

# DIGITAL SOCIETY

Developing digital innovations for daily life and a thorough understanding of the relationship between digital advancement and society.



Professor Maurice Benayoun (first row, second from left), Dr Tobias Klein (first row, first from left) and the Neuro-Design Lab team members.

## Finding the “Real Value” of Human Values

With the advancement of information and communication technologies, digitalisation has permeated our daily lives. We can easily quantify many different things, but how about abstractions like *love, peace, respect*, and other human values? **Professor Maurice Benayoun**, in the School of Creative Media (SCM) and a renowned artist, theorist and curator in media art, has been working on the “MindSpaces HK - Responsive Neuro-design for Urbanism, Architecture and Interior Design” project with interactive exhibitions to consider social, innovation and technology challenges in a different way.

*MindSpaces* is a big project funded by the European Union (EU) to improve the design process in indoor and outdoor environments through participatory design, involving multisensory measurements of individuals’ responses. Started in Europe, it has formed a consortium of 12 partners worldwide, including

Professor Benayoun and CityU. As one of the two projects funded by the Research Grants Council (RGC) under the EU-HK Research and Innovation Cooperation Co-funding Mechanism, the *MindSpaces HK* project is an extension of this, using the same technologies, like artificial intelligence (AI), machine learning and Brain-to-Computer Interface (BCI), to create individual and collective “neuro

design”, from shaping abstractions to shaping objects and architecture.

### Neuro design and the Brain Factory

“Neuro design is the idea to use brain to control the evolution of shapes and forms,” said Professor Benayoun. With external contributions from the



Visitors are invited to produce various shapes based on different abstractions at the exhibitions.

MindSpaces consortium partners and neuroscience support from **Dr Rosa Chan Ho-man, Professor Sir Colin Blakemore** and **Professor Bruce Ransom** from CityU as advisors, he worked with **Dr Tobias Klein**, Associate Professor in the SCM and the team at the Neuro-Design Lab, part of the CityU Centre for Applied Computing and Interactive Media (ACIM) lab and developed a technology called a "Brain to Shape" machine, based on Brain-Computer Interaction. It can get electroencephalography (EEG) information from the users' brains, which helps them figure out how the users react to the shapes they see.

To calibrate the system accurately, the team started with the most difficult things to design - abstractions, like *space, power* and *love*. They created the *Brain Factory* project and exhibitions, in which they invited exhibition visitors to produce various shapes based on different abstractions. The EEG headsets monitored the visitors' brain waves, and the produced electrical signals contributed to the assessment and the evolution of the 3D shapes on a screen.

The shapes, which look like liquid in motion or dancing flames, were then converted using 3D printing into actual objects for distributing to the visitors, or sculptures for displaying in exhibitions. Professor Benayoun described this materialisation process

as "reification", meaning converting thoughts into objects.

In collaboration with a CityU alumnus **Dr Nicolas Mendoza**, they went one step further, creating the *Value of Values* project to help people understand human values better "by giving shapes to values". Instead of receiving a 3D-printed shape, this time the visitors got a "Value of Values" (VoV) token in their digital wallet and owned the shapes registered on a blockchain. The shapes are converted into "VoV" tokens, so that people can barter or sell the "values". "On this blockchain trading platform, we can see what the transaction and ranking of values is for different human values across various individual cultural backgrounds and countries," said Professor Benayoun.

### Trading human values on blockchain

Based on the transactions, a series of *ethical statements* were automatically generated, creating "Transactional Poetry". "If you give love for peace, or if you give money for sex, it says different things. This is what we called an 'ethical statement'," he said. "A collection of VoV tokens also reflects the collectors' priorities in their life."

Professor Benayoun and his team are working on the next step of the project by adapting the technologies to architectural design. They will

generate shapes in a different way, using a huge database of architectural history, AI and machine learning, and see how people react.

