. Of course, KTH is coordinating on system level integration of foot sensor and the exoskeleton.

Which are the areas of expertise of ECE that complement the research focus of KTH?

I think it's ECE's strong background in statistical signal processing, and that complements our work capabilities. Also, in this project it's important to understand the requirements of the stakeholders, and find out how we can support them. In this respect, the discussion with the society on the Indian side is carried out by the IISc, and that has helped a lot.

Could you please tell us a bit about successful collaborations between ECE and KTH in the past?

In 2010 we basically initiated the first generation of shoe mounted sensors for the positioning of fire fighters. Shoes with sensors were successfully tested on fire fighters in Sweden. That was also the first time I visited IISc.

What is that you enjoy most in your work with ECE?

I think, in technical terms, the 'high dynamic range' in the Indian society compared to Swedish society. Of course, I enjoy the quality interactions I have on the scientific problems. You learn a lot about other cultures while working here.

How do you find the campus and the Bangalore city?

The campus is like a retreat. It's very green with lot of birds and lot of animals. Of course there is a stark contrast between the campus and the city outside it. For me, as a researcher, it's the perfect place to be, with almost everything available in a couple of minutes' walk.

Tried Indian food?

Yes! I actually have an idly maker at home. It may be because we don't have a tradition in food, and we have adapted different food cultures over the years. I would say, in Sweden, it's easier to find an Indian restaurant than a Swedish restaurant.

About Peter Handel

Peter Handel is a Professor and Head of the Department of Signal Processing, Royal Institute of Technology, Stockholm, Sweden. He has published more than 100 journal articles, 150 conference papers, and holds 15 patents. He has been a frequent visitor to the Department of Electrical Communication Engineering since 2010. Presently, he is in the department, and has also given a talk at 'Telematics India Conference'.

Know more about Prof. Peter Handel by visiting his webpage through the QR code.

Image Credits: Prof. Peter Handel

Going Entrepreneurial with Dr. Kumar Sivarajan

Dr. Kumar Sivarajan shares his Entrepreneurial Streak and his experiences juggling between academica and the industry.

About Kumar Sivarajan

Dr. Sivarajan is an alumnus of IIT Madras and obtained his PhD from Caltech. He worked on wireless communication for his PhD. He joined ECE in 1994. Here he taught a course on Statistical Theory of Communication, Communication Networks, and an elective on Optical Networking. He also wrote a textbook on Optical Networking, based on his teaching experience at IISc. "I have fond memories of developing and teaching the course, writing a text book, and tormenting students with problems!

Around 2000, optical networking was very hot. It was like the e-retail business today. There were about a hundred startups around the world in this area, and I had an opportunity to start something here in Bangalore. It was the only start up that came up in Bangalore, and the other 99 were in the USA. I got this opportunity through Deshpande, who had his own company in the US. He was trying to get something started in India, and I left IISc in 2000, and started Tejas Networks with two others". And the rest is history.

When you decided to quit IISc and venture into entrepreneurship, what are the aspects you considered? Did you have a prototype ready?

No. We didn't have a prototype. I left on May 1, and on March 15, I had no idea about leaving my academic position. A year before I left, I even filled a form for pension thinking that I would stay in IISc for more than thirty years! But, in 2000 I thought it was a good time to start a product company in India. At that time, it was unheard of to build products in India. I had invitations to join a couple of product companies in 1999, but they were in the Bay Area. Since my wife and I had made a personal decision to spend the rest of our lives in India, and particularly in Bangalore, I didn't go and join them in the US. But, when an opportunity arose to do something in Bangalore itself, I took it!

At that time, I thought it would take a couple of years, and I could come back to IISc later. Because, that's how it works in Stanford and other places. But it took much longer for a variety of reasons. One is that the whole market went down at that time, but we didn't wind up. We decided that it was only the global market that is down, but the India market was good. We hadn't looked at the India market till then, because our idea was to build here for the world. Probably, we were influenced by the software companies! When the global optical networks market crashed in 2001, we changed strategy and decided to build in India for India.

