

주요우울장애 환자의 성별 및 약물 복용력에 따른 뇌파 특성을 고려한 딥러닝 기반 컴퓨터 보조 진단 시스템

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Division of work



이은경

팀원들의 연구 진행사항 체크 및 앞으로의 진행 방향 피드백
프로젝트 진행과 관련하여 매주 연구와 관련한 개념에 대해 강의



박소정

연구에 사용하는 데이터 전처리 진행 및
뇌파스쿨에 참여하여 뇌파 분석에 대한
교육을 받고 팀원들에게 공유



조해리

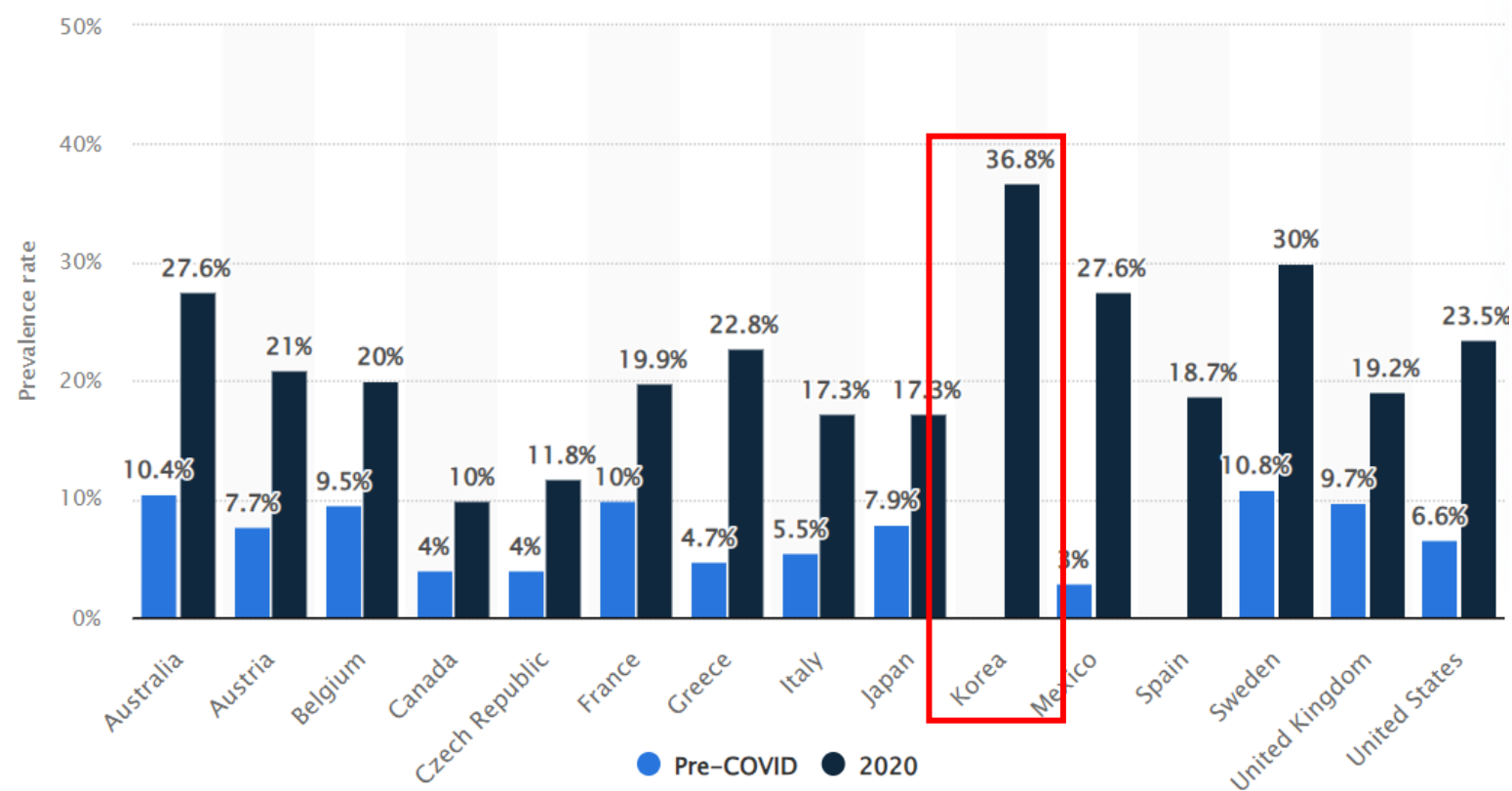
머신러닝 분석(feature selection,
Linear discriminant analysis algorithm을
사용한 시스템 결과 도출)을 이끌어 나감



