

# mmJaw: Remote Jaw Gesture Recognition with COTS mmWave Radar

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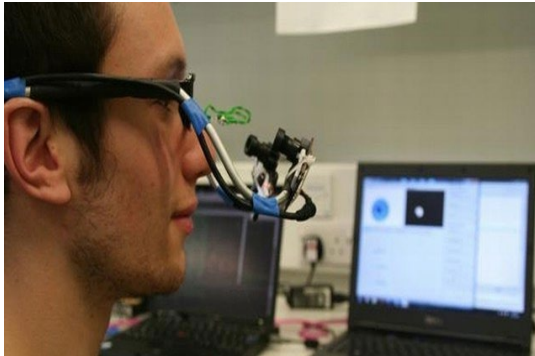


# Outline:

- Introduction
- Objective
- Related Work
- Basic Sensing Model
- Challenges
- Evaluation
- Conclusion



# Introduction



# Teeth Gestures

- Introduction of teeth gestures as an input modality
- Types of gestures: tapping, clenching, sliding



Tapping



Clenching

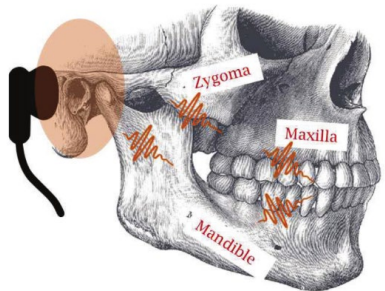


Sliding



# Related Work

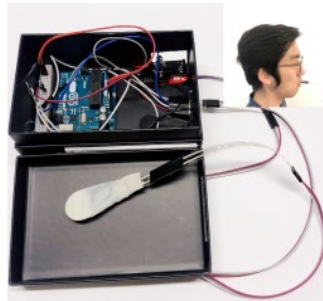