Also, as part of the *MindSpaces* project, he is working with famous American-Turkish artist **Refik Anadol** on "DialoG" to reflect on the difficulty of building mutual understanding beyond social and cultural differences. This is an urban art installation project in which each of them is developing a "living entity". "These two artworks will be like aliens, strangers or immigrants landed in a city that they don't know. They will need to learn how to understand each other. And they will be affected by the reactions of the people around them," Professor Benayoun explained. At Ars Electronica Festival 2020, a major global media art festival, they presented the "baby aliens" for the first time before they were fully grown. They will meet face to face later.

"So this global project is very complex," said Professor Benayoun. "We develop technological tools to make 3D design, to design objects, to design architecture, and to give shape to human thoughts. We make artworks with a high level of engagement in society, going beyond aesthetics, into the fields of ethics, finance, neuroscience and social awareness. This may allow us to have a better understanding of the real value of human values."

"Reification", converting thoughts into objects through 3D printing.

“ By developing technological tools to let people give shape to thoughts, we make artworks with a high level of engagement in society. This may allow us to have a better understanding of the real value of human values. ”

– Professor Maurice Benayoun



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Value of Values at Digital Art Festival 2019 in Taipei.

#### Major Awards

- Novum Design Award, Golden Interior Design Award
- ACIM SCM-CityU Research Fellowship

#### Key Projects

- EU-HK Research and Innovation Cooperation Co-funding Mechanism by RGC 2018/19: MindSpaces HK – Responsive Neuro-design for Urbanism, Architecture and Interior Design (Other CityU project members include: Professor Lu Jian, Dr Rosa Chan Ho-man and Dr Tobias Klein)
- HORIZON 2020 S+T+Arts Lighthouse EU Collaborative Research Programme 2019-2021

#### Highlights of Participation in International Exhibitions

- *Ars Electronica Festival 2020*, Hong Kong, September 2020:
  - "Refik Anadol & Maurice Benayoun's Dialogue about DialoG" (opening talk)
  - "DialoG: Alien Life in the Telescope" (live performance & streaming)
  - "Speculative Speculations on Art and Values. How Linking the Brain to the Blockchain Reveals the Value of Human Values" (lecture)
- *International Symposium of Electronic Arts (ISEA) 2020*, "After the Tunnel, the Shifting Ontology and Ethology of the Emerging Art-subject" (paper & lecture), Montreal, October 2020
- *Ars Electronica Festival 2019*, "Value of Values by the Brain Factory", Linz, Austria, 6 September 2019
- *ISEA 2019 Special Exhibition*, Lux Aeterna, "Value of Values", Gwangju, June - July 2019
- *Digital Art Festival 2019*, MoCA Taipei, October 2019
- *Microwave Festival*, (Exhibition & Conference), Hong Kong, 2018
- "Why the Future Still Needs Us" Exhibition, Brisbane, 2017, and Art Center Nabi, Seoul, 2017



Video: Value of Values, Transactional Art on the Blockchain

# Intelligent Multidimensional Data Analysis for Imaging and Medical Advancement

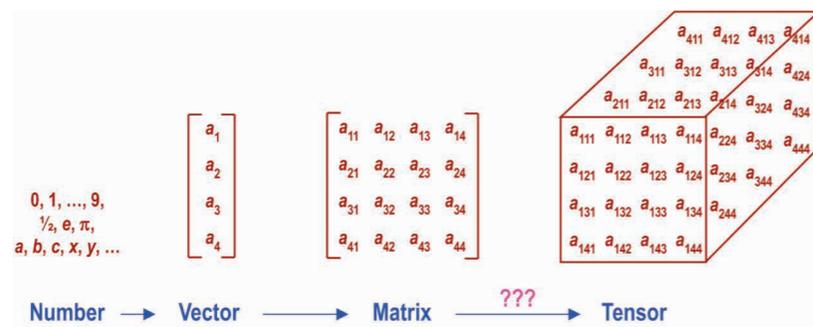
As the mechanisms of biomolecular interactions, which are the key to finding the causes of diseases and developing new drugs, have yet to be fully understood, developing the concepts and tools of multidimensional data analysis and image recognition can help advance medical science and other fields to the next level. Having made a significant contribution to image and biomolecular pattern recognition techniques, **Professor Yan Hong**, a CityU expert in imaging science, has proposed new theories and the computation of complex tensors to expand its application in imaging, biology, medicine and beyond.

