MyDJ:

Sensing Food Intakes with an Attachable on Your Eyeglass Frame

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Food journaling brings awareness of the food intake and leads to a healthy choice of food

People often **fail** to maintain **long-term food journal**

Most cited reason of failure: **Forgetting (54%)** to journal

(Cordeiro et al. 2015)

Automated food intake monitoring on wearables

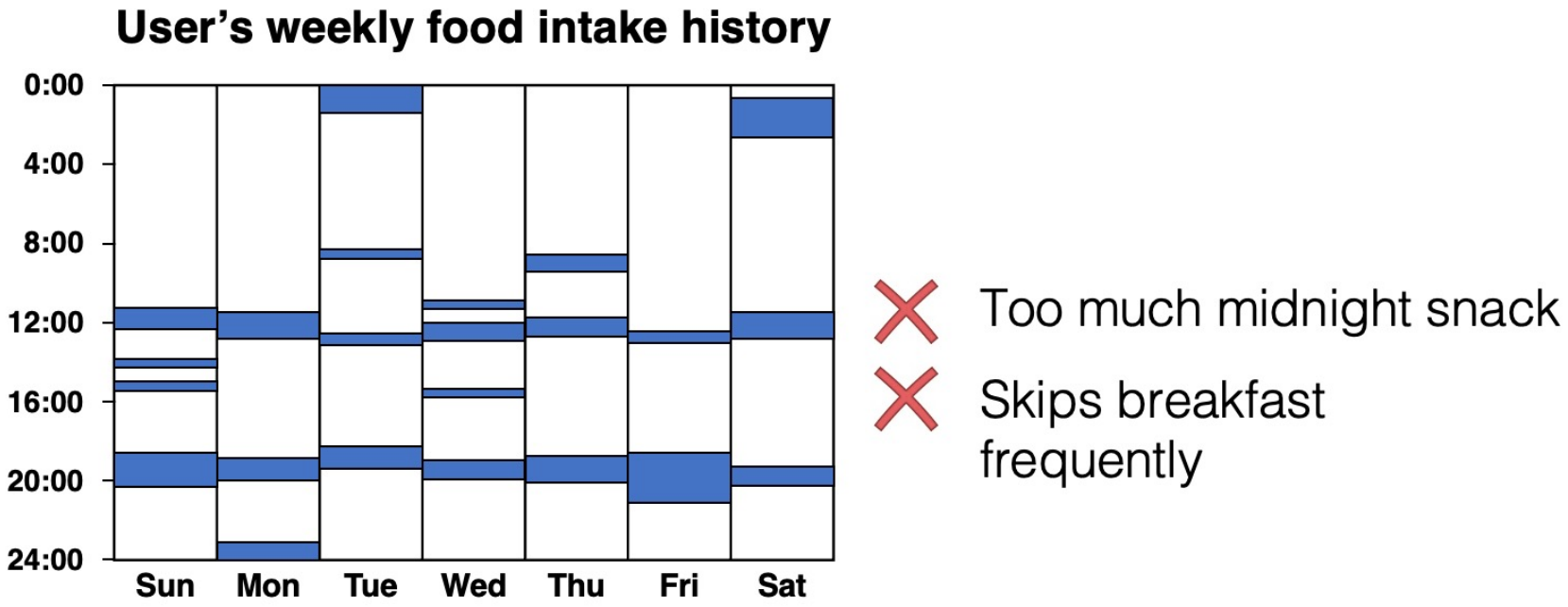
(1) *when* does eating take place, (2) *what* is eaten, and (3) *how much* is eaten

Wearables for detecting eating moments: Use cases

- Provide Just-In-Time Adaptive Interventions (JITAI) on user's eating activity

Wearables for detecting eating moments: Use cases

- Provide long-term feedback based on detected eating activities



Wearables for detecting eating moments

headgear

(Bi et al. 2018)

necklace

(Chun et al. 2018)

neckband

(Farooq et al. 2014)

wristband

(Dong et al. 2014)

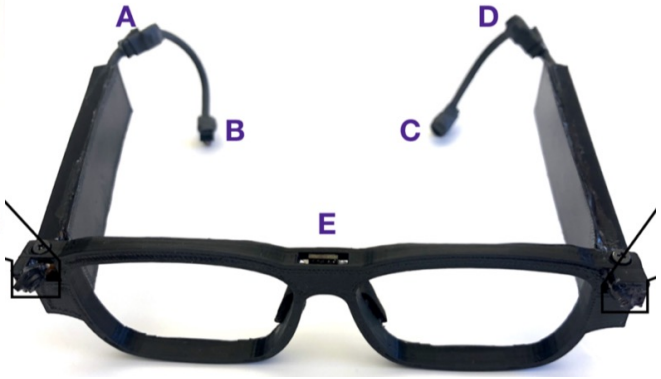
- Low accuracy at outside-the-lab environments
- Limited social acceptability and comfort

A promising approach:
Eating detection on eyeglasses

- An ideal condition to detect eating due to its close proximity to the mouth
- User familiarity and comfort

