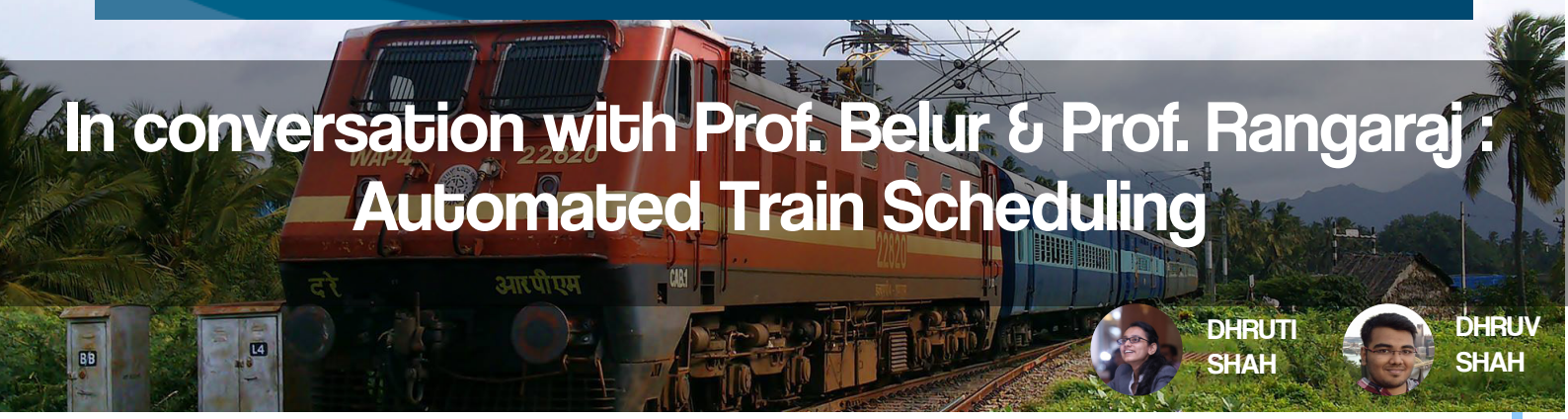
BACKGROUNDHUM

DEPARTMENT OF ELECTRICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY



In conversation with Prof. Belur & Prof. Rangaraj : Automated Train Scheduling

DHRUTI SHAH

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Prof. Madhu Belur has been with the Electrical Engineering Department since 2003. Although his primary research area is in the domain of Control Theory, his research has blurred boundaries between different branches of Engineering. The present research underlines the importance of the contribution the academic world can make to improve daily lives.

An avid traveller himself, Prof. Narayan Rangaraj of Industrial Engineering and Operations Research Department has always taken a keen interest in improving transportation in India. No wonder he has done a large number of projects for the largest transportation network in the country - The Indian Railways. This is just another chapter in his commitment towards the improvement of this massive network.

The Times of India Feb 17, 2017

"Central Railway's chief public relations officer Narendra Patil told Mumbai Mirror that they had been working on this project with the IIT professors for the last two years. 'This will not only help us in more efficient and easier planning but also give us a lot of options for adopting time tables for suburban operations according to our needs', added Patil."

Every other news company around the country has been talking about this. Did you anticipate this feedback?

NR: All the uproar was completely unanticipated. It may happen. The work has reached a certain stage where its prospects are being appreciated. It was a routine meeting, albeit the press interaction at the end, which eventually led to outburst of the news. Maybe after another six months, one could write about it if the system is implemented in a certain way. In July, when the annual charting of the time table takes place, we would be happy if they actually use our methods, and are happy with it. Right now, it is being tuned and fine tuned, but the potential has been shown to them.

How long have you been involved with this project?

MB: About two years on the current version of the system, for scheduling. We have been involved with railway scheduling for a much longer time, though.

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NR: I took a sabbatical from IIT Bombay in 2000 and spent it with the Railway Staff College, Vadodara, interacting with the people in the domain and trying to understand their requirements. My specific interest in railway operations has been present for at least the last 15 years.

Can you talk about some recent additions in the algorithm, that were not previously implemented, or accounted for?