EarSense  
Mobicom '20



Bitey  
MobileHCI '16



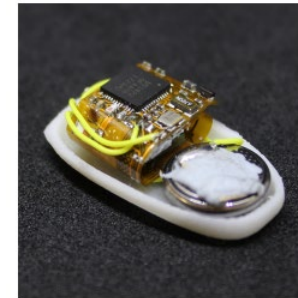
Clench Interface  
CHI '19



Teethtap  
IUI '21



Chewit  
IUI '19



ClenchClick  
IUI '19



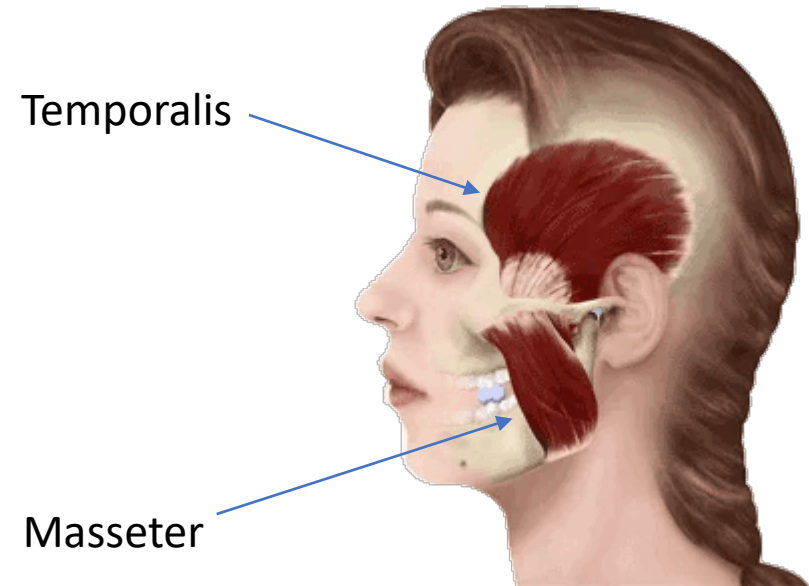
Require Physical Mounting





# Mastication

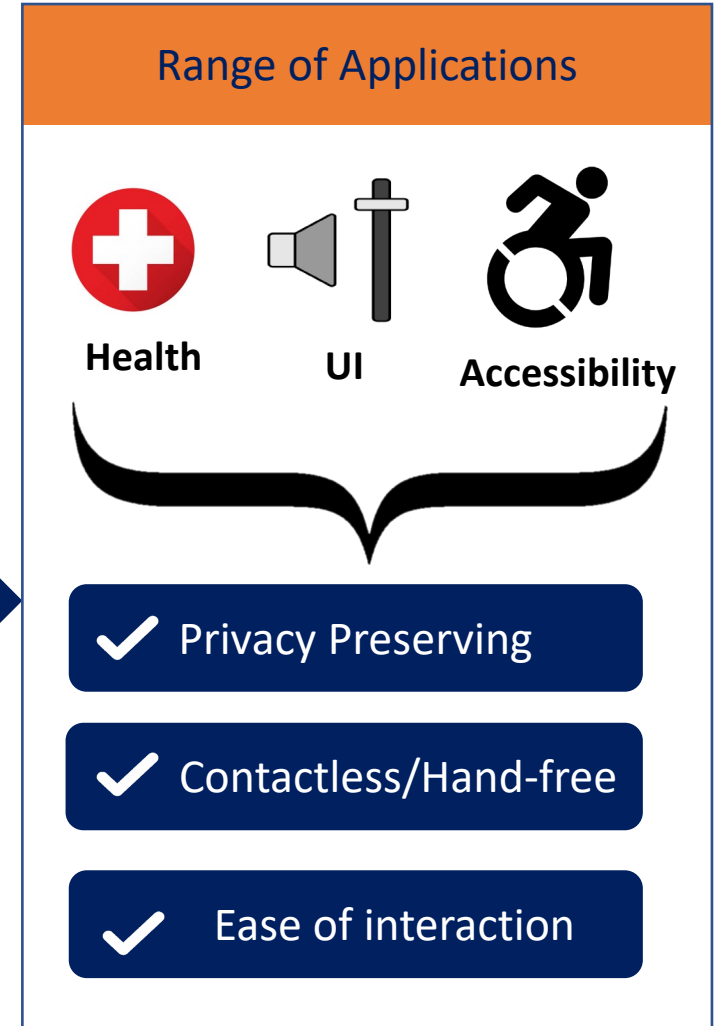
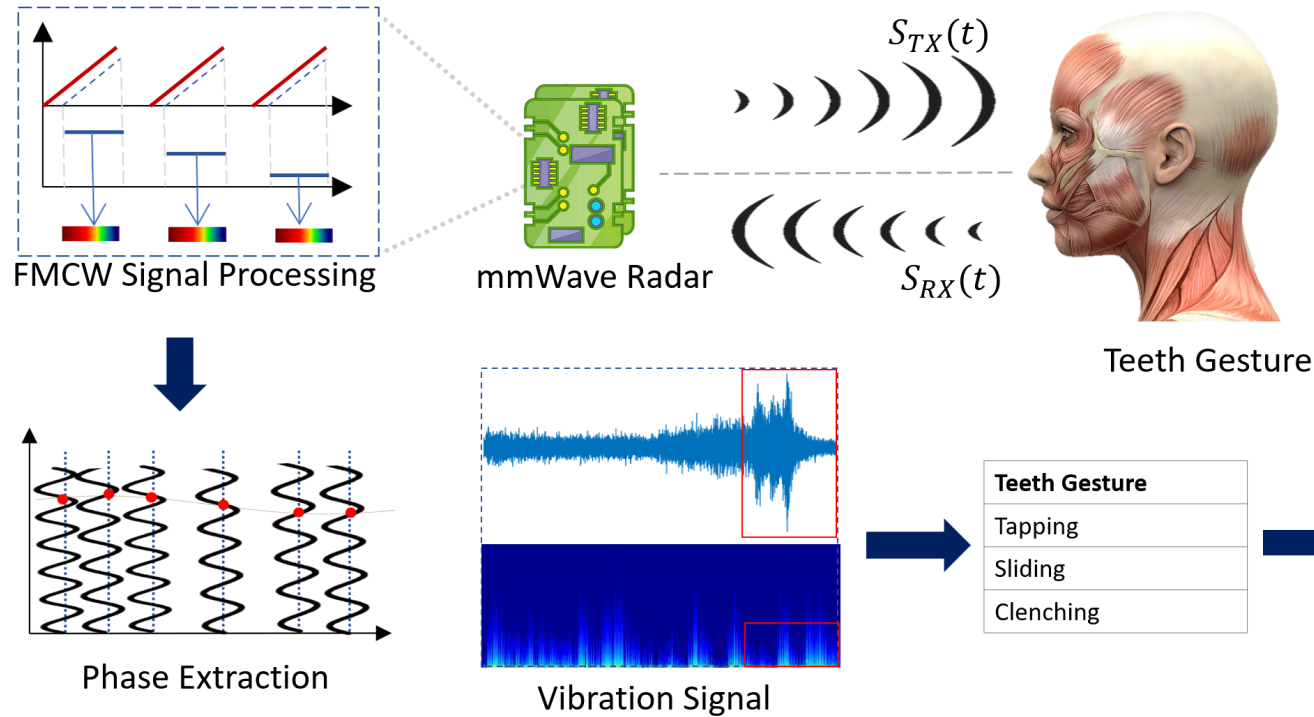
- The process of teeth movements such as Chewing, Biting, Clenching is called **Mastication**
- Two muscles involve in this process are **Masseter & Temporalis**



