Demo: Leveraging Earables for Unvoiced Command Recognition

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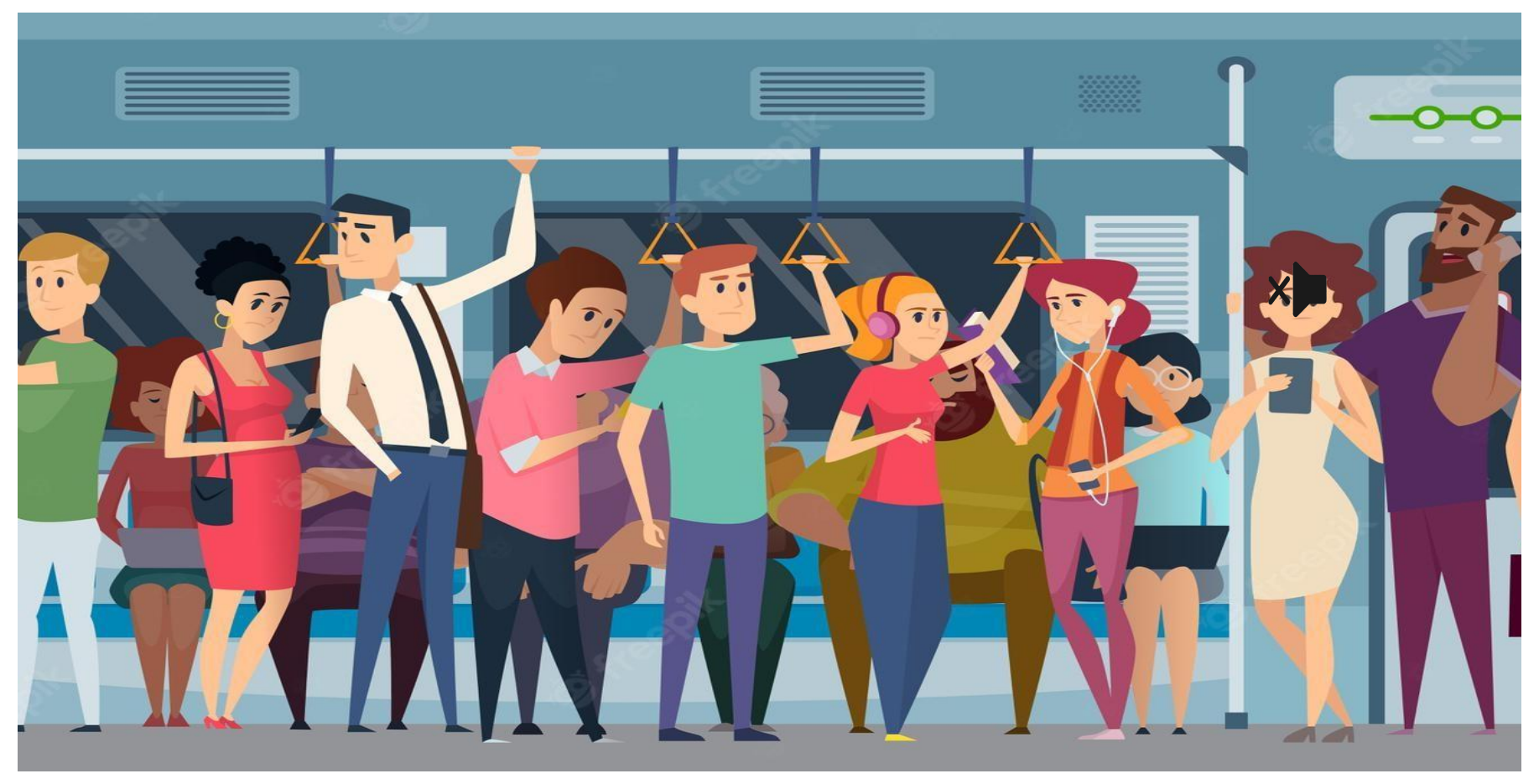
MOTIVATION