NR: At the current stage, our program is in a position to provide a draft timetable covering all the important aspects, including timings of trains, deploying of rakes, distributing coaching units to different services, platform allocation and services at the terminals. We are able to present all the operating documents in a unified way, as a draft, depending on what you want to achieve with the timetable. This has happened for the first time, and the railways are pretty happy about it as they can now potentially try out a couple of different options in a fairly quick manner. Otherwise, the draft timetable would generally take about 2 weeks to prepare, with inputs from highly experienced officials.
At least, now they can verify and test out certain arrangements using our package in a fairly quick manner. The draft suggested by the algorithm is sort of foolproof and can be easily verified by their decision maker, speeding up the process by a great factor. All the constraints which have to be met can be pre-specified, and different arrangements can be checked for feasibility and planning inconsistencies. This is something that has not been implemented on a problem of this scale, till date.

What were some of the aspects that were overlooked in the previous methods, that have not been addressed?

NR: One of the major issues with the current system is that there was no algorithm as such, and despite the system being very sophisticated, the railways were highly dependent on human intelligence, built over a number of years. What was lacking was they had never written down all the constraints and requirements in a formal way, the way we tackle problems. But it is key to note that the output was not shoddy or suboptimal. For one of the largest railway networks in the world, the planning is amazingly executed.

What led to your persistent interest in the Bombay Suburban Railway Network?

NR: The Bombay Suburban network amazed me with its throughput and the variety it is able to serve - different orders of trains, customers and speeds, all keeping the prices affordable. We have a long way to go, in safety certainly, but we provide something at very affordable rates, and to a very large number of people. The technology needs some big upgrades.

"I've been interacting with the Railways for the last 25 years. Anything to do with railways is of interest. The question boils down to finding right person with whom you can interact and discuss the requirements."

Were there any students involved in this process?

NR: Right now, Soumya Dutta is actively involved with us in the process. Many other students have been involved over the years. Shashank, a Dual Degree student in Mechanical Engineering department had also put in a lot of effort in the earlier stages. Apart from this, we have had input from some public interest groups who are interested in tasks like scheduling. All this started when the Bombay High Court had instructed the Railways to seek technical advice, because they received a PIL accusing the Railways for suboptimal output.

Soumya Dutta: In Europe the main concern is quality of service, rather than quantity and the catered audience. Most of them talk of robustness. But in India, the purpose of the railways is kind of different - we need to provide as many services in as little time as possible. For the suburban network, it is crucial to ease the rush on the stations and in the trains. The Bombay, Kolkata and Chennai Suburban Network accounts for 7% of track-length in India, but the passenger count is almost 50% of the number of all the Indian Railways caters. That gives an estimate of the rush the three main suburban services (Mumbai, Calcutta, Chennai) have to address. So if the scheduling has to be periodic, it can get very difficult to manually compute all the timings. For this reason we decided to create a mathematical model for it, solving which we get a feasible timetable solution.

How did you come across this use case of the Bombay Suburban?

NR: I've been interacting with the Railways for the last 25 years. Anything to do with railways is of interest. The question boils down to finding right person with whom you can interact and discuss the requirements. This was not a major issue since I have been involved with the Railways since long. K.N. Singh has been our collaborator in the Railways, along with Gopalakrishnan (from the Western Railways), OP Yadav and SV Naidu. C Sebastian, who have been involved with the timetable generation till now, have been a great help in understanding the constraints and parameters.

What are the future prospects of this algorithm and how soon do you expect to see this implemented, in practise?

NR: We are still engaging with them, trying to provide a robust interface in which they can specify their constraints etc. In the current stage, it is very data-intensive and technical, not like your regular user-friendly "app". We hope to achieve this by May, and present it to the Railways. Once they are convinced of its potential, we can use it to reduce their work by assisting, if not taking over completely. Recently, CRIS (Centre for Railway Information Systems) has also showed interest in our project.

How did you convince railways to actually adopt this proposal?

MB: The Railways has been interested in this since a long time. They are convinced that Prof. Rangaraj here understands their requirements, a result of decades of communication and interaction. In general, if we develop something and the railways does not use it, it is more of our fault than theirs, as we could not address their requirement well. It is not right that we make something for publishing sake and leave it at a prototype stage. But Prof. Rangaraj had been closely involved in this and made sure that we addressed the real problem at hand.
An important thing to note here is that unlike what the news articles said, we did not "show" the Railways how this can be done. It has been the output of continuous involvement from both sides and an exhaustive process of proposals and feedback, that has resulted in this end product.

You were also the Dean of AP. How did you manage both, administrative work along with your research?

NR: The administrative job is just about a position where I have to coordinate various things; the support of the staff of over 40 people at the academic office comes handy. There were a lot of meetings to attend, but the bulk of the work was done by the academic office staff. I had been involved with the launching of the new B. Des. and the EMBA program. Another highlight of the tenure was the proposal regarding Bachelor of Science program in Economics, which is being discussed. Apart from this, routine updates of the program structures and troubleshooting became a part of my work. The administrative setup is ever-growing, but not an unmanageable task, if done the right way.