노동한

딥러닝 학습 및 성별에 따른
딥러닝 기반 보조 진단 시스템 개발
(Shallow ConvNet모델을 사용한 시스템
결과 도출 및 고도화) 진행

'Pandemic of mental illness' soaring through COVID-19



- People, who suffer from depression symptoms, have been increased after COVID-19.
- The rate of prevalence in South Korea – 36.8 %

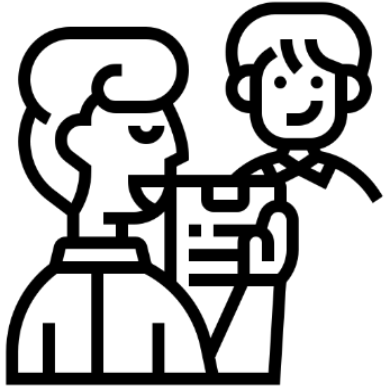


- Symptoms – depressed mood, sadness, loss of interest
- Late diagnosis and treatment → leading to **suicide**
- Early treatment → high recovery rate (> 54 %)

To improve the resilience of MDD patients after treatment,

early diagnosis and early intervention are necessary!

- The limitation of current diagnostic tool

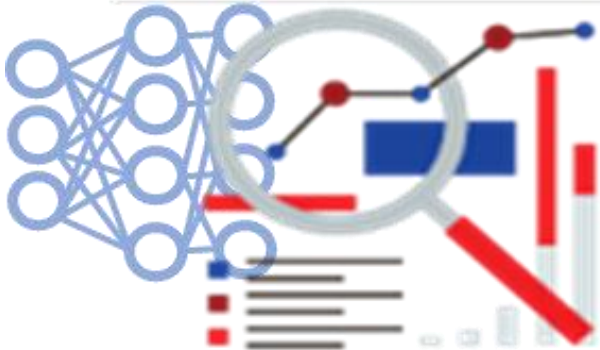


Based on **personal interview** and **questionnaires** by the clinical experts

→ Lack of consistency and objectivity

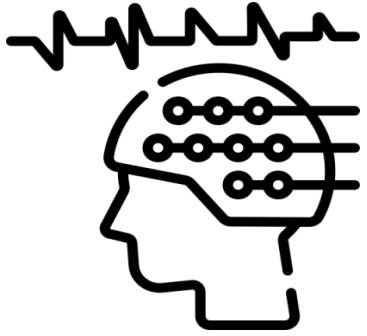
→ **High misdiagnosis rate**

Computer-aided
diagnostic (CAD) system



→ **The object biomarkers-based computer-aided diagnostic (CAD) system can improve the diagnostic accuracy of MDD patients**

- Objective CAD system using EEG



Why EEG?

- MDD patients showed **the altered functional brain characteristics, such as emotion and cognitive function**, rather than anatomical problem.
- Altered functional brain characteristics are well revealed by EEG due to high temporal resolution.
- **A lot of EEG-based CAD system for MDD patients have been developed.**
- **However, the developed CAD systems were based on conventional machine-learning algorithms.**

Limitations of conventional machine-learning-based CAD system using EEG for MDD patients,

1. Hand-crafted features

- Less efficiency
- Biased diagnostic accuracy

2. EEG features

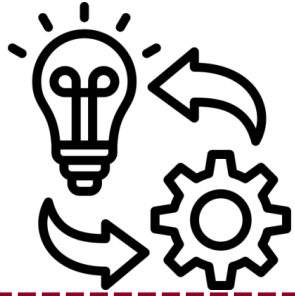
- Gender-specific
- Medication controlled

overcome limitations



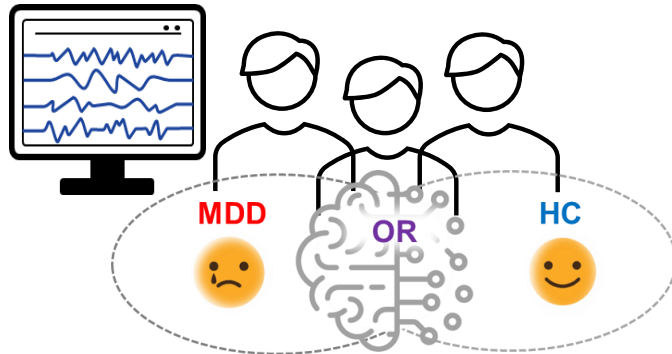
**Deep-learning-based CAD system for
drug-naïve, gender-specific MDD patients!**

