HARNESSING EVOLUTIONARY INSIGHTS TO PREDICT TREATMENT OUTCOMES

Despite decades of research, the prevention and effective treatment for many forms of cancer remain elusive to scientists. Now, the pairing of big data and cancer genomics is deepening understanding of the evolutionary history of tumors, opening up improved forecasting of the course of the disease in individual patients and greater potential for optimized therapeutic options, rather than the current one-size-fits-all approach.

The computational models of mathematician and bioinformatics specialist Prof Jiguang Wang and his lab are at the forefront of such advances in precision medicine. A combination of human algorithmic ingenuity, big data, and genome sequencing has located genetic markers that help to trace cancer tumor evolution. Then, by comparing findings across a growing database of genomic information, case histories and treatments, past treatments that have proven successful can serve as a model for existing patients with similar cancer genome markers.

"We think of the cancer system as dynamic, not static, using mathematical methods to study the past to predict the future," Prof Wang said. Wang Lab members regularly handle 200-400 terabytes of data, made accessible through projects such as The Cancer Genome Atlas.

> What fuels me to work harder is the idea that we can provide some hope in often hopeless situations

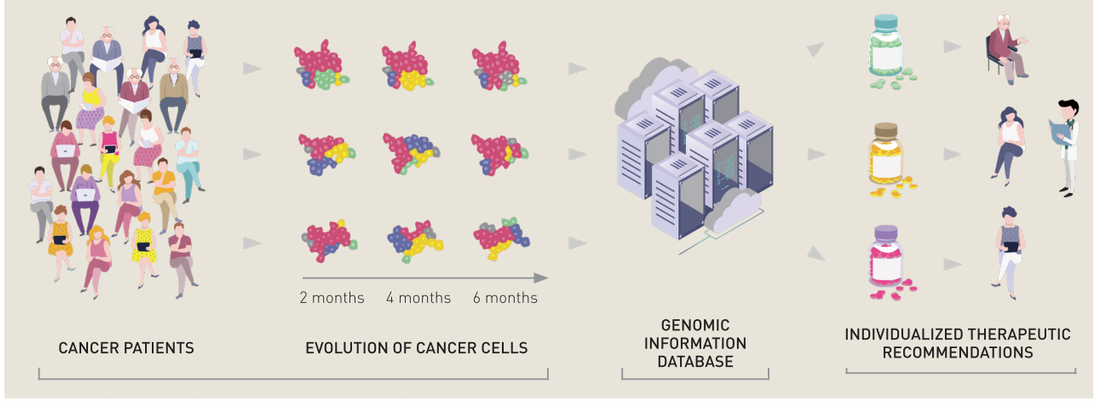
PROF JIGUANG WANG
Assistant Professor of Life Science and Chemical and Biological Engineering

The novel analytical approach allows researchers to longitudinally map changes in the mutations of a single tumor across many points of time and to integrate this with cross-sectional analysis of tumors from many different patients, using statistical models to indicate the relationships of cancer-driving gene mutations and the order in which they usually occur (*eLife,* 2014). Prof Wang is now adopting the method to glioblastoma, a particularly aggressive and invariably fatal brain cancer, as well as using a similar strategy for pan-cancer analytics.

In collaboration with Columbia University, Samsung Medical Center, and other institutes, Prof Wang and co-researchers identified a highly branched evolutionary pattern for the disease under therapy (*Nature Genetics,* 2016 and 2017). They found mutations in the initial tumor might not be present in relapsed tumors, suggesting clones discovered after treatment had diverged ahead of diagnosis. Indeed, researchers estimated they may have been in existence as early as 10 years before the cancer was first discovered.

Working with Samsung Medical Center and Beijing Neurosurgical Institute, Prof Wang also revealed significant amplification of several proto-oncogene proteins present in glioblastomas, with a positive response observed after using targeted inhibitors (*Nature Genetics,* 2018; *Cell,* 2018). Finally, targeting truncal rather than branch alteration, which might lead to repopulation of non-targeted branches, was more effective in preventing tumor reoccurrence.