Along with this newsletter, we also have an online blog which is hosted at:

https://backgroundhum.wordpress.com.

Do go and check it out!
Your suggestions and feedback are welcome and highly valuable. You can contribute to the blog and make it even more useful.
For that and any other queries, feel free to contact any of our members or drop us a mail at:

eebackgroundhum@gmail.com.

TEAM Bh

Automatic Speech Recognition

and Its application

SAURABH KUMAR

Recently with the launch of Google Assistant, several of us have a personal assistant right in our hands, always available to answer various questions we might have on the go. It can remind us about certain facts we ask it to remember along with letting us set reminders for tasks. Live traffic conditions, nearest shopping mall, hospital, place to go grab a cup of coffee, Flight delays, and a lot of other things right at our fingertips. A few of other big tech giants have also stepped into this field to offer their flavour of the mobile assistant, like Amazon and Microsoft, with Apple being in the market from much earlier.

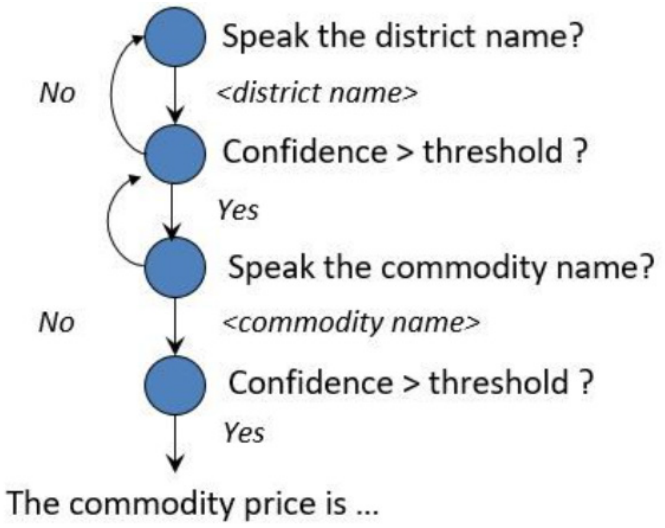
Have you ever wondered how these personal assistants like Siri/Cortana and the Amazon Echo/Alexa and Google Home, listen to you and respond accordingly? Also given a choice would you prefer a computer taking down notes or writing an article while you dictate the same to it rather than manually typing it all out and correct both the syntactical and semantical errors?

BH speaks to Hitesh Tulsiani from the Digital Audio Processing Lab about these technologies and his research.

The basic building block of such systems lies in Automatic Speech Recognition (ASR) technology, which converts speech to text using various digital signal processing and machine learning techniques. ASR has two major components: (i) The Acoustic Model and (ii) The Language Model. The acoustic model basically maps the long audio to phones, which is the smallest possible speech unit whereas Language model puts a constraint on the sequence of words that can occur in a particular language.

Here is one of the applications of ASR technology developed at the Digital Audio Processing(DAP) Lab of our department. In this application, the motive is to help farmers acquire the prices of various commodities traded in different districts of Maharashtra using spoken queries through their mobile phones in the Marathi language.

The researchers have set up a server at the DAP-Lab, where the farmers can call and query the commodity prices in real-time. To achieve this, they have designed a simple call-flow which asks for district and commodity information and subsequently plays out the price which is crawled from a government maintained website. Also, as with any other system, their ASR system is also prone to errors and hence after every response by the farmer, it is checked if the recognised text has a confidence value above some threshold. If yes, the system asks the subsequent question else the same



question is asked again. The research challenges ahead are to get the system to be robust to background noise and to the large variety of speaking accents encountered.

Recently, they have also started providing weather forecast information to help farmers plan their crops accordingly.

Wanna test this system, just give a call to 022-25720116 !

Know Thy Professor

Professor Rajesh Zele is the alumnus of IIT Bombay, having completed his B.Tech. in 1989. He joined IIT Bombay after 22 years of industrial experience.
Before joining IIT, Prof. Rajesh Zele was the Director at MaxLinear, developing the next generation CMOS RF and Mixed-Signal SOCs for Digital Cable and Satellite Communications. Dr. Zele has also served as the Vice President of MindTree, leading the team for Bluetooth and short range wireless transceivers.