Professor Yan's current research focuses on tensor computing to detect and analyse meaningful patterns in datasets. A tensor is a multidimensional array of data. In mathematics, a number can be considered as a tensor of order zero, a vector as a first-order tensor, and a matrix as a second-order tensor. These data representations and structures are now well-understood. "However, the existing mathematical theories and computation methods are far from mature for analysing higher-order tensors of order three or more. We need new concepts and theories for tensors, which cannot be simply extended from matrix theories," explained Professor Yan, Wong Chun Hong Professor of Data Engineering and Chair Professor of Computer Engineering in the Department of Electrical Engineering.

## New theories for analysing higher-order tensors

Although biomolecules and image analysis are studied in two different disciplines, biomolecular interactions appear to follow the same principle of the perception of images by computer technology. "Computers recognise an object in an image with consistent positions of points, lines, areas and their relations. Similarly, two molecules interact with each other because they fit consistently with complementary surfaces and charges," he elaborated. "Therefore, understanding tensors is crucial. They provide a rigorous mathematical model to represent consistent features and their higher-order relations."

Working in close collaboration with mathematicians, biologists, medical doctors and computer engineers, Professor Yan and his team have developed co-clustering methods, based on tensor models. While



A tensor is a multidimensional array of data.

conventional machine learning and pattern recognition methods classify objects according to their features, their new approach can classify both objects and features.

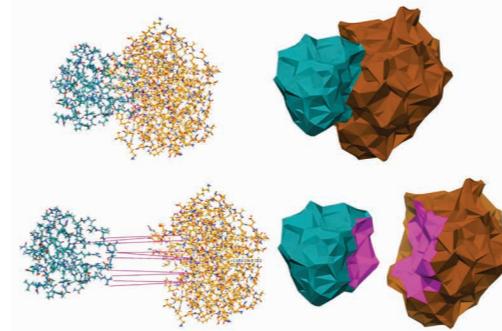
"For example, a group of genes may be co-regulated under a group of conditions. These genes and conditions form co-clusters. If there are many genes and conditions, the computational time will increase exponentially," he said. "But our group has solved this problem using tensor methods. Our new method enables the simultaneous detection of several types of co-clusters, which can even overlap in the data."

Based on tensor and hypergraph models, the research team has developed efficient computer algorithms for matching datasets. They have solved an optimisation problem to deal with all the compatibilities among matched data entries through high-order relations.

## Application in lung cancer cell mutation analysis

Furthermore, Professor Yan has applied tensor computing to cell division data analysis and biomolecular surface characterisation. Lung cancer is the leading cause of cancer deaths worldwide. Non-small-cell lung cancer (NSCLC) constitutes about 85% of all lung cancer cases. Mutation of the epidermal growth factor receptor (EGFR), a type of protein, is a common cause of NSCLC, whose incidence can reach 60% in East Asian populations.

Working with medical doctors at Queen Mary Hospital in Hong Kong, Professor Yan's team analysed all known EGFR mutants and created a database of their 3D structures. The innovative methods proposed will help researchers understand the mechanisms of drug resistance and help doctors plan optimal personalised treatment for cancer patients.



Two molecules interact with each other because they fit consistently with complementary surfaces and charges. The original protein data (upper left diagram) are obtained from the Protein Data Bank (rcsb.org) and the other three diagrams are done by Professor Yan's team after analysing the shape and charge complementarities and how two proteins are matched to form an interaction complex.

