



# Brain Computer Interaction

## *Class #1* Introduction to Data



### COURSE INSTRUCTORS

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User can be  
anyone

# Users



Novice user



Language illiterate



Old-age people

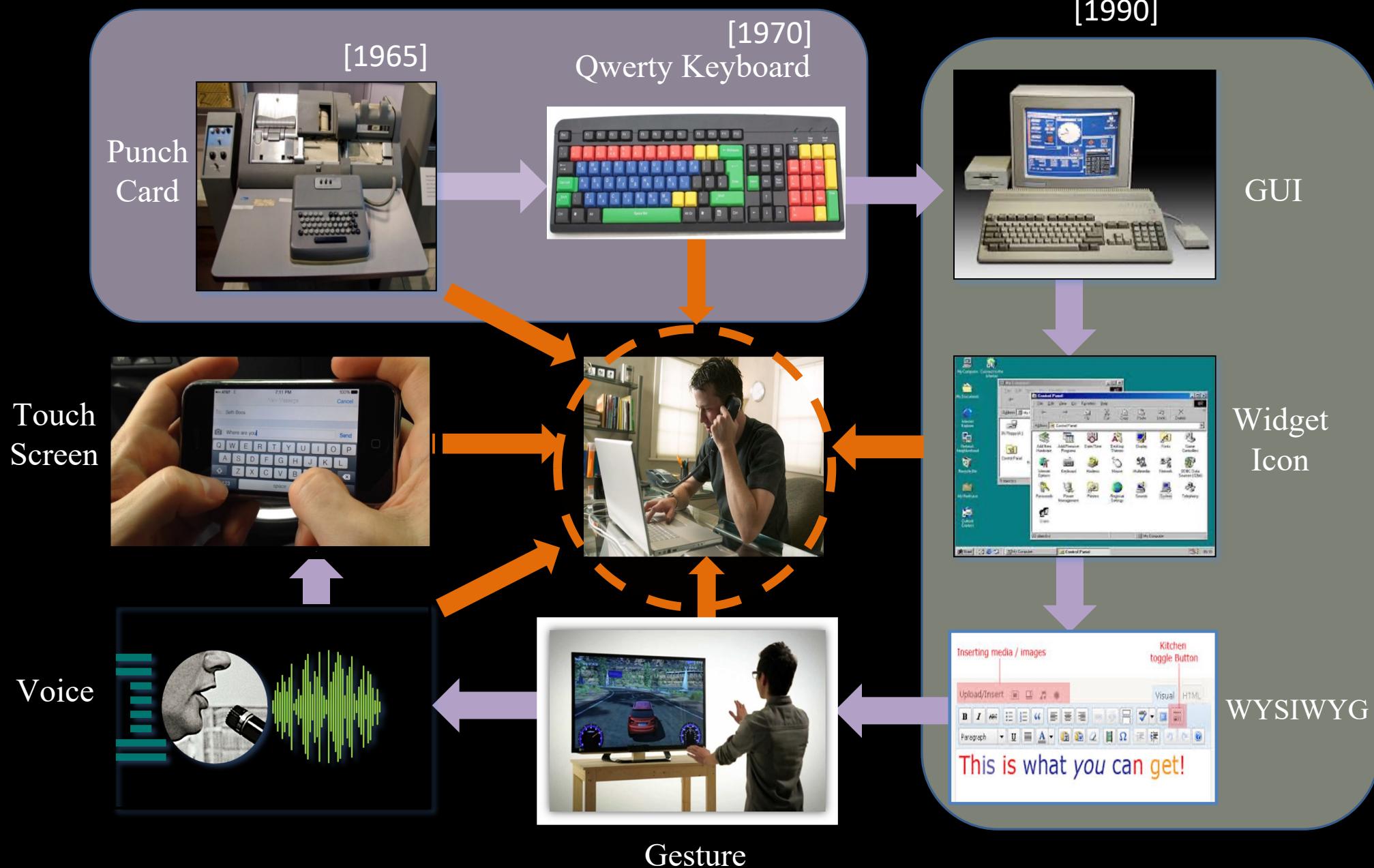


Disabled user



Blind user

# Evolution of HCI with computer generation



# Recent Advancements in HCI

## Possibility of next generation HCI

- 01 | Virtual reality
- 02 | Augmented reality
- 03 | 3D Holographic projection
- 04 | Brain computer interaction