AKASH MUKHERJEE

SAURABH KUMAR

Well most of the time, the biggest question I get asked is 'What drove you to come back to India and join IIT Bombay?' And my answer has been quite elaborate. I graduated from here more than 25 years ago. I did my graduate studies in the US. Since then I've worked in several companies. I did my own start-up in India and worked in many start-ups in the US as well. I enjoyed working in the corporate environment. I got to do quite a few new things during my time. Some days, it was developing a new design centre, other days it was lifting off a new company. But I was always involved in the technical work. I have done many chips that I'm proud of. Some of them are used widely; in fact some of you might be using a few of them in the devices around you. My area of interest has been in the RF/Analog/ Mixed Signal Circuit Design.

When I was here at IITB, I was part of the Micro-Electronics group lead by Prof. Chandorkar, Prof. Vasi and Prof. Lal, the great trio of our time. When I went to the US, I had an awesome professor, Prof. David Allstot who steered me towards circuit design. If you look at the area of IC design, over the years there's been a lot of automation. However there's one area; RF/Analog/Mixed Signal circuit design where you just can't do that because of the complexity and the human effort involved. Every single chip that you create is a piece of art requiring so many disciplines working together. Extremely difficult to replicate exactly. The art of RF/analog design isn't something that you can pick up in a short time and be consistently good at it. Every chip that you tape-out teaches you new lessons when it comes back from the foundry and you start testing it in the lab. Especially what not to do. (Laughs).

When you work in this area for so long, you pick up all these subtle nuances of design learning from the absolute Masters of the craft. However, all the knowledge that you gain is mostly restricted to a close-knit community of designers and I felt the need to disseminate that knowledge and influence young minds. I joined back in September last year. I had a great time teaching RF Microelectronics class last semester. Students here are extremely sharp. They surprised me many times. This semester I am teaching CMOS Analog IC design. I tell many stories in the class from my professional experience. I think the students like that. That's why the classroom is packed and alive; many times with laughter.

On the research front, there're many areas which we could start attacking and publishing. So many new things can be done in the very high frequency design space. But my focus has been to pursue ideas which will make a difference to India. All the projects that I'm working on with my students have been specifically targeted keeping the national interest in mind. I tell my M.Tech. and Ph.D. students that whatever they work on, they have to develop something new. I always push my students to work as a team player. Because in the real world, you rarely work alone. You are always part of a team. It is really important to be conscious about it. I'm on a mission to create students who are absolute professionals in their field. When you go out into the real world, it is very important how you carry yourself. I'm trying to instil that among the students right at the start. This is really an interesting aspect of my job and I'm loving it so far.

The art of RF/analog design isn't something that you can pick up in a short time and be consistently good at it. Every chip that you tape-out teaches you new lessons

The buzz around millimetre waves circuits and systems

AKASH MUKHERJEE

The history of millimetre-wave (mm-wave) research in India dates back to the time of Sir Jagadish Chandra Bose who first demonstrated their utility by controlling the firing mechanism of a gun at Calcutta Town Hall in 1895. The instruments in his setup were made by Sir J.C. Bose himself and even though were highly advanced for their time; they were limited by the inherent technological constraints of their age. But times have changed, and along with it; technology. Large metallic resonators used to generate mm-waves over a century ago have been replaced by monolithic silicon ICs no bigger than a coin. Although miniaturizations of mm-wave generation and processing circuits have been carried extensively; new challenges have cropped up that need to be solved.

Circuits at mm-wave frequencies (30GHz-300GHz) have been (and are projected to be) used in a myriad range of applications from medical imaging and non-intrusive body scanners (for e.g. X-ray scanner which are harmful) in public spaces (airports, malls etc.) and from vehicular radars to smart self-driving cars. The largest application area, however, is prospected to be the area of cellular data communications as part of the 5G technology framework. High-frequency millimetre waves with large bandwidths (in several GHz) are well suited for high data rate (>10 Gb/s) information transfer. The fact that the 57-64 GHz band is unlicensed in most countries around the world also serves as a tremendous motivation for exploration into mm-wave circuits and systems.