In addition to contributing to medical advancement, Professor Yan has used tensor models to tackle other problems in science and engineering. One discovery involves detecting objects in images and tracking motion in videos, which does not require prior training and represents a major improvement over commonly used classifier-based systems.

Professor Yan and his team will continue to work on tensor and hypergraph theories with the aim of developing robust computer algorithms and parallel processor-based hardware and software, and applying them to many more real-world systems for image, video and biomedical data analysis.

"Throughout history, many major technological breakthroughs have relied on fundamental theories. For example, information theory was the key to the development of modern digital communications systems. To solve the multidimensional big data analysis problem, I believe we need to understand tensors, and develop new theories and computational methods."

- Professor Yan Hong



### Major Awards

- Elected Member of European Academy of Sciences and Arts, 2019
- Norbert Wiener Award for contributions to image and biomolecular pattern recognition techniques, IEEE Systems, Man and Cybernetics Society, 2016

### Key Projects

- Collaborative Research Fund: Efficient Algorithms and Hardware Accelerators for Tensor Decomposition and Their Applications to Multidimensional Data Analysis
- Health and Medical Research Fund: Computational Platform for Modeling, Analysis and Prediction of Anti-EGFR Drug Resistance for Lung Cancer
- General Research Fund:
  - Analysis of Interface Patterns Between Biomolecules Based on Alpha Shape Models
  - Detection of Hyperplanar Co-cluster Patterns in Multidimensional Singular Vector Spaces

### Selected Publications & Patents

- Cao, J., Guan, G., Ho, V. W. S., Wong, M. K., Chan, L. Y., Tang, C., Zhao, Z. Y. & **Yan, H.** 2020, "Establishment of morphological atlas of *Caenorhabditis elegans* embryo using deep-learning-based 4D segmentation", *Nature Communications*, vol. 11, no. 1.
- Che, M., Wei, Y. & **Yan, H.** 2020, "The computation of low multilinear rank approximations of tensors via power scheme and random projection", *SIAM Journal on Matrix Analysis and Applications*, vol. 41, no. 2, pp. 605-636.
- Khan, S., Nawaz, M., Guoxia, X. & **Yan, H.** 2020, "Image correspondence with CUR decomposition-based graph completion and matching", *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 30, no. 9, pp. 3054-3067.
- Cui, C., Li, Q., Qi, L. & **Yan, H.** 2018, "A quadratic penalty method for hypergraph matching", *Journal of Global Optimization*, vol. 70, no. 1, pp. 237-259.
- Yan, H.** 2017 "Co-clustering of multidimensional big data, a useful tool for genomic, financial and other data analysis", *IEEE Systems, Man and Cybernetics Magazine*, 3(2):23-30.
- Zhou, W. Q. & **Yan, H.**, "Methods for modeling and analysis of interface between point patterns", US Patent US10,475,528, granted 2019.
- Yan, H.**, Chan, L.H.L., Chim, H., Ching, H.Y., & Choi, C., "Monitoring user activity using wearable motion sensing device", US Patent US10,347,108, granted 2019.
- Chen, L., Zhao, Z., & **Yan, H.**, "Method for tracking an object in an image sequence", US Patent US10,255,692, granted 2019.

# Data-driven Solutions for Fintech in Greater China and Beyond

Digital innovations are reshaping our daily lives in many areas. Digital finance, for example, is transforming how people transact and borrow, and how financial services are provided. Combining the advantages of first-class scientific research capability and extensive fintech industry experience, a joint laboratory in financial technology and engineering at CityU has been undertaking cutting-edge research to create industry-leading solutions, especially in financial risk identification and management. The joint endeavour will help define the way forward for the future of fintech development in the Greater China region and beyond.

Established in early 2019, the joint laboratory was formed between CityU and JD Digits, which was the financial technology arm of JD.com, a global e-commerce platform, and has now become one of the leading digital technology companies in the region, offering technology solutions to corporates

and other clients to enhance their digital development.