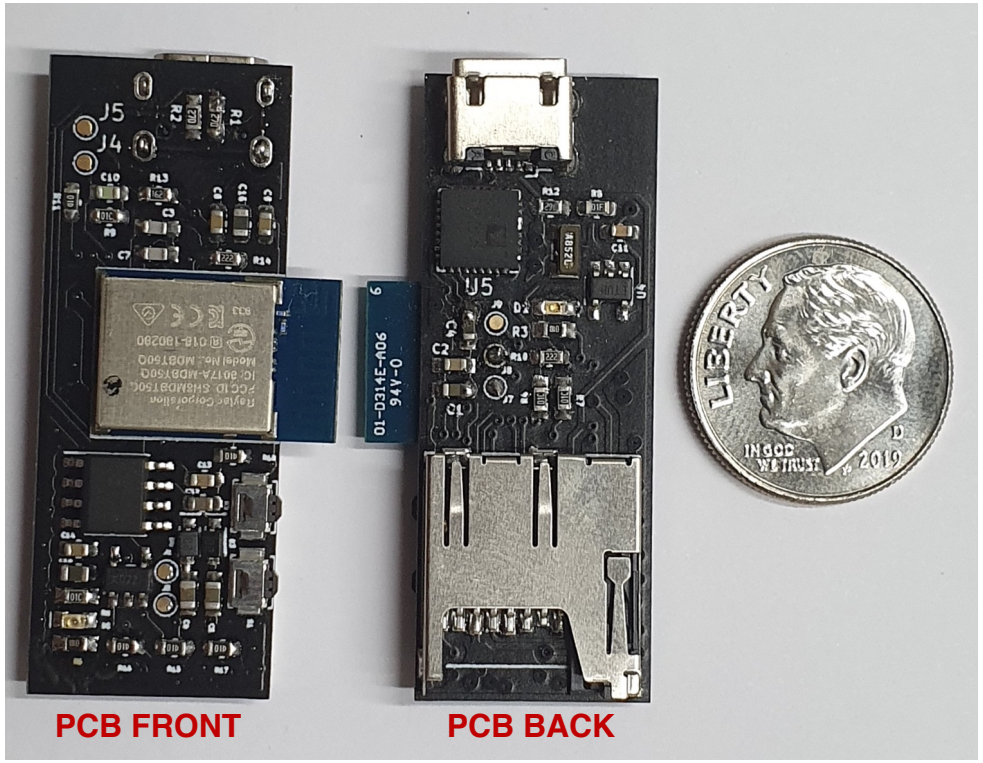
Limitation of eyeglass-based approaches

Zhang et al. 2018



Bedri et al. 2020

- Requires **custom-built frames** to accommodate various sensors
- Energy inefficient or inaccurate in practical settings



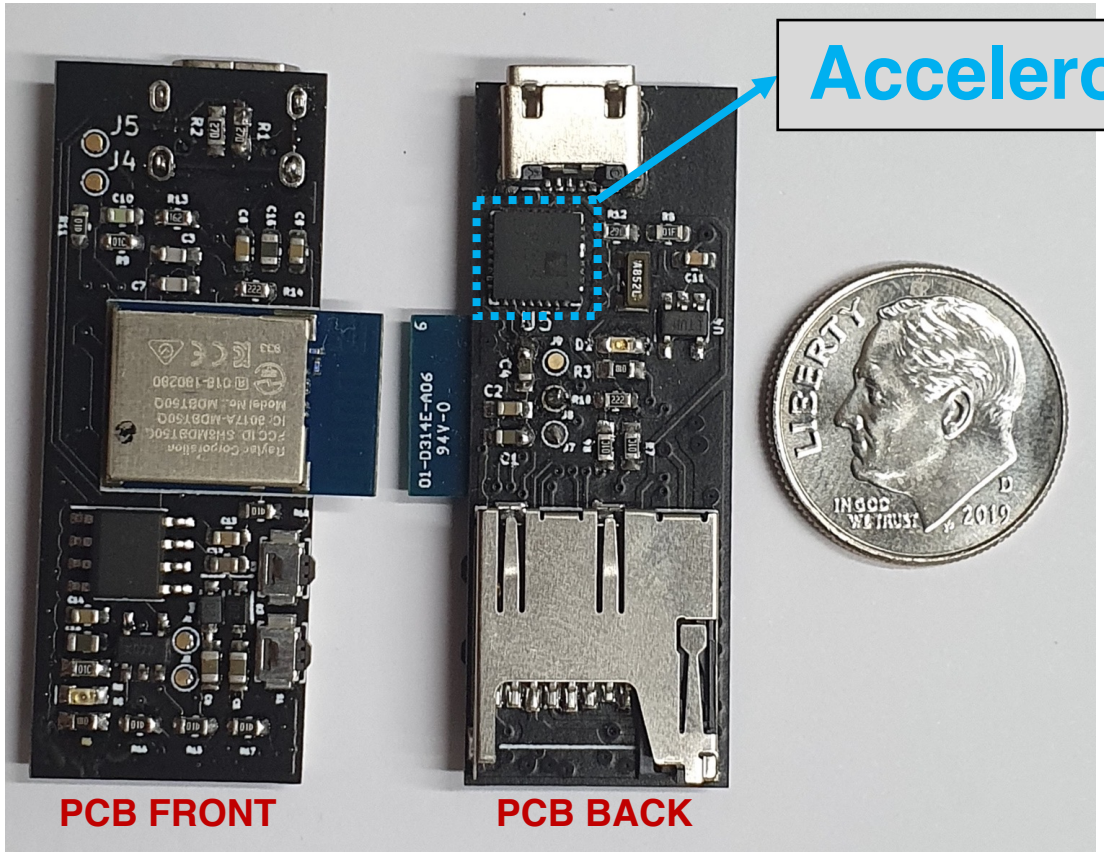
MyDJ (**My D**ietary **J**ournalist):