Of course, I was in touch with the faculty members in the Department of ECE, but I didn't have time to teach. Recently, when I got an invitation from the Department to rejoin as an adjunct faculty member, and essentially do what I thought was useful, I decided to do something here. Now I am teaching an informal course in entrepreneurship. Now I am more aware of the department because I attend seminars etc. It's fun to be back! My interest is to see if IISc can make an impact on the industry, particularly startups. I want to see how students and faculty members can turn their ideas into products. This is how things work in the Bay Area. Innovations come from the Universities, and most of them become startups. Of course, 99% of them fail, but something succeeds.

I think the ideas are there. I don't think that the ideas in IISc are anyway inferior to ideas anywhere else. We just have to create some examples. Money is there; IISc itself provides seed funding. VC interest is there, and market is there. There is a huge market at our doorstep. My overall goal working as an adjunct faculty member here is to see how to take innovations here and help make an impact.

Advice for faculty members who are interested in entrepreneurship.

Go through the classical approach. Get prototypes, get initial models. Make use of the Entrepreneurship Centre and SID. And then seek funding to scale. Consciously build for markets you know and for problems that exist here. One thing I have learnt is that you can't build for a market that you don't know. So look out for the problems that interest you and can be solved. It has to be a good marriage between the needs of the market and your own domain expertise. If the product is targeted well, there is enough venture funding. There are also people to take it over. If someone is interested in doing something but not so much interested to spend their lifetime on it, we have to find a model that will allow such people to spend some time on their product, and come back as faculty. They can have some of their students continue working on the product. Another way is to build IPs and see if established companies are interested. However, startups are better because the established companies have their own teams to develop products. Faculty can build the product to a certain level, and continue in an advisory capacity. But the real hard work should be done by people who are willing to commit five to ten years of their lives.

What do you mean by knowing the market?

Let me explain with Internet of Things (IoT) as an example. The western concept of IoT is like switching on your coffee maker, a refrigerator that knows when to order milk, starting your car automatically on a hot day etc. These are useful products that can actually take off. But, most of them do not take off in India because our needs are different. Here there are more mundane tasks like monitoring air and water quality, water leak monitoring. That's what I mean by knowing the market: you work on problems that are relevant here. It doesn't mean that you sell only in this market. You could sell in any market. But in order to build a product and get it working perfectly, you need this feedback loop. The users are the best people to give feedback. Sometime it's enough to have serious users, money is not that important initially.

Just build IP or end to end products?

Building a product requires a lot more investment than developing IPs. So, it's not about the engineering capability, which is definitely available in Bangalore, but it's

about risk appetite. The challenge is to find people who have long lived interest and who want to build products.

TEJAS® NETWORKS

Future Ready. Today.

How has the industry changed since you started Tejas Networks?

When we started, there were not many product companies. The software services sector was booming, and not much thought was given to products. However, today many more people are open to the idea of starting something on their own. Back in 2000, that spirit was not there; people were looking for secure jobs. Now venture firms willing to fund ideas have also increased. Then we used to build only software, now we know how to build hardware too.

Indian Market

India has enough people who can spend money on new products. You don't have to reach out to all the 1.2 billion people. If you can reach out to 200 million people out of 1.2 billion, then that's a market as big as the US and a few European countries put together. Of course, you could target the one billion people at the bottom of the pyramid, but that requires you to build something different. So market is not a problem. The problem is that we don't have anything that is better than what foreign companies can offer.

A PhD student and an entrepreneur, both are trying to do the same thing - push the boundaries in their respective areas. On what aspects do you think that they should think alike?

I think they are doing similar things, but in completely different dimensions. A PhD student is trying to do something that is considered novel in his own peer group. For him, it just has to be novel, not necessarily useful. However, an entrepreneur is trying to solve an actual problem, and for him utility is more important than novelty.

You expressed interest in promoting research ideas and making an impact. What do you think that IISc can do in this direction?

I think IISc has provided the environment. We have SID which also provides incubation space. This is the best that a University can do. There is space. There is money. There is a pat on your back to do this. I think IISc has done enough for those who are interested in entrepreneurship.

What has changed in your life after you left academia?

First thing is, I lost solitude. In IISc, I would come at around 8 am, sit in my room, lecture three hours a week, and spend a few hours discussing with students. So, five to six hours of seeing somebody in your office. And, if you close your doors, nobody would disturb you. So, you know you are alone, and develop a systematic method of working. But the industry is different: if you close the doors, nobody cares. In the industry, you have to work with other people all the time. Secondly, personal achievement hardly counts. Team work is much more prevalent in the industry than in academia. In academia, there is much less need to intensely collaborate. In the industry, everything is collaborative.