## Data modelling for loan pricing

With the aim of creating cutting-edge data-driven business solutions for the development of the financial industry, the joint laboratory specialises its research in areas such as asset pricing, financial risk monitoring and user behaviour. It focuses particularly on uncovering new data modelling and analysis techniques to develop practical applications of financial engineering, technologies and big data in risk-based loan pricing.

"In the School of Data Science, we have a strong team of world-class faculty with expertise in both theory and application. This provides a strong foundation for us to excel in research and offer solutions that benefit both industry and society," said **Dr Wu Qi**, Associate Professor in the School of Data Science and also Director of the

CityU-JD Digits Joint Laboratory of Financial Technology and Engineering.

Dr Wu received interdisciplinary training in mathematics, business and engineering, and specialises in quantitative finance and business analytics within the broad area of operations research and management science. His previous research centred on modelling financial derivatives and their risk implications for market participants.

## Understanding consumer credit risk

One of his recent research collaborations with researchers from JD Digits features the use of cutting-edge, industrial-level deep-learning architecture developed by the team to estimate and forecast consumer credit risk. When an e-commerce platform provides unsecured lending to finance customers' purchases, it needs to manage the subsequent credit exposure. The research team

proposes that the inclusion of shopping behavioural data in addition to conventional payment records, and using a deep-learning approach to break down a consumer credit risk into three determinants: i) subjective risk, indicating the consumer's willingness to repay; ii) objective risk, indicating the ability to repay; and iii) behavioural risk, indicating behaviour characteristics.

The findings demonstrate the effective forecasting performance of this new approach compared to conventional machine learning and other deep-learning models. This enables real-time assessment of future default risk, particularly when payments are financed without providing collateral.

## Novel approach to managing retail credit risk

Another joint research project conducted by Dr Wu in collaboration with JD Digits represents the first retail credit risk study. It focuses on the expected difference in borrower's repayments when there is a change in the lender's credit decisions.

To address the problem of classical estimators that overlook the confounding effects between the lender's credit decisions and the borrowers' credit risk, as well as significant biases in risk assessment, the research team put forward a novel approach to construct the estimators that have proven to substantially reduce the estimation error. This will help technology conglomerates



(From left) Dr Wu Qi, Professor Alex Jen Kwan-yue, Professor Way Kuo and Professor Lu Jian from CityU, and representatives from JD Digits in the strategic collaborative agreement signing ceremony.

manage retail credit risks in the online marketplace, which are fundamentally different from the credit-card default risks faced by commercial banks.

"In addition to providing innovative solutions for the development of global financial markets, we offer a common platform for technology firms, academics and students

to explore new models in the research and application of financial technologies," said Dr Wu. "We aspire to help groom management professionals in Hong Kong, mainland China and the region by promoting exchange and training, organising academic forums and sharing resources."

### Key Projects

- General Research Fund:
  - Generative Models of Multivariate Dependence for Asset Returns
  - Studies on Margin Procyclicality - the Impact of Volatility Persistence and Nonlinear Payoffs
- CityU New Research Initiatives: Interpretable Machine Learning Methods for Financial Risk Management
- JD Finance Strategic Collaboration: Fundamental Research of Financial Technology and its Strategic Application in Financial Industry