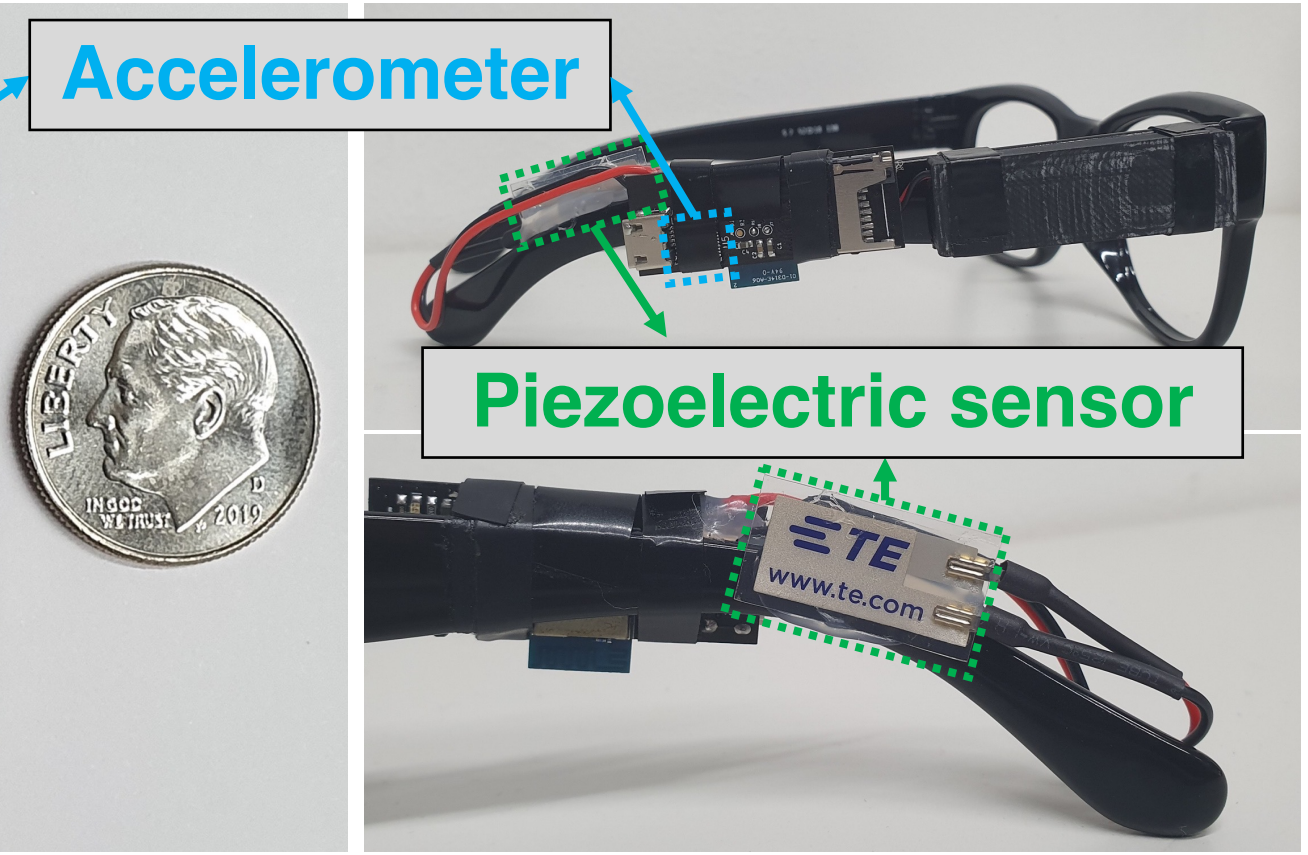
An ***attachable*** eating detection system on eyeglasses

Live Demo

Design goals

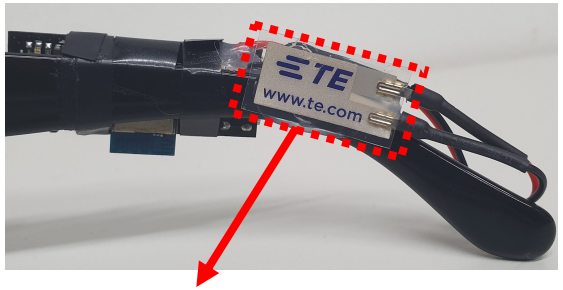
- Robust and accurate sensing in the wild
- Energy-efficient
- Easily integrate with existing eyeglass frames
- Comfortable to wear



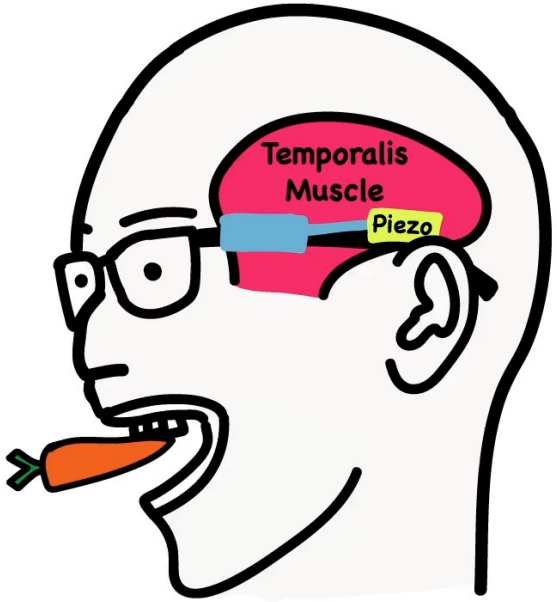


Multimodal sensing with low-power sensors,

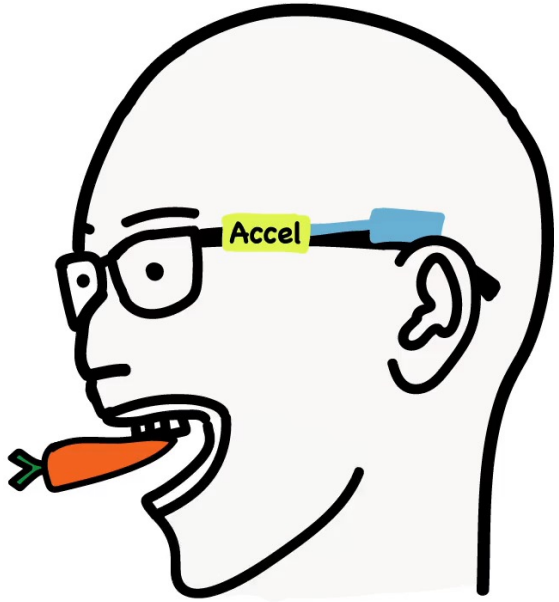
(1) an accelerometer and (2) a piezoelectric sensor



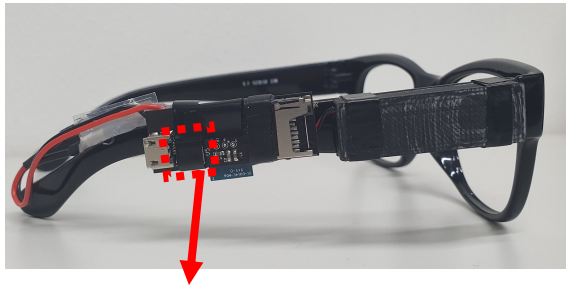
Piezo on the **inner side** of the frame near ear



