

CONVOLUTIONAL NEURAL NETWORK APPROACH FOR EEG-BASED EMOTION RECOGNITION USING BRAIN CONNECTIVITY AND ITS SPATIAL INFORMATION

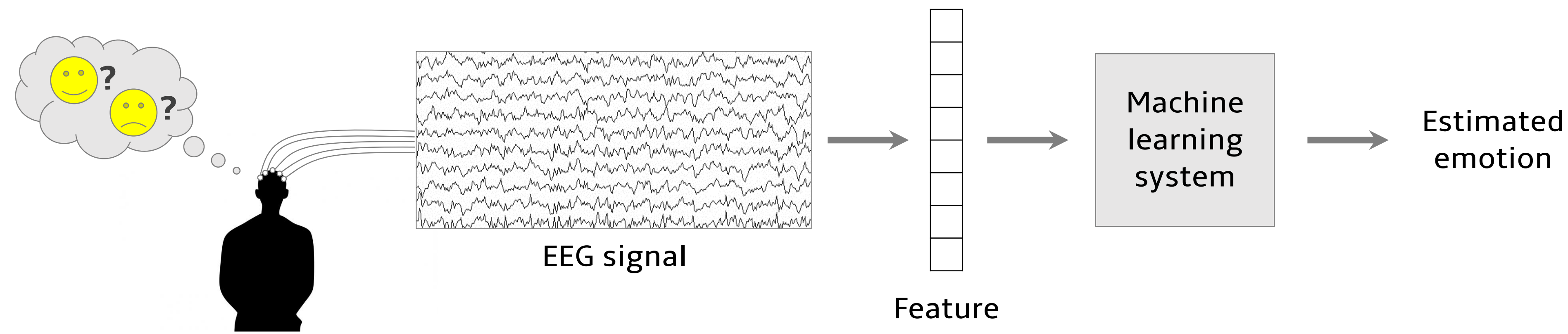


Seong-Eun Moon, Soobeom Jang, and Jong-Seok Lee

School of Integrated Technology, Yonsei University, Korea

{se.moon, soobeom.jang, jong-seok.lee}@yonsei.ac.kr

Conventional automatic emotion recognition using EEG (electroencephalography)



- Only signals from a **single electrode** are considered
- Spatial arrangement** of EEG electrodes is not considered

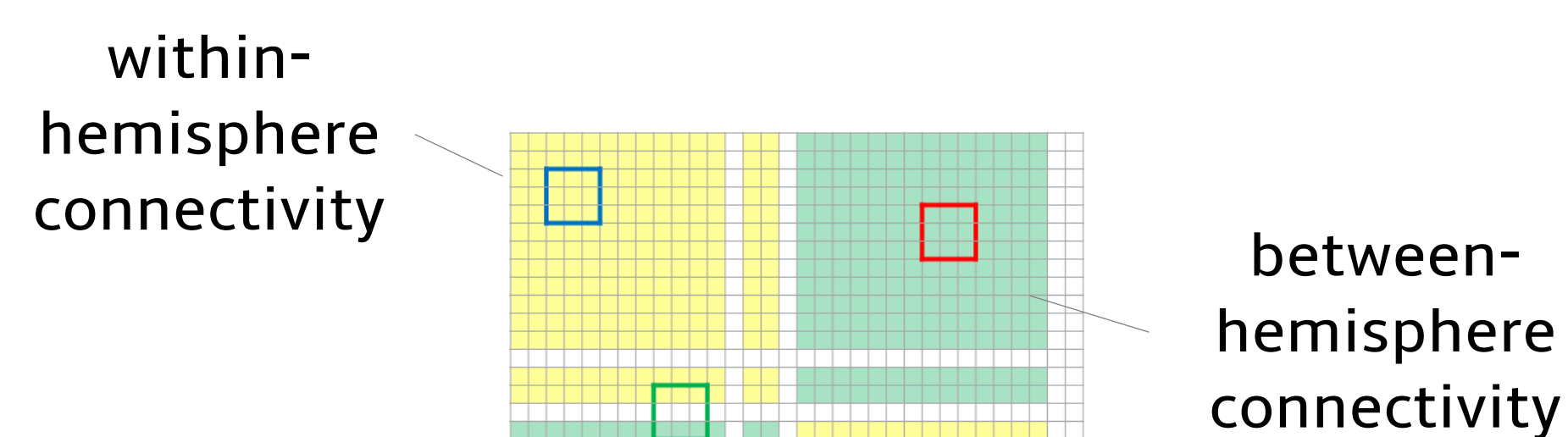
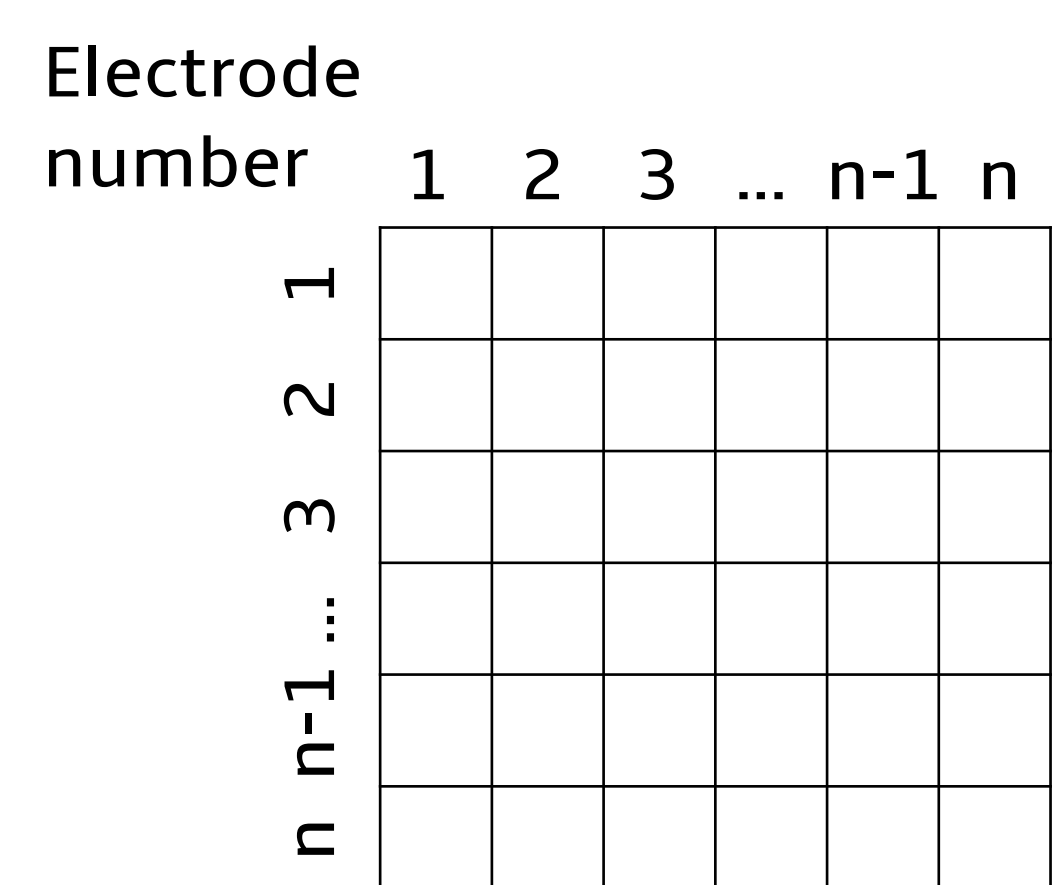
Brain connectivity of EEG signals

