THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Department of Computing
電子計算學系

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Featuring
Dr Shuai Li & Dr Daniel Luo

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SMART COMPUTING
Drives Innovation

Interview with Dr Li Shuai

Dr Li just joined COMP in 2014. His research areas cover Robotics, Dynamic Systems and Control, Recurrent Neural Networks, Distributed Control and Optimization.

"USA is my first choice for PhD study as it is a place with leading conferences and famous professors in the fields of robotics and control theory."

Could you share with us your educational background?

I received my Bachelor of Engineering (B.E.) degree in Precision Mechanical Engineering from Hefei University of Technology, China in 2005; and the Master of Engineering (M.E.) degree in Automatic Control Engineering from University of Science and Technology of China, China in 2008 with my research area focused on robotics; and the PhD degree in Electrical and Computer Engineering from Stevens Institute of Technology, USA in 2014 with my research area in robotics and control theory.

During my post-graduation period at University of Science and Technology of China, there was an atmosphere of going abroad for advanced study. I was influenced by the atmosphere and decided to study abroad for my PhD degree. The development of robotics and control theory in USA was more advanced and up-to-date, also most of the leading conferences took place there and most of the famous professors in the fields were also from USA, therefore I applied for universities in USA.

Your research interests cover a wide scope of areas. What are your major focused areas? Could you tell what inspire you to start working in these areas?

My research interests are broad and span across different areas of research. I mainly focus on applied control theory and applied optimization. The word 'applied' means that we apply the theoretical concepts of control theory; signal processing theory and optimization theory to solve real-world problems like wireless sensor networks and robotics. All these fields which I investigate are closely related and connected to each other.

Many applications appear to be different but many of them actually share the same mathematical foundation and similar theoretical frameworks can be applied. I encountered two applications during my post graduate study in Mainland China which could serve as excellent examples, they are "coordination of multiple robots" and "localization of sensor network". The limitation of the robotic network was on how to adapt existing central robotic algorithm to a distributed ad-hoc network; while the limitation for sensor network was on how to adapt conventional computational framework to distributed ones such that the communication burden could be significantly reduced. Many research groups worked on these two topics but most of them were constrained by the traditional approach which dealt with the problems at application end. Breakthrough was brought about by new approach which looked at the problems from the theoretical end. Modifications were made on theoretical tools in order to adapt to the specific problems of the applications. Although these two applications appeared to be different, they were finally handled and solved by similar mathematical models under 'game theory'.

I decided to work in fields of optimization and control theory because I think they would be important to research and could bring the current research to another level. In addition, I have background in robotics and automation which equipped me with appropriate theoretical tools in optimization and control theory, and facilitated my work. My ultimate goal is to modify available theoretical frameworks to provide universal frameworks which could be widely adapted to different applications.

Up till now I still think my direction and focus of research is on the right track.

"My biggest satisfaction comes from my hard work. Hard work could lead to more thorough understanding of the problem and strengthen my knowledge through the extra explorations I made."

What gives you the biggest satisfaction while doing your research?

The biggest satisfaction comes from my hard work which is rewarding. Hard work could lead to more thorough understanding of the problem and strengthen my knowledge through the extra explorations I made. And of course if I could successfully solve the problems through my hard work, it would give me the biggest satisfaction but this is not a promised result. Other than that, there are other aspects of work that would make me feel satisfied, such as getting grants. When I joined PolyU, a friend of mine, who is a professor in a reputed university in USA, shared with me his strategy in grant application. He told me that I need to calculate the amount which I need to support my research. For example, if I require HK$1,000,000 for each year then I have to split that into monthly amount. In this way, I could estimate the gross size of the grant. Based on this, I could decide the number of proposals that I need to write each year. I am quite new to grant application and I will follow his advice.

Our department emphasizes on the impact and practicality of research. Could you share with us the practical side of your research?

I work on control theory and optimization and use my theoretical tools to solve real problems. Let me give an example of a research problem that I encountered before. The problem was about oil spillage which happened in USA several years ago. We had no idea about the source of the oil spillage and could not work on solution to stop the spillage. So we decided to look at this problem with our mathematical tools. We designed a controller and robotic network which could achieve three goals simultaneously:

1. Robot network maintained a desired formation
2. Individual robot only communicated with its direct neighbor
3. The whole group of robots went to the source of oil spillage automatically

Eventually the network served to identify the source of oil spillage very well.