Piezoelectric sensor



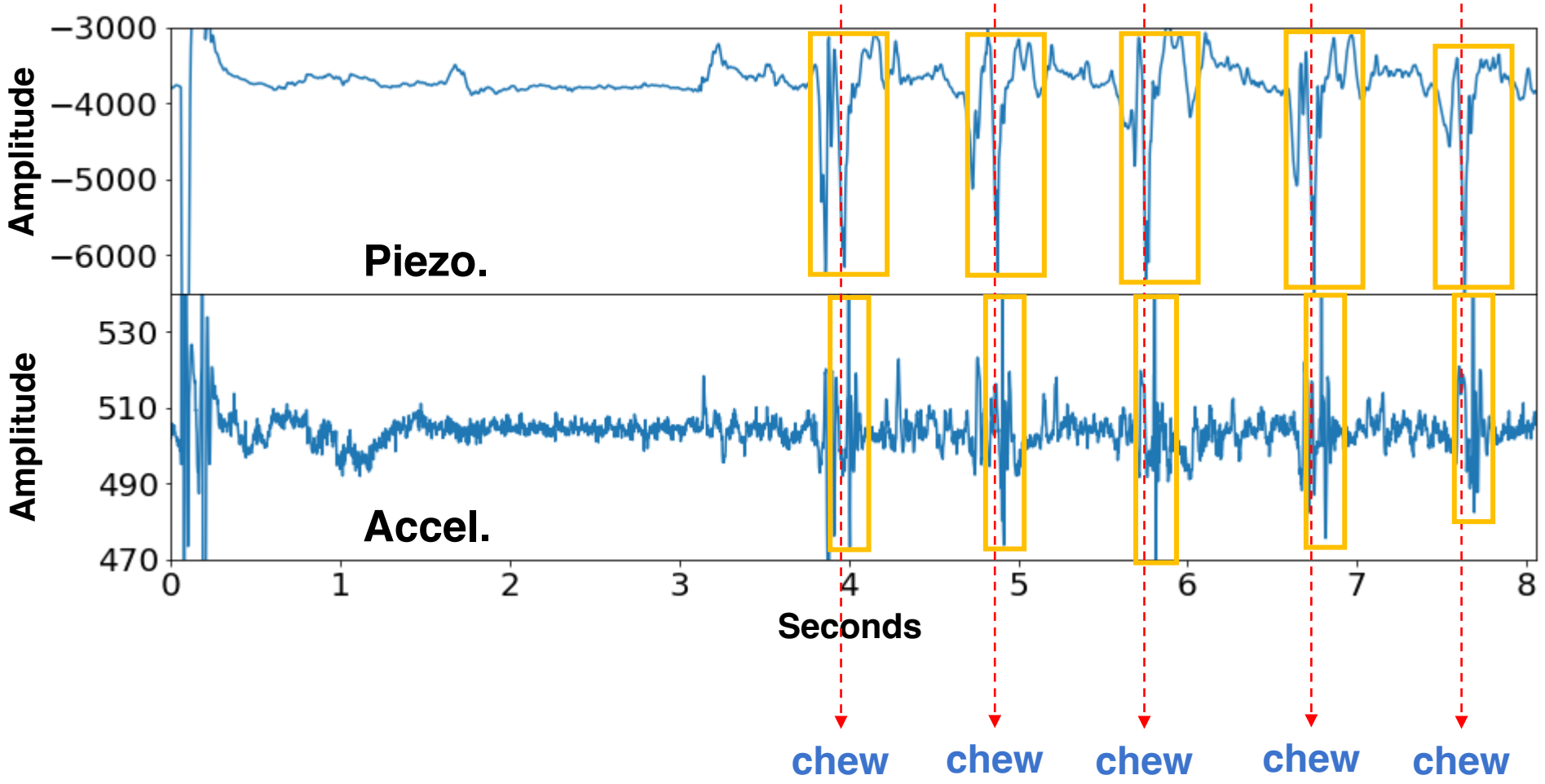
Accelerometer



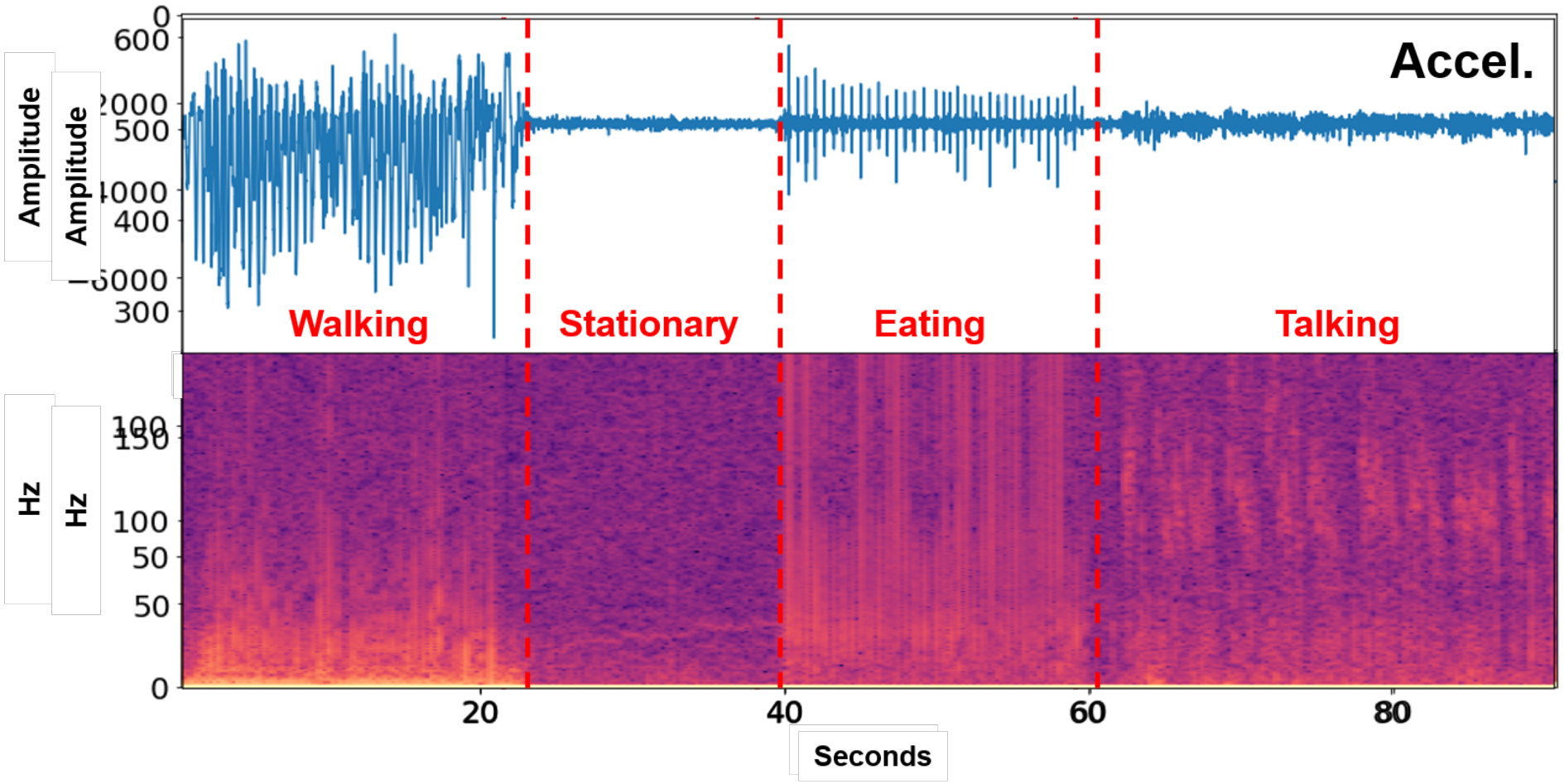
Accel placed on a **temple (leg)** of the frame

Each sensor captures complementary chewing signals for robust and accurate sensing