Purpose of this study



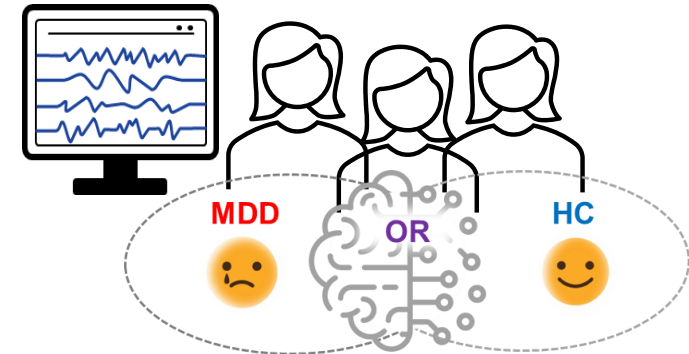
Development of deep-learning-based CAD system **considering gender and medication-controlled EEG features in MDD**

Study 1.



Development of a CAD system for accurate diagnosis of **male** MDD patients

Study 2.



Development of a CAD system for accurate diagnosis of **female** MDD patients

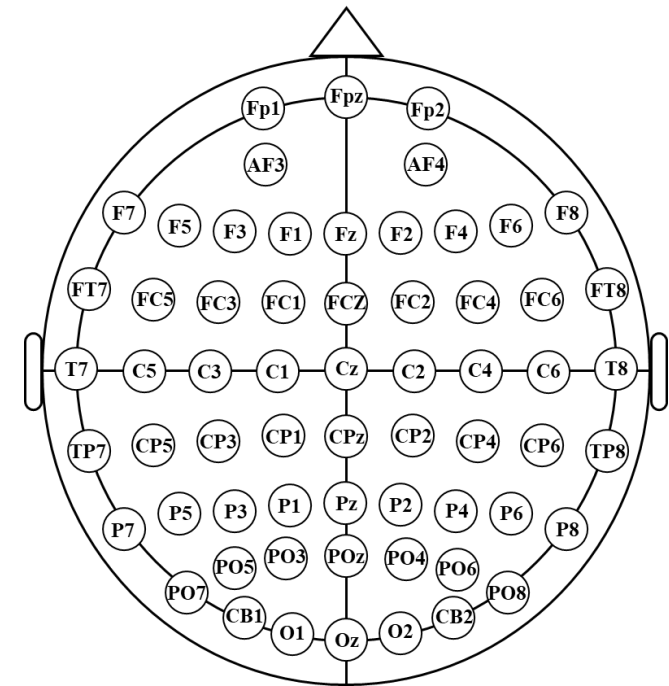
Methods

Subjects

- Study 1: 40 male participants for MDD and 41 male healthy controls, respectively
- Study 2: 49 female participants for MDD and 49 female healthy controls, respectively
- Symptom scores: depression (HAM-D) and anxiety (HAM-A)

EEG recording and preprocessing

- 64 channel (references - M1 and M2)
- Eyes-closed resting-state EEG (5 minutes)
- Band pass filtering: 1 – 55 Hz
- Independent component analysis (ICA)
- Common Average Reference (CAR)
- Downsampling: 1,000 Hz → 200 Hz
- Segmentation: about 3 minutes



Machine-learning strategy

- **Feature extraction**

- Power spectral density (PSD) using short-time Fourier Transform (STFT)
- 7 frequency bands: delta [1 – 4 Hz], theta [4 – 8 Hz], low-alpha [8 – 10 Hz], high-alpha [10 – 12 Hz], low-beta [12 – 22 Hz], high-beta [22 – 30 Hz], and gamma [30 – 55 Hz]
- Total 434 features

- **Classification**

- Feature selection: Independent t -test, number of features: 1 – 50
- Classifiers: Linear discriminant analysis (LDA)
- Cross-validation: Leave-one out cross-validation
- Performances: Classification accuracy, sensitivity, and specificity

Deep-learning strategy

- **Classification**

- Model: Shallow ConvNet
- Input data: artifact-free EEG data (about 3 mins, time-series)
- Cross-validation: leave-one out cross-validation
- Performances: classification accuracy, sensitivity, and specificity