The interdisciplinary Wang Lab is now working closely with leading front-line oncologists, particularly in Asia, to apply this knowledge. An artificial intelligence system is being trained to correlate drug response and genomic data. It is hoped that the system can automatically predict the optimal drug for different patients.



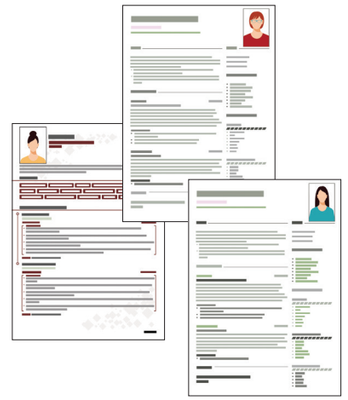
Cancer patients' clinical records, biomedical images, blood, tumor tissues, and genomic information are captured over time in a database. A combination of algorithms, big data, machine learning, and genome sequencing are applied to patients' genomic information, to reveal patterns, causal relationships, and clinical biomarkers from these multimodal data. HKUST is developing an AI system to correlate drug response and genomic data for prediction of optimal therapies. If a "twin" case is matched in the huge database and the treatment successful, this can be used to predict the optimal drug for current patients with similar cancer genome markers.

EXPLORING GENDER PREFERENCES IN ONLINE LABOR MARKETS

All else being equal, a female applicant has

13%

higher odds of being hired than a male applicant



The rapid growth of online labor platforms, such as Upwork, Freelancer, and Zhubajie, allows millions of workers to perform a range of administrative tasks, design and web programming work without geographical and temporal constraints. Many organizations are now using the online workforce as a convenient and cost-effective way to meet business needs.

In the first academic study of its kind, Prof Jing Wang and her co-author examined gender hiring bias in the online labor market and found evidence of a preference in favor of female workers. While gender inequality has been a long-standing issue in labor economics, Prof Wang's findings stand in stark contrast to the majority of traditional labor market research that has revealed discriminatory behaviors against females.

The study used a conditional logistics econometric model to analyze a dataset of 264,875 job postings and 5.7 million job applications from a leading online labor platform. Findings showed that the odds of a female applicant being hired were 13% higher than that of a male applicant, after controlling for observable worker attributes. "The platform does not collect gender information, but we were able to infer workers' gender from their names and profile photos by utilizing machine learning techniques," she said.

Prof Wang also introduced a quasi-experimental technique to address endogeneity issues by identifying workers with names that are unlikely to reveal their gender and contrasting the likelihood of workers being hired before and after they posted a profile photo. "Females with uncommon names enjoyed a 17% increase in the odds of being hired after posting a profile photo, compared with only 5% for males, suggesting that revealing their gender gives a disproportionate advantage to females," she noted.

To identify the mechanism underlying the female hiring preference, Prof Wang conducted a further experiment via Amazon Mechanical Turk. This showed female-associated traits such as trustworthiness and cooperativeness help overcome the uncertainty and opportunism of online marketplaces. She also observed that female hiring bias diminishes as employers gain more experience with online labor platforms; and such bias stems solely from consideration of applicants from developing countries, not developed ones.

"As online labor marketplaces continue to grow in size and reach, it is imperative for policymakers to establish guidelines and regulations to promote equality in labor participation and generate socially efficient hiring outcomes," Prof Wang said. She suggested that platform owners should allow workers to use pseudonyms or avatars on their public-facing worker profiles. "Workers, especially males, could add information to their profiles to signal trustworthiness and cooperativeness. Female workers should upload their photos to maximize their gender advantage," she said.

> We are the first to look at this gender bias in online markets and I am fascinated to see a positive hiring bias in favor of female workers

PROF JING WANG
Assistant Professor of Information Systems, Business Statistics and Operations Management

The novel approaches that Prof Wang developed for this research called on her distinctive background of having earned a first degree in computer science and doctoral studies in management information systems. She has published articles in *Management Science, Information Systems Research, Proceedings of the National Academy of Sciences (PNAS),* and *Data Mining and Knowledge Discovery.*