Mathematical Conversations

Tony Chan: On Her Majesty's (the Queen of Science's) Service >>>

Tony Chan

An interview of Tony Chan by Y.K. Leong

Tony Chan is well-known for his interdisciplinary research at the interface between applied mathematics and current rapidly developing areas in image processing, computer vision, VLSI circuit layout and advanced architecture parallel computers. He is one of the few scholars with rare administrative and organizational skills which he has put to good use in advancing the image of mathematics and mathematicians in the eyes of the public and the policy makers in the United States. His boundless energy and enthusiasm for the promotion of mathematics is legendary.

He serves on the committees of scientific bodies like the Society of Industrial and Applied Mathematics (SIAM), American Mathematical Society, National Science Foundation (US) and the Lawrence Livermore National Laboratory (US). He is also on the editorial boards of numerous well-known international journals on applied mathematics and scientific computing. He has been invited to address many international meetings.

He has been Professor of Mathematics at the University of California at Los Angeles (UCLA) since 1986. He helped to establish the Institute for Pure and Applied Mathematics (IPAM) at UCLA, and was the Institute's Director from July 2000 to August 2001. He is currently the Dean of the Division of Physical Sciences, College of Letters and Sciences at UCLA.

The Editor of *Imprints* interviewed Tony Chan on 12 December 2003 when he was an invited guest at the Institute's program on imaging science and information processing and gave a public lecture. The following are excerpts of the edited transcript of a spirited interview in which he talks about the interface between applied mathematics and other scientific disciplines like engineering and computer science and about his personal efforts for the cause of the mathematical profession.

Imprints: You were originally trained in engineering and aeronautics in the early seventies, and you quickly switched to computer science for your PhD. What made you switch? Was computer science already attracting many talented students at that time?

Tony Chan: The way I switched to computer science is due to serendipity. What happened was that I went through Form 7 in Hong Kong and I was good in math and physics. I was reading a magazine in high school about Feynman and Gell-mann who had just won the Nobel Prizes in the mid-sixties. So I said "Hey, this is where I want to go, to this place called the California Institute of Technology (Caltech)." I wanted to be a physicist and I applied only to Caltech. I did not apply to any other places.

At Caltech, I took physics classes. After sophomore I had to decide what to major in. I realized what I was good at is actually solving math problems. I was never able to say where the equations came from. I just cannot imagine that I was able to come up with those equations. What I really wanted to do is more practical things. At Caltech you can do one or two things. After sophomore, either you take pure math, like abstract algebra, or you take applied math like Laplace transforms, separation of variables and things like that. So I took the second one. I graduated with a general engineering degree. But at Caltech theoretical engineering is applied math. I also took some graduate classes in the applied math department: complex analysis, CFD (computational fluid dynamics) and numerical analysis courses.

When I was graduating, I had to decide what graduate school I wanted to go to. I was learning all these applied math. Most of the applied math problems traditionally come from fluid dynamics. You know the equations but nobody was able to solve them except in very simple cases. I do not know how to go from there to, say, designing an airplane. All I can do is flow over a flat plate rather than flow over a real wing. So I asked one of the professors: Joel Franklin. He told me there was a new field in which people used computers. I said "Where do I go for this?" He said, "Stanford has this new Computer Science Department, and they have two very good people." One is Don Knuth and the other one is Gene Golub. It happened that Golub had just visited Caltech and I was at his talk. When the time came for me to apply to graduate school, I applied to many different areas. At Stanford, I applied to Computer Science. At Berkeley it was in Math. I also applied to some operations research departments. I was applying to places where I knew math could be applied.

Computer Science in those days (1973) was very, very new. The Stanford computer science department was only a few years old. You ask whether it was attracting a lot of talented student. I would say some but there was still a lot of skepticism about this new field called Computer Science.