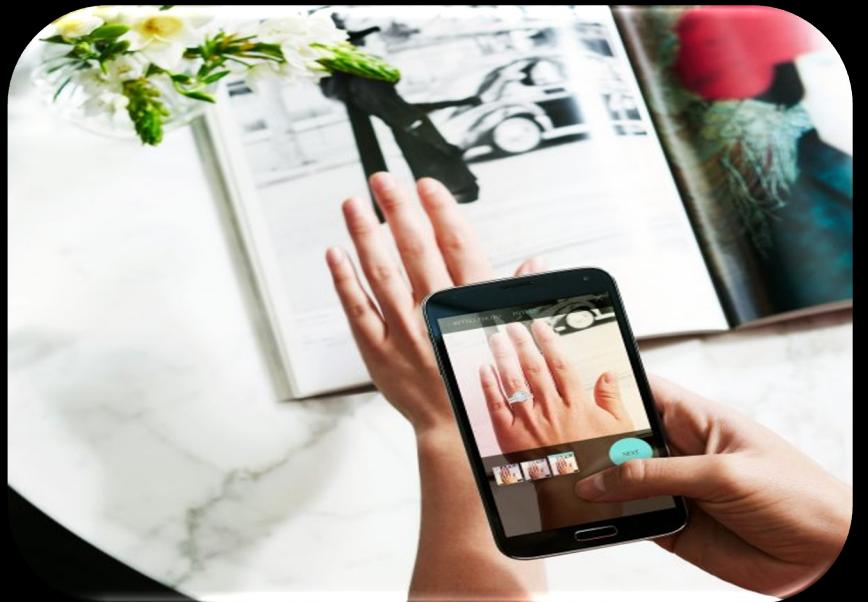
# Virtual Reality



# Augmented Reality



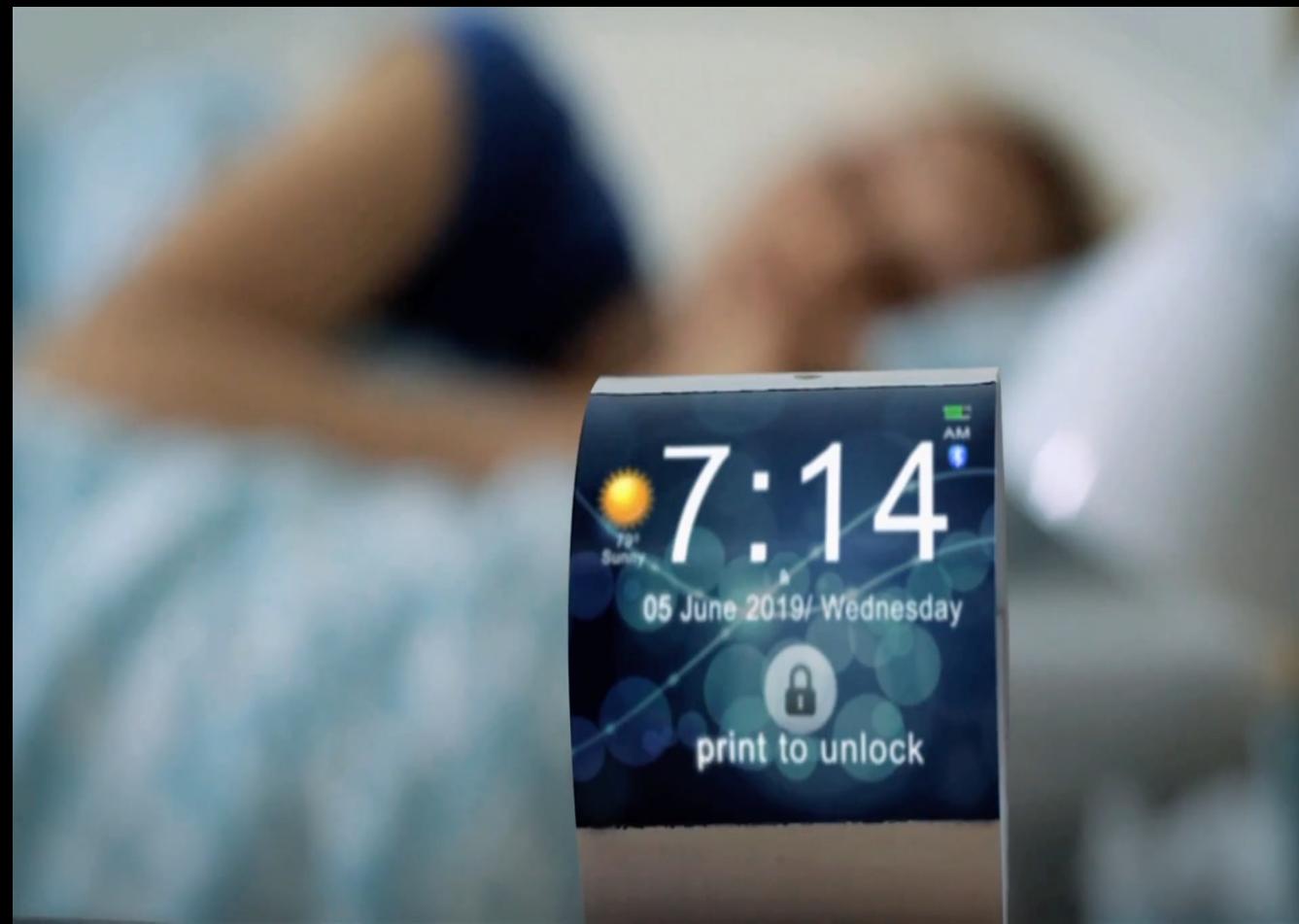