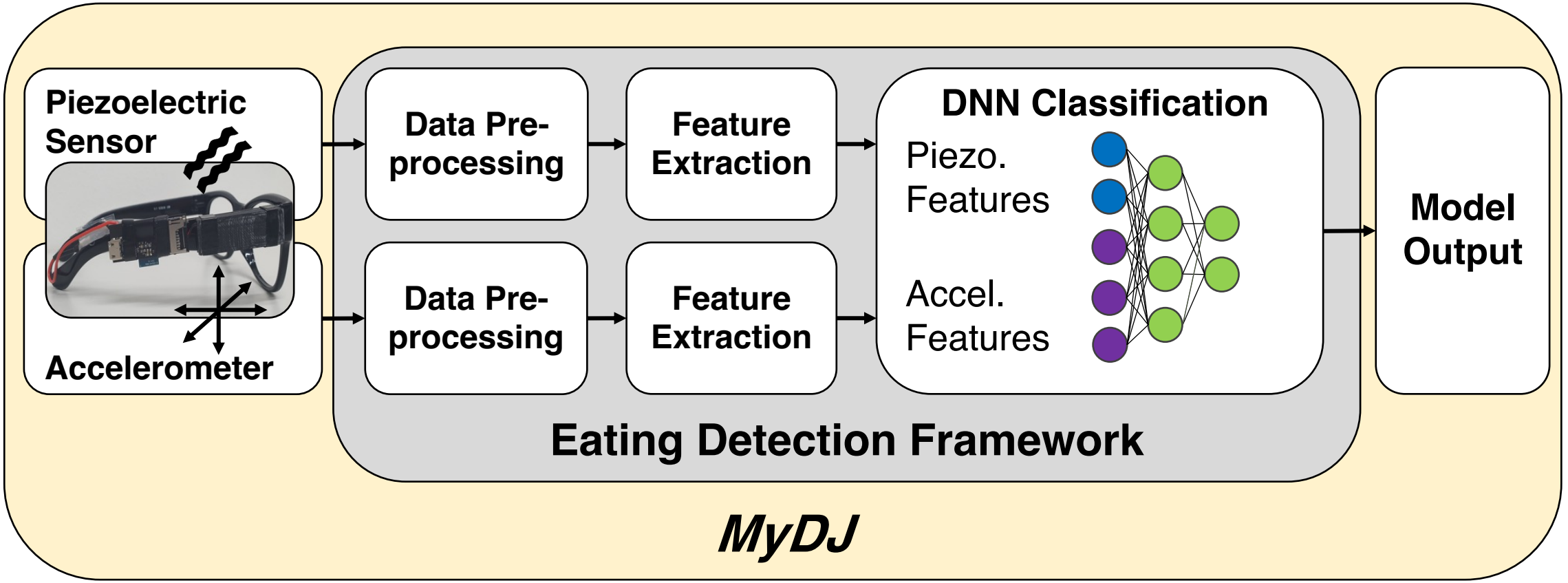
- **Piezo:** Captures the temporalis muscle contraction for jaw elevation while chewing
- **Accel:** Captures the propagation of mechanical vibrations from chewing food