The Relative movement between Temporalis & Masseter muscles can be captured by mmWave radar



# Basic Sensing Model:



# Challenges



Effects of Dynamic Background



Extraneous Body Movements



Facial Accessories(Mask, Glasses, etc)



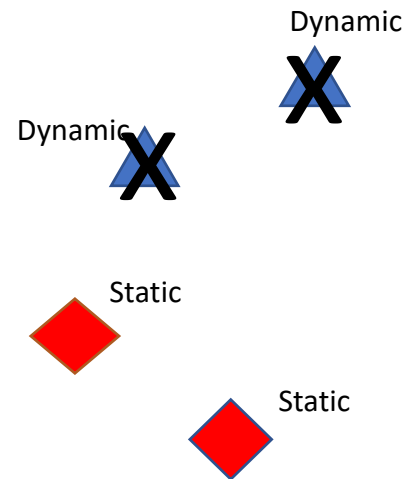


# System overview:

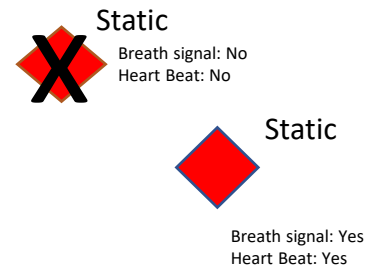
## Range Estimation



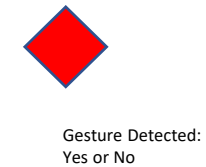
## Range Bin Segmentation



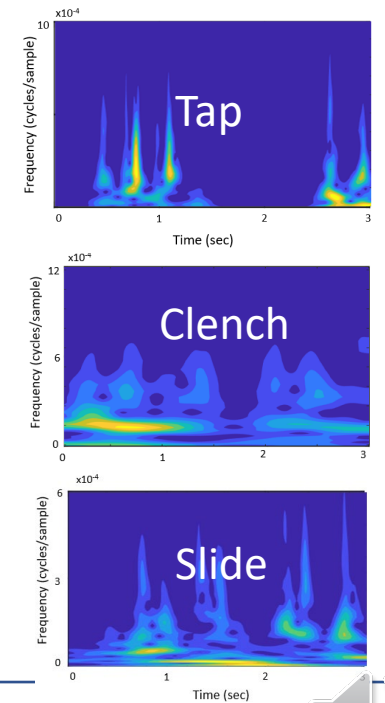
## Biometric Verification



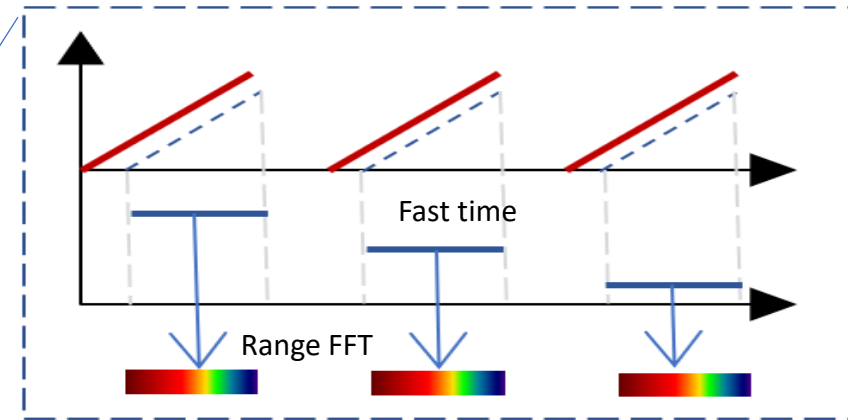
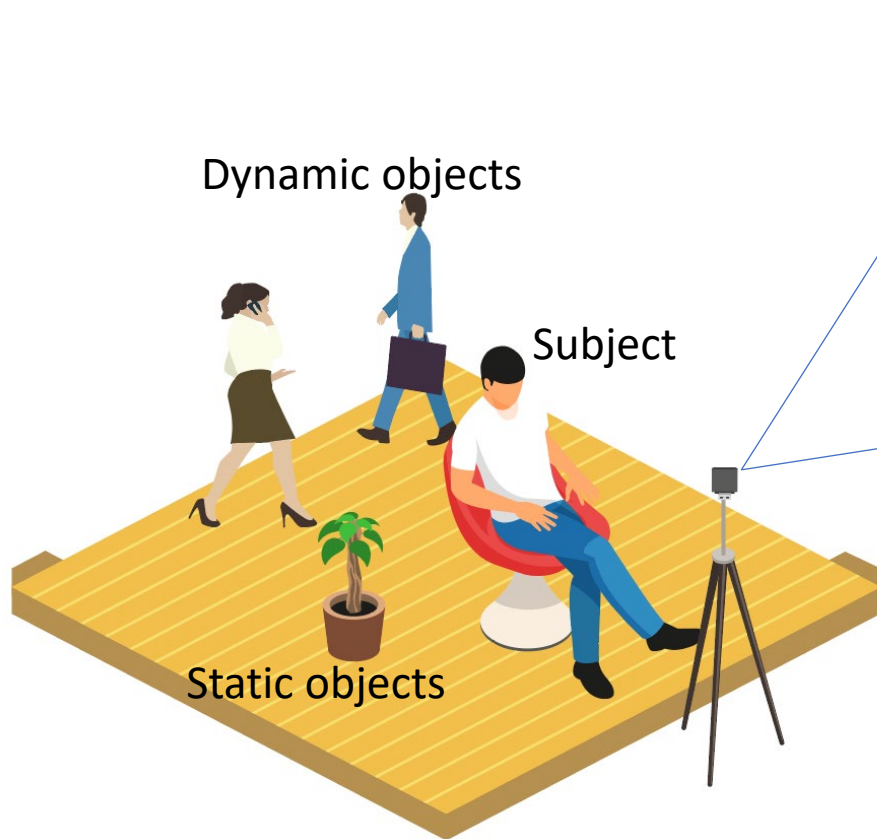
## Teeth Gestures Detection