Hunting and catching pokemon



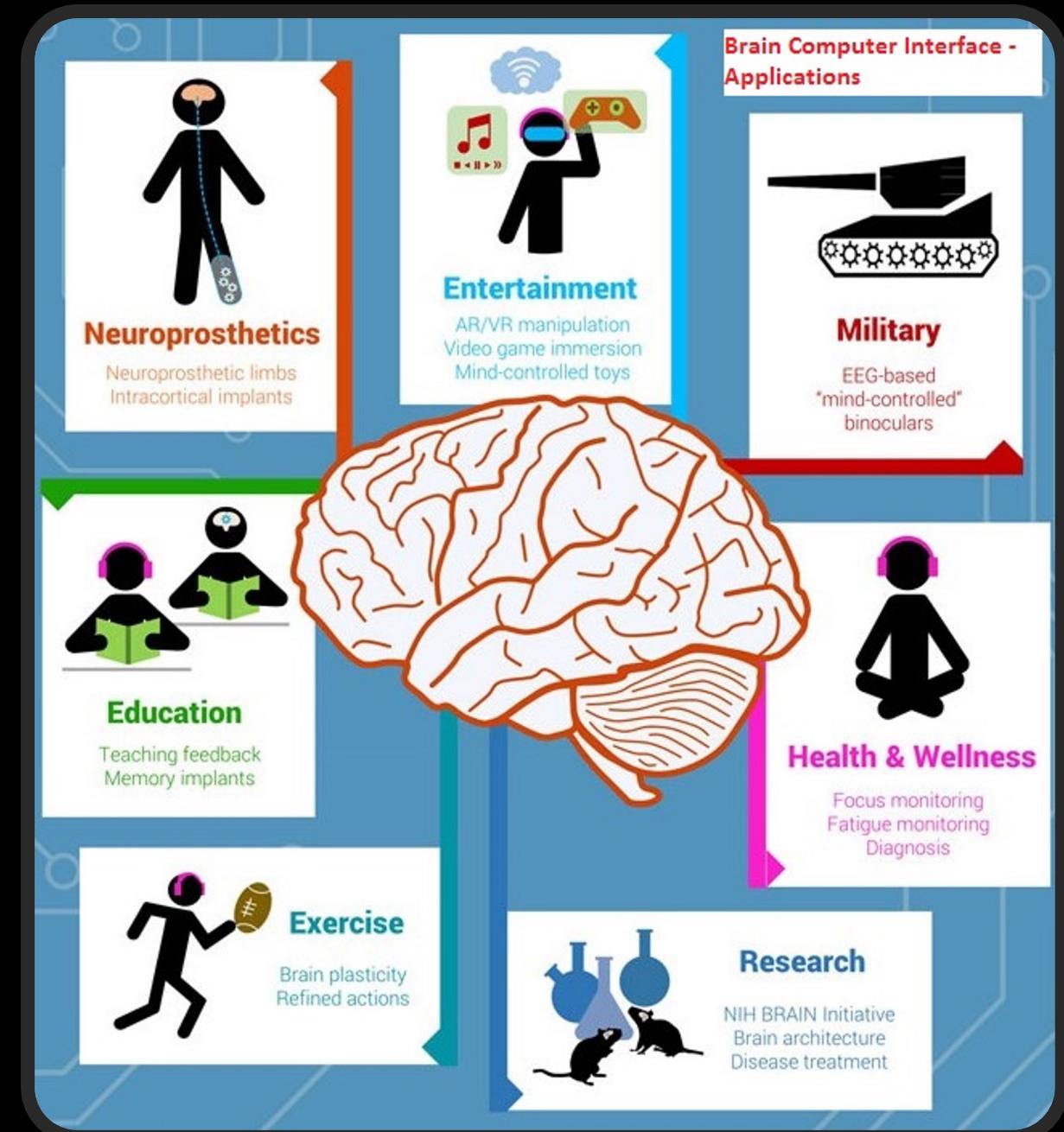
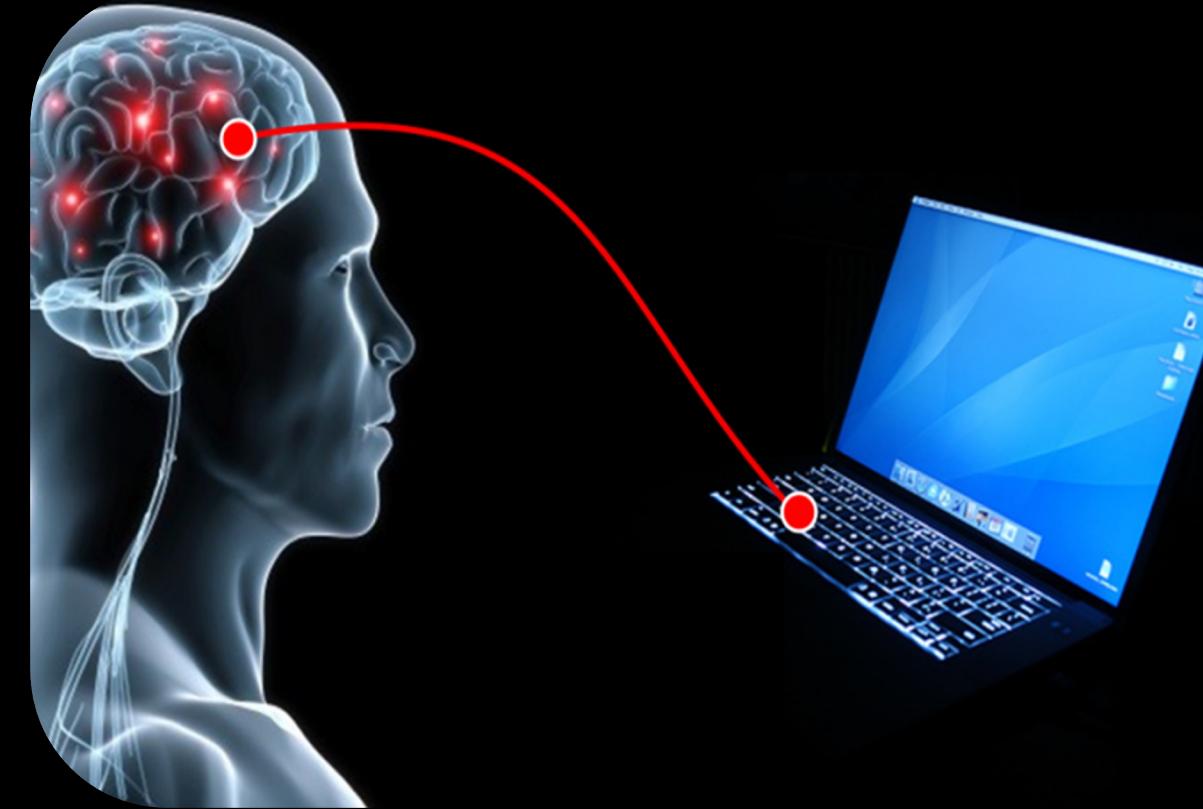
Finding suitable wedding rings



