Deep Learning for Odor Sensing

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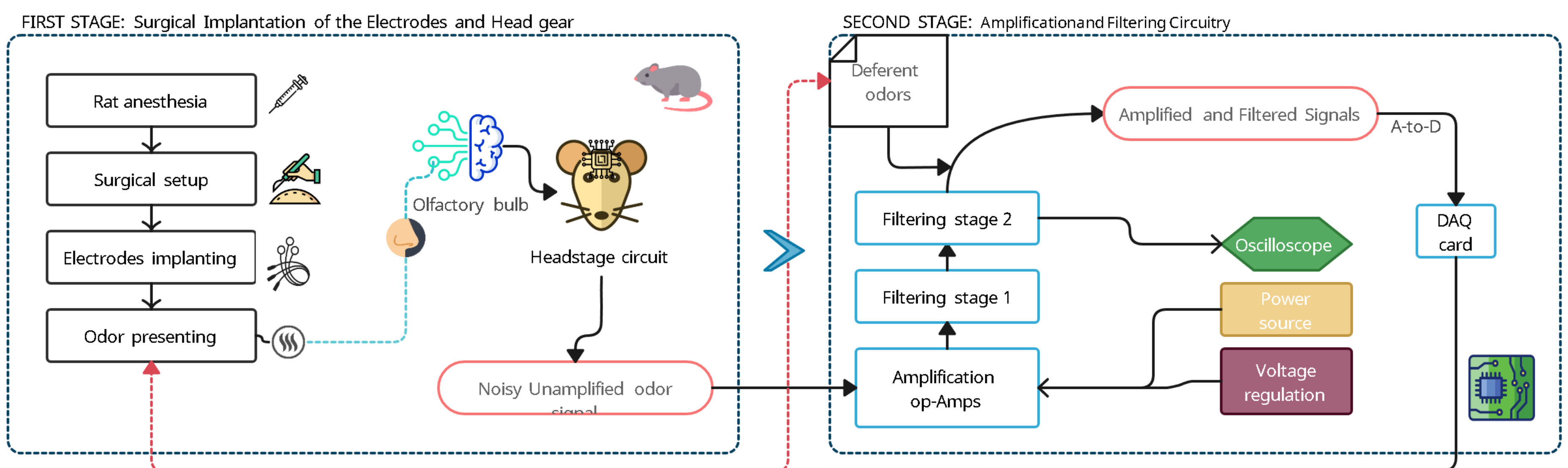
Introduction

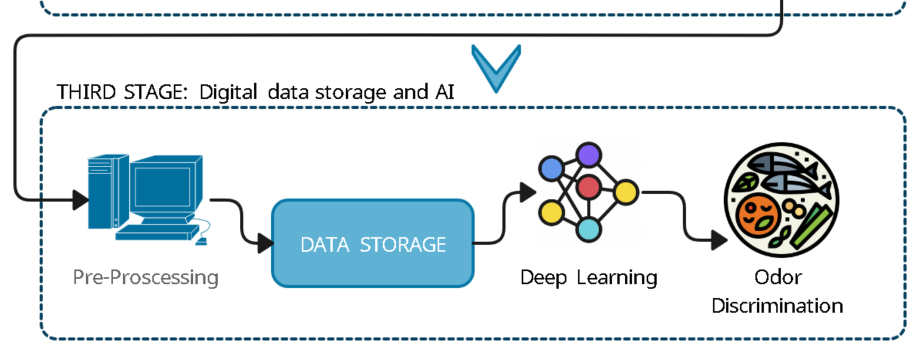
This study aims to improve odor detection by using a mouse's olfactory bulb and artificial intelligence algorithms. However, data collection issues prevented the creation of the required dataset. As an alternative, an EEG dataset was used, achieving a classification accuracy of 96%. The designed system helps in creating multiple stages for acquiring odor data including surgical setup, circuit design, electrode array design and AI models.

Motivation

This project addresses the limitations of current odor detection technologies by combining a mouse's olfactory bulb with artificial intelligence. The goal is to enhance odor classification and advance AI capabilities in sensory perception. In a world where human sense-based technologies such as cameras and microphones are already integrated into daily life applications, this project aims to integrate the sense of smell to technology.

