Professor Miao Jianmin
Decrypts Future Currents

High rise apartments and complexes are a trademark of Singapore's luminous cityscape. They are of course employed as a means to mitigate the constraints of land scarcity. If built too closely to each other, however, poor airflow around these structures can occur. Further compounding this problem is Singapore's humid weather where a stuffy environment is a hotbed for airborne viruses. Professor Miao Jianmin from the School of Mechanical and Aerospace Engineering at Nanyang Technological University, has been collaborating with SMART on research projects involving microelectromechanical systems (MEMS) sensors which can effectively map and monitor the flow of wind and water currents. He brings to the table his 20 years of expertise in MEMS.

Staying Cool

More than just spaces, the houses in Singapore are synonymous with a high quality of living, and the offices a mark of modernity. To perpetuate this trend, data such as the measure of air velocity is becoming increasingly important to architects as they develop the blueprints. They need to know the optimal distance to line each building and the best way to cluster the buildings to maximise airflow. "Natural ventilation is important because it brings about comfort," explains Prof Miao. "Gentle breezes can really help to cool the temperature. Homes that have good ventilation are generally cosier to live in."

Together with the SMART team led by Prof L. Norford, they have created MEMS-based equipment that can monitor the airflow pattern around a high rise building. This innovation is a new rendition of the bulky and costly accelerometer, an existing technology in the market.

And a key advantage is that these sensors are very cost-effective. "The sensors, on their own, measure up to a millimetre and they are very cheap," says Prof Miao. "To accurately monitor the environment and airflow, you need a lot of sensors, maybe not just hundred sensors but thousands of sensors to map the airflow around the buildings, and at different locations and different heights."

Each sensor array is lightweight and it can even be mounted on an object the size of a ping pong ball. As such, installation of the MEMS-based system anywhere on the buildings is a breeze. The readings by the sensor arrays, when juxtaposed against those registered by the accelerometer, reflected the same results, indicating a high level of accuracy.

Cruise control

At SMART, collaboration between interdisciplinary teams is widely encouraged. Working closely with Professor Michael Triantafyllou as well as Professor George Barastathis, Prof Miao has made considerable headway on another SMART project, the premise of which involves attaching MEMS pressure sensors to the sides of a ship.

The derivation of this research idea is quite fascinating. Since 2008, they began an in-depth study of the Mexican cave-blind fish. Despite having lost their eyesight, this species of minute fish are able to swiftly manoeuvre around obstacles. Sensitive to the slightest change in water pressure, the fish's lateral line systems have 'passive sensors' that give them this ability.

To replicate this phenomenon, the professors have attached the MEMS pressure sensors along the body of a ship; they give the ship the ability to sense the presence of nearby obstacles and the direction of an oncoming current. Battery-powered autonomous underwater vehicles (AUV) or robots often have to expend energy to fight the ocean currents and this drains the lifespan of the battery. Now, with the sensors, pre-emptive measures such as charting a new route can be taken and the AUV can avoid sailing into the turbulent currents altogether.

Blue Skies

The future mode and mobility of these micro-sensors is intriguing. Prof Miao is now in talks with various government agencies to see how best to adapt this technology for their respective operations. The sensors currently rank amongst the world's most innovative technologies.

Prof Miao says that the collaboration with SMART has helped combine the strengths of the two research communities. "MIT professors have the 'big' vision, and the students, who have the technical knowledge, get to understand how they think, and be involved in SMART activities," enthuses the Shanghai-born professor. He sees Singapore being increasingly at the epicentre of future research.

Prof Miao hopes to see a paradigm shift towards blue skies research. He encourages his PhD students to be independent thinkers. "The research topic the students take on should be new. It should be research that nobody has done before - not in Singapore, not in Asia, not in the world."

So essentially, the laboratory becomes a playground for the researcher. Prof Miao believes it is about being creative and being entrepreneurial. Perhaps even stretching students beyond the mind-set of graduation and being focused on making a breakthrough. After all it is noteworthy that serendipitous scientific breakthroughs have been made thanks to this research style — precedents include the discovery of X-rays and advances in stem cell biology.

*Associate Professor Miao Jianmin is the Founding Director of Micromachines (MEMS) Centre in the School of Mechanical and Aerospace Engineering at Nanyang Technological University, Singapore. To date, Prof Miao has published over 300 papers in international journals and conference proceedings, several books/book chapters and filed 10 patents. He has received many project grants from government agencies such as A*Star, MOE and DSO. Prof Miao has chaired and co-chaired several MEMS/Nanotechnology conferences and is often invited to give plenary, keynote speeches and talks at international conferences.*

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