# 3D Holographic projection



# Brain Computer Interaction



# Some real-time BCI Applications



Communication



Device Control



Automatic Motion Controlling



Attention Monitoring



Games & Entertainment

# Functions of Human Brain

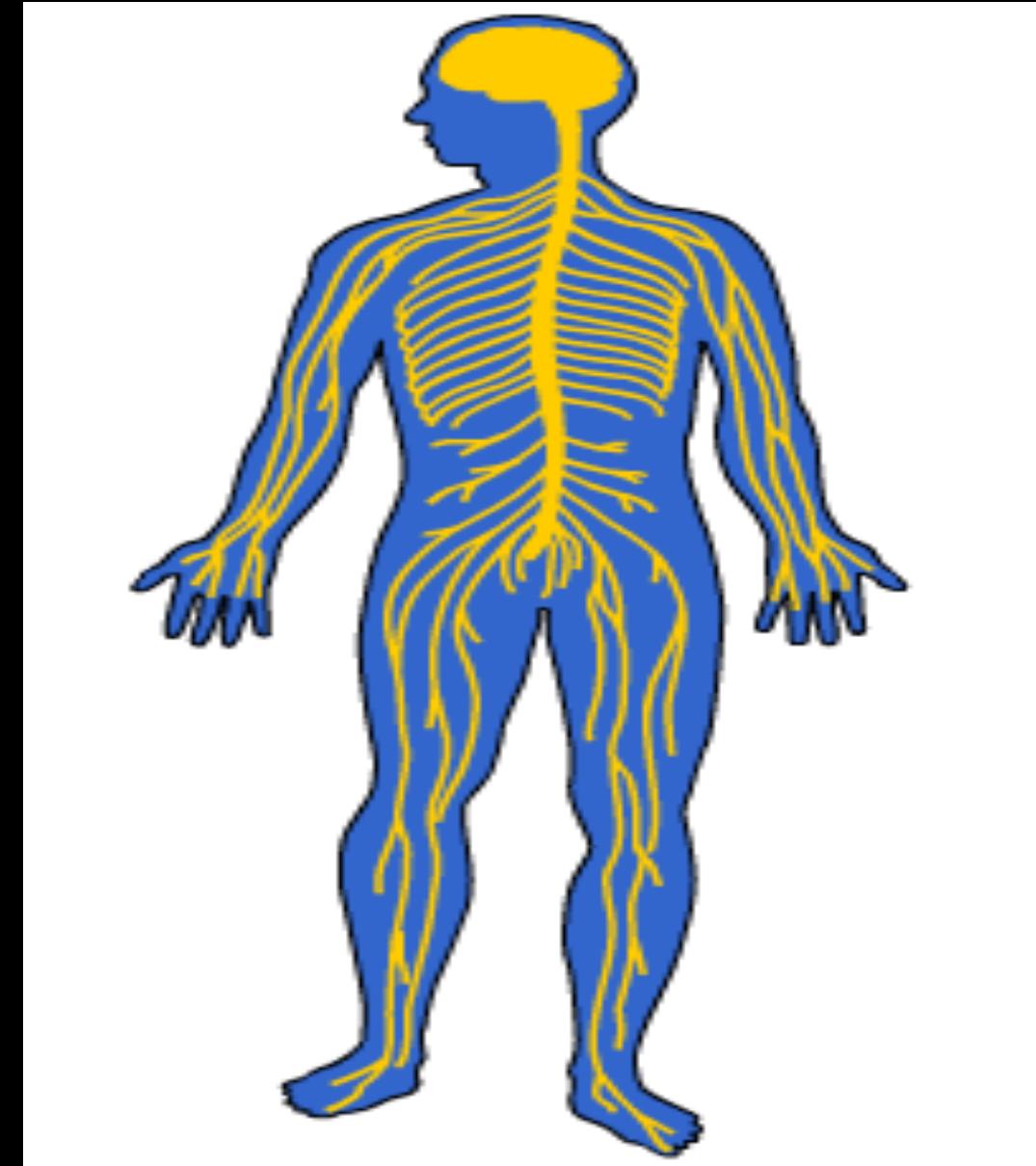
# Neurons and their activity

- An average human brain weighs about 1.5 kg and consists of approximately  $10^{10}$  to  $10^{11}$  neurons or cells specialized in information processing.
- Most of the neurons are located in the central nervous system consisting of brain and spinal cord.
- Neurons are highly specialized for electrochemical signaling. They accept input from other cells at their dendrites and send an electrochemical signal along the axon. An average neuron have ten thousands of dendrites.
- Neurons maintain a particular ratio of anions and cations inside the cell as well as outside the cell membrane.
- When this concentration of ions changes, cells are able to produce a transient electric charge and they are termed as *neuron firing*.

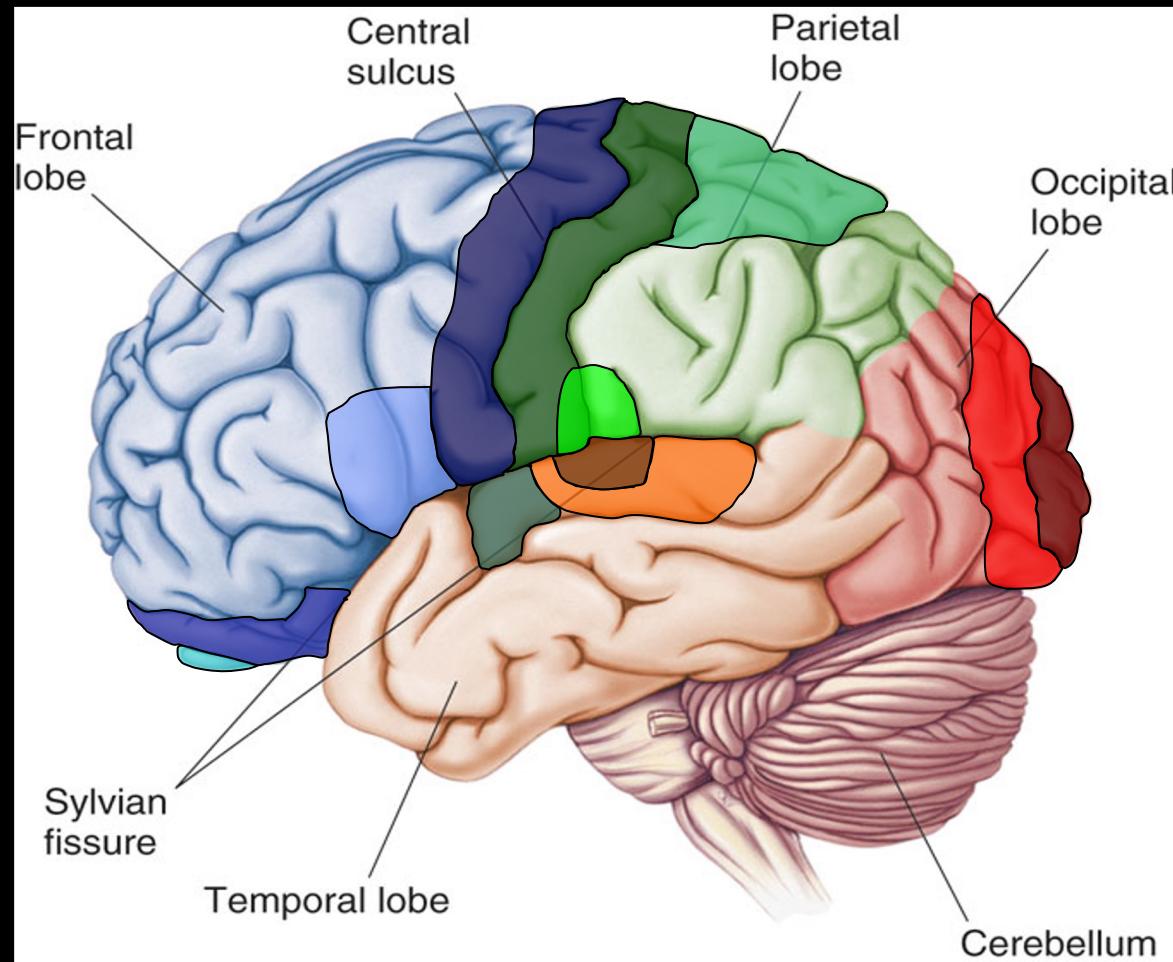


## Nervous system

- The nervous system controls every part of your daily life, from breathing and blinking to helping you memorize facts for a test.
- Nerves reach from your brain to your face, ears, eyes, nose, and spinal cord and from the spinal cord to the rest of your body.
- Sensory nerves gather information from the environment; send that information to the spinal cord, which then send the message to the brain. The brain then makes sense of that message and fires off a response.
- Motor neurons deliver the instructions from the brain to the rest of your body.
- The spinal cord, made of a bundle of nerves running up and down the spine, is similar to a superhighway, sending messages to and from the brain at every second.