- **Explainable artificial intelligence (XAI)**

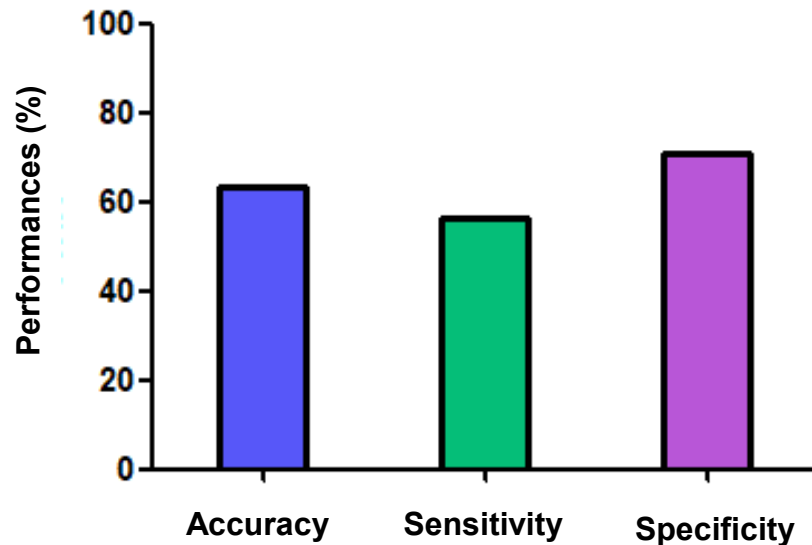
- A method for assisting the interpretation of the results from AI algorithms
- Layer-wise relevance propagation (LRP)

Comparison of best classification results (Male)

Linear Discriminant Analysis machine-learning

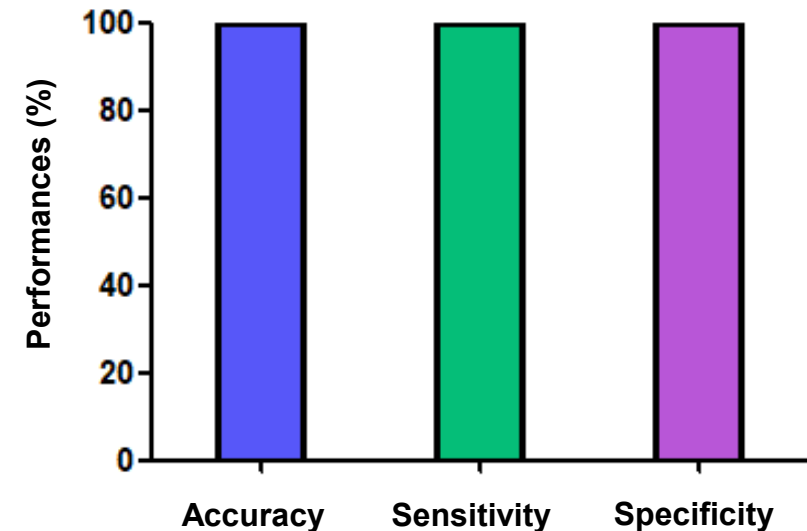
The best classification accuracy of ML was achieved when using 17 features.