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Remember that was pre-Silicon Valley, pre-dot-com, pre-Apple. Of course, Stanford had very talented students, so it was really a bit of pioneering spirit. People knew that this was a new area and there were a lot of new problems but people did not even know whether computer science was a real science in those days. Maybe it was a fad, maybe after ten years nobody will study computer science. It was like that.

I: Much of your research spans different areas in mathematics and computer science. Does it require a special kind of intellectual temperament or mental outlook to venture into interdisciplinary research?

C: I think it does. What you need is an open mind. You've got to have some curiosity. You have to be interested in the context of your problem more than just the problem itself - where the problem arises and its broader impact. Not every mathematician has this interest. That is how I was driven into what I do. If you look at many mathematicians, they got interested in math because they discovered that they were good at math and problem solving. You give me a problem and I know how to do it. Just a very specific task. You look at the Math Olympiad, the Putnam exams. It is just problem solving and that is the antithesis of interdisciplinary work.

When you do interdisciplinary math, you are working with someone from outside math and you are often asked the following questions. Why can't the other person do what you do? Why do they need you? Why do the engineers do this? Why do they need mathematicians? But many mathematicians say "I don't do the science or engineering stuff even though I could. But they can't do what I do." One of the most powerful things about mathematics is that it can extract ideas from one area and apply them to many different areas. The engineers and scientists are only interested in their own problems. They are not interested in other problems. So a mathematician can be a sort of broker. I personally have done it many times. For example, I am looking at imaging, but many of the problems, ideas and techniques came from computational fluid dynamics. When you come down to the mathematics it is really the same idea. That is one big advantage for mathematicians and I think it is very powerful. It is not just that you know the technical aspects of math better than the engineers.

I: In principle, the engineers could learn the mathematics themselves.

C: But in most cases they are only interested in their own problems. That is the difference between mathematicians and engineers. They don't get awards by looking at the broad mathematical theory. They get awards by solving their engineering problems. I have always said that mathematicians don't have a monopoly in doing mathematics. It's just that we are called mathematicians. The engineers do it, the scientists do it, the statisticians do it.

I: But mathematicians do it better, probably.

C: Well, it depends on what you need. Mathematicians, of course, do the internal structures and they look at extensions. They also do proofs. Nobody else does that. But if you look at mathematics in terms of being relevant and of having impact, I think some of the non-mathematicians are also very good at that. You can see this many times even in this workshop. Many ideas came from physicists, engineers and others. It is not a static world. Historically, many ideas in mathematics came from other fields.

I: But the original ideas that came were sort of non-rigorous. Mathematicians couldn't stand anything that is non-rigorous.

C: Right. I think it is good and desirable to be able to prove things and to be rigorous. But even that is not the exclusive definition of mathematics. I know that's how many people define mathematicians: we do proofs and other people don't. I don't agree with that definition.

I: But don't you think that mathematicians have some kind of compulsion to do things rigorously? It is in their nature.

C: But it should not be exclusive. In applied mathematics, it is often different. In pure math, of course, you cannot publish "kind of a" theorem. You know there is no such thing. In applied math you are willing to tolerate a bit more. You know something works, has a sound basis and has been demonstrated a lot. You also try to prove what you can. You trust your intuition. It is a different culture and a different mentality.

I: You have been actively and deeply involved with efforts to advance the lot of mathematics and mathematicians. This must have required much personal sacrifice of time for your research. Was there any special calling that you were responding to?

C: I wouldn't say calling. I have not realized how much of a sacrifice it has been. First of all, time. But the other is a change in mentality. It is often political because when you have to deal with other people there is controversy and the issues are not clean. It is not just true or false, as in mathematics. You have to deal with human mistakes and broader political issues. There is no clean answer. For mathematicians it is frustrating because we want well posed problems with unique solutions. In human and political problems there is no such thing. You have to compromise, to give and take. In a way, it is for the same reasons that I do interdisciplinary mathematics. You got to look at it from a broader perspective. What we do is just part of a whole complex of human activities. How do we relate to society, to human history?

I: Somebody has got to do it.