# Brain and its Activities



- Sight
- Interprets Information (Image recognition and image perception)

- Processing of tactile information
- Awareness of body in space
- Controlling movements of the body

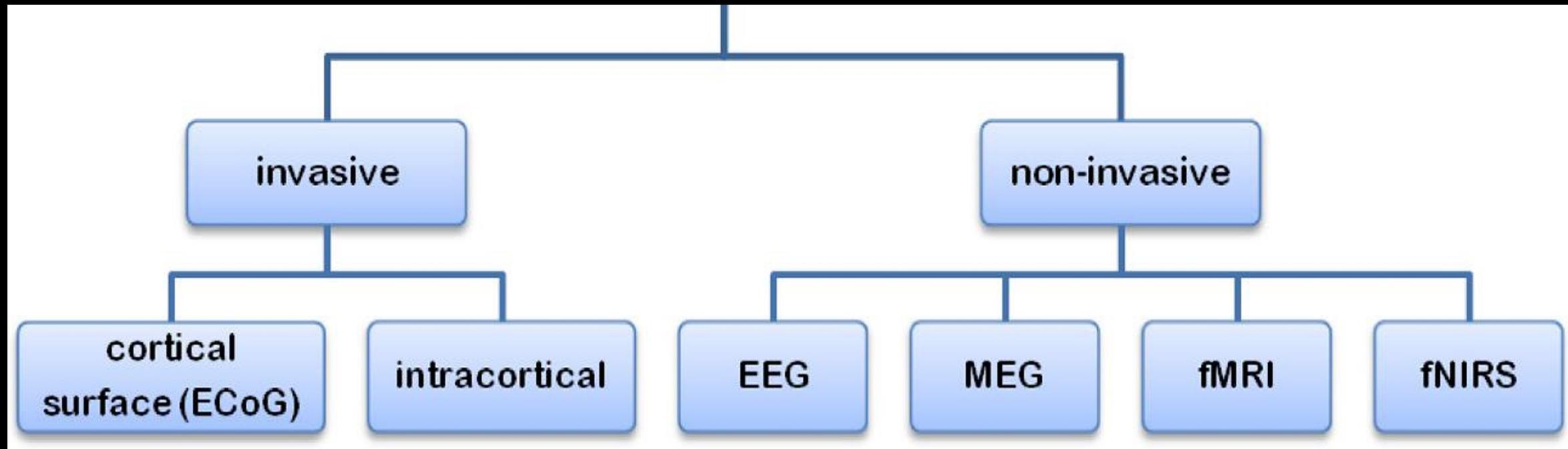
- Responsible for hearing
- Language comprehension

- Sensation of Smell
- Interprets Smell

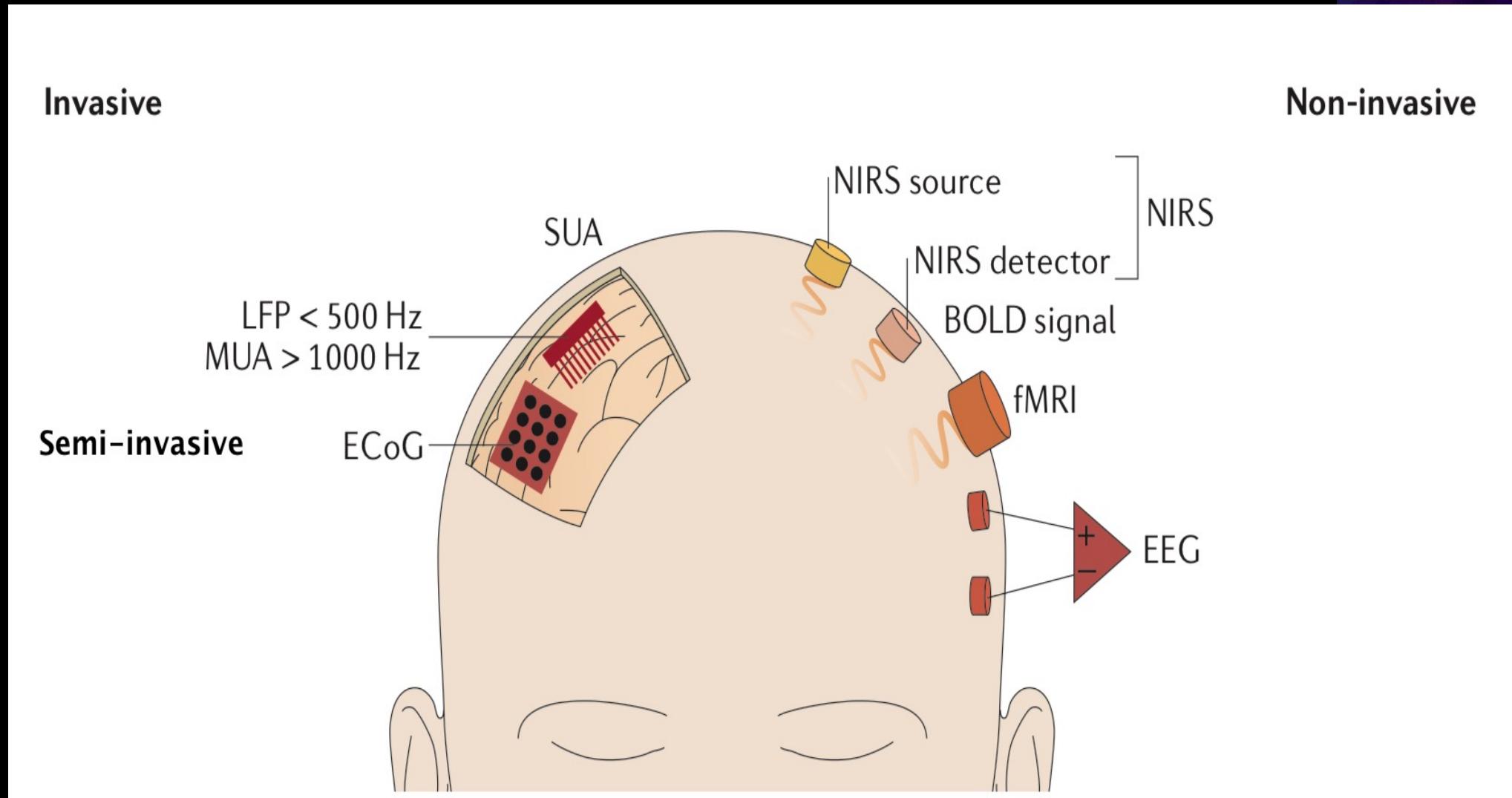
- Facial neurons and Speech
- Sensation of Taste
- Decision Making