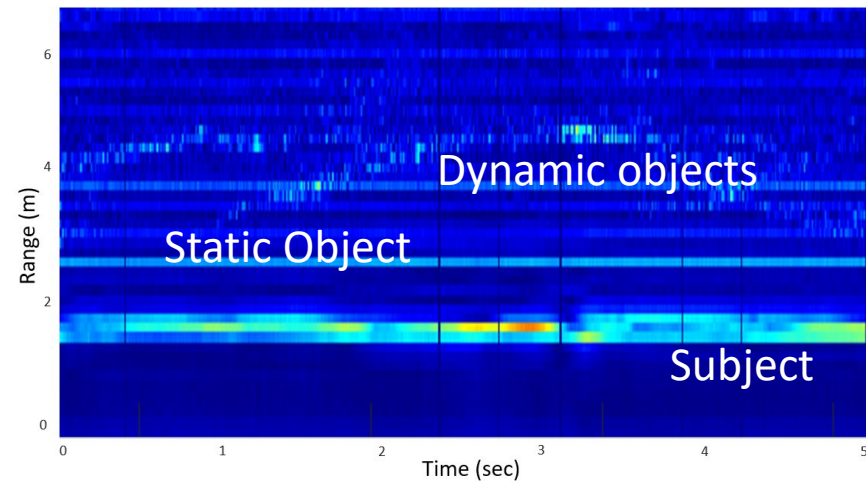
## Teeth Gestures Classification



# Dynamic Object Removal



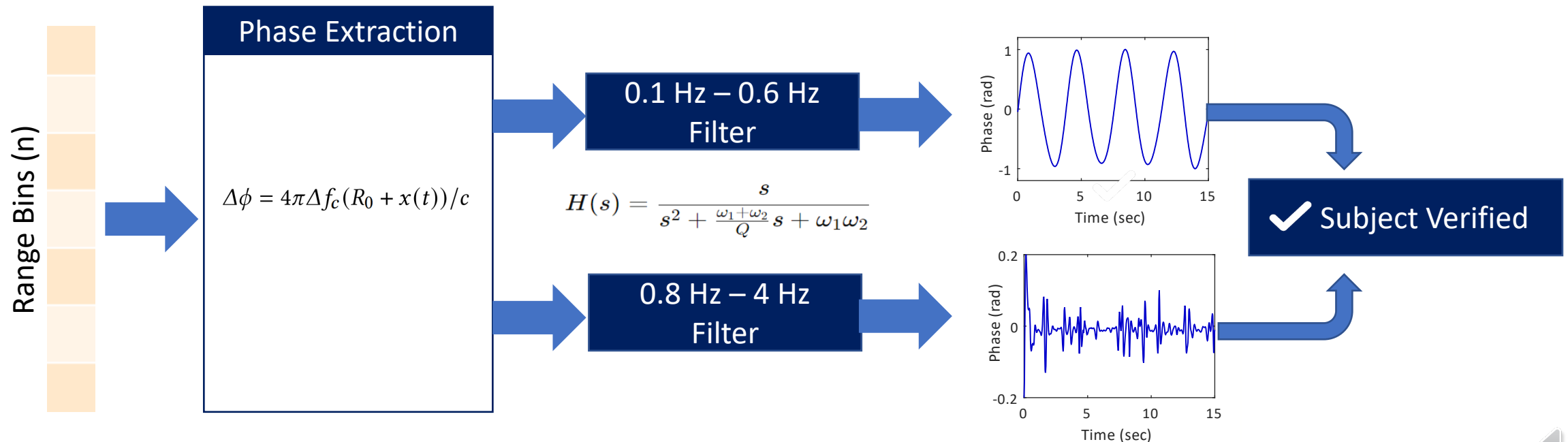
$$S_{Tx}(t) = \exp[j(2\pi f_c t + \pi K t^2)]$$
$$S_{Rx}(t) = \alpha S_{Tx}[t - 2R(t)/c]$$



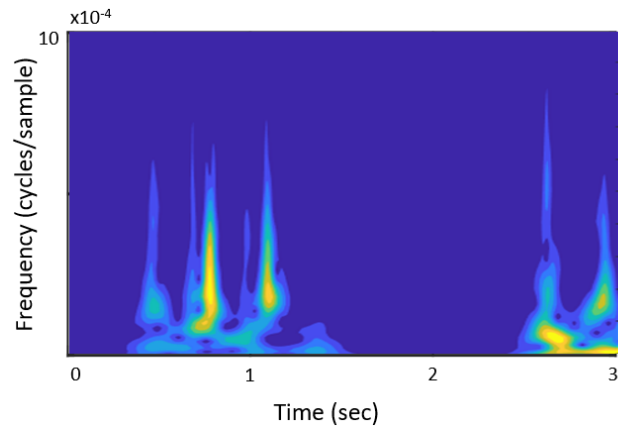
# Biometric Verification for the static objects

Step 1: Ignore all the dynamic range bins.

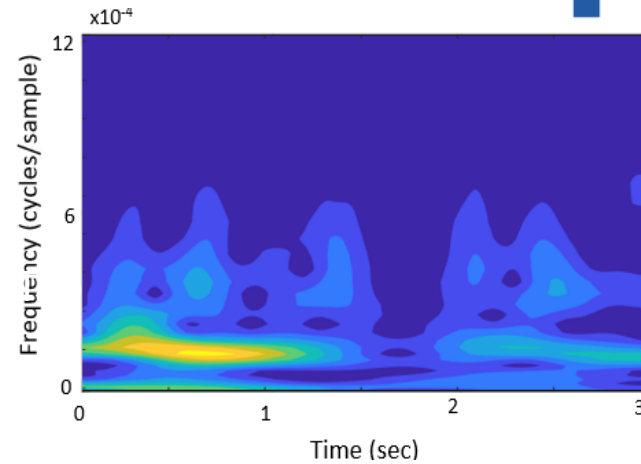
Step 2: investigate each static bin for vital signs i.e. Heart beat and Respiratory motion