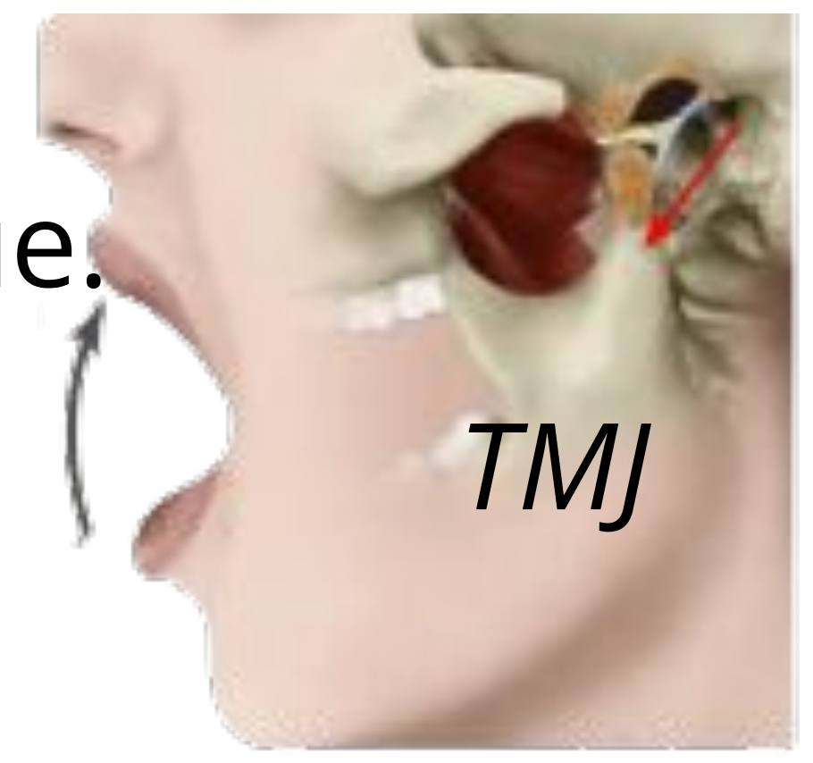
- ★ Voice assistants are limited by their unreliability in noisy environments and privacy concerns.
- ★ We present an earable to detect unvoiced words by capturing jaw movements using IMU.



