Demonstration of a Jaw-Mounted Inertial Sensor For Eating Behavior Microstructure Characterization

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Abstract

Capturing the fine-grained mechanics of eating, including individual bites and chews, is critical for addressing dietary health but remains challenging to measure passively in real-world environments. We present a wearable system designed for the unobtrusive, objective measurement of these eating mechanics. Our system pairs a minimalist, jaw-mounted inertial sensor placed over the mandibular condyle with a commodity smartwatch to capture high-fidelity mastication and food delivery gestures. Evaluated in a 30-participant multi-site study, the system achieved a bite detection F1 score of 0.833 and a chew-counting Mean Absolute Percentage Error (MAPE) of 8.565%. In this demonstration, attendees will observe a live, real-time visualization of 6-axis IMU data streamed from the jaw sensor as the presenter performs ambulatory motions, vocalization, and active food consumption, highlighting the system's ability to isolate chewing signals from extraneous noise.

CCS Concepts

• **Human-centered computing → Ubiquitous and mobile computing**.

ACM Reference Format:
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1 Introduction

Understanding the microstructure of ingestive behavior (IB), such as individual biting, chewing, and intra-bite pauses, is essential for developing effective interventions that reduce overall energy intake and improve satiety [8]. Traditional dietary monitoring relies heavily on subjective self-reporting, which is notoriously prone to recall bias and participant attrition [4]. While Automated Dietary Monitoring (ADM) systems mitigate these biases, they predominantly focus on macro-level eating patterns. Systems that do attempt to capture fine-grained microstructure often suffer from form-factor limitations: smart glasses are not universally worn [1], earbuds block the auditory canal and pose hygiene risks during prolonged use [2, 5], and necklaces are susceptible to ambulatory motion artifacts [3].

To address this methodological gap, we demonstrate a novel, wearable system designed for the objective, unobtrusive capture of eating microstructure. By pairing a minimalist, jaw-mounted inertial sensor with a commodity smartwatch, our system captures both the anatomical source of mastication and the wrist motions characteristic of food delivery.

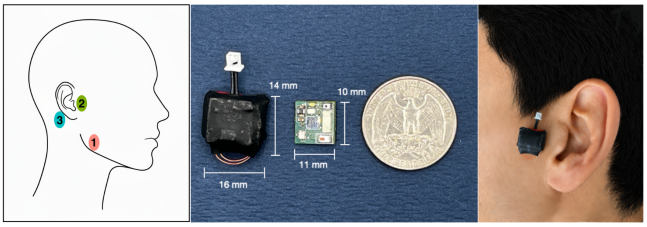


Figure 1: The three facial locations evaluated during the placement pilot study (left), the jaw-mounted sensor hardware alongside a US quarter (center), and the optimal device placement on the mandibular condyle (right).

2 Hardware Architecture and Device Placement

The demonstrated system consists of two primary sensory components. The first is a custom-built, jaw-mounted inertial sensor utilizing a Nordic nRF52832 microcontroller with Bluetooth Low Energy (BLE) capabilities, paired with a Bosch BMI323 6-axis IMU to capture high-fidelity eating motions. Powered by a 3.7V 40mAh Lithium Polymer battery, the module maintains a discreet footprint of 16 × 14 × 10 mm (Figure 1) and a battery life approaching 24 hours. The second component is a commodity smartwatch (e.g., Apple Watch Series 8) worn on the dominant wrist, which tracks food preparation and intake gestures to provide contextual data.

To determine optimal location on the face for the sensor, we conducted a pilot study evaluating three distinct locations, identifying the mandibular condyle (anterior to the tragus)

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as the optimal site for capturing the strongest masticatory signal while minimizing extraneous noise [6, 7]. The sensor is secured directly to the skin over this location using double-sided cosmetic tape, leaving the user's ear canal completely unobstructed. This adhesion method proved highly effective and comfortable. In a post-study usability evaluation, 100% of participants reported no application or removal discomfort and confirmed the device remained securely in place throughout the session. Furthermore, participants noted the device was highly discreet, lightweight, and did not interfere with natural eating mechanics.

3 System Evaluation

The sensing approach and algorithms driving this demonstration were validated in a 30-participant, multi-site laboratory study. To ensure algorithmic robustness across various food types, participants consumed a standardized four-course meal featuring distinct food textures (*crispy* chips, *crunchy* carrots, *soft* rice, and *chewy* churros) [6]. By fusing the jaw and wrist inertial data, the system achieved a bite detection F1 score of 0.833 by leveraging lightweight deep learning architectures and a chew-counting Mean Absolute Percentage Error (MAPE) of 8.565% with a heuristic peak-detection algorithm.

4 System Demonstration

To illustrate the feasibility of the device form factor and the nature of the inertial data, we will conduct a live, real-time demonstration of the jaw-mounted sensor. During the session, the presenter will wear the device adhered to the mandibular condyle. Raw IMU data will be streamed via BLE and projected onto a screen for the audience to observe.

The demonstration will guide attendees through a sequence of distinct behavioral states: ambulatory motion (walking), vocalization (talking), and active food consumption (eating a snack). The primary objective of this live visualization is to contrast the distinct features of chewing, which manifest as rhythmic, predictable peak patterns in the gyroscope axes, against the irregular signal noise generated by non-eating facial and body movements. By observing the real-time data stream, attendees will gain an intuitive understanding of the underlying biomechanical signals that drive our microstructure segmentation models.

5 Future Directions

To achieve long-term deployability in naturalistic settings, our ongoing research targets miniaturization and power efficiency. Because continuous BLE streaming is energy-intensive, we evaluated the feasibility of an on-device eating detector to trigger transmissions only during active eating. An ultra-lightweight, 1.6k-parameter model analyzing only gyroscope data sampled at 25Hz achieved an eating detection F1 score of 0.890, as shown in Figure 2.

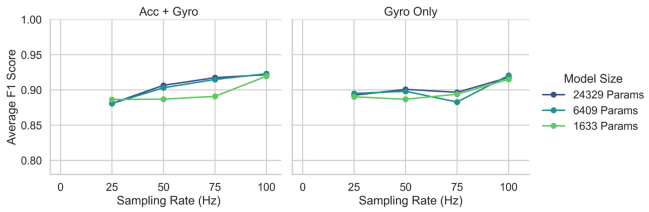


Figure 2: Eating detection F1 scores across three lightweight model sizes, comparing Accelerometer and Gyroscope performance (left) against Gyroscope-only data (right) at multiple sampling rates.

Future iterations of the sensor will explore replacing the 40mAh battery with a significantly smaller cell paired with a capacitor to safely handle the current spikes required during periodic BLE discharges. Additionally, we aim to investigate alternative, low-power wireless data transfer methods and explore energy harvesting integration, moving closer to an even more discreet and always-on dietary monitoring sensor.

Acknowledgments

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