- Accuracy: **63.41 %**
- Sensitivity: **56.10 %**
- Specificity: **70.73 %**



Shallow ConvNet deep-learning

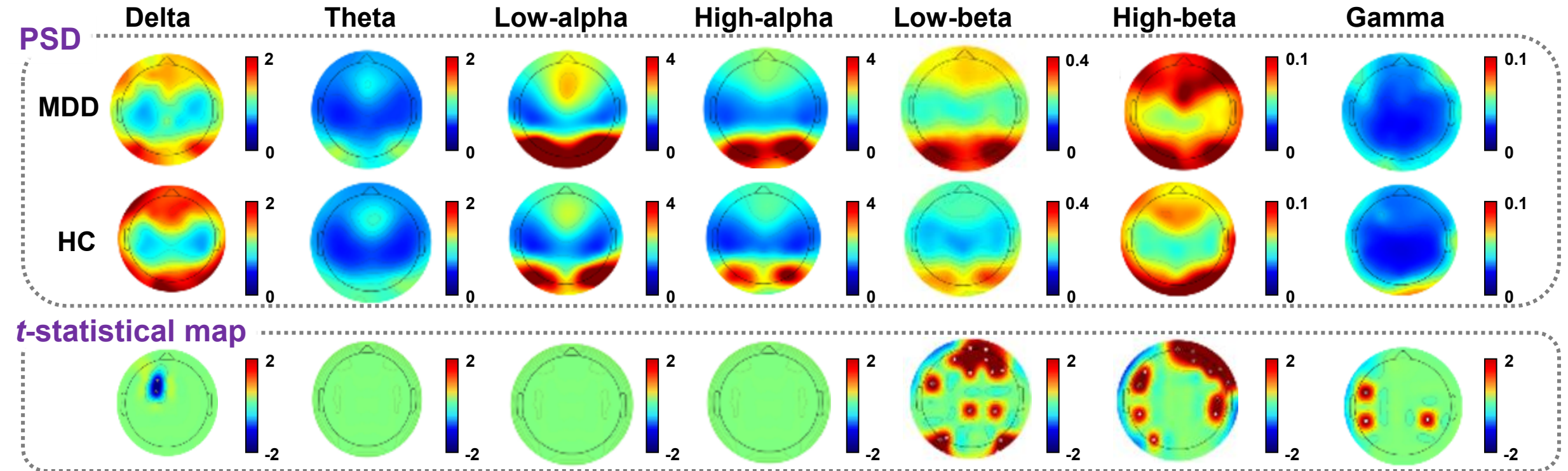
- Accuracy: **100.00%**
- Sensitivity: **100.00 %**
- Specificity: **100.00 %**



Investigate the neurophysiological characteristics of patients (Male)

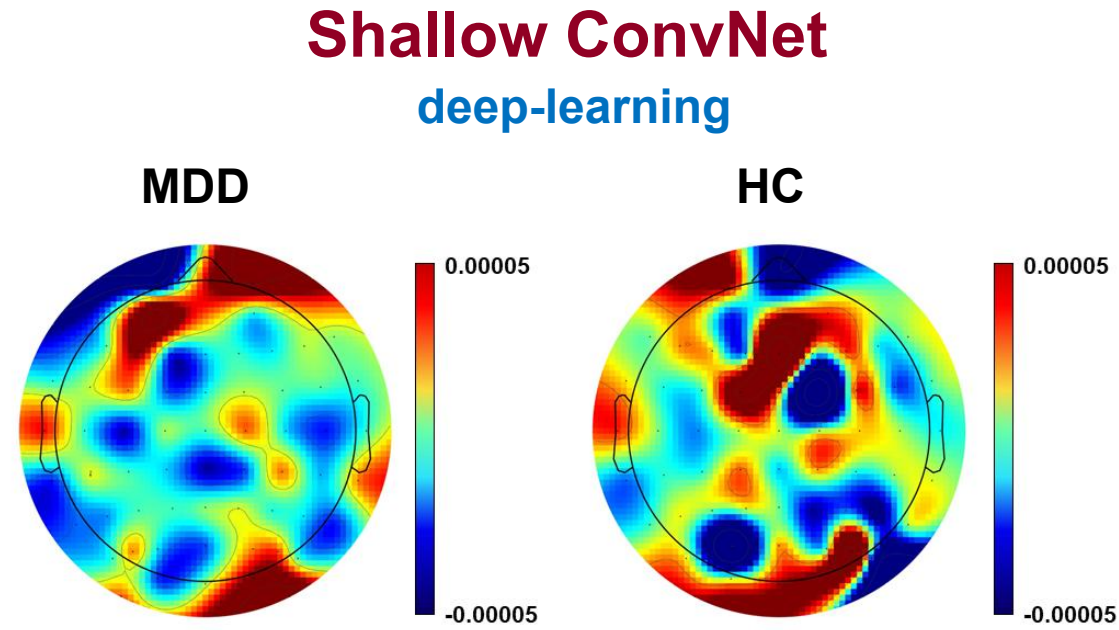
Support vector machine

machine-learning



- 17 selected features: Delta – 2, Low-beta – 6, High-beta – 8 and gamma – 1
- MDD patients showed the **significantly increased PSDs** in beta bandwidth at occipital lobe and right hemisphere frontal lobe as compared to healthy controls ($p < 0.05$).