By taking the top-down approach, we are now solving the application problems from the theoretical model level. In the future, I would like to build a universal platform with my students and colleagues which will incorporate my research and implement theoretical models. Only minor adaptations on the universal models are needed to apply to different practical applications. In this way, the power of theoretical tools can be fully demonstrated to solve real problems.

Can you share your view and experience in interdisciplinary research with us?

I think interdisciplinary research is very important because it can help us understand the problem from multiple angles and produce optimal solution. For example, traditional researchers in mathematics field work purely on mathematics; and researchers in biology field work purely on biology. However, researchers from the two fields realise that they need to come together to bring along integrated results which cannot be generated by either field solely. This is how the field of “bioinformatics’ emerges.

Currently I am undertaking interdisciplinary research with five other experts in the field of optimization and control robotics. Some of my collaborators are working in the field of robotics like surgical robots and they look for high precision control. Traditional control theory cannot be applied directly as its strong dependence on accuracy of theoretical model is the major issue and concern. We are designing a robust control method which increases the accuracy using advance algorithm with same devices of low accuracy. The performance of this control method is comparable to high-cost method which uses expensive devices with high accuracy. In this research, our team collaborates with researchers in other fields e.g. bioinformatics, software engineering, etc. We need to go through recursive procedure of discussion and trial and error processes until reaching agreement on any final solution.

"Programming language is a language to communicate with computer. We also need to find a right language to communicate with the students."

You have started teaching, do you have any experiences to share? What do you think about the new generations of computer science?

I am teaching the course "Middleware and Distributed Objects" in this semester. Our department's teaching focuses on the practical applications for the students e.g. how to programme and preparing students for what they need to know for their career. This is important as most of the students would join the workforce instead of proceeding to further studies. However, I believe that the concept and model can bring deeper insight for students. Even though I do not tell them how to deduce the solution mathematically, I teach them the physical meaning so that they can have intuitive understanding and knowledge about the problem. In this way, they can come up with respective solution when they encounter a similar problem even though they may not know the theory behind. For example, when I teach programming I have tried to bring out the knowledge of the art of programming instead of the theories behind.

Practicality could always arouse students' interests.

From my experience, I do not find much difference in my generation when compare to present students. Although my colleagues tell me that students usually do not response to questions raised in class, I think it is about finding the right way to communicate with them. Just like we have to use programming as the language to communicate with computer, we also need to find a right language to communicate with the students.

What is your plan of research?

The ultimate goal for every researcher is to produce high impact research. There are steps to achieve the goal. For my research, my focus is on applying applied optimization and applied control theory to areas of robotics and wireless sensor network, and many other fields. In order to facilitate the application, I need to understand the actual problem and explore the theoretical part by studying theoretical tools. I would like to practise with more powerful theoretical tools and improve them, and even better, to generate my own analyses to make the theoretical part more applicable to real problems. My final goal is to close the gap between application and theory.

I work in the fields of robotics and control theory. In robotics field, if you understand the ideas fully, you could design feasible models based on hypothesis made from theoretical knowledge; while in control theory, you need to undertake rigorous analysis and investigation before you could prove the design works. Therefore, I act like the bridge between the two fields. At one end I need to pop up with practical application which is very promising, while on the other hand I need to undergo rigorous analyses. From my experience, only 20% cases would succeed under rigorous and multiple analyses. This is the fact we have to accept as the results are to be applied to industry where even 1% failure rate is unacceptable.

Interview with Dr Daniel Luo

Dr Luo is a Research Assistant Professor(RAP) in the Department of Computing. He received PhD degree from COMP in 2007 and joined COMP again as an RAP in 2012. His research interests cover Network and System Security, Information Privacy, Internet Measurement, Cloud Computing.

Could you tell us your education background?

I received my Bachelor of Science (B.S.) in Communication Engineering and Master of Science (M.S.) in Communications and Information Systems from Wuhan University. I obtained my PhD degree in Computer Science from the Hong Kong Polytechnic University, under the supervision of Dr Rocky K.C. Chang. After that, I spent two years at the Georgia Institute of Technology (Gatech) as a post-doctoral research fellow advised by Prof. Wenke Lee.

I have studied in Mainland China, Hong Kong and USA and these are 3 different stages of my study. In Mainland China, I focused on building solid foundation of knowledge; in Hong Kong, I enjoyed the freedom in exploring my research interests; while in USA, I had great opportunities to interact and learn from international experts.

