SUPPLEMENTARY INFORMATION

A visual-olfactory multisensory fusion spike neural network for early fire/smoke detection

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Supplementary Notes:

1. Gas Sensors in Dataset Establishment

Supplementary Figure 1 shows one of the gas sensors used in the dataset establishment. These gas sensors are convenient to use and use RS485 communication protocol with 5 pins. The Printed Circuit Board (PCB) of communication circuits used in conjunction with these sensors is shown in Supplementary Figure 2. The sensors can be directly inserted into the circuit for use, which is very convenient. In the experiments, the PCB needs to be connected to a power cord and a USB adapter cable. The sensor is powered by 5V DC. The sensor is connected to a computer through the USB adapter cable, and the computer receives and saves data in real-time. The gas sensors used in the experiment are all commercial ordinary electrochemical or infrared sensors.

2. Scenario settings during data collection

All data collection was conducted in a qualified chemical laboratory fume hood, ensuring the safety of the experiment. Some scenes with or without fire are set, as shown in Supplementary Figure 3, respectively. In the setting of the experimental scene, we tried our best to ensure a balance between the two types of scenes with and without fire. At the same time, we also fully considered the complexity and diversity of the experimental samples. 27 and 23 sets of experiments were designed for scenarios with and without fire, respectively. Differences were made between the experimental in terms of sensors' position, camera angle, scene complexity, etc. In addition, some interference content groups have also been set up. Supplementary Figure 4 shows some typical samples with fire. Supplementary Figure 5 shows some typical samples without fire.

3. Estimation of response time to fire

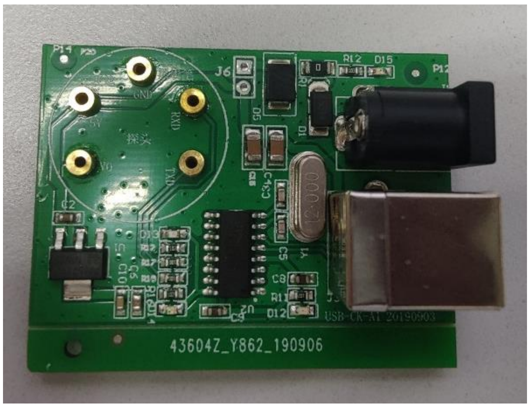
In the research of gas sensors for detecting flames, the response time corresponds to the time from the occurrence of the fire to the sensor response. In this study, we inherited this concept while considering both the response time of the gas sensors and the image sensor. In the estimation, the response time of the image sensor is extremely short, and based on our sampling frame rate, the response time of the image sensor is 0.167 seconds. Therefore, the overall response time is ultimately constrained by the response time of the gas sensor. In the experiment, the gas sensor takes up to 15 seconds from being powered on to completing preheating. The response time of gas sensors to fire varies from about 5 seconds to about 45 seconds, depending on factors such as combustion scale, sensor location, smoke concentration, etc. In the statistics, we recorded the response time of our method according to the worst-case scenario, that is about 1minute. Compared to [1], Their customized sensor array has a response time of approximately 5 minutes to fire, while traditional smoke detector has a response time of approximately 14 minutes. Considering that the experiment is conducted in different scenarios, it is impossible to quantitatively compare the response time. Compared to the experimental scenario data in [1], we comprehensively believe that the response time of this method is on the same level as that of the customized sensor array, which is much faster than traditional smoke detector. The fast response time of this method is due to the fact that the experiments are all conducted in a fume hood, which accelerates the airflow speed. On the other hand, the fusion method has natural advantages in response time. After the image sensor responds, our method can initiate the judgment and achieve the judgment accuracy based on visual methods.