Investigate the neurophysiological characteristics of patients



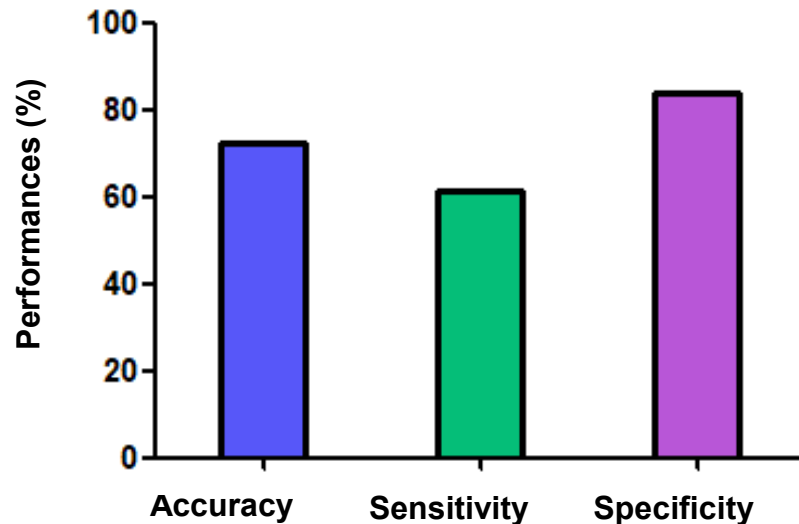
- The averaged relevance scores for MDD patients and HCs in the test set (LRP with $\gamma=0.5$).
- MDD patients showed **higher relevance scores in the prefrontal and occipital lobes in the right hemisphere** than HCs.
- On the other hand, **higher relevance scores were observed in the prefrontal and occipital lobes of the left hemisphere** in HCs.

Comparison of best classification results (Female)

Linear Discriminant Analysis machine-learning

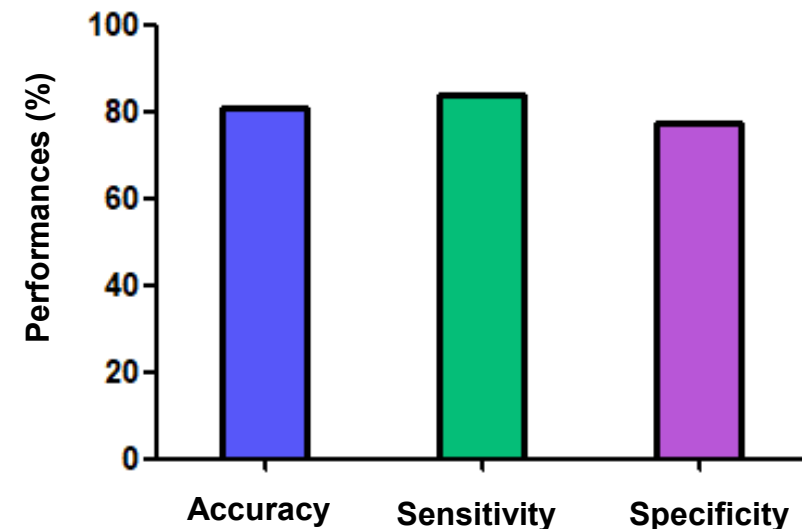
The best classification accuracy of ML was achieved when using 6 features.