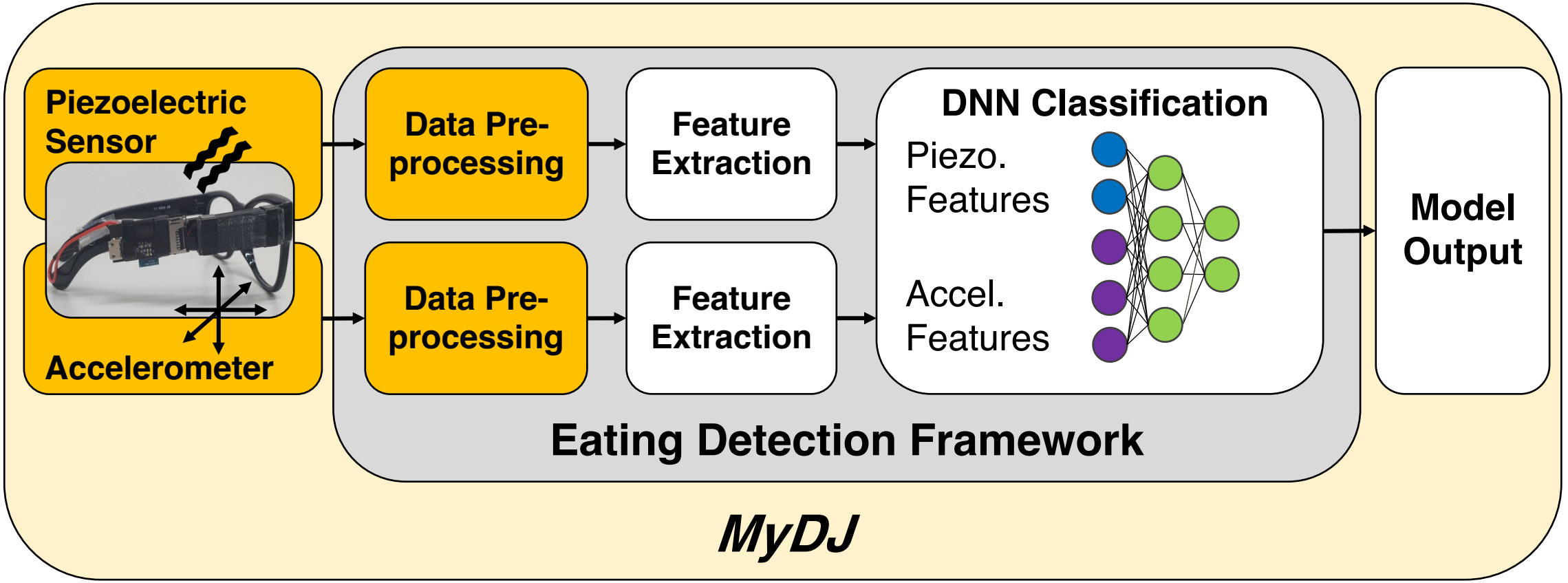


Each sensor captures unique signals with sensor-specific patterns of peaks with chewing