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C: Yes, somebody has to do it. Not every mathematician is cut out to do it. You have to be willing to think in this fuzzy way, you have to interact with people. Many mathematicians would think that the time used to deal with these other issues is time wasted because you can prove another theorem. It's certainly true at a personal level. I have been a professional mathematician for 30 years and I can continue doing it for twenty more years and then I will retire. But I can also do something else. It depends on whether you think you are only good at one thing or also good at another thing. I don't plan it. The opportunity arises and then I am willing to try new things. That is what I am like. I think my own interest, and perhaps my talent, is not limited to one area. I always say that if I don't try it now when the opportunity comes, I will regret it later. I am willing to take failure if it doesn't work out.

I: Not everybody is approached to do this.

C: Yes, it is part of a feedback system. So even though I don't seek it out, other people seek me out. I don't take myself too seriously, maybe I'm good with people and I don't offend people.

I: Do you see any improvement in the status of mathematics, or at least of applied mathematics, in the public perception?

C: Yes and no. Yes in the sense that you see it in the mass media. There is actually a lot of coverage of mathematics in the movies: John Nash, *Beautiful Mind*, *Good Will Hunting* and so on. There is a lot of awareness but if you look deeper into it, I don't think it is because people realize how important mathematicians are. Mathematicians are still viewed as a different breed. John Nash is a good example: obviously he is a genius but he is so smart that he has gone crazy. In a way, they are saying that mathematicians are just different and are not relevant to what they do. I think the big danger is that even if people are revering mathematicians, they don't know why mathematicians are doing it.

I talk to a lot of other scientists. They sometimes view us mathematicians as very, very smart people who prove theorems but are not aware of what other scientists do. They think that mathematicians are just not relevant and not part of their enterprise, not part of science. They do not know the history of mathematics. That is the big danger especially in the US where mathematics is viewed as science, not as art. In a way you can also look at math as art, I know in NUS you can get an arts degree in math.

I: Would you say that public perception of mathematicians has changed over the years?

C: No. There is more media coverage, people are more aware of mathematicians. But in terms of what mathematicians actually do, the relevance to their everyday life, I don't think it has improved. I am giving a public talk on Monday. That is my reason for giving it.

I: Could it be that mathematics is something like the software? What people see is really the hardware.

C: I have said in a front page article in *Los Angeles Times* (1977) that math never gets into the story while everybody else gets the credit. For example, in medical imaging, you have computer aided tomography. Think about it. Why "computer aided"? It should be called "mathematics aided" because when you look at the basic point - it is mathematics. But the public doesn't understand. The public equates the computer as the one that solves everything. They don't think about algorithms because they are too abstract. They think about software. Software you can see, something you can buy. Computer and software replace mathematical concepts and algorithms. Even the newspaper editors don't use those words. They only say "computer", "software".

You know, in weather forecasting, viewers say the computer using this software is doing it. That's all they say even though a mathematical concept is there. I think that this is a big danger. Mathematicians are not out there reaching the public. In order to simplify and in order to reach the public, the mass media just bypasses the mathematicians at the interface. The computer is a tool. You would never say a writing pad is a great novelist even though the writing pad is an important tool. It is the intellectual ideas that should matter, not just the tools. And what goes into the computer is a part of what mathematicians do. But that is never talked about and people don't know. That really is the problem.

I: You chaired the Local Organizing Committee for the AMS conference on "Mathematical Challenges of the 21st Century" in 2000 at UCLA. From your point of view, what is the greatest mathematical challenge of this century?