### Selected Publications

- Huang, Y., Leung, C.H., Yan, X., **Wu, Q.**, Peng, N., Wang, D. & Huang, Z. 2020, "The causal learning of retail delinquency", *Thirty-Fifth AAAI Conference on Artificial Intelligence (AAAI 2021)*.
- Zhang, Y., **Wu, Q.**, Peng, N., Dai, M., Zhang, J. & Wang, H. 2020, "Memory-gated recurrent networks", *Thirty-Fifth AAAI Conference on Artificial Intelligence (AAAI 2021)*.
- Wang, D., **Wu, Q.** & Zhang, W. 2019, "Neural learning of online consumer credit risk", *Management Science*.
- **Wu, Q.** & Yan, X. 2019, "Capturing deep tail risk via sequential learning of quantile dynamics", *Journal of Economic Dynamics and Control*.
- Yan, X., **Wu, Q.** & Zhang, W. 2019, "Cross-sectional learning of extremal dependence among financial assets", *Advances in Neural Information Processing Systems (NeurIPS 19)*.
- Yan, X., Zhang, W., Ma, L., Liu, W. & **Wu, Q.** 2018, "Parsimonious quantile regression of financial asset tail dynamics via sequential learning", *Advances in Neural Information Processing Systems (NeurIPS 18)*.

# Understanding Political Polarisation in the New Media Age



Dr Chris Shen Fei

The distribution of public opinion signals social preferences. People make many decisions in their daily lives based on their perception of the opinion climate. Similarly, policy makers formulate policy proposals based on their understanding of public opinion. With digital and social media becoming an integral part of people's daily lives for information and communication, the proliferation of digital technologies is changing not only how public opinion can be represented, but also how it can be studied. By adopting a big data-based approach, **Dr Chris Shen Fei**, a CityU scholar in the Department of Media and Communication specialising in the social and political impact of new media technologies, has proposed ways of understanding public opinion through online textual mining.

## Big data analysis of public opinion

"We are living in a time in which timely and comprehensive understanding of public opinion is greatly needed," said Dr Shen. He pointed out that traditional polling has many limitations, such as high cost and respondents' sensitivity to question wording. "But big data provides us with a new direction for public opinion analysis by taking full advantage of people's openly shared expressions on the internet," he said.

Launched by Dr Shen and his team, the Hong Kong Online Public Opinion

Data Mining Project (<http://www.webopinion.hk/>) aims to understand online public opinion using automatic textual analysis. After identifying 12 important online platforms as data sources, including discussion forums, news portal sites, and alternative news media sites, the team performed data crawling, data cleaning, tokenisation, lexicon development and data analysis to transform unstructured data into a visualised pattern of public opinion over time in Hong Kong.

"We hope the datasets and analysis derived from the platform can benefit decision-making by policy makers, the public and the academic community in the long run," said Dr Shen.

The project found that in the past several years, online political discussions have become more and more sensational, which have led to polarised opinions and a divided society in Hong Kong. This poses a great challenge to

political discussion, which is Dr Shen's other research interest.

"Hong Kong's problem does not lie in the ideological differences among citizens; rather, the major issue is that people of different political stripes view each other as enemies. Sensational discussions and hate speech are commonly seen on social media platforms. While it is undesirable and even impossible to eliminate political differences, reducing political affective polarisation is one of the greatest tasks faced by society," said Dr Shen. "Political affective polarisation means the tendency of people to dislike or distrust others simply because of a different political stance."

## Pilot experiments on deliberation

Much evidence suggests that when communication and discussions are

not properly facilitated and conducted, they can easily lead to the proliferation of extreme ideas and negative emotions. To explore the ways of reducing political polarisation in Hong Kong through communication, Dr Shen conducted two experiments to compare the effects of deliberation and casual discussion.

In Study 1, people holding opposing views on Article 23 of the Hong Kong Basic Law were invited to participate in a 90-minute discussion session. They were randomly assigned into one of two groups: deliberation or casual discussion. The deliberation group received an information booklet on the issue and had to strictly follow the rules, whereas the casual discussion group had no such stimulus. In Study 2, which tested whether watching other people's discussion and deliberation would have a similar effect, video recordings from Study 1 were presented to another two groups

of participants. One group watched the deliberation video and the other group watched the casual discussion video. Pre-test and post-test surveys were conducted in both experiments.