- Accuracy: **72.45 %**
- Sensitivity: 61.22 %
- Specificity: 83.67 %



Shallow ConvNet deep-learning

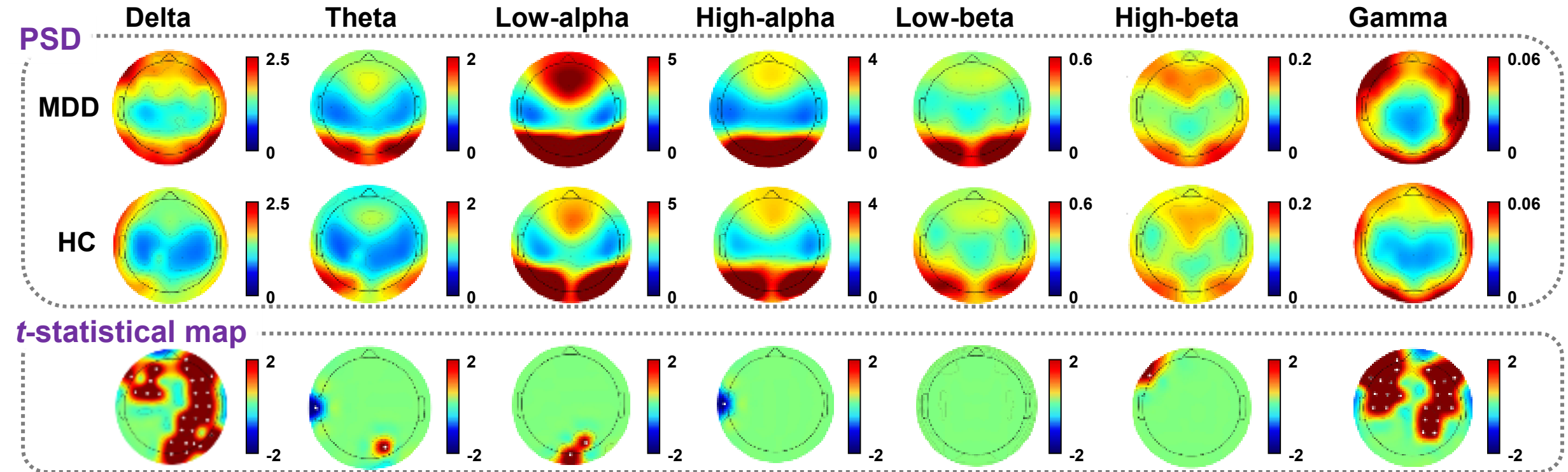
- Accuracy: **80.61 %**
- Sensitivity: 83.67 %
- Specificity: 77.55 %



Investigate the neurophysiological characteristics of patients (Female)

Linear Discriminant Analysis

machine-learning



- 6 selected features: Delta – 2 and gamma – 4
- MDD patients showed the **significantly increased PSDs** in delta and gamma frequency bands as compared to healthy controls ($p < 0.05$).

Conclusions

Deep Learning-Based Computer-Aided Diagnosis (CAD) System Considering Gender and Medication-controlled EEG Features in Major Depressive Disorder



The significances of this study

- When using deep-learning-based Shallow ConvNet for male subjects, **the high classification performance of 100.00 %** was achieved without hand-crafted feature extraction.
- Also, for the female data, **the classification performance was 80.61%,** which is 8.16 % higher than using machine-learning-based LDA algorithm.

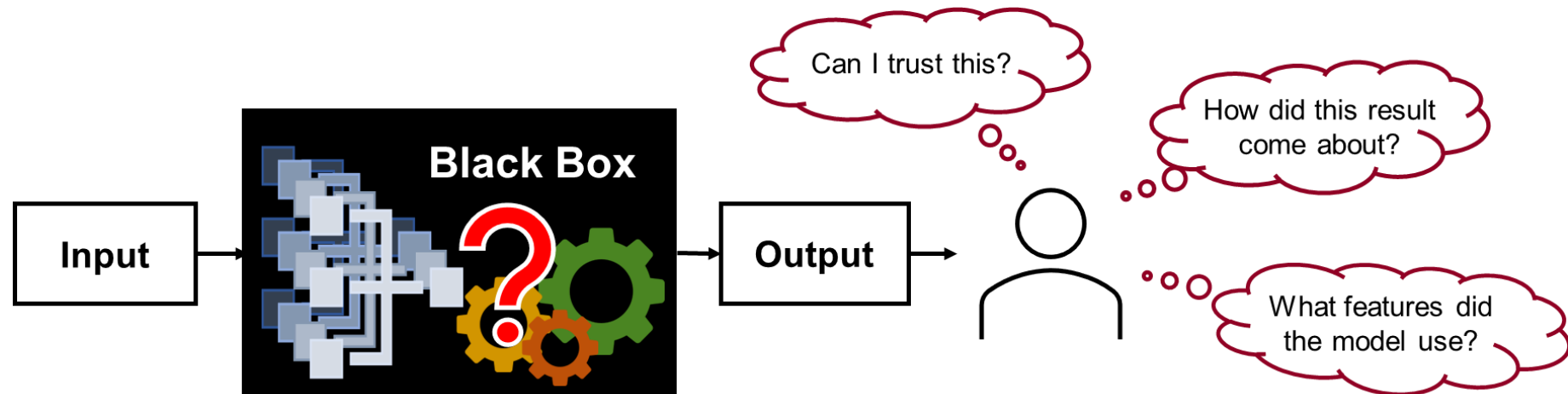
Conclusions

Development of deep-learning-based CAD system **considering gender and medication-controlled EEG features in MDD**

Future works



- Explainable AI (XAI) based CAD systems



Thank you for your attention :)

