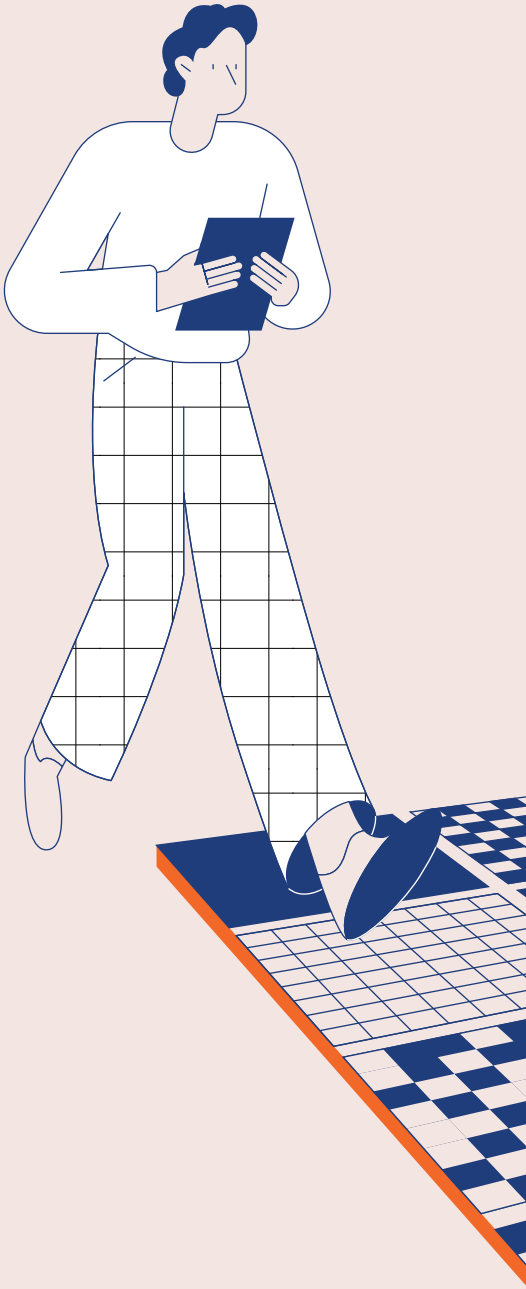
MACHINE LEARNING

If floors could talk

Floor mats equipped with deep learning could take us one step closer to truly smart homes.



Mention the phrase 'smart home' and a host of appliances come to mind, from fridges and speakers to the intelligent microwave oven you never knew you needed. While all these objects offer convenience and new functions, the biggest—and possibly most useful—smart home feature might be right at your feet: the floor.

When used at home, smart floors could help to detect falls without the use of privacy-invading video cameras. In places like office buildings, smart floors can help reduce electricity consumption by automatically turning of lights and air conditioning in unoccupied rooms. But smart floors have yet to hit the mainstream due to two main challenges; firstly, finding an efficient way to power them and then making sense of the data generated.

By tapping on triboelectricity—the same phenomenon that causes static—a team from the SIMTech-NUS joint lab has developed a low-cost smart mat that uses a deep learning algorithm to transform triboelectric signals into accurate information about occupants of a room.