The concept of using mm-waves for the above applications has always been popular and their advantages were well known. The reason they were not in widespread use until now is that of problems that are much deeper. Millimetre-waves correspond to extremely high frequencies. Making a circuit work reliably at those frequencies is a challenge in itself due to all the extra parasitic effects that come into play. Device models provided by the fabrication foundries are validated only up to certain frequencies which fall well below the mm-wave range. Moreover, at such high frequencies, the behaviour of most devices and components deviate from their ideal nature by a fairly large margin. Since CMOS technology had become cheap and reliable; researchers were looking for ways in which to generate and process mm-waves through CMOS monolithic ICs. With each generation of device scaling, as MOSFET devices became smaller and smaller, their maximum operable frequencies increased well into the mm-wave range. Also, a large number of foundries now provide separate mm-wave device libraries and models for use which are usually validated up to(and sometimes even beyond) 100GHz. Thus, a quantum leap in technology (CMOS processing, fabrication, modelling etc) has enabled us to explore mm-wave CMOS circuits in greater depth than ever before.

Mm-waves have been used in a myriad range of applications from medical imaging and non-intrusive body scanners in public spaces (airports, malls etc.) and from vehicular radars to smart self-driving cars

Here at IIT Bombay, current research work is being carried out by Sivaramakrishna (Ph.D.), Girish Tiwari (MTech) and Akash Mukherjee (MTech) under Prof. Shalabh Gupta. The idea is to design, fabricate and test a wideband CMOS 60GHz Phase Locked Loop (PLL) chip. The proposed PLL would be used as part of a 60GHz transmitter based on polar modulation technique. The large frequency range of the PLL would be made possible by a wide tuning range quadrature phase oscillator which would operate in the mm-wave range with a centre frequency of 60GHz. Besides the oscillator, highfrequency Miller divider circuits operating in the mm-wave range are also being designed. The circuits are to be taped out soon and the fabricated chips are expected by February 2018. The proposed transmitter has been targeted to achieve data rates of 10Gb/s.

The field of mm-wave analog circuits and systems has witnessed a steady increase in both interest and involvement over the past few decades. With time, this enthusiasm will only intensify. Millimetre-wave technologies are predicted to open up new sub-areas of research and application and further allow unprecedented access to new ideas and insights that will help us to create better wireless systems than ever.

Department Facilities Trivia

SAURABH KUMAR

Our department, being the largest among all the others in the institute, offers various facilities to its students and faculty. In this article, we present highlights of a few of these facilities you might be unaware of and should certainly try to make the most of during your stay.

Being a student or a faculty one can find himself doing a lot of modeling and simulations which require a lot of computing resources. The department SysAd room houses two high performance compute nodes, a 4 core - 16 GB RAM machine named Ravan (10.107.1.5) and a new 24 core - 32 GB RAM machine dubbed Rudra (10.107.1.6). These servers are equipped with Nvidia GPUs and common software like Matlab 2015 and CUDA. These servers are available to all the students and faculty and can be accessed via the EE credentials. The students are offered a storage of 500 MB,

1 GB, and 1.5 GB for B.Tech, M.Tech, and Ph.D. scholars respectively. Faculty can request for storage on an on-demand basis.

Doing all this interesting work, one would certainly want to portray it out to the world. Although there are platforms like LinkedIn and GitHub, they sure don't make up for having your own web page and that too on the ee.iitb.ac.in domain. SysAd room offers this facility of making your own web page and hosting it on the EE website. All one needs to do is build a web page and contact the SysAds for enabling it. This is as simple as it can get. After this, you can edit it any number of times and all the changes will reflect on your homepage. The SysAds also provide a template you may choose to use for getting started with setting up your homepage. All the Labs in the department are also offered web hosting space for their websites similarly.

Talking about the PC Lab, the favorite meeting spot for a lot of student groupconversations and the place to slog out during exams. PC Lab is managed by the Research Assistants in the Sysad room located right next to it. The Lab houses a total of around 30 PCs equipped with both Windows and Ubuntu Linux. All the PCs are equipped with a lot of useful software one can use from anywhere in the institute, without needing to install them on their own computers. Ten computers among these are also equipped with Nvidia GPUs along CUDA toolset and Cilk compiler for parallel computing. Below is a small list of what all are available:

- Matlab 2008
- GNU Radio
- GHDL
- PSpice
- Ngspice
- Quartus
- CUDA

There is also an information entry portal for the faculty to keep a database of all their publications, projects, seminars, awards and more. The entered data then automatically reflects, in an organized format, on the faculty web pages. Another similar facility is currently under development and will soon be available to the research scholars of the department as well.

Apart from this, the SysAd room can help you out if you need access to data from a foreign university FTP servers. This might require faculty permission though. Also, the @ee.iitb email addresses are managed by them. Everyone associated with the department usually gets an EE mail id when they join, which lets them access these facilities. If you don't have one, you can contact the SysAds to get your own!

For more info visit:
https://www.ee.iitb.ac.in/pclab