Interview by Madhukara Putty and ECE Editorial Team.

ECE observed Open Day earlier this year!

Image credit: ECE WebTeam

Know our new faculty

The Newsletter Team had a brief Q&A with the recent members of faculty who have joined ECE.

Aditya Gopalan

1. Could you tell us a bit about your educational background?

I obtained my Bachelors and Masters degrees in Electrical Engineering from IIT Madras. I then went on to receive my PhD, in electrical and computer engineering, from the University of Texas at Austin in 2011. Subsequently, I was on a postdoctoral fellowship at the Technion (Haifa, Israel), before starting as an Assistant Professor in ECE, IISc in 2014.

2. What are the research questions that excite you, and why do you like them?

I am broadly interested in strategies for control, learning and decision-making under uncertainty. These find applications across a variety of domains such as communications (cognitive radio, scheduling and resource allocation), finance (automated trading) and Internet applications (recommendation systems, advertising, social networks). With the advent of modern, low-cost techniques that allow us to sense and store large amounts of dynamic data, it is of interest to investigate how we can design large-scale, data-driven automated systems that can exploit available information to optimize metrics of interest.

3. What do you do apart from research?

I try to keep up a long-distance running routine, and occasionally swim in the wonderful IISc pool. Other interests are playing the guitar and cooking at home!

Parimal Parag

1. Could you tell us a bit about your educational background?

I was in five year dual degree program at IIT Madras, at the end of which in July 2004, I obtained my Bachelor of Technology and Master of Technology in electrical engineering, with specialization in communication systems. I received my PhD in Electrical and Computer Engineering from Texas A&M University in December 2011.

2. What are the research questions that excite you, and why do you like them?

I am excited about theoretical questions in communication and computation over networks. Networks are fascinating objects, and are of interest to engineers and scientists in equal measure. There are many theoretical questions in this domain, whose answers can have major impact on future networked systems.

3. What do you do apart from research?

Apart from research, I have dabbled with volleyball, surfing, and field hockey with varying degree of incompetence.

Himanshu Tyagi

1. Could you tell us a bit about your educational background?

I received my PhD from University of Maryland, College Park. Prior to that, I did a dual degree in Electrical Engineering from the Indian Institute of Technology, Delhi. I also spent 2014 as a post-doctoral researcher at the Information Theory and Applications center of UCSD.

2. What are the research questions that excite you, and why do you like them?

I am interested in information theory in general. In particular, I work on problems that lie at the intersection of information theory and cryptography, theoretical computer science, statistical learning, and control. Broadly speaking, I like to work on engineering problems where clean mathematical formulations can lead to a notion of optimal performance.

Kausik Majumdar

1. Could you tell us a bit about your educational background?

I have a Ph.D. from Indian Institute of Science, an M. Tech from Indian Institute of Technology Delhi and a B.E. Jadavpur University.

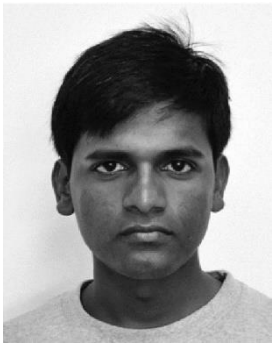
2. What are the research questions that excite you, and why do you like them?

There are many, and they keep changing with time. Currently interested in making alternate switches for very low power computing.

3. What do you do apart from research?

Plenty of stuff – and again they keep changing quite frequently

Aditya is an Assistant Professor in the Dept.



Parimal is an Assistant Professor in the Dept.

Himanshu is an Assistant Professor in the Dept.

Kausik is an Assistant Professor in the Dept.

Rajiv Soundararajan

1. Could you tell us a bit about your educational background?

I did all my schooling in Chennai at PSBB Senior Secondary School. I got my bachelors from BITS Pilani in 2006 in Electrical and Electronics Engineering. I then went on to get my masters and doctoral degrees in Electrical and Computer Engineering from The University of Texas at Austin.