Methodology





The methodology of this project is divided into 3 key stages, each contributing to the creation of an odor detection system:

Stage-1: Surgical Setup and head stage, were

Stage-2: Amplification and Filtering Circuit

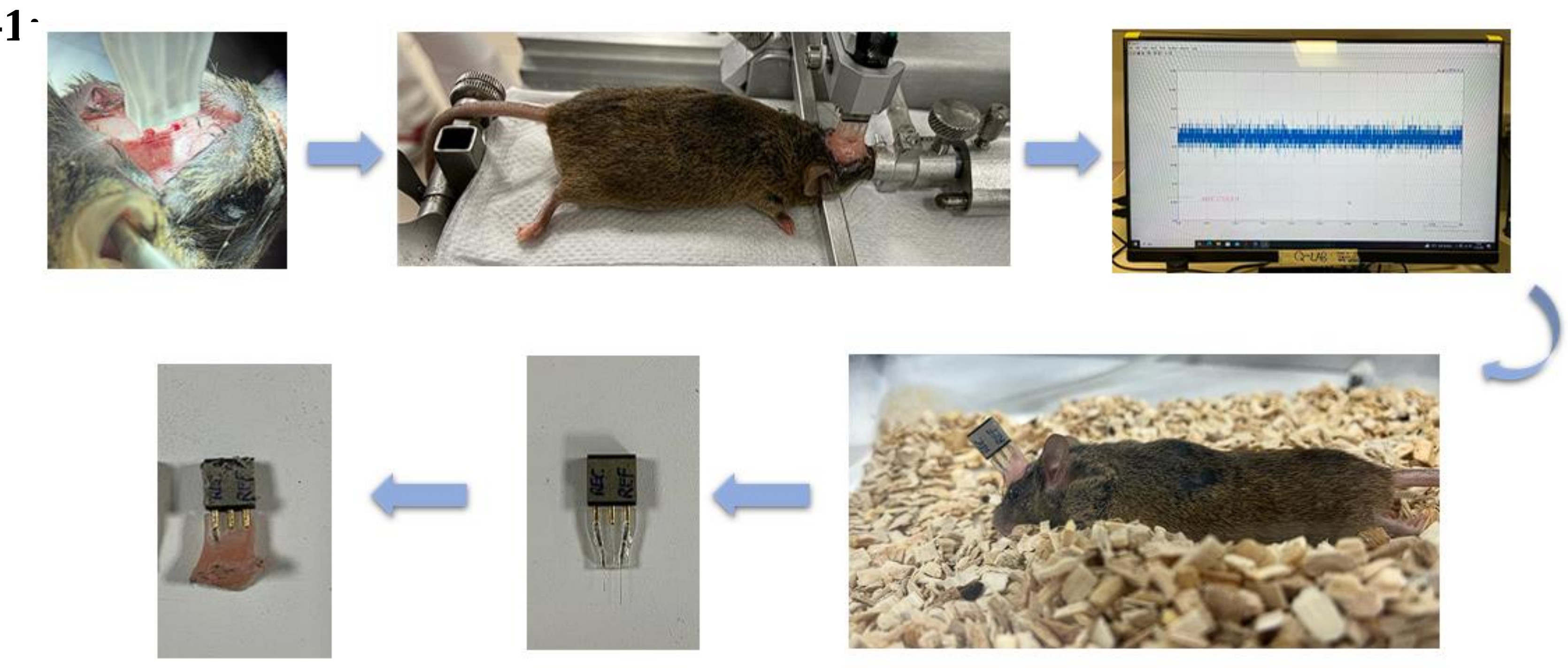
Stage-3: Data Storage and AI:

Objectives

- Developing a data collection system to gather data from the olfactory bulb, which is the part of the brain that is responsible for detecting and identifying odors.
- Helping in developing research infrastructure for the sense of smell, to integrate it into human sense technologies like cameras for sight and microphones for ears.

