2018 Pujiang Innovation Forum

All systems go in Shanghai for connecting innovators

China's Minister of Science and Technology, Wang Zhigang, underlined the crucial role of scientific innovation in a country's economic fortunes when he addressed the recent 2018 Pujiang Innovation Forum held in Shanghai.

Wang cited the work of New York University professor, Paul Romer, who won the 2018 Nobel Prize for economic sciences for 'integrating technological innovations into macroeconomic analyses'. The minister referred to Romer's work on the endogenous growth theory, which links investment in innovation, knowledge and human capital to growth.

The conference theme was 'innovation driven development and supply-side structural reform in a new age'. "The core of supply-side structural reform is to improve productivity," said Wang. "The key is technological innovation, the essential force that propels social progress." The minister emphasized the need to investigate the origin of innovation, transfer of innovative technologies and the ecosystem for novel discovery. "Innovation begins with breakthrough ideas," said Wang. "We need to be free of our conventional mindsets." It is also important to integrate academia and industry, and encourage interactions between scientists. "We also need to think globally when it comes to innovation," said Wang.

To build a global centre in science and technology innovation, Shanghai will embrace collaborative innovation, and gather resources from around the world, said Li Qiang, secretary of the Shanghai municipal party committee. He said Shanghai should become a spring of innovation, a source of novel academic ideas, scientific discoveries, technological inventions and industrial innovations. "We need to achieve zero-to-one breakthroughs," said Li. "This entails fostering a vigorous ecosystem for innovation, and we encourage diversity, open source and tolerance, to motivate creativity."

Complexity science for innovation

Data researchers attending the future science sub-forum of the 2018 Pujiang Innovation Forum agreed that diversity is the key to innovation. "And to foster innovation, we need to understand the complexity of information-processing systems, such as the brain, or society as a whole," said Hernan Makse, head of the Complex Networks and Data Science Lab, City College of New York.

We are awash with data in this information age. The data we generate annually equates to the total amount generated between the beginning of human history to 2003. The solution is to reduce big data to a few influencers, said Makse. Using the example of the spread of fake news on social media, Makse demonstrated how the collective influence algorithm, within hours, helped find the influencers in social networks of 200 million users. Here, influencers are defined as crucial nodes in the network that, if removed, would result in most users becoming isolated. He also introduced cases of using stock market data to predict tipping points in economic ecosystems, and analysing genetic data and brain networks to predict diseases. His tool made understanding complex systems and massive datasets possible.

Sune Lehmann from the Technical University of Denmark used phone call data to study social networks. He recruited 1,000 students and handed them cell phones to track them for more than two years. "I wanted to get a densely connected network to understand individual behaviours," said Lehmann. Cell phone use data, with location information, enabled him to model geographically-based human contact networks. Such data also throw light on human mobility. For instance, it is found that people normally have a set of places that they visit regularly, but if a new place is found, an old one disappears from mobility networks. Our social experiences in the past can be used to predict our social locations in the future. Social networks can also help with understanding the spread of illness, such as infectious diseases transmitted via drug use, based on which, we can optimize prevention strategies.

Focusing on infectious diseases, Vittoria Colizza from the French National Institute of Health and Medical Research demonstrated how the modelling of disease spread informed interventions. "Diseases such as SARS and Ebola have a high economic and social cost," said Colizza. "Prevention is the best way to fight them." Based on population, mobility and epidemic dynamics data, her model allows simulation of disease spread, which shows the effects of travel restrictions in controlling diseases. A pause, or surge, in travel volume can change the picture of disease diffusion. In the case of controlling MERS in a hospital setting, her analysis suggests that rather than simply eliminating physical contact by medical staff — an impossible feat — reorganizing nurses' shifts may effectively prevent disease spread, as contact between nurses themselves affects disease diffusion. "Data is the most important element of this innovation," said Colizza. "With mathematical and statistical tools, we are able to unlock them, making evidence-based decisions."

Adilson Motter, a physics professor from Northwestern University, focuses on power grid networks. In 2003, the United States experienced its largest blackout, affecting 55 million people. It was caused by cascading failure in the interconnected power transmission system, in which a failure of one or several parts will trigger failures of other components that need to compensate for the interruptions, explained Motter. His team has designed a model to map cascade vulnerability and predict outcomes, considering the physics of cascades, grid operation practices, and conditions. Motter finds that large cascades are determined by co-localized events and small vulnerable sets, which are unevenly distributed geographically. Powerlines in the centre of the network are more likely to fail and cascades propagate outward, but tend to be confined to the triggering region. "The solution is to transition to smart power grid technologies," said Motter, who is leading an ambitious project involving energy and network scientists to apply information technology to gridline design, aiming to reduce energy waste and improve grid stability.

Indeed, innovation can take many different forms, said Federico Levi, senior editor of *Nature Physics* who chaired the session. "The innovative ways we interpret the world, understanding complex systems, for example, can be an important aspect of innovation beyond inventing new devices or technologies." ■

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