Noisy Environment

Private Interaction

HUMAN SPEECH ARTICULATION



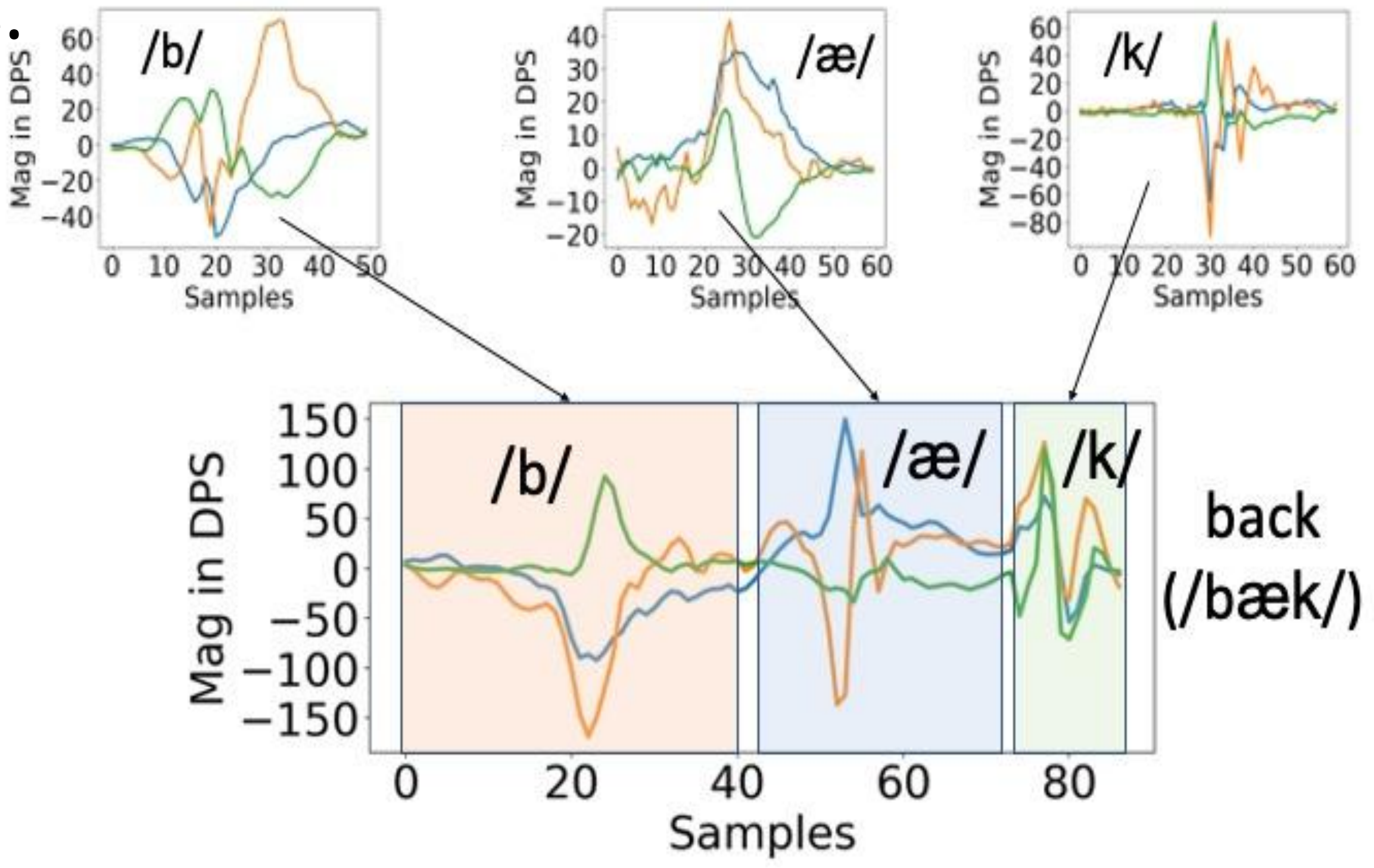
- ★ Primary articulators
  - ○ Example: Lips, teeth, and tongue.
  - ○ Interact with other articulators to produce sound.
- ★ Secondary articulators
  - ○ Example: Jaw and nose.
  - ○ Cannot themselves make contact other articulators.
- ★ Jaw rotates about the TMJ to facilitate movement of tongue and lips.

KEY IDEAS

- ★ Recognize unvoiced speech from jaw motion.
- ★ Intuitive and unobtrusive input modality.
- ★ No ML-based word classification model.
- ★ Near-zero-effort scalability to recognize a large number of words.
- ★ Robust in presence of motion artifacts.