# BCI Technologies

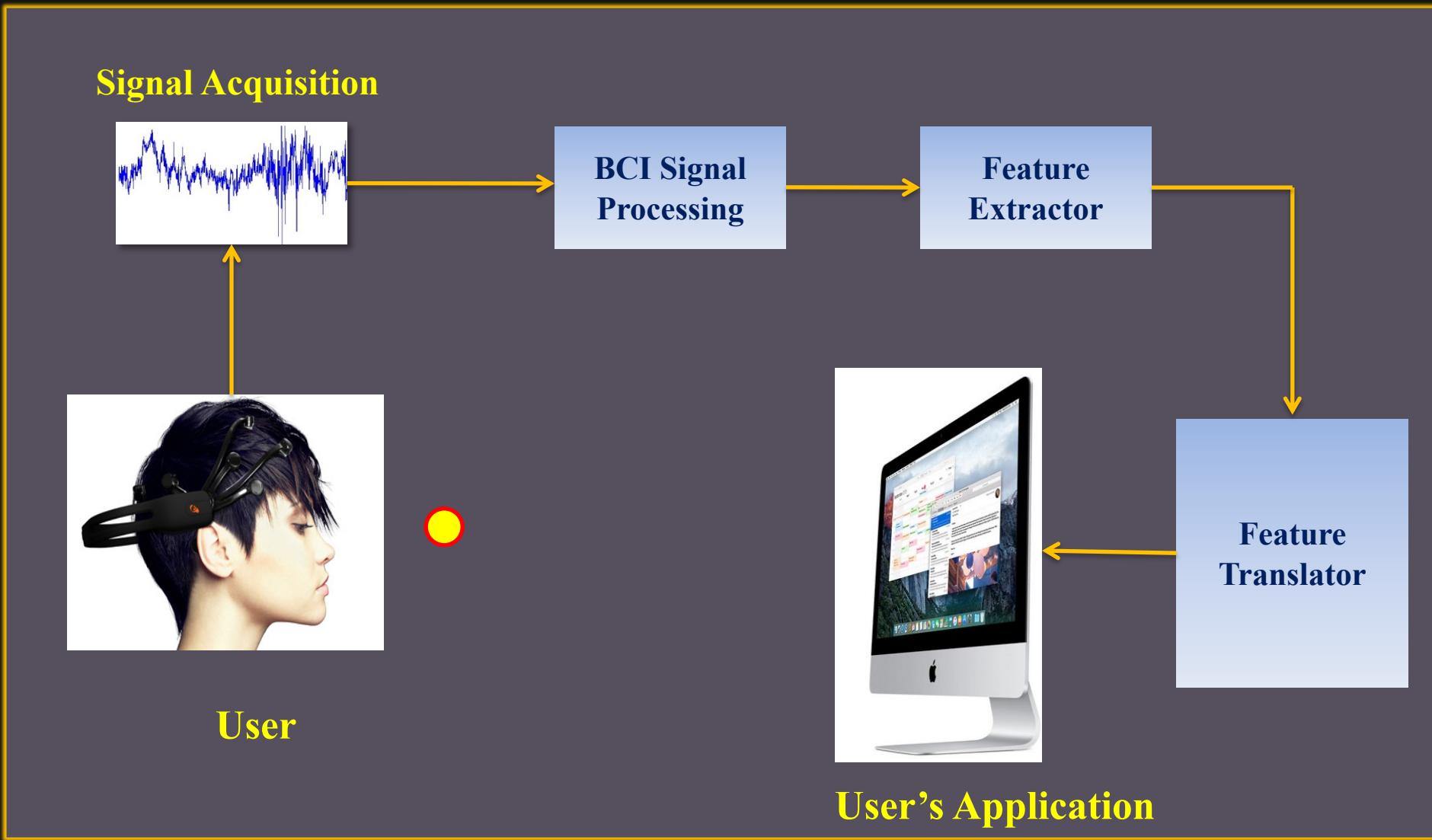
# BCI devices



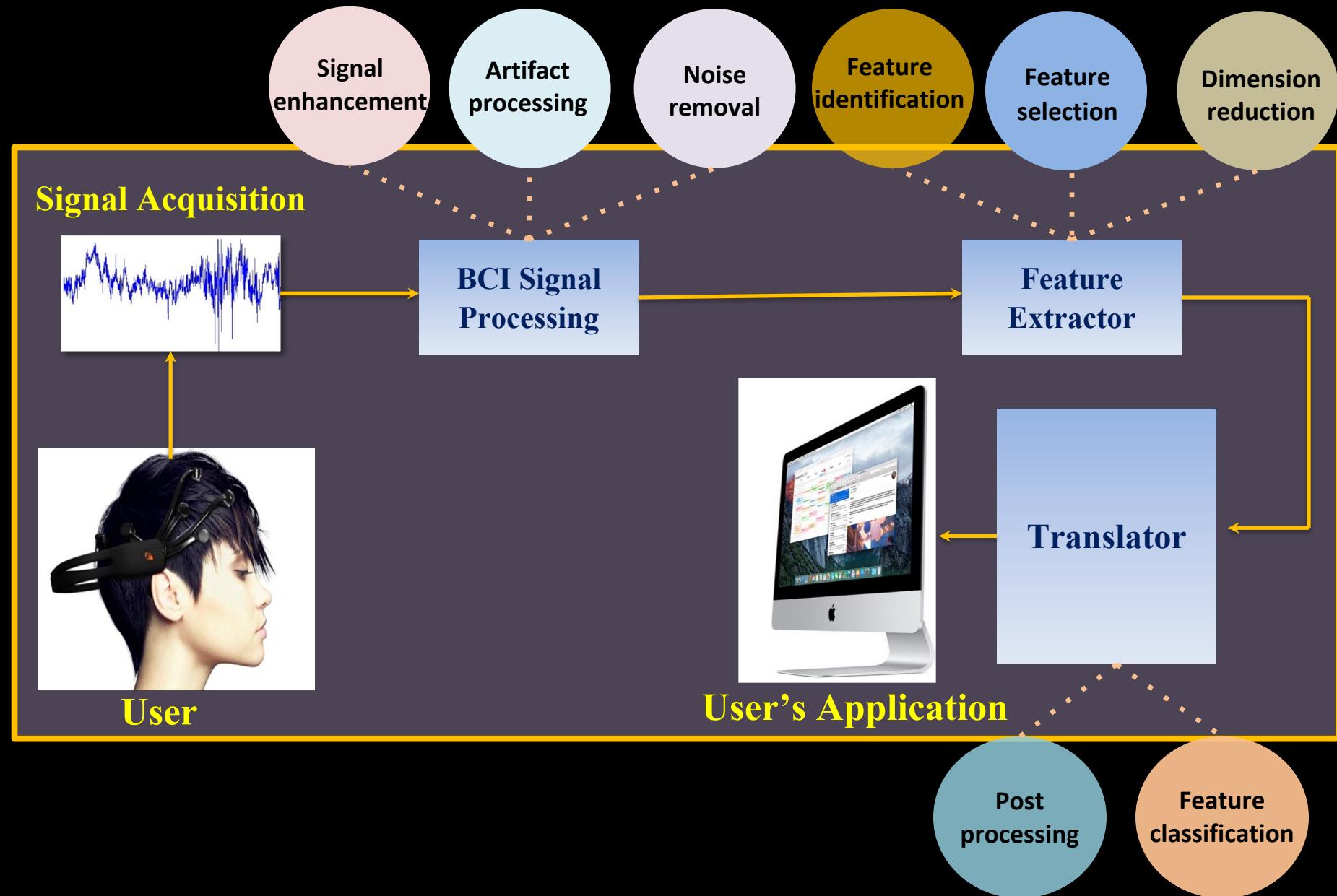
# BCI devices



# BCI Architecture



# BCI Architecture

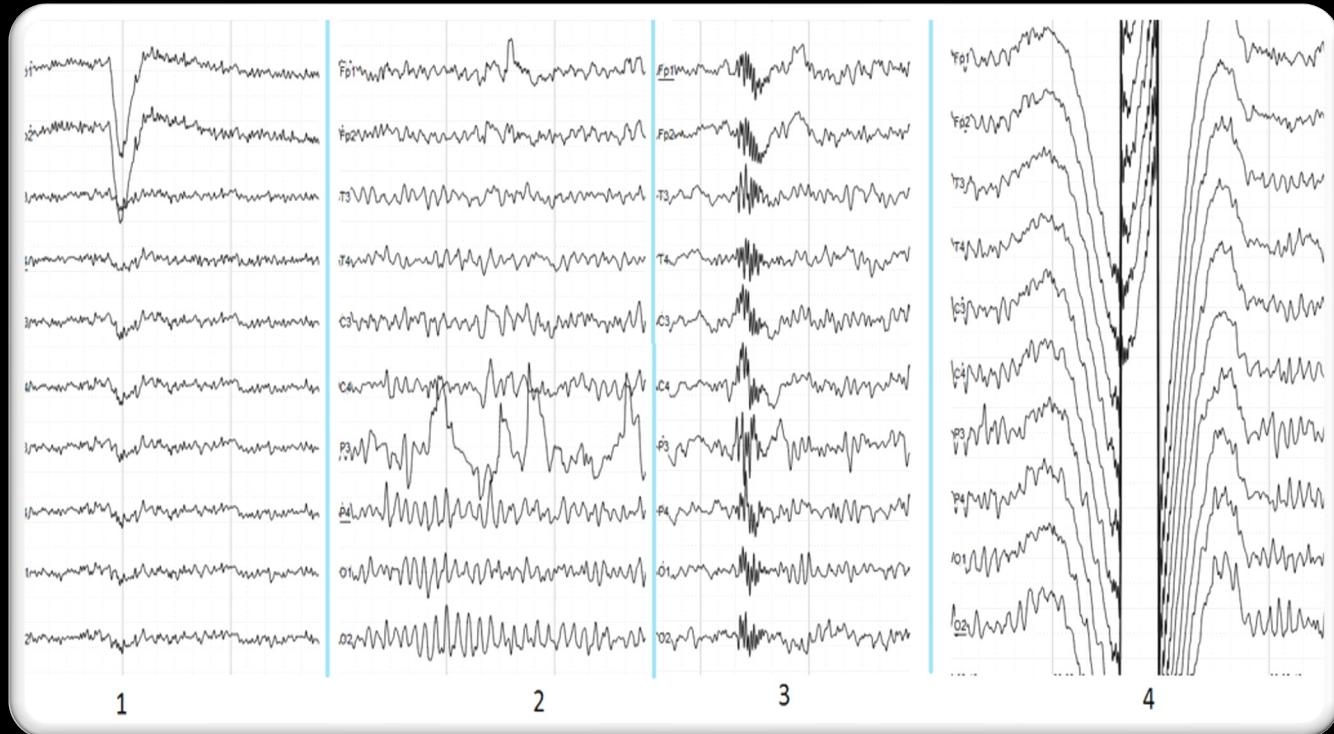