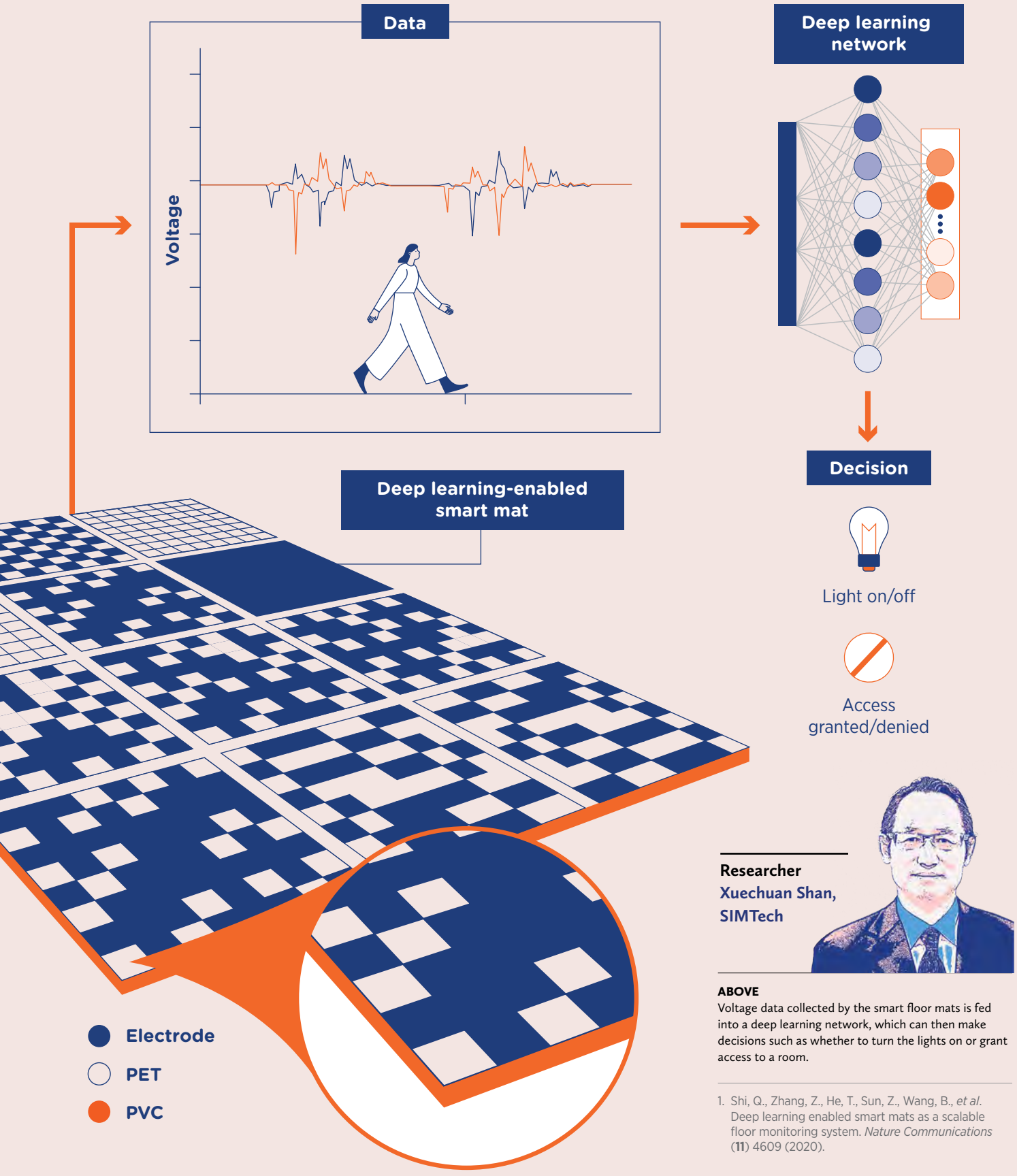
"The design concept was inspired by the QR code system," said study co-author Xuechuan Shan, a Senior Scientist at A*STAR's Singapore Institute of Manufacturing Technology (SIMTech), explaining the 3 x 4 array of mats with electrodes of different densities that are screen-printed onto a plastic film. "Employing these unique 'identity' electrode patterns enabled the parallel connection of numerous floor mats in an array configuration, minimizing the number of output terminals and system complexity."

When a shoe comes into contact with the top layer of the mat, friction causes the sole to be negatively charged; and as it is pulled away, the mat is left positively charged, Shan explained. The positive charges attract negative charges from the ground through the printed electrodes, creating a flow of current that traces a person's footsteps while generating electricity at the same time.

While the phenomenon is well known, the sensor configuration is more critical and gait recognition is more computationally complex to analyze than other biometrics. To get around this problem, the researchers used a well-developed deep learning model to convert the signals into gait information.

"After optimizing the network structure and other high-level parameters, we were able to achieve an average prediction accuracy of 96 percent for a ten-person dataset, offering high accuracy in practical, real-time scenarios," Shan said.

Not satisfied with these promising initial results, Shan believes that they can push the envelope further. "We will further optimize the sensors to improve robustness, accuracy and functionality," he said. "We plan to expand the application beyond user identification to smart-home-based interactions like motion recognition and gesture prediction." ★



Researcher
Xuechuan Shan, SIMTech

ABOVE
Voltage data collected by the smart floor mats is fed into a deep learning network, which can then make decisions such as whether to turn the lights on or grant access to a room.

1. Shi, Q., Zhang, Z., He, T., Sun, Z., Wang, B., *et al.* Deep learning enabled smart mats as a scalable floor monitoring system. *Nature Communications* (**11**) 4609 (2020).