2. What are the research questions that excite you, and why do you like them?

I primarily work in the area of image and video quality assessment where we are interested in the predicting the quality of visual signals in the way humans perceive them. This problem becomes even more challenging when we are only presented the distorted image or video and have no knowledge of the original. The part about this research area that excites me is that a perceptual question is addressed through objective algorithms using tools from statistics, signal processing and visual neuroscience. In addition to image and video processing, I am also interested in information theory. Here I like to understand the fundamental limits of lossy compression in multiterminal systems.

3. What do you do apart from research?

Apart from research, I enjoy singing Carnatic music occasionally. I also keenly follow cricket and play tennis.

Rajiv is an Assistant Professor in the Dept.

Events and Achievements

Catch up with latest events, feats and achievements by faculty and students of the Department

The seventh **International Workshop on Signal Design and its Applications in Communications (IWSDA'15)** was held in the Department from September 13 –18, 2015. The IWSDA workshop series dates back to September 2001 in Chengdu, China, and since 2005 has been held every 2 years in Yamaguchi, Japan, Chengdu, China, Fukuoka, Japan, Guilin China, and Tokyo, Japan, respectively.

A special feature of this particular workshop was it celebrated the 60th birthday of Prof. P. Vijay Kumar.

Faculty achievements

M. Ashok Kumar and Prof. Rajesh Sundaresan's paper titled "Relative α-Entropy Minimizers Subject to Linear Statistical Constraints" has won the Best Paper Award in NCC 2015 held at IIT Bombay.

The paper "A reduced order model for electromagnetic scattering using multilevel Krylov subspace splitting" by Neeraj Kumar, K.J. Vinoy and S Gopalakrishnan won the 2015 Ulrich L. Rohde Innovative conference Paper Award at the 2015 IEEE International Conference on Computational Electromagnetics at Hong Kong Feb 2-5, 2015.

Prof. Bharadwaj Amrutur has been awarded with the 2015 INAE Fellowship.

Prof. Gaurab Banerjee awarded the 2014-15 Visvesvaraya Young Faculty Research Fellowship from DeITY.

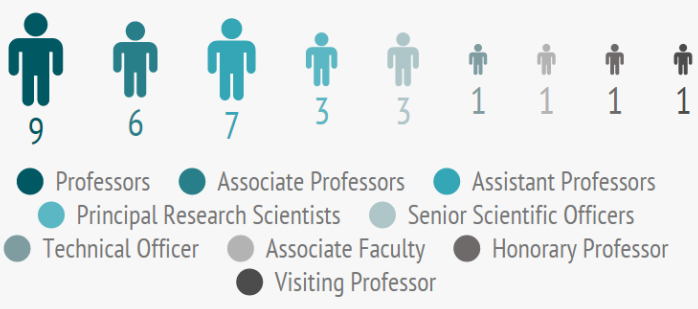
Student achievements

"Stack Analyze" a cognitive app designed by Sagar G. V. and Bhargava Srivatsa gets into Top 5 projects in IEEE/IBM Watson Showcase Competition. The award includes a cash prize of USD 2000. Sagar and Bharghava are PhD research scholars at Embedded Sensing, Communications and Processing Lab lead by Prof. Bharadwaj Amrutur.

Geethu Joseph, PhD student working with Prof. Chandra R. Murthy in Signal Processing for Communications Lab has been awarded the 2015 Intel Fellowship.

Nikita Ambasana, PhD student working with Prof. Dipanjan Gope, wins the Software Demonstration Prize at EPEPS 2015 held at San Jose.