CHALLENGES

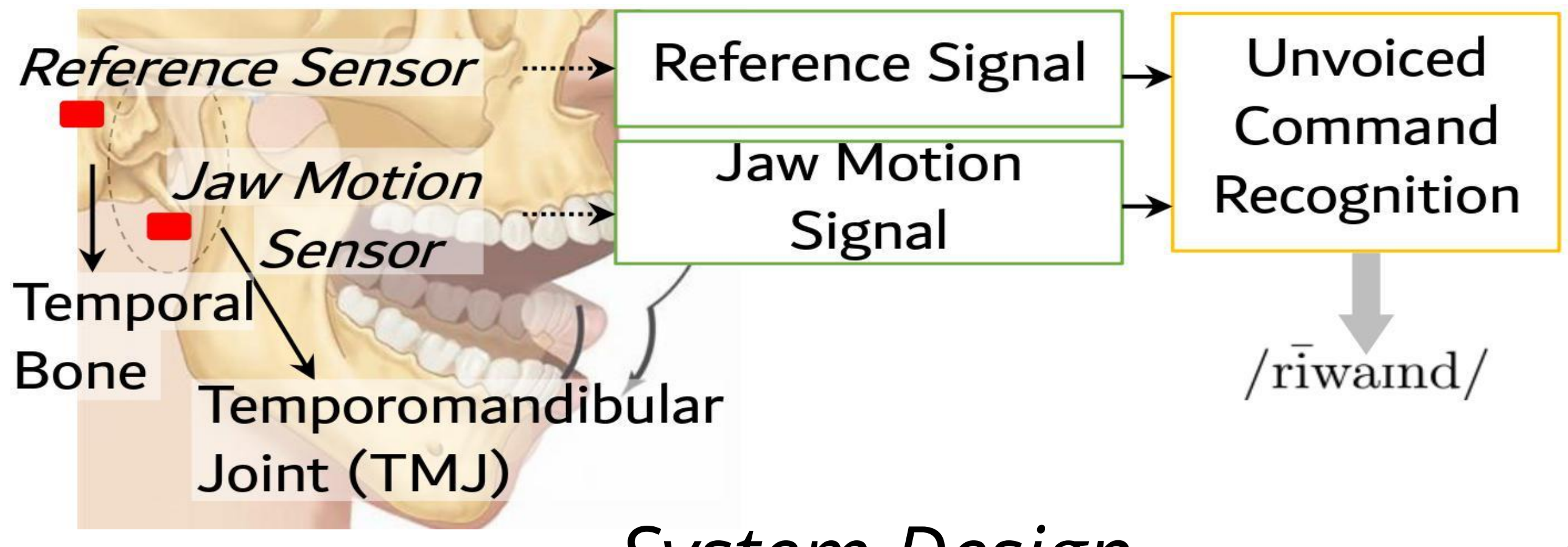
- ★ Detecting unvoiced speech from a secondary articulator.
- ★ Jaw motion is polluted by head and body motion.
- ★ Multiple sounds have similar jaw motion. Example: {/m/, /b/, /p/} and {/t/, /k/}.
- ★ Phonemes overlap to produce compound sounds.



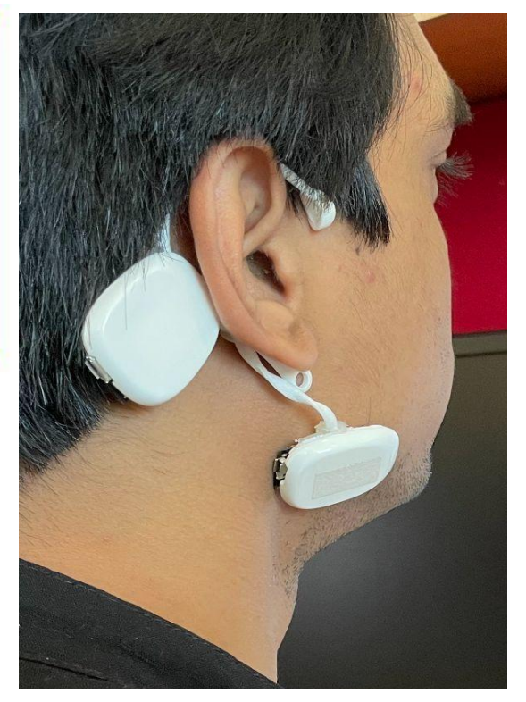
Overlapping of word components

SYSTEM OVERVIEW

- ★ Twin IMU setup to remove motion artifacts.
- ★ Disaggregate word signal into phonological components (syllables, vowels, visemes, and plosives).
- ★ Reconstruct word from partial phoneme sequence using probabilistic estimation.