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We learn that your research includes Traffic Analysis, Network Security, Internet Measurement, and Android Security and Vulnerability. Could you tell how you get into these areas?

Traffic analysis and network security are the major topics investigated during my PhD study. I have started such research since the time of my Master study. The research was on diagnosing network faults by investigating network traffic and other information collected from different sources. Although the two research topics are different, they have some common techniques and knowledge. One topic may inspire new ideas for the other. My interests in network security and privacy help me enter these areas smoothly.

The research on Internet measurement started from my class project of COMP5311, which was to measure packet reordering. I proposed and developed a new active network measurement approach without the need to install specific software on a remote host. This research was also motivated by the fact that it was difficult to get network traces from network providers because of security and privacy concerns. It turned out that such measurement approaches can be applied to many areas such as network security, network fault detection, online streaming, etc. So, I continue the work on it.

While I focused on network security in my PhD study, the Postdoc training in Gatech gave me an excellent opportunity to learn and investigate system security. Android is a good platform for me to conduct the research that combines both system security and network security. So, I get into it.

In my opinion, Android security and vulnerability is a promising research direction as smartphone becomes an indispensable part of our daily life, especially Android smartphones. Android has become the target of cybercrime because of three reasons: (1) It is dominating the mobile OS market; (2) the original design/implementation of Android does not consider potential security/privacy issues carefully. Therefore, it has many loopholes; (3) Android is somewhat new to developers and has many unique features. Developers may not have a good understanding of Android's security architecture and may lack of experiences in constructing secure Android apps.

Could you share with us the impacts of your research?

For Android security, our research has made several impacts. First, we have identified vulnerabilities in many popular apps and reported them to the corresponding companies. They appreciate our work. Second, we have developed the first dynamic taint analysis system for apps with native codes and made it open source. One comment to our paper is "It is a very useful and valuable research work. It represents a substantial effort in terms of research and implementation work." Third, I wrote an ITF T-3 proposal on discovering vulnerable Android apps and secured the grant. The project was finished a few months ago. Moreover, I was invited by security/IT organizations like OGCIO, CNCERT, (ISC)2, etc. to give talks on mobile security.

For traffic analysis and network security, besides publishing papers in top venues, I was asked by Tor (the largest anonymity network) to provide suggestions on how to defend against trace-back attacks; and by IETF to give comments on HTTP 2.0, especially the part for preventing traffic analysis attacks. Moreover, our systems, such as HTTPOS published in NDSS'11, have been used by leading security groups.

For internet measurement, my research facilitated in securing two ITF T-3 grants and one ITF T-2 grant. The research has resulted in two US patents (already granted). Moreover, I received a CCF-Tencent Research grant last year. The project has been finished recently and the good outputs earned us an award of excellence from CCF-Tencent. Furthermore, one core technique of my research is used by a system that keeps monitoring HARNET and HK major web sites.

"When I was a PhD student and a postdoc, my target was to produce more excellent research outputs by myself or collaborating with fellow colleagues; while I am now a faculty member, I will lead the team to conduct more impactful research and help all members achieve their goals."

You started PhD study in our department, and now you become a faculty member. Could you share with us your experience on this change?

Besides doing research, I need to develop more skills, such as leadership, communication skills, etc. Moreover, I need to manage my time more efficiently for three parts: teaching, research and service (administrative service and professional service). I read the book "The Power of Habit: Why We Do What We Do in Life and Business" recommended by Prof. Cao and found it quite useful.

Research funding is very important for both supporting our research and demonstrating our performance. Could you tell us how you made your effort to get external competitive grants?

First, I would focus on important and practical problems that are interested by both the academic community and the industry. In order to grasp the trend and needs in the IT industry, it is important to talk to experts and practitioners in the industry. Second, I learnt from colleagues who are very kind to provide suggestions and comments on how to prepare proposals. For example, it would be good to submit proposals with more theoretical study to GRF; and proposals with more practical impact to ITF. Third, I would keep writing and submitting proposals.

Besides research, you are also teaching COMP students, what is the most important thing that you want the new generations of computer science to learn from you?

I taught Master students as well as undergraduate students. From my observation, Master students have stronger motivation in learning. One possible reason is that most of the Master students have jobs and know exactly what and why they need to learn; while undergraduate students are still searching for their goals. There are Master students from Mainland China and they always sit at the first row. Local students are more active in class and more willing to ask and answer questions. A piece of advice from me to them is "If you want to do research, get your hands dirty and read papers."

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