Department's faculty strength



Snapshots from the Department

List of Research Theses defended since January 2015

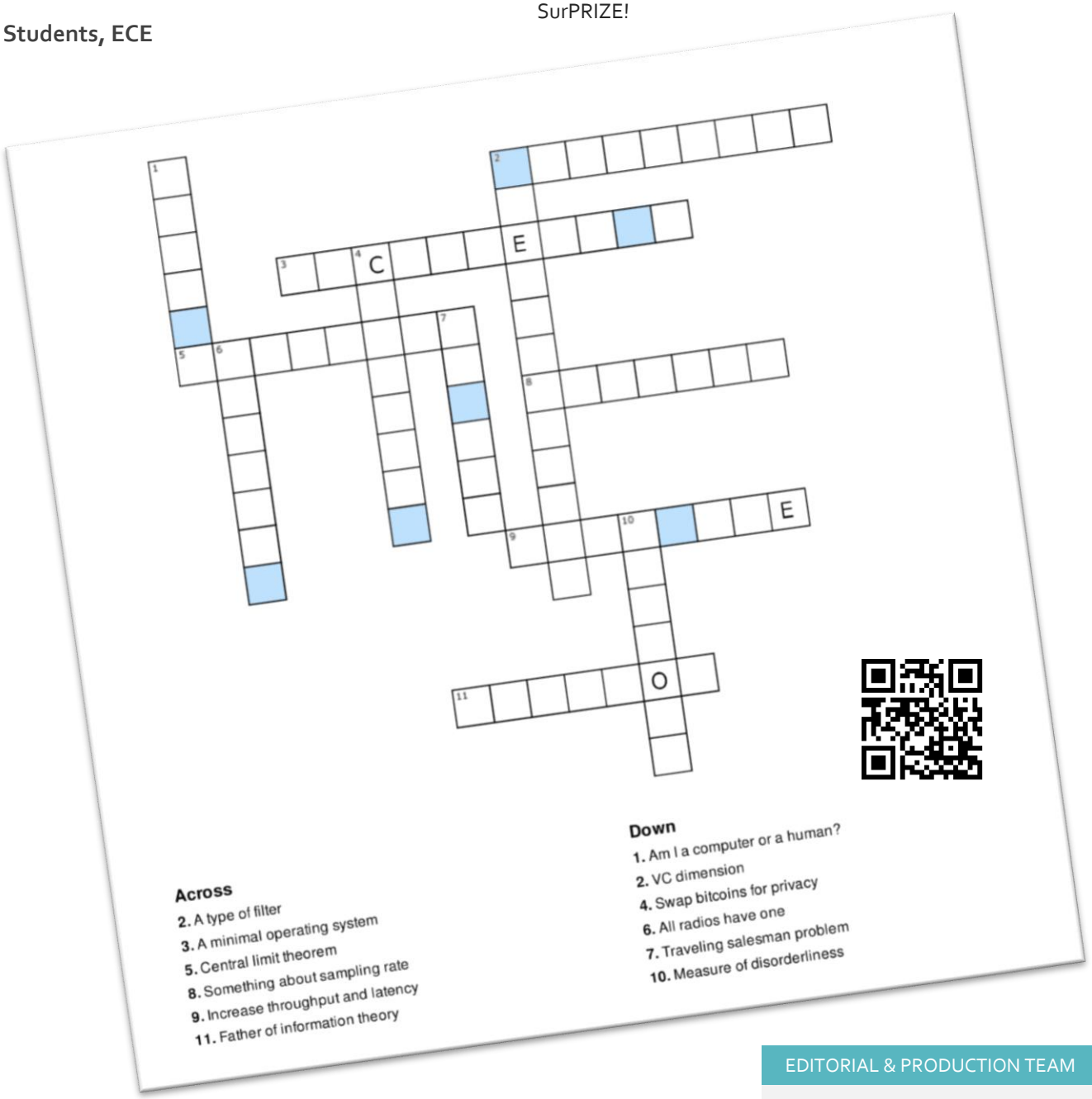
No.	Name of the Student	Programme	Title	Advisor
1	Abhay Sharma	PhD	Finding a subset of non-defective items from a large population	Chandra R. Murthy
2	Amit Kumar Dutta	PhD	Transceiver Design based on the Minimum-Error-Probability Framework for Wireless Communication Systems	K. V. S. Hari
3	Ananya	MSc (Engg.)	On the best-m feedback scheme in OFDM systems with correlated subchannels	Neelesh B. Mehta
4	Arijit Ghosh	PhD	Dynamics, Fluctuations And Rheological Applications Of Magnetic Nanopropellers	Ambarish Ghosh
5	Arpan Chattopadhyay	PhD	Sequential Decision Algorithms for Impromptu (or "As-You-Go") Deployment of Wireless Sensor Networks	Anurag Kumar
6	D. Meena	PhD	WDM Based Optical Link for Multipoint Distribution of Hybrid Signals in Phased Array radar applications	T. Srinivas
7	Dinesh Dileep Gaurav	PhD	Algorithms for Homogeneous Quadratic Problems and Applications in Wireless Networks	K. V. S. Hari
8	Kaushik Ghosal	PhD	Power Scaling Mechanisms for Low Power Wireless Receivers	Bharadwaj Amrutur
9	Krishna Murthy	PhD	Physical Layer Impairments aware Transparent Wavelength Routed and Flexible-Grid Optical Networks	T. Srinivas
10	Lalitha Prasad	PhD	Coding Schemes for Distributed Subspace Computation, Distributed Storage and Local Correctability	P. Vijay Kumar
11	M. Ashok Kumar	PhD	Minimization problems based on a parametric family of relative entropies	Rajesh Sundaresan
12	M. N. Sujatha	PhD	Analysis of Printed Periodic Structures and Their Applications in Antennas and Absorbers	K. J. Vinoy
13	Manikandan R. R.	PhD	Low Power and Low Spur Frequency Synthesizer Circuit Techniques for Energy Efficient Wireless Transmitters	Bharadwaj Amrutur
14	N. Prakash	PhD	Codes with Locality for Distributed Data Storage	P. Vijay Kumar
15	Parthajit Mahapatra	PhD	Fundamental Limits of Communication in Interference Limited Environments	Chandra R. Murthy
16	Pritam Som	PhD	Performance Analysis of Space Shift Keying in Cooperative Relaying Systems	A. Chockalingam
17	Ranga Prasad N	PhD	On the Sum-Rate Capacity of Gaussian X Channels	A. Chockalingam
18	Ranjitha Prasad	PhD	Sparse Bayesian Learning for Joint Channel Estimation and Data Detection in OFDM Systems	Chandra R. Murthy
19	Sainath Bitragunta	PhD	Optimal Amplify-and-Forward Relaying for Cooperative Communications and Underlay Cognitive Radio	Neelesh B. Mehta
20	Sanjay Vishwakarma	PhD	Transmitter Optimization in MISO and Relay Wiretap Channels for Physical Layer Security	A. Chockalingam
21	Sooraj K. Ambat	PhD	Fusion of Sparse Reconstruction Algorithms in Compressed Sensing	K. V. S. Hari
22	Srikanth Pai	PhD	Classical Binary Codes and Subspace Codes in a Lattice Framework	B. Sundar Rajan
23	Vikas Kumar Dewangan	PhD	Role of Power Control in Enhancing the Performance of Opportunistic Selection Schemes	Neelesh B. Mehta

