AI-Powered Electronic Tongue That Can Assess Safety & Freshness of Food

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Courtesy of SynEvol
Credit: Saptarshi Das Lab/ Penn State

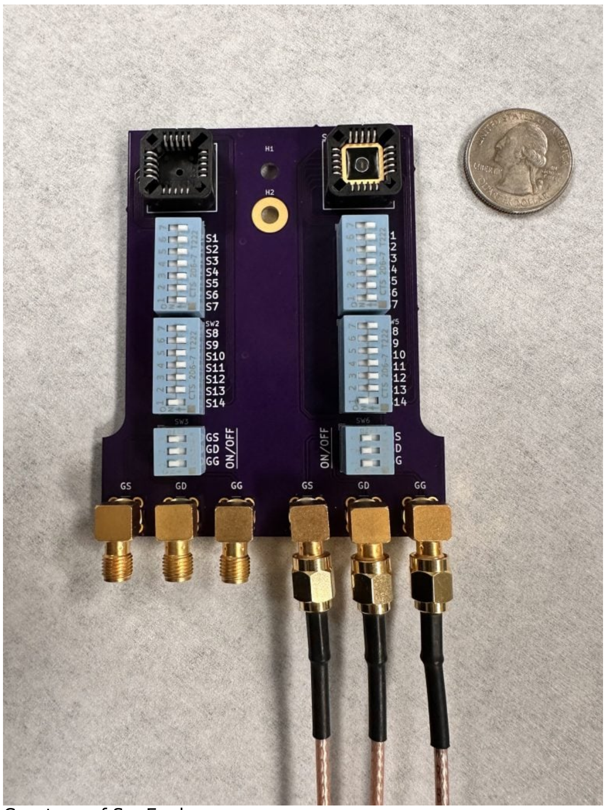
A recently created electronic tongue is capable of identifying a wide range of items, such as various soda varieties and coffee mixes, as well as tiny variations in comparable liquids, such as milk with variable water contents. Additionally, it can identify any problems with food safety and fruit juice deterioration. The team, led by Penn State academics, found that when artificial intelligence (AI) interpreted the data generated by the electronic tongue using its own evaluation criteria, accuracy increased dramatically.

The researchers claim that the electronic tongue has potential applications in medical diagnosis and food safety and production. Together, the sensor and its AI are able to identify and categorize a wide range of compounds while evaluating each one's quality, legitimacy, and freshness. According to the researchers, this evaluation has also given them insight into how AI makes judgments, which may result in improved AI applications and development.

According to corresponding author Saptarshi Das, an Ackley Professor of Engineering and professor of engineering science and mechanics, "We're trying to make an artificial tongue, but the process of how we experience different foods involves more than just the tongue." "We have the tongue itself, which is made up of taste receptors that interact with different types of food and communicate that information to the gustatory cortex, which is a biological neural network."

Taste receptors mainly classify foods into five basic categories: sweet, sour, bitter, salty, and savory. The gustatory cortex is the part of the brain that detects and interprets different flavors beyond what taste receptors can detect. The brain becomes more adept at differentiating flavors as it gains knowledge of their subtleties. The researchers used a neural network—a machine-learning program that simulates the human brain in evaluating and comprehending data—to artificially replicate the gustatory cortex

As a doctoral student in engineering science and mechanics who Das advised, co-author Harikrishnan Ravichandran said, "Previously, we looked into how the brain responds to different tastes and mimicked this process by integrating different 2D materials to develop a kind of blueprint as to how AI can process information more like a human being." "Now, we're looking at a number of chemicals in this work to see if the sensors can detect them accurately. In addition, we're looking at whether they can detect subtle differences between similar foods and identify instances of food safety concerns." "Now, we're looking at a number of chemicals in this work to see if the sensors can detect them accurately. In addition, we're looking at whether they can detect subtle differences between similar foods and identify instances of food safety concerns."



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The tongue is made up of an artificial neural network that has been trained on a variety of datasets and is connected to a graphene-based ion-sensitive field-effect transistor, or a conductive device that can sense chemical ions. Crucially, Das pointed out, the sensors are non-functionalized, which means that instead of having a single sensor for every possible chemical, one sensor may detect several kinds of chemicals. The 20 distinct factors that the researchers gave the neural network to evaluate are all connected to the way a sample liquid interacts with the electrical characteristics of the sensor. The AI could reliably identify samples based on these researcher-specified parameters, such as watered-down milks, various sodas, coffee blends, and several fruit juices at varying freshness levels, and report on their content with more than 80% accuracy in around a minute.

We chose to give the neural network the raw sensor data so it could determine its own figures of merit after it had achieved a respectable level of accuracy using human-selected parameters. When using the machine-derived figures of merit instead of the ones supplied by humans, we discovered that the neural network achieved a nearly perfect inference accuracy of over 95%," said co-author Andrew Pannone, an engineering science and mechanics doctorate student Das mentored. "Therefore, we employed a technique known as Shapley additive explanations, which enables us to inquire about the neural network's thoughts following a decision."

In order to give values to the facts under examination, this method makes use of game theory, a decision-making process that takes into account the choices made by others in order to anticipate the outcome of a single player. The team was able to gain insight into the neural network's decision-making process, which has been mainly unknown in the field of artificial intelligence, by using these explanations to reverse engineer an understanding of how the neural network weighed different sample components to reach a final conclusion. The Shapley additive explanations showed how important the neural network viewed each input data, and they discovered that rather than only evaluating individual human-assigned parameters, the neural network evaluated the data it determined were most essential combined.

According to the experts, this evaluation may be likened to two individuals consuming milk. Both of them are able to recognize that it is milk, but one may believe it to be skim that has gone bad while the other believes it to be 2% that is still fresh. Even the person conducting the assessment finds it difficult to articulate the subtleties of why.

Das stated, "We discovered that the network examined more nuanced aspects of the data — things that we, as humans, find difficult to adequately define." Additionally, the neural network mitigates daily changes by taking into account the sensor features holistically. The neural network can identify the milk's fluctuating water content and, in turn, identify whether any signs of deterioration are significant enough to qualify as a problem with food safety.According to the experts, this evaluation may be likened to two individuals consuming milk. Both of them are able to recognize that it is milk, but one may believe it to be skim that has gone bad while the other believes it to be 2% that is still fresh. Even the person conducting the assessment finds it difficult to articulate the subtleties of why.

Das claims that the tongue's abilities are only constrained by the data it is trained on, which means that although this study focused on food evaluation, it may also be used for medical diagnosis. Furthermore, the researchers stated that although sensitivity is crucial in any application, the resilience of their sensors offers a way ahead for widespread use across several industries.

According to Das, machine learning algorithms can analyze all the data and still come up with the correct result, so the sensors don't have to be exactly the same. This results in a production process that is more cost-effective and feasible.

Das stated, "We discovered that we can tolerate imperfection." "And that's what nature is—it has flaws, but like our electronic tongue, it can still make sound decisions."