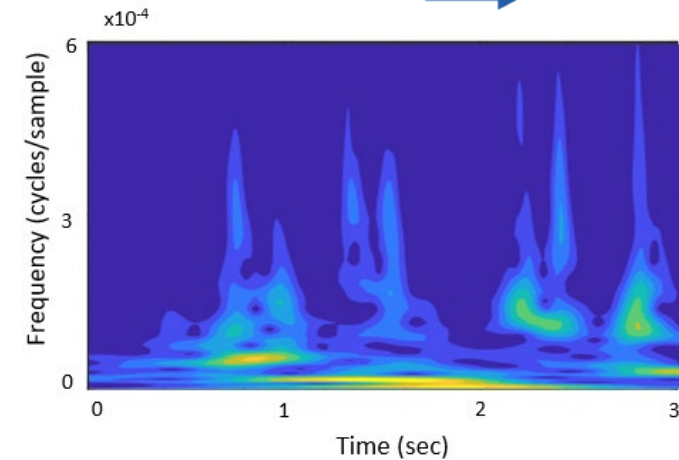
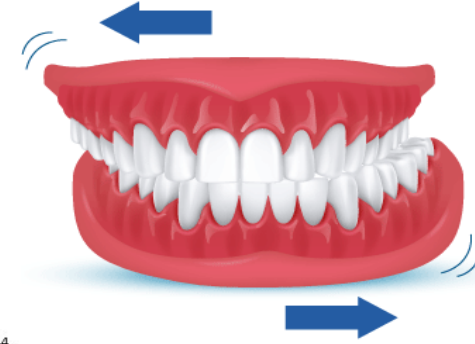
# Gesture Detection



Tap



Clench



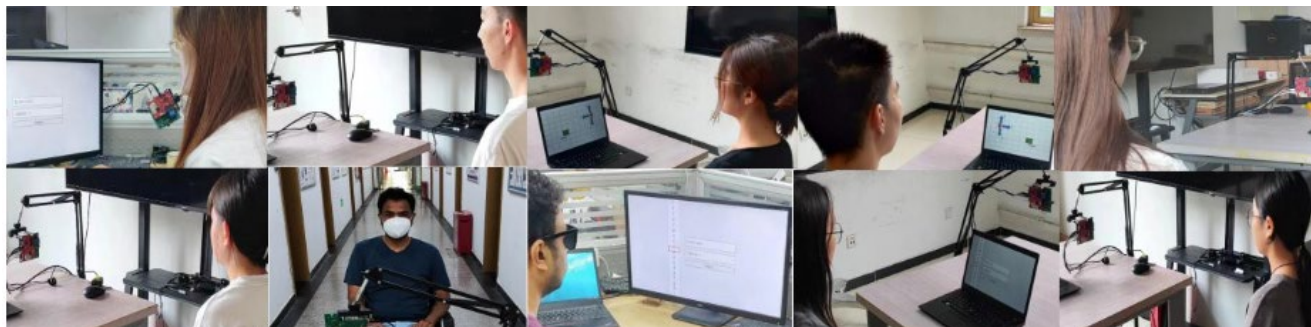
Slide



# Implementation

## Scenarios:

Location	Distance
Hallway	1m, 1.5m, 2m, 2.5m
Conference Room	1m, 1.5m, 2m, 2.5m
Lab	1m, 1.5m, 2m, 2.5m