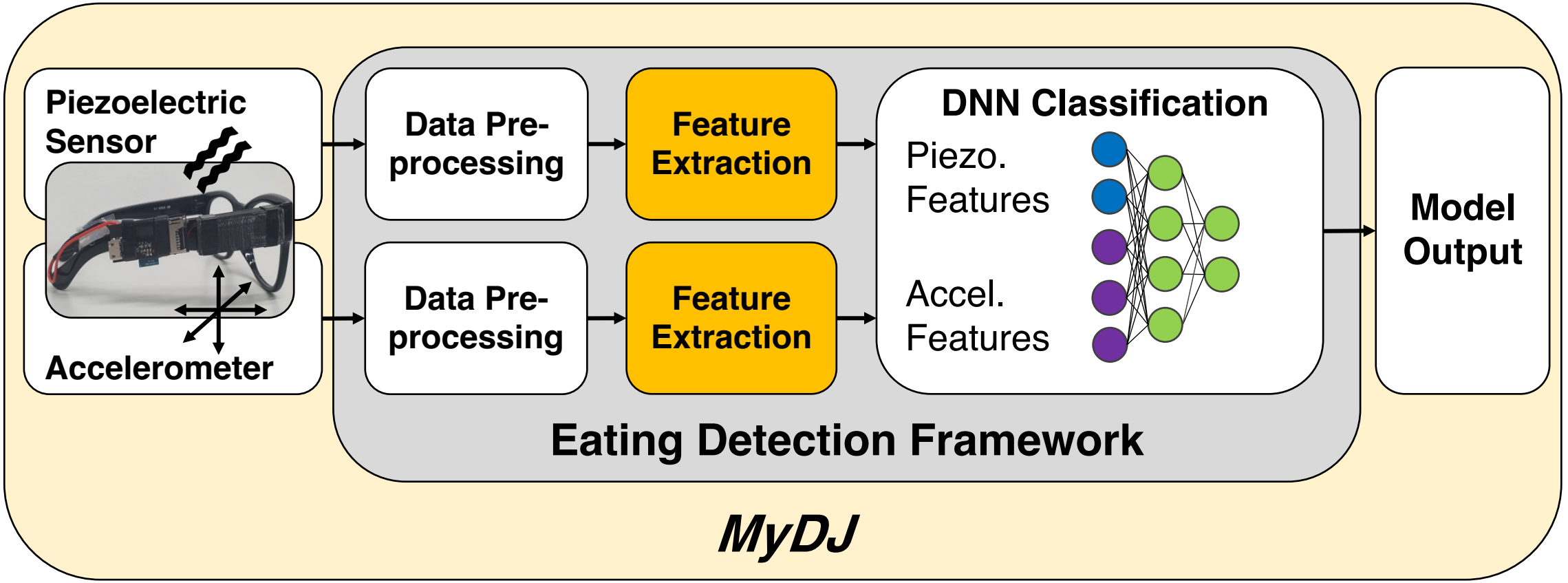


Eating is well-distinguished from other activities on **MyDJ**

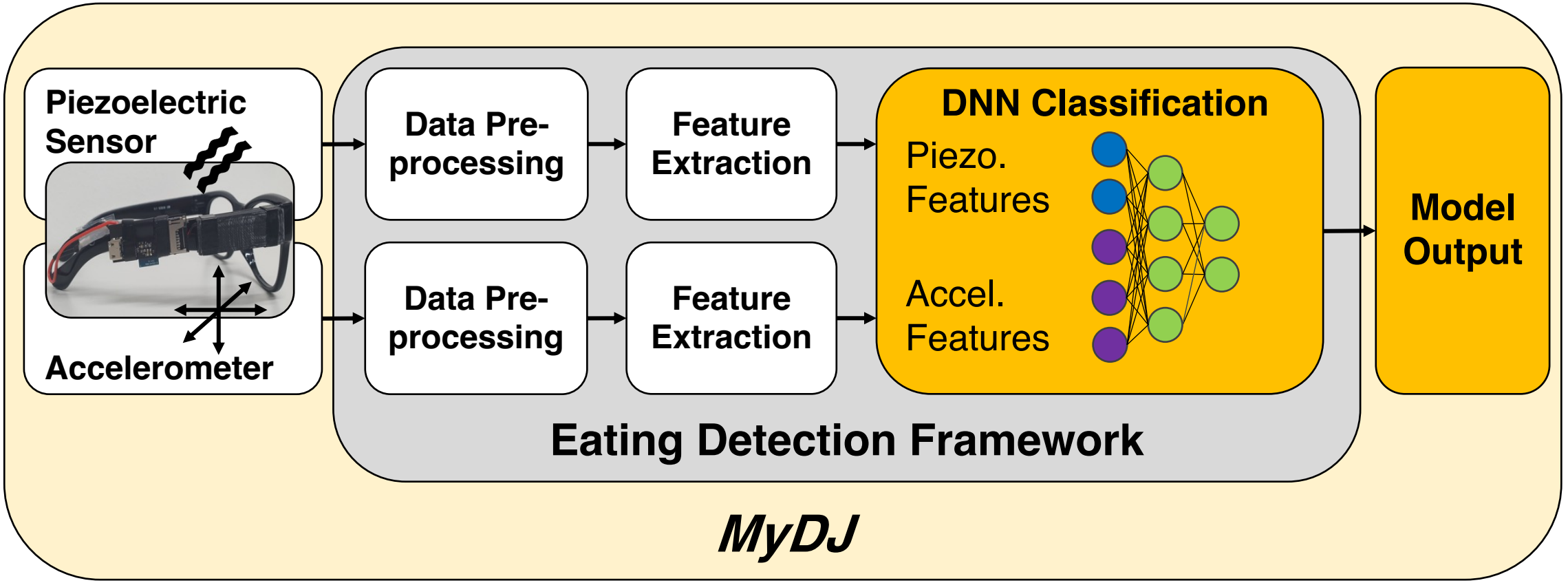

Piezoelectric Sensor
Accelerometer
Data Pre-processing
Feature Extraction
Data Pre-processing
Feature Extraction
DNN Classification
Piezo. Features
Accel. Features
Model Output
Eating Detection Framework
MyDJ



- **Data Preprocessing**
  - Both sensors continuously generate raw data stream
    - (**Piezo:** 256Hz, **Accel:** 400Hz)
  - The data stream is segmented into three-second windows



- **Feature extraction**
  - Short-Term Fourier Transform (**STFT**), Mel-Frequency Cepstral Coefficients (**MFCCs**)
  - Further selected minimal but optimal set of features
    - Joint Mutual Information Maximisation (**JMIM**)



- **Classification**
  - Lightweight DNN classifier with one hidden layer with 50 hidden nodes of 10.61KB size

Data collection studies in the wild

Day-long study

- 24 participants wore **MyDJ attached on one eyeglass frame** for a day – **237 hours** of data
- Collected **ground-truth with camera** to precisely capture user behaviors

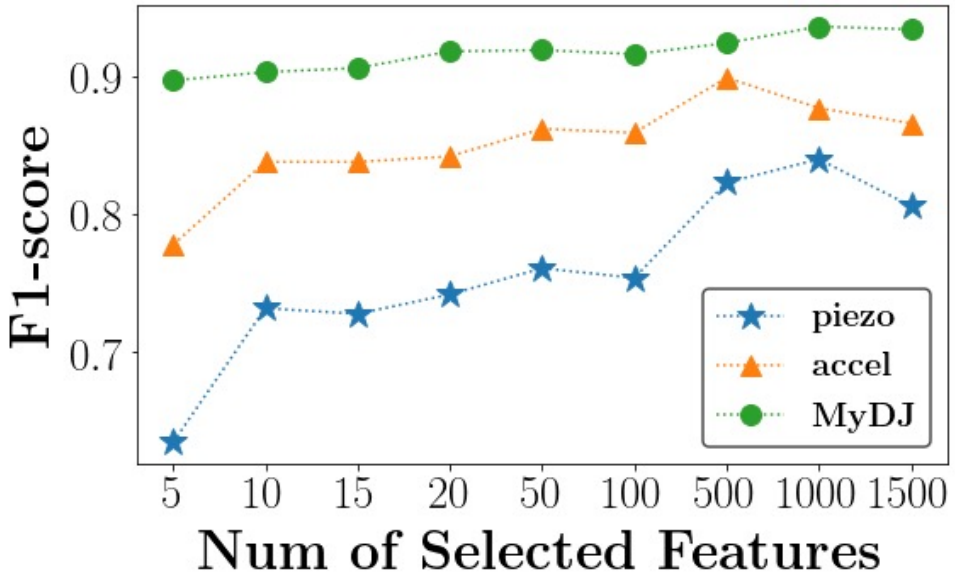
train

Week-long study

- 6 participants wore **MyDJ attached on their own eyeglass frame** for a week – **477 hours** of data
- Collected ground-truth without camera, based on the manual user logging