4. Anti-noise numerical experiment

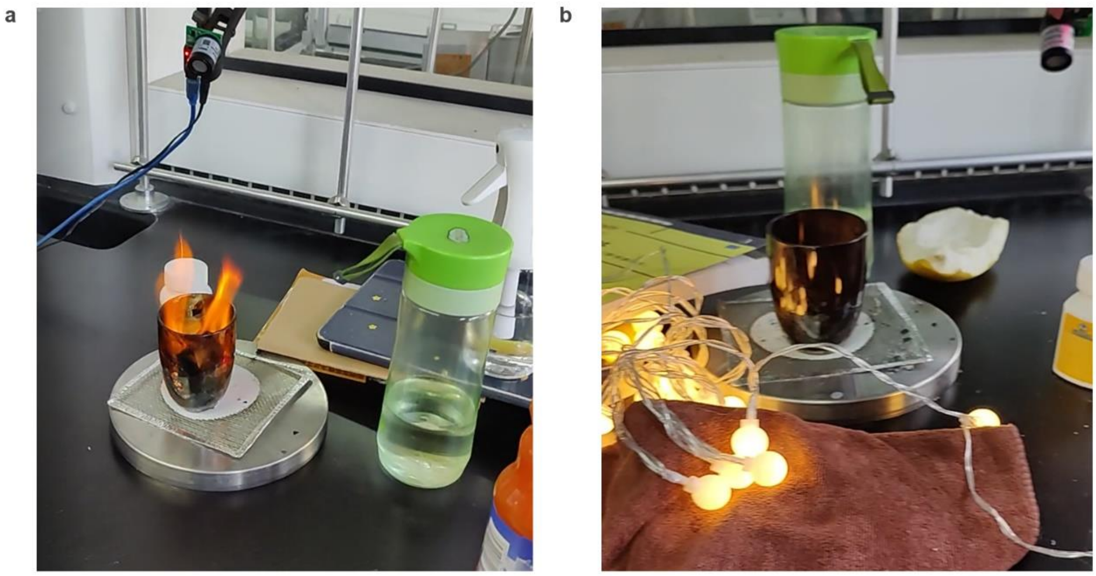
To verify the anti-noise performance of the fusion method, we add different random Gaussian noise to the samples of the dataset, and check the performance of the method. In the experiment, random noise is added by computer according to the calculation method of Gaussian noise, and the normalized standard deviation is 0.05, 0.1, 0.15, 0.2 and 0.25 respectively. The experiment comprehensively considered and tested the accuracy of fusion methods with noise added to all data, only image data with noise added, and only gas data with noise added, as well as the accuracy of SNN methods with noise added to image and gas data

Supplementary Notes:

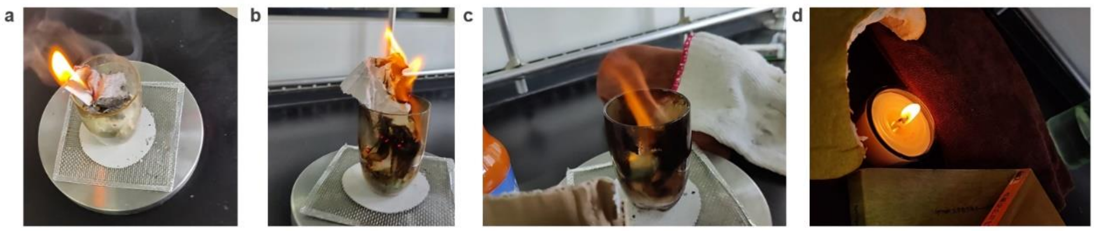
Supplementary Figure 1. Photo of gas sensors used in the dataset establishment.



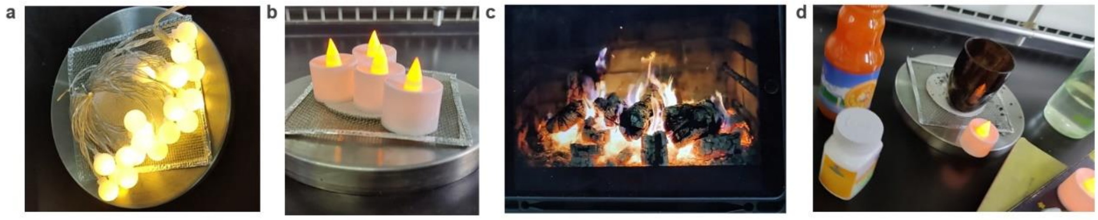
Supplementary Figure 2. Photo of Printed Circuit Board (PCB) of communication circuits.



Supplementary Figure 3. Photo of scenes with fire (a) and without fire (b).



Supplementary Figure 4. Some typical samples with fire (image).



Supplementary Figure 5. Some typical samples without fire (image).

Supplementary References

1. Solórzano. A., et al. Early fire detection based on gas sensor arrays: Multivariate calibration and validation. Sensor. *Actuat. B-Chem.* **352**: 130961 (2022).