## mmWave Radar



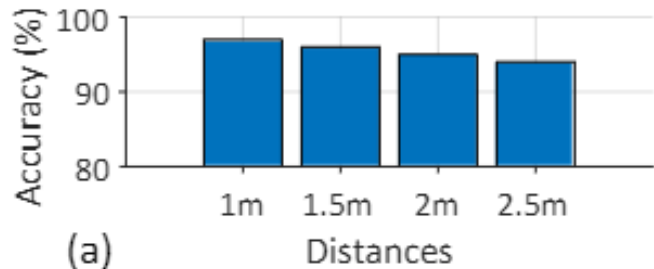
## Data Processing

PC (CPU: Intel i7-12700H)  
Matlab 2023b  
Python 3.7

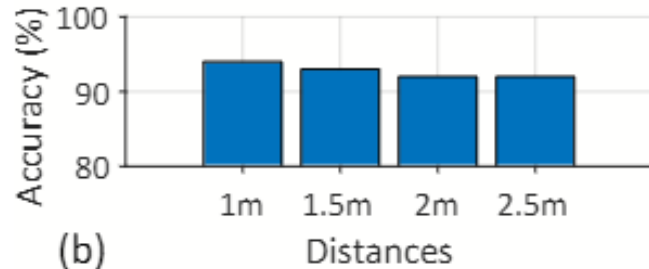




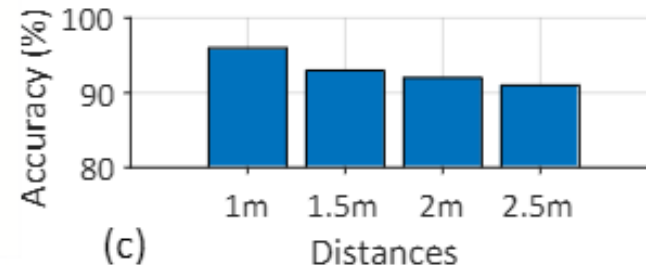
The accuracy of **binary classifier** in various environments



Hallway



With Facial Accessories

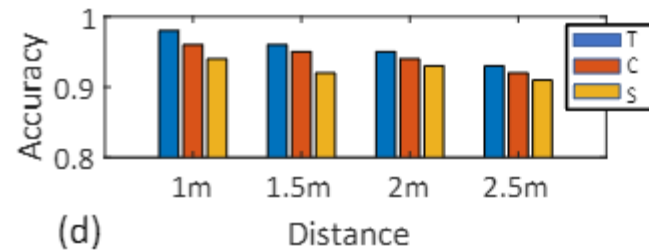


Indoor

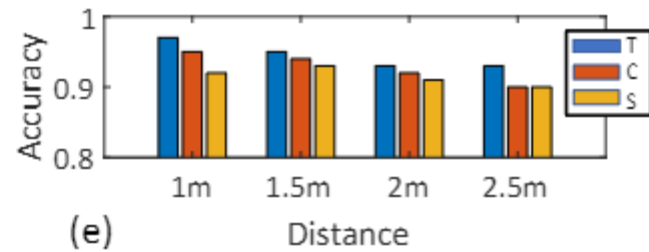
- There is a slight decline in accuracy with respect to increase in distance
- Resilience with different location settings.



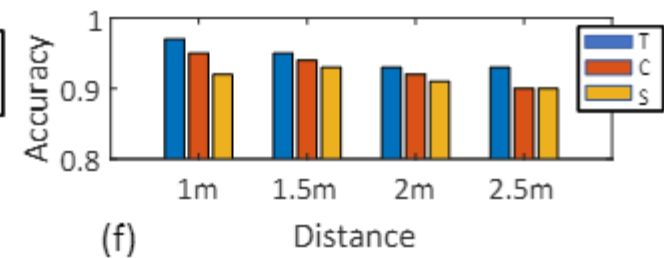
The accuracy of **gesture classifier** in various environment



Hallway



With Facial Accessories

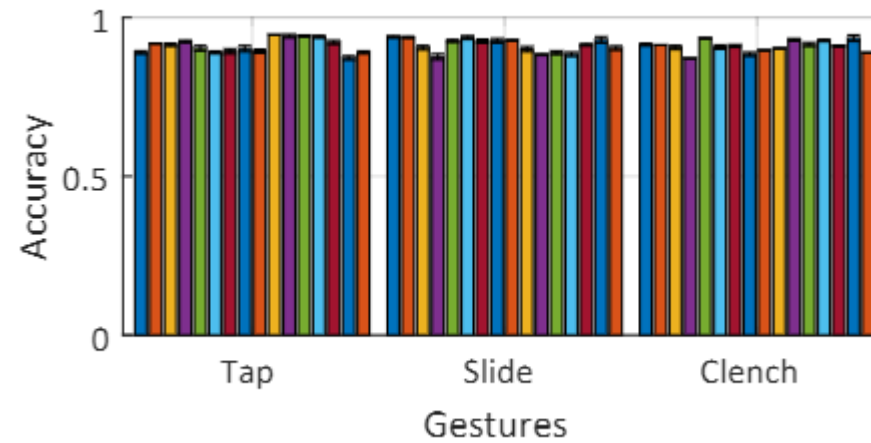


Indoor

- There is a slight decline in accuracy with respect to increase in distance
- Resilience with different location settings.



# Accuracy across different users



# Conclusion

- A novel method for Remote Detection of 3 Teeth Gestures with mmWave Radar
- High Accuracy up to 2.5m
- Resilient against Facial Accessories such as Glasses and Mask