Results

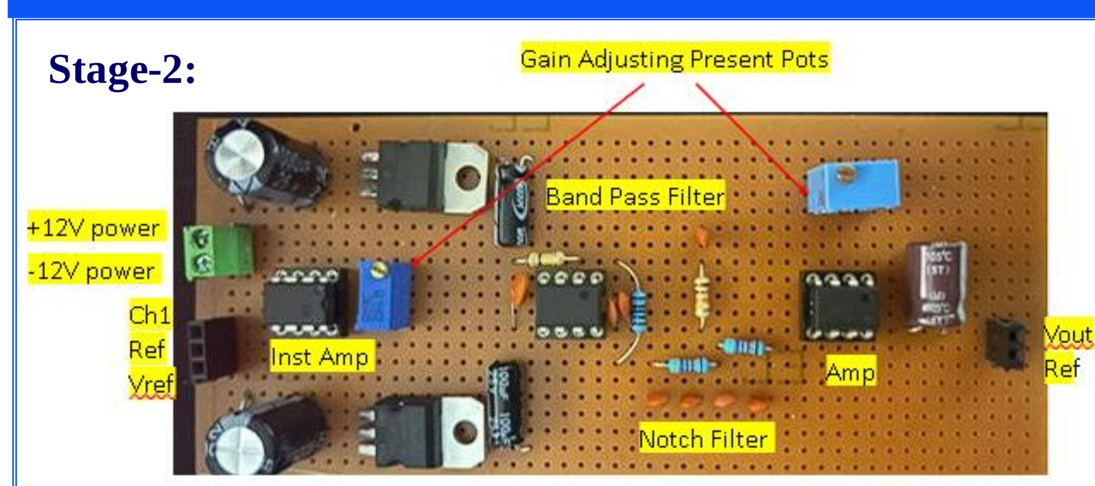
Stage-1



The electrode array designed for the olfactory insertion.

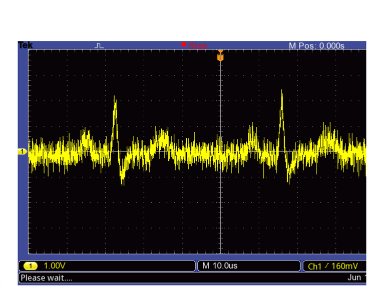
Results

Stage-2:



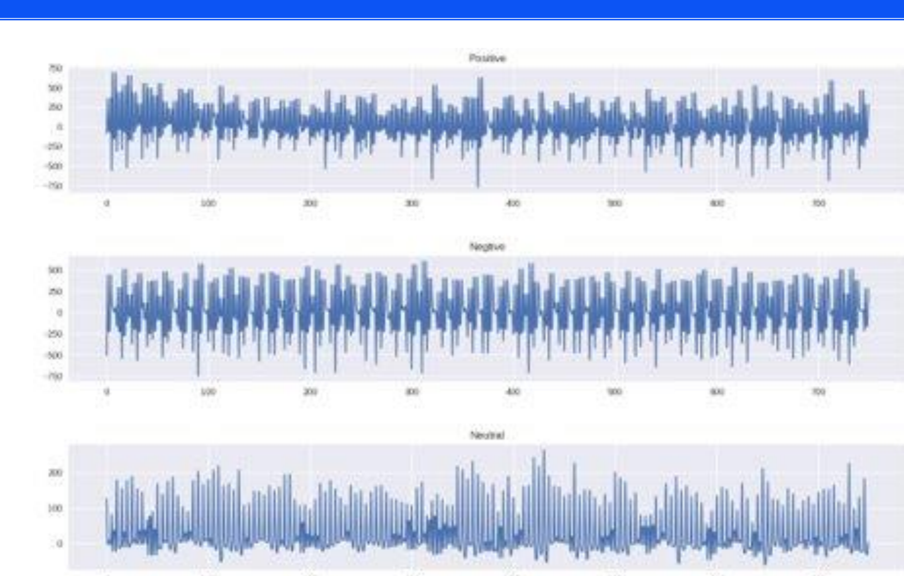
Main Specifications:

	Min	Max
Vin	10 µV	6 mV
Bandwidth	250 Hz	10 kHz
Gain	1550 V/V	12300 V/V
Power rales	±10 V	±15 V
V offset	5 µV	_
CMRR	_	95 dB
Vout	Vin	3.5 V



The circuit designed to amplify and filter small neuron signals while maintaining a high SNR with two pots for gain adjustment.

Stage-3:



Algorithm	Accuracy Result
LSTM	96.562%
CNN + LSTM	96.719%
DNN	97.5%

The EEG dataset utilized to evaluate AI algorithms, with the DNN model showing the highest accuracy.

Conclusions

In conclusion, the project successfully demonstrated the effectiveness of AI algorithms in classifying the effects of smell on the brain. Despite challenges in the electrophysiological recording stage, the overall success rate reached 90%. The high accuracy rate of 97.5% achieved by the DNN algorithm showcases its potential for odor discrimination and opens avenues for further research in this field.

Demo Video

Warning! The following demo contains surgical graphic content which might disturb some viewers.

References

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•J. Guo, Y. Cheng, D. Luo, K. -Y. Wong, K. Hung and X. Li, "ODRP: A Deep Learning Framework for Odor Descriptor Rating Prediction Using Electronic Nose," in *IEEE Sensors Journal*, vol. 21, no. 13, pp. 15012-15021, 1 July 1, 2021, doi: 10.1109/JSEN.2021.3074173.