# BCI Signal processing

# BCI Signal processing

## ✓ Sensitive to artifacts

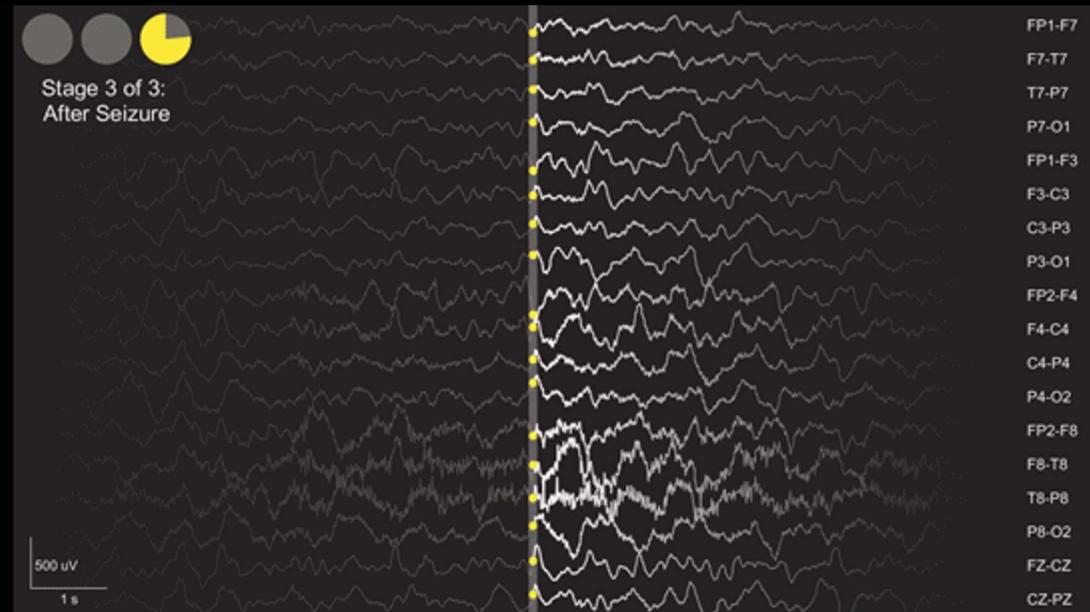
- Eye blinks
- Head and body movements
- Muscle activity
- Speech
- Heart rate
- Environmental noise



