Researchers invent interactive mouthguard that controls electronic devices by biting

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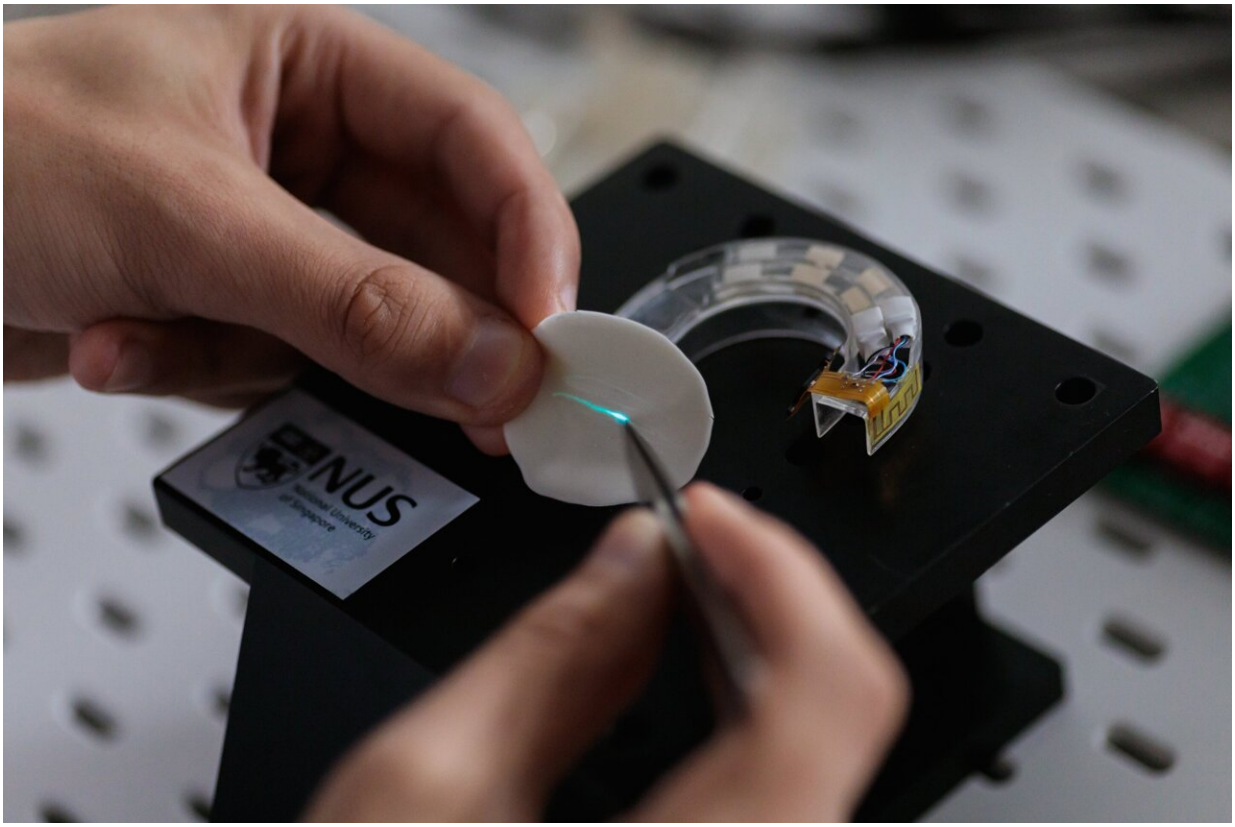

This revolutionary mouthguard – a first-of-its-kind bite-controlled optoelectronic system - invented by researchers from the National University of Singapore is affordable, light-weight, compact, and requires less training time compared to existing assistive technologies. Credit: National University of Singapore

Individuals who have limited hand function can soon have a simple way

of controlling devices such as computers, smartphones, and wheelchairs by wearing a smart mouthguard that translates complex bite patterns accurately and quickly into instructions to control electronic gadgets. This first-of-its-kind bite-controlled optoelectronic system was invented by a research team led by Professor Liu Xiaogang from the Department of Chemistry at the National University of Singapore (NUS) Faculty of Science, together with collaborators from Tsinghua University.

Various assistive technologies such as voice recognition, eye tracking and brain-computer interfaces have been developed in recent years to help people—especially those with limited dexterity or neurological disorders—control electronic devices. However, these technologies have limitations associated with environmental interference, control accuracy, cost and maintenance.

To offer a promising alternative to existing assistive technologies, Prof Liu and his team have successfully designed and demonstrated a smart mouthguard containing integrated pressure sensors to detect occlusal patterns. These patterns are translated into data inputs with 98% accuracy, and can be used to control computers, smartphones and wheelchairs.

The team's technological breakthrough was published in the journal *Nature Electronics* on October 10, 2022.

Besides supporting human-computer interaction, the interactive mouthguard can also be used for medical assistance, healthcare devices such as smart electronic skin, and dental diagnosis.

Limitations of current assistive technologies

Assistive technologies help to promote independence and autonomy for people with disability. Unfortunately, such technologies also have

significant drawbacks. For example, voice recognition requires a large operating memory and needs to operate in a low-noise environment, while eye tracking requires a camera to be mounted in front of the user and is prone to fatigue. Although brain–computer interfaces have improved considerably in recent years, this technology is invasive and requires cumbersome wired instruments.

Bite force, often used as a parameter to assess masticatory (chewing) function, is a promising area that is not well understood or capitalized. As dental occlusion provides high-precision control and requires minimal skill, Prof Liu and his team came up with a new concept for assistive technology by utilizing unique patterns of occlusal contacts.

Translating bite patterns into useful data for device control

The research team first designed a sensor comprising a series of contact pads containing different colored phosphors—these are substances that emit light in response to pressure. The array of contact pads is placed within a flexible mouthguard.

Biting causes the contact pads to mechanically deform and emit light in different colors and intensities, which can be measured and processed using machine learning algorithms. The data collected is then used for high-accuracy remote control and operation of various electronic devices, such as a computer, smartphone and wheelchair.

Weighing about 7 grams, the novel mouthguard requires less training experience when compared to existing assistive technologies.

"Our bite-controlled optoelectronic system is capable of translating complex bite patterns into data inputs with 98% accuracy. We have also

demonstrated that our novel sensors can distinguish mechanical deformations, including strain, compression and bending, making them applicable to multifunctional mechanical sensing applications, such as miniaturized force sensing, flexible electronics, artificial skin, and dental diagnosis," explained Prof Liu.

Each smart mouthguard currently costs S$100 (US$70) to produce in the lab, and the team expects the cost to be reduced substantially in mass production. Although the current prototype is designed for well-aligned teeth, a mouthguard with an irregular arrangement of phosphor-infused pads could be developed for users with different tooth patterns or for individuals who wear dentures.

The research team has filed a patent for this innovative technology, and they are exploring opportunities to validate their device in a clinical setting, such as care centers or nursing homes. Concurrently, the researchers are also looking at ways to enhance their technology, such as faster data processing and training.

More information: Bo Hou et al, An interactive mouthguard based on mechanoluminescence-powered optical fibre sensors for bite-controlled device operation, *Nature Electronics* (2022). DOI: 10.1038/s41928-022-00841-8

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