The studies revealed the following:

- i) Both deliberation and casual discussion had mixed effects on reducing political polarisation. While issue attitude and issue polarisation remained largely unchanged, people's attitude towards those with opposing views became more favourable and affective polarisation was effectively reduced.
- ii) After discussion, people's knowledge level remained largely unchanged, but their sense of national identity became stronger.
- iii) These effects were more prominent in the deliberation group than in the casual discussion group.

iv) People who watched others participating in deliberation and casual discussion showed similar effects, but to a much smaller extent.

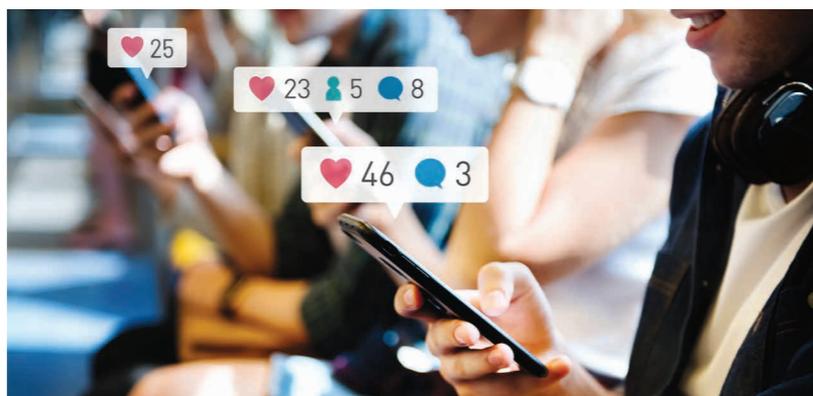
Based on these findings, Dr Shen recommends the policymakers provide opportunities and set up platforms for political dialogue among the public. These activities could be organised at the community level by non-governmental organisations. A more realistic approach would be to identify a few communities as field experiment sites and conduct a longitudinal study to follow the long-term impact of a community-based social dialogue programme. "In the long run, Hong Kong society needs institutions and organisations to promote discussions among citizens, with the government acting as an incubator, providing the necessary resources," said Dr Shen.

### Major Awards

- Facebook Research Award (Foundational Integrity Research) 2020
- External Fellow, Center for Information and Communication Studies, Fudan University, 2016 - present
- External Fellow, Center for Internet and Governance Research, Sun Yat-sen University, 2015 - present
- Faculty Associate, The Berkman Klein Center for Internet and Society, Harvard Law School, Harvard University, 2015-2016
- Google Faculty Research Award 2014

### Key Projects

- Facebook Research Award (Foundational Integrity Research): Can Third Party Fact-checkers on Facebook Reduce Affective Polarization?
- Public Policy Research Funding Scheme (Special Round): How to Reduce Political Polarization in Hong Kong: A Pilot Experiment of Deliberation
- General Research Fund:
  - Tracking Public Opinion Through Real-time Textual Mining: A Public Service Platform with Big Data-based Approach
  - Trust in Media Revisited: A Rational-emotional Model
- Google Faculty Research Award: An Empirical Study of Asian Values and Freedom of Expression



### Selected Publications

- Min, C. & Shen, F. 2021, "Grievances, resources, or values? Predicting online citizen-initiated government contacts in China", *Telematics and Informatics*, vol. 56.
- Shen, F. & Tsui, L. 2018, "Revisiting the Asian values thesis: An empirical study of Asian values, internet use, and support for freedom of expression in 11 societies", *Asian Survey*, vol. 58, no. 3, pp. 535-556.
- Shen, F. 2017, "Internet use, freedom supply, and demand for internet freedom: A cross-national study of 20 countries", *International Journal of Communication*, vol. 11, pp. 2093-2114.
- Shen, F. & Liang, H. 2015, "Cultural difference, social values, or political systems? Predicting willingness to engage in online political discussion in 75 societies", *International Journal of Public Opinion Research*, vol. 27, no. 1, pp. 111-124.