C: The idea for this conference that we called the Millennium Conference came from the then AMS President Felix Browder. It was to be like the one in Paris (in 1900). One thing you realize is that, unlike what Hilbert did, one person cannot do it anymore. There were 36 experts and in fact, they were not all mathematicians. There were some computer scientists and some physicists. I'm not a pure mathematician but I went to every single talk. It was a chance of a lifetime. One thing I realized is that the connection between the different fields is one of the strong themes that came up. The connections between analysis, number theory and geometry go back to Fermat and Andrew Wiles. The Langlands program is one of the big challenges. We haven't quite come full circle but, to me, the connection between mathematics and other disciplines is the big thing - mathematics and computer science, mathematics and the biomedical world. And there are other intellectual fields. In a way, everybody knows that this century is going be the century of the biomedical world because of the genetic revolution. So the biggest challenge is what the role of mathematics is in this. I really do not think that mathematicians have grasped this opportunity yet. A lot of other people have. Certainly statisticians have. Physicists and

chemists have also gone in there. But mathematics as a field has not really come to grips with this.

I: What about applied mathematicians?

C: Yes, some of them. Even then it is not so clear because it requires learning another field. It requires a new way of thinking about new problems. In my view, you have to learn what the relevant problems are and then you ask what are the relevant techniques that you have or what new techniques you have to develop in order to apply them. That requires a change in direction. I think one of the liabilities that a mathematician has is that it takes so much time and effort in learning the tools in a certain area, especially in a very difficult field in pure mathematics in which you have invested. It makes it very difficult to change fields. But in applied math it is a little bit easier to change.

Applied math is where you extract the ideas, like PDEs, how to compute and so on. And this can be applied to many different fields. So by this very nature we can adapt. And the problems that motivated some of the techniques change through time. The typical applied mathematician probably changes, not the field, but the problems that they solve. At least two or three times in their career. In pure mathematics you don't change as much.

I: But how do you get the topologist to be interested in a problem about protein folding and this sort of thing?

C: You probably need a few leaders. You need some people who will the take the risk. There is a famous example in computer science: Dick Karp, who won a Turing Award. A decade ago, he thought that biology was going to be important (the genetics stuff) and he probably said, "I have proven myself and won the Turing Award. I am now willing to learn about biology and I want to find out." So it takes people like him to lead and then people follow the role model.

I: What is your greatest achievement in your efforts to bring public awareness and recognition to mathematics?

C: I have a ready answer for that. I mentioned this *LA Times* article. After the article was released, I got feedback and I realized the power of the mass media. When you really want to reach the public, the mass media is so much more powerful. I think more people read about my work through the *LA Times* article then the rest of my papers combined ten times. The *LA Times* is read by several million people a day. A typical math journal: if you get over 100 citations it is very good.

I: In some sense the exact nature of mathematics works against it.

C: Yes. But we are not trying to publish a theorem, we are just trying to publicize the idea. So you have to put the precision aside. Some journalists are very good at knowing what the public wants and at translating what you say. They know that if I use this word, it is too abstract and too technical. That is why I have more respect for these science journalists after the interview. I would argue with them and say, "Look, this is the right word." They said. "No, no. Say it this way and the public will understand."

I: It seems that technological advances in computers have pushed us into the direction of using more and more sophisticated computational techniques in solving concrete and real-life problems. Is this the way to go for advancing our knowledge of the universe? Could we have missed some ideas which could revolutionize science and which are basic and "idealistic" but non-computational?

C: I know exactly what you mean and I agree. But in the end the computer is just a tool. It is a very important tool and it is becoming more and more powerful, so people are using it more. But I don't think we should abandon the thought process, the ideas, the understanding. The computer is important but it is not going to solve all the world's problems. You have got to have understanding.

I: Are we over-relying on the use of computers to solve problems which cannot be solved exactly?

C: I don't think it is over-relying. It is a relatively new tool and people are exploring it. There are still physicists who think about string theory, the grand theory of everything and they don't rely on computers. I don't think we are running into any danger.

I: Would the use of computers one day shed some light on how the brain works?

C: Yes, that I believe. People are doing that. You can simulate models. What happens if the human mind were to work this way and what can it do. You can then use the computer to simulate. People in computer vision do that. But you cannot turn it into computer software. I don't believe in that.

I: You have covered so much ground and issues. Thank you for your time.