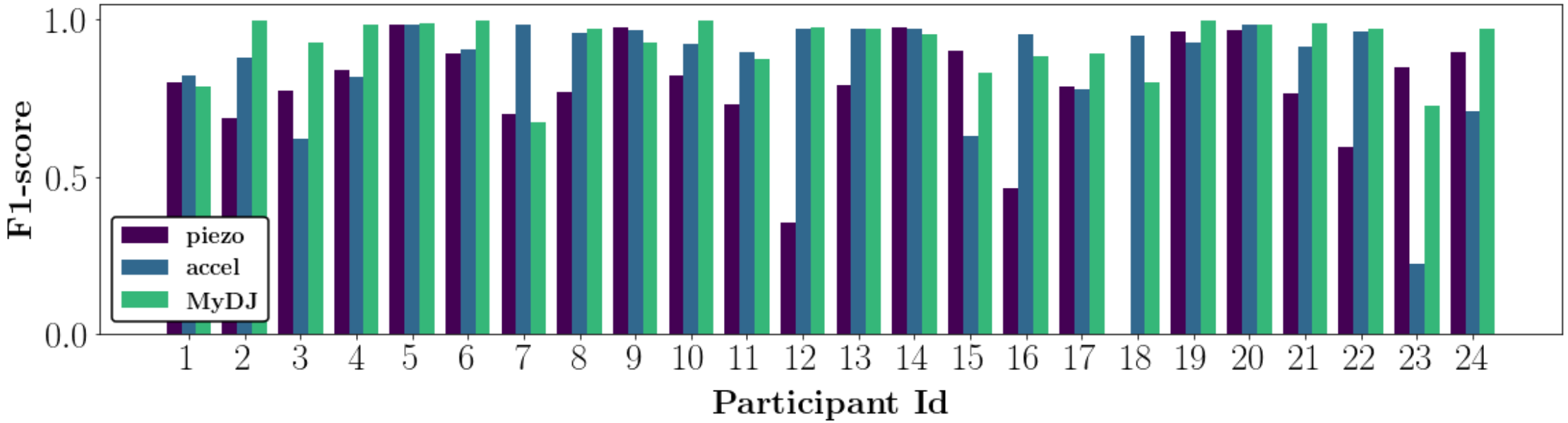
Eating detection accuracy: Day-long study

Mean F1-score from the day-long study



- Our multimodal sensing (MyDJ) outperforms single sensor-based approach
- MyDJ with 50 input features result in:
  - **98% accuracy, 0.92 F1-score, detect 92 out of 94 eating episodes**

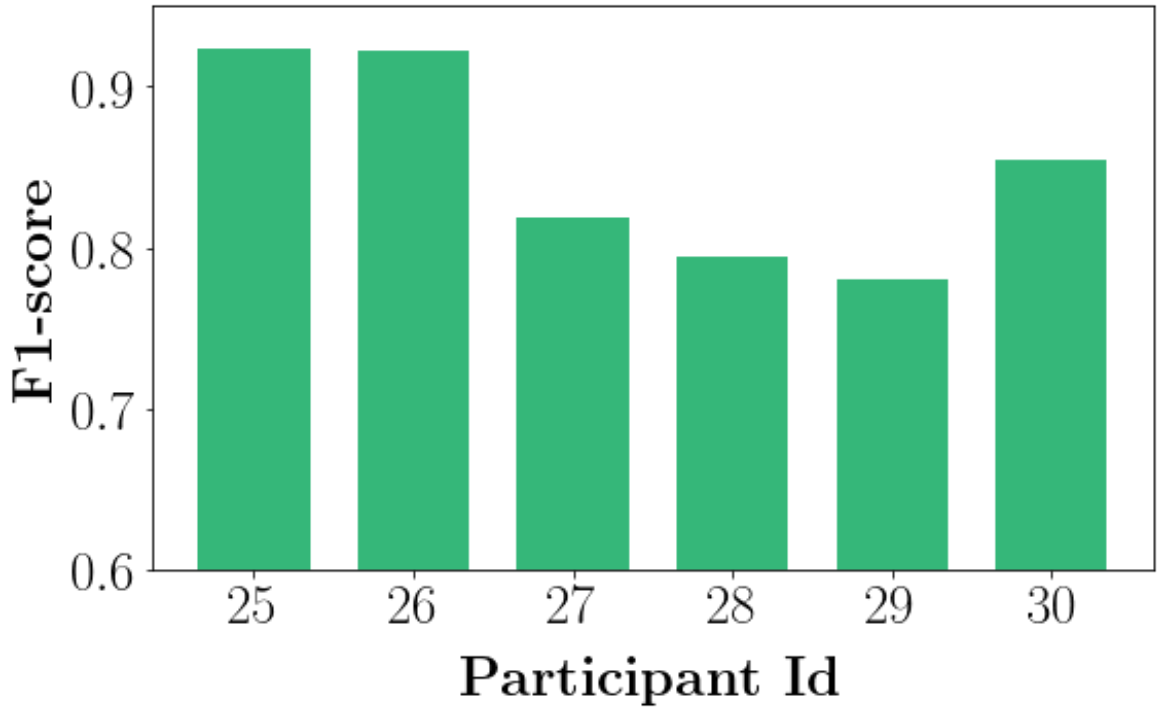
Eating detection accuracy: Day-long study



- MyDJ consistently shows high F1-score for every participant
  - Lowest F1-score of MyDJ: **0.671**, P7
  - Lowest F1-score of Accel: 0.221, P23
  - Lowest F1-score of Piezo: 0.0, P18

Eating detection accuracy: Week-long study

Per-participant F1-score from the week-long study



- MyDJ achieves high mean F1-score (0.85) while being attached on the user's eyeglasses for a week.

Power efficiency of MyDJ

Approaches	Battery life (on 470mAh)	Power draw
State-of-the-art	16 hours 53 min	105.08 mW
MyDJ	66 hours 38 min	26.06 mW

MyDJ achieves 4.03× battery life compared with the state-of-the-art (Bedri et al.)

Usability of MyDJ

Questions	Regular eyeglasses	MyDJ
Q1. How convenient was it to put on the wearable device?	7.13 ± 1.90	6.58 ± 2.15
Q2. Would you wear this device in your daily life?	6.70 ± 2.42	6.54 ± 2.45

On usability questions, MyDJ scored 95% of the regular eyeglasses on average

Usability of MyDJ

Long-term wearability:

- *"The eyeglasses feel mostly the same with and without the attachable device, and there was nothing that I couldn't do because of the device."* (P25, P27)

Social acceptability:

- *"Most of my colleagues did not notice it at first glance." (P30)*
- *"Some of my colleagues asked if the device is recording video." (P28)*

Weight imbalance:

- *"I initially found it disturbing, but soon I got used to it. It feels like wearing a new eyeglass and adapting to it." (P29)*

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Questions or want to chat?
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Contributions

- Design and implementation of an attachable eating detection system that easily integrates on any eyeglass frames.
- Evaluation based on a week-long in the wild data collection in which users attach MyDJ on their eyeglasses.