RESEARCH NEWS

Cognitive load

Smart Sensor Network and AI Algorithms Ease Strain on Stressed Drivers

Fraunhofer researchers have developed a system that uses sensors and AI to monitor a driver's cognitive load. In the future, this technology could ease driver strain when they reach their stress limit. The system can also be applied in other fields, such as for pilots or surgeons. The researchers are using an innovative sensor network for the project — as well as a PC game for preparing virtual sushi.

Driving seems so natural that many people are hardly aware of the enormous amount of information they have to process behind the wheel. The display indicates speed, RPM and fuel level; the navigation system shows the route; traffic lights, road signs and other road users must be observed. What's more, drivers may be talking to passengers or listening to the news on the radio. Once a driver reaches their cognitive load limit and has to make a decision in a critical traffic situation, things can become dangerous.

Researchers at the Fraunhofer Institute for Integrated Circuits IIS in Erlangen are developing a system that is to support individuals in performing complex activities in various settings while taking into account their cognitive load limit. They are implementing two proprietary technologies for this purpose: a network of sensors that measures biosignals, such as pulse, respiratory rate and movements, and AI-driven algorithms that recognize when a person has reached their cognitive load limit. The criteria for evaluating the biosignals were defined based on studies in which the researchers investigated the relationship between biosignals and cognitive load in test subjects.

In practice, the system could ensure that the vehicle electronics relieve the driver of certain tasks to reduce overall complexity or simply recommend a break at the next rest stop.

Mobile and multimodal sensor network

To implement their idea, the Fraunhofer researchers developed the maphera® sensor network. "We integrated a large number of different sensors into a system that not only works in the lab but is also mobile, allowing it to be used in a wide variety of situations. maphera® is modular in design. Depending on the application or requirements, we combine different sensors," explains Norman Pfeiffer, Group Manager for Medical Sensor Systems at Fraunhofer IIS. These sensor systems can be integrated into clothing

Contact
Monika Landgraf | Fraunhofer-Gesellschaft, Munich, Germany | Communications | Phone +49 89 1205-1333 | presse@zv.fraunhofer.de
Thoralf Dietz | Fraunhofer Institute for Integrated Circuits IIS | Head of Corporate Communications | Phone +49 9131 776-1630 | Am Wolfsmantel 33 | 91058 Erlangen, Germany | www.iis.fraunhofer.de/en.html | thoralf.dietz@iis.fraunhofer.de

or embedded in wristbands and smart patches — intelligent, mostly skin-adhering, wireless sensors that can continuously monitor biosignals. The data is then transmitted using Bluetooth Low Energy (BLE).

What sounds simple is, in fact, technically challenging. This is because different sensors are equipped with different microcontrollers that operate at different clock frequencies. With short-term measurements, this is not a problem. However, when used while driving or in the field of occupational safety, measurements often run for several hours. In these cases, clock drifts accumulate, and the biosignals fall out of sync. They can then no longer be assigned to the same point in time. The Fraunhofer researchers have succeeded in calculating the clock drifts caused by the different microcontrollers when collecting the sensor data. "With our system, the data is in sync, with a tolerance of just 30 microseconds," says Pfeiffer. Hence the project name maphera®. The name comes from ancient Greek and means "to transfer simultaneously."

Testing cognitive load with computer games

The second part of the extensive research initiative focuses on the relationship between biosignals and cognitive load. The test subjects solve tasks of increasing difficulty in an exposure cabin where they are not disturbed by external influences such as temperature changes, drafts or noise.

To solve these tasks, they play computer games. As a chef or kitchen staff in a sushi restaurant, they take orders and assemble sushi dishes. Over time, both the number of orders and the complexity of the dishes ordered increase. While the test subjects perform their tasks, sensors record their bodies' biosignals. This data is then collected and combined with the *n*-back test, a standard psychology test that examines cognitive abilities such as attention and memory. The tests are followed by one-on-one interviews with the test subjects.

Nadine Lang-Richter, Group Leader for Medical Data Analysis at Fraunhofer IIS, says: "In the final step, we bring all the information together and analyze it using AI algorithms that we developed in-house. This allows us to create a personal cognitive load profile."

Driver monitoring systems in new cars

Systems like these could use sensors, including cameras, to monitor drivers and intervene when they reach their cognitive load limit. Car manufacturers are showing a strong interest in this technology since camera-based advanced driver distraction warning (ADDW) systems will be mandatory in new cars from 2026 as part of the EU's General Safety Regulation (Regulation (EU) 2019/2144). These systems are designed to assess whether the person behind the wheel is paying attention and will also be mandatory for self-driving cars. Here, too, the driver must remain vigilant in order to be able to intervene quickly in an emergency.

Pilot training

The new Fraunhofer technologies could also be used in aviation. For pilots, the individual load profile could complement and improve their training. In the future, the technologies could even be used in operating rooms. Monitoring systems could increase the safety of long surgical procedures, which require sustained performance and focus over many hours.

The Fraunhofer IIS researchers will be presenting maphera® and their technologies at the Medica 2025 trade show (November 17–20, 2025, Hall 12, Booth C31) in Düsseldorf, Germany.

Fig. 1 The maphera® sensor network measures biosignals even outside the lab. Depending on the application, maphera® can be tailored to individual requirements.

© Fraunhofer IIS

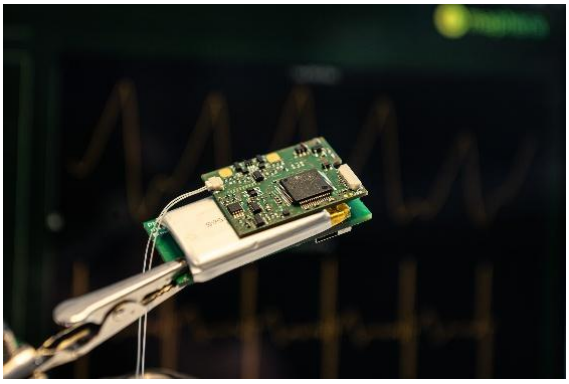

Fig. 2 The miniaturized maphera® sensor node without housing records an ECG. By interconnecting two circuit boards, the individual sensor nodes can be adapted to other applications.

© Fraunhofer IIS / Stephan Göb

Fig. 3 Unobtrusive while driving: The driver wears a wrist sensor node and a chest strap (under the shirt) to record an ECG. The maphera® user interface is displayed on a tablet, showcasing the data in real time.

© Fraunhofer IIS / Paul Pulkert

Fig. 4 In the exposure cabin, test subjects complete their tests without being subject to external influences such as noise, drafts or temperature. The biosignals and camera recordings can be observed in real time during the test.

© Fraunhofer IIS