A Memorable Trip

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It was my first trip to the US. It had not yet sunk in that I had been chosen by ACM India as one of two Ph.D. students from India to attend the big ACM Turing Centenary Celebration in San Francisco until I saw the familiar face of Stephen Cook enter a room in the hotel a short distance from mine; later, Moshe Vardi recognized me from his trip to IITB during FSTTCS, 2011. I recognized Nitin Saurabh from IMSc Chennai, the other student chosen by ACM-India; 11 ACM SIG's had sponsored students and there were about 75 from all over the world.

Registration started at 8am on 15th June, along with breakfast. Collecting my 'Student Scholar' badge and stuffing in some food, I entered a large hall with several hundred seats, a brightly lit podium with a large screen in the middle flanked by two others. The program began with a video giving a brief biography of Alan Turing from his boyhood to the dynamic young man who was to change the world forever. There were inaugural speeches by John White, CEO of ACM, and Vint Cerf, the 2004 Turing Award winner and incoming ACM President. The MC for the event, Paul Saffo, took over and the panel discussions and speeches commenced. A live Twitter feed made it possible for people in the audience and elsewhere to post questions/comments which were actually taken up in the discussions. Of the many sessions that took place in the next two days, I will describe three that I found most interesting.

***Panel Discussion*: Turing, the Man**

The panellists in the first session of the event were all directly or indirectly associated with Turing. 91 year old ACM veteran Kelly Gotlieb met Turing regularly when in Manchester; Wendy Hall was in King's College during the last days of Turing and Charles Bachman personally met and interacted with Turing's mother Sara Turing. The last speaker, William Newman (well known for his book on graphics with Bob Sproull), had seen Turing frequently during his school days as his father, Max Newman the mathematician, played a very important role in Turing's research career. I came to know that the first biography on Turing was written by his mother in 1959 (Cambridge University Press has brought the book back into print for the Turing Centenary year). This biography formed the basis for the most scholarly biography of Turing by Andrew Hodges. About the Turing award, Bachman narrated an interesting anecdote: when Sarah Turing first heard about the Turing award (years after Turing's death), she thought it was probably a running award given in the children's school that Alan went to! In the discussions I learnt that Turing is also regarded as the father of Chaos Theory and his work on the mathematical foundations of morphogenesis still remains as one of his most influential papers!

How did ACM choose to institute an award in Turing's name in the 1960's when he was not well known then? According to Kelly Gotlieb, it was the importance of artificial intelligence at the time that brought Turing to the public eye. Dana Scott added that during that period in the US, there was a lot of work on logic and recursive function theory and people like Stephen Kleene held Turing and Turing machines in high esteem.

The second interesting question was why Church's lambda calculus is not as popular as Turing machines as a model of computation though it was proposed a few years earlier. Dana Scott felt that Turing started from first principles (as opposed to Church's more abstract formulation) and that is what caught everyone's attention. Moshe Vardi agreed that while lambda calculus, recursive functions and Turing machines are all equivalent, the last is the only one which really modelled the

mind of the problem solver and was thus much more convincing than the other formalisms.

The third interesting question was: How would computing have changed if Turing was alive? Kelly Gotlieb believes Turing would have tackled the problem of large data which is so important these days. Keith van Rijsbergen believes that Turing would have taken up quantum computation since Turing had bought von Neumann's book on the foundations of quantum mechanics when leaving school and had returned to the subject in his last few years. In a later speech, Leslie Valiant said he regarded Turing as a natural scientist, so Turing would have continued the work on biology he had begun a few years before his death.

Panel Discussion: **Human and Machine Intelligence**

This session immediately followed the first session. The panelists were Raj Reddy (the only Turing award winner from India), Ed Feigenbaum and Judea Pearl (the 2011 Turing award winner)

The moderator Barbara Grosz introduced the panellists and started the discussion by pointing out that through his legendary seminal paper on AI, Turing not only raised the philosophical question of `Can machines think?' but also replaced it with an operational one, namely `Can a machine play the Imitation Game (the Turing Test) in a manner indistinguishable from a human?'. Ed Feigenbaum said that Turing's belief, even in those very early stages of computer science, was that computers need not be used only for calculating and could in fact 'perform any task a human can carry out'. He referred to Donald Michie who had been with Turing during the Bletchley Park days and said that Turing convincingly argued for a behavioural definition of intelligence - intelligence *is* as intelligence *does*: this has been the principle that has guided the success of AI. Feigenbaum also talked about the Knowledge vs Search problem. AI research initially focussed on search techniques but the focus shifted to the knowledge base paradigm and knowledge representation has become a central subject in AI. Raj Reddy made a very interesting point about experience (read knowledge), namely that experience translates a lot of reasoning (read search) to recognition and then the latter mostly is instantaneous. For lots of things, we hardly do any reasoning at all – it's all instantaneous recognition. It's only to prove difficult theorems that we sit down and cogitate. In support, Ed Feigenbaum was emphatic that almost everything that constitutes human behaviour is stored in the mind and retrieved by the recognition process Raj Reddy talked about and almost none of it is done by reasoning except in a shallow way.