Crack this Crossword

by **Sagar GV, Srivatsa Bhargava and Tarun Choubisa**

PhD Students, ECE

Solve the anagram from the letters in the shaded squares and post your answer online by following the link in the QR code. All correct entries will enter into a lucky draw for a shot at a SurPRIZE!



From the Press

The Department's work has been regularly featured in the print media.
A select snapshots from the press is presented here.


THE HINDU

» TODAY'S PAPER » SCI-TECH & AGRI

Published: June 4, 2015 00:00 IST | Updated: June 4, 2015 06:02 IST June 4, 2015

Rat brain cells power a computer

• Mohit M. Rao

Cells from rats' hippocampus were used. – Photo: Sushil

A rat trained to control a robot is an interesting 'Pavlovian navigate through an obstacle seems straight out of science f.

Having cultured brain cells on a glass plate and kept in sterili demonstrated that this tissue culture can read signals from an appropriate, accurate solution.

BangaloreMirror

MUMBAI MIRROR | AHMEDABAD MIRROR | PUNE MIRROR

PUTTING THE INTERNET OF THINGS TO WORK WITH WATER

Bangalore Mirror Bureau | Jul 28, 2015, 04.00 AM IST

2015 2022

Sensor-based system to detect forest intruders

Bengaluru: A team of IISc researchers has come up with an infrared sensor-based system that can detect intruders in forests, by distinguishing their movement that of animals.

CLOSE WATCH

oscillations of the vegetation," principal researcher Prof Vijay Kumar said.

For every signal detected, the system does two rounds of classification: First to differentiate between vegetation

EDITORIAL & PRODUCTION TEAM

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