EEG Signal with noise (Artifacts)

# BCI Signal Processing

- Filtering techniques
  - Band-pass filtering
- Artifact removal techniques
  - Independent component analysis
  - Principal component analysis
  - Sparsity-based methods
  - Wavelet-based methods
- Channel Selection
  - Common spatial pattern
  - Sequential feed forward selection



# Feature Extraction

# Feature Extraction

Different classes of features:

- Statistical features
- Derivative features
- Time domain features
- Frequency domain features
- Wavelet domain features
- Entropy features
- Cross-correlation features

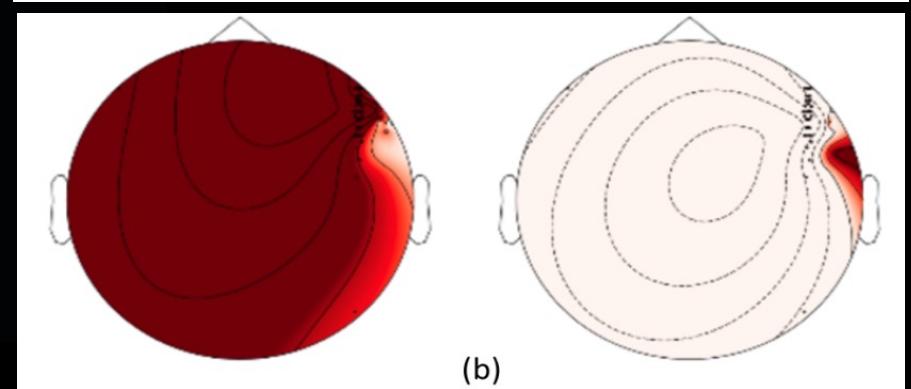
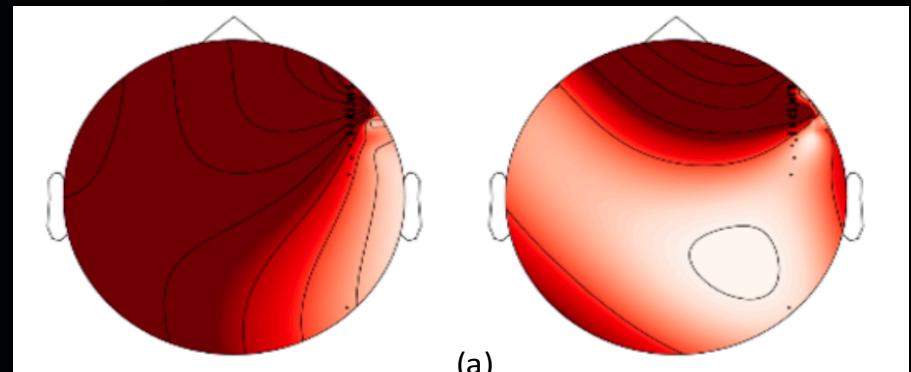
# Feature Selection

# Why Feature Selection?

- Simplification of models to make them easier to interpret
- Shorter training times
- To avoid the curse of dimensionality
- Enhanced generalization by reducing overfitting

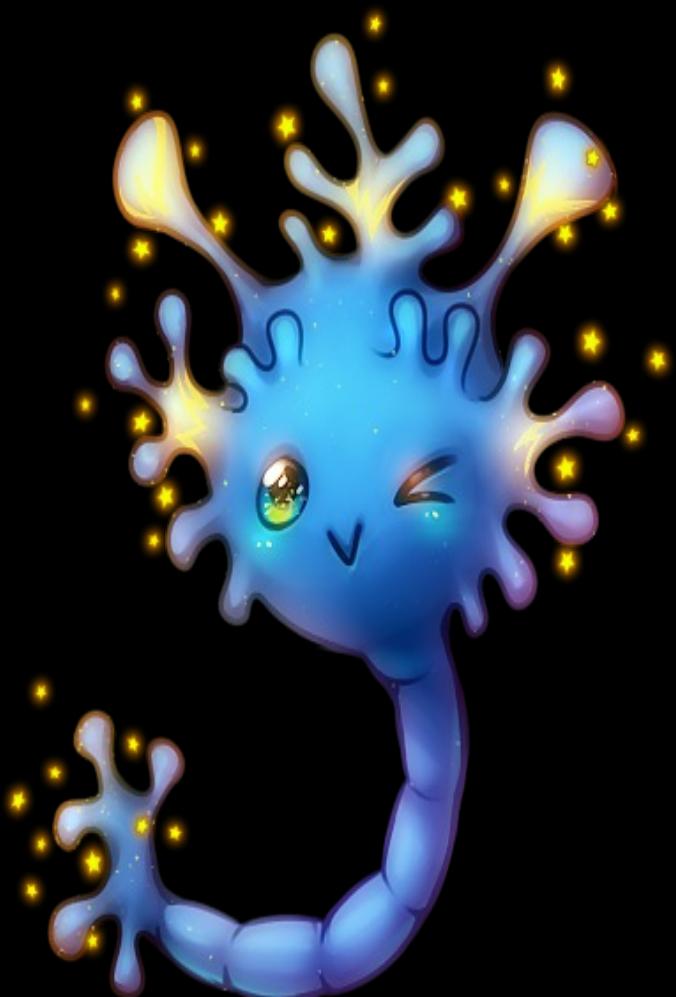
# Feature Classification

- Machine learning algorithms
  - ✓ (e.g. SVM, LDA, kNN, etc.)
- Deep learning architectures
  - ✓ (e.g. RBM, CNN, LSTM, etc.)
- Optimization techniques
  - ✓ (e.g. Sparsity approach)



## Example of Hand-free Touch-free Interaction:





Thank You!