Finally Judea Pearl had the highly philosophical view that the quest to make machines think is really the result of our quest to understand ourselves, and what better way to do that than emulate ourselves in a machine! He also believes that a lot of his research thus far has been guided by the simple question: if humans can do it, then it can be done, so why can't machines do it?

After lunch, I was hurrying to a session when I caught up with Donald Knuth and introduced myself. He looked at me up and down and said he didn't take students taller than him in his classes (we're about the same height)! On asking about his volumes on the Art of Computer Programming, he said that it was his life's most important project and that he was currently on Volume 4B.

During a panel discussion on the Turing Computational Model, Moshe Vardi asked what the panellists (and later the audience) felt about the P = NP question and, unlike the others, Donald Knuth remarked that he wouldn't be surprised if P = NP. His reasoning was a bit hard to grasp: `There could very well be a poly-time algorithm for an NP-complete problem just because there might be only finitely many reasons for it not to exist!' Quoting Mike Paterson from the 70s, Knuth said that all of NP could very well be P, but P then would contain two kinds of problems - one

which we *know* how to solve in polynomial time and the other which we *don't* (and possibly never will) know how to solve in polynomial time! Moshe Vardi added that Dick Lipton and Michael Rabin also shared that view.

Panel Discussion: **The Algorithmic Universe**

(This session took place on the second day, 16th June. The panellists included Donald Knuth, Leslie Valiant, Leonard Adleman, Richard Karp and Robert Tarjan and was amusingly moderated by Christos Papadimitriou.)

After an entertaining introduction by Papadimitriou of the luminaries, the session began with Knuth talking first about the spelling of `algorithm'. In 16 CE, it was called `Augrime' (and Knuth held up a mini-poster for everyone to see) which underwent changes over time to morph into the word `algorithm'. He spoke about how it has been his passion to look at all things in an algorithmic way, citing even his music lessons as an example, and believes that this paradigm of thinking will be the way of the future. Valiant, as well as Adleman and Karp, emphasized how computer science has had connections with the natural sciences since its earliest days; Valiant believed that Turing was deeply interested in natural phenomena as shown by his interest in physical, biological and cognitive phenomena. Karp said that the earliest computers built by von Neumann's group were designed to solve problems in the sciences, for instance those related to nuclear weapons, weather prediction, biology and the brain. In fact, von Neumann was so impressed with the idea that humans could reproduce themselves that it led him to formulate the theory of self-reproducing automata. Both Adleman and Karp pointed out that computation is ubiquitous and not just restricted to the technological gadgets that we use. The theory of computation can yield insights into even naturally occurring computation thus providing valuable additional information to the physical scientists. Valiant and Karp emphasized that Turing's balanced approach towards knowledge was why he was so successful, something we would do well to emulate though Karp pointed out that since biologists do not talk our language, this must be done with caution.

Finally Tarjan ended on a philosophical note: luck favours the prepared mind and young people should follow their hearts, read well and challenge and question what they read.

This was followed by some very interesting questions. On being asked if there could be another Turing today, Karp quoted Sanjeev Arora (winner of the ACM-Infosys award for 2011) saying that current day CS is like 19th century mathematics where the field is possibly still just manageable for a single person to know. Dana Scott asked if one can recognize computational thinking when it is happening. Knuth replied that it was possible: he was reading the translation of a 13 CE Sanskrit text on music in which it was clear that the author was doing algorithmic thinking on permutations. Valiant added that it is also important to be able to recognize problems having a computational component.

Adleman ended by asking if the Strong Church-Turing thesis (any problem that can be computed in poly-time in any reasonable model of computation is poly-time Turing computable) taken as a law of physics would preclude time travel! It took a while for the suggestion to sink in and there was a huge roar of laughter when Papadimitriou hinted that even he found that a radical idea.

The last session of this two day event was an interesting panel discussion on Data Security in the Future with panellists like Adi Shamir, Ronald Rivest, Bob Kahn and John Hopcroft with Vint Cerf as the moderator who kept the audience entertained with his humour and wit. At about 1:30pm, the event concluded with Paul Saffo and Vint Cerf rightly saying that the event had fulfilled its purpose

of celebrating the life and legacy of Turing and also giving everyone the opportunity to become friends with their personal heroes.

I got to meet many more Turing laureates: Richard Karp, Ken Thompson, Stephen Cook, Allen Emerson, Adi Shamir, Juris Hartmanis, Butler Lampson, Dana Scott and Les Valiant. I missed Michael Rabin who has contributed so significantly in the area of formal logic (my research area) and I learnt from Shamir that Rabin was over 80 now and felt too old to travel.

I also met some of the ACM India Council members: Anand Deshpande, P. J. Narayanan and Mathai Joseph. I was surprised to find Narayana Murthy at the event discussing the impact of Godel's work in logic.

As I headed for the airport, my mind buzzed with memories of the event. I recalled one of Turing's famous quotes `We can only see a short distance ahead, but there is plenty there that remains to be done'. A great experience I will cherish in a long time to come.

Many thanks, ACM India!