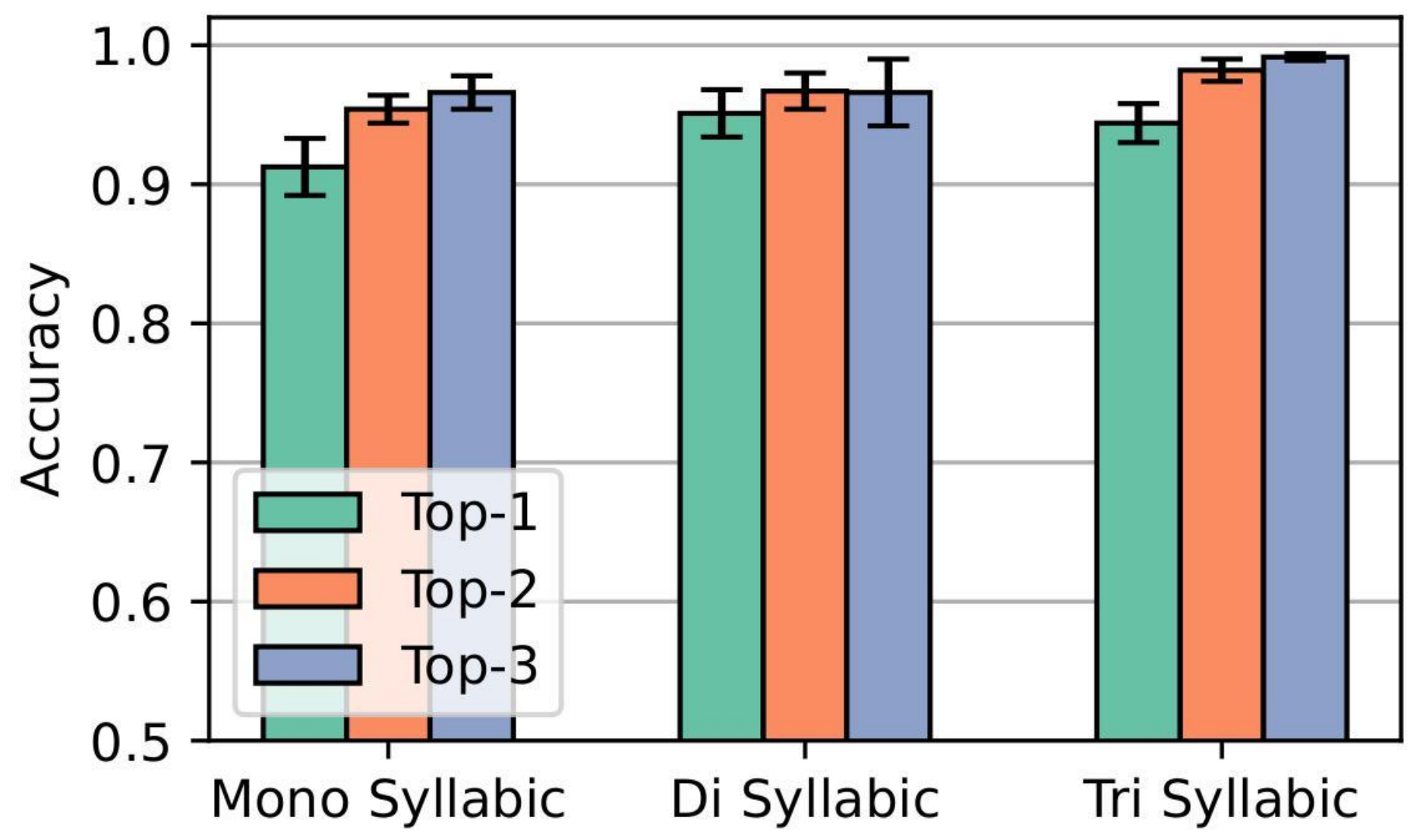


System Design



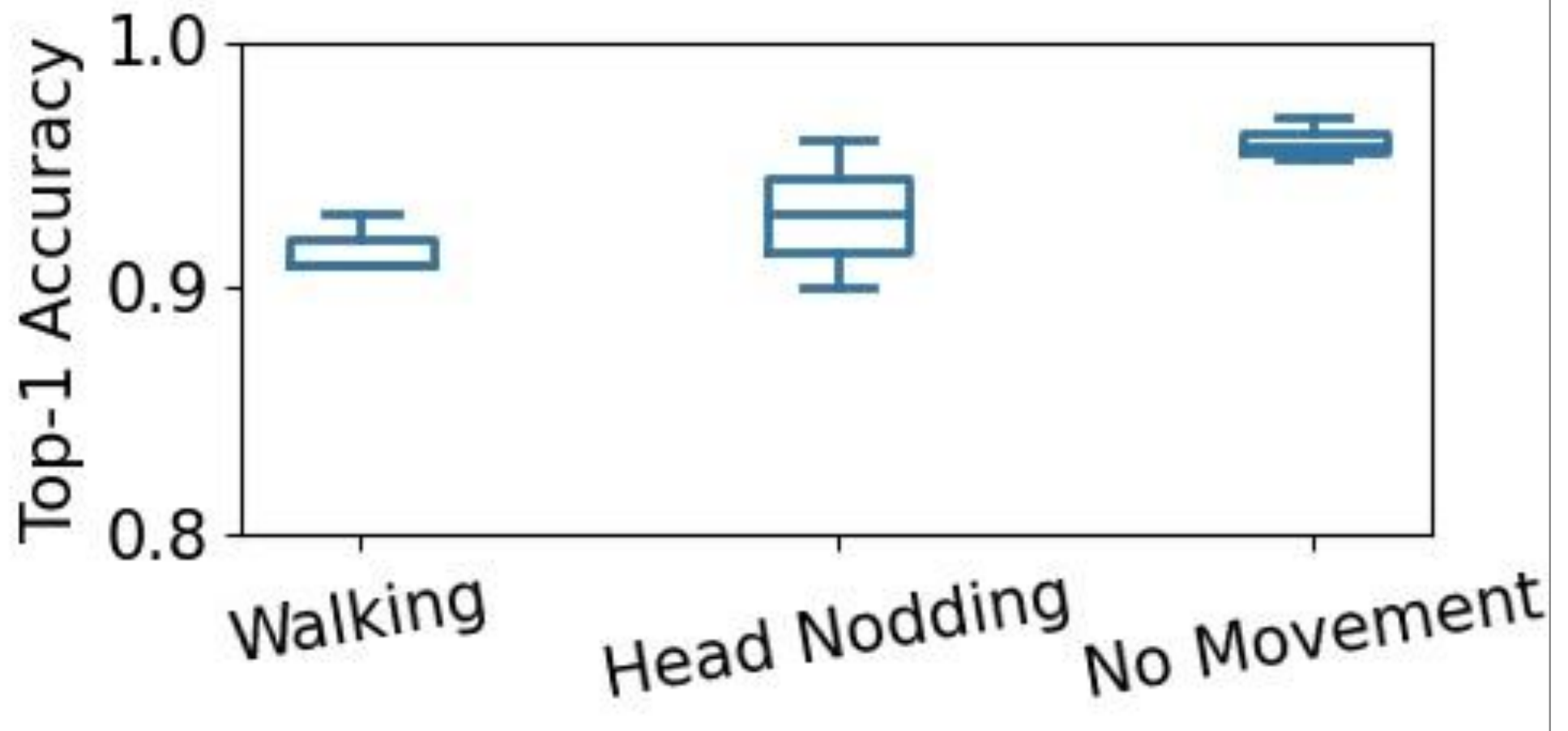
Prototype

RESULTS



Mean top-1 accuracy of 95.6% for 100 words across 15 users.

- ★ Accuracy when users are moving their head is 93.2%



- ★ Accuracy when users are walking is 91.6%