For two EEG signals x and y captured from **different brain regions**,

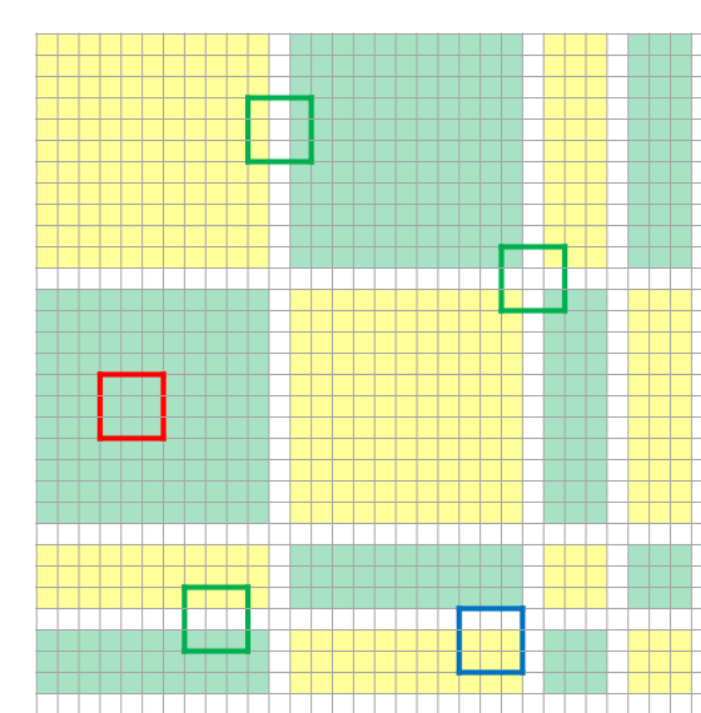
- PCC (Pearson correlation coefficient): $PCC = \frac{\text{cov}(x,y)}{\sigma_x \sigma_y}$
 - PLV (phase locking value): $PLV = \frac{1}{N} \left| \sum_{n=1}^N e^{j\Delta\phi_n} \right|$
 - PLI (phase lag index): $PLI = \frac{1}{N} \left| \sum_{n=1}^N \text{sign}(\Delta\phi_n) \right|$
- $\text{cov}(\cdot)$: covariance
 σ : standard deviation
 $\Delta\phi_n$: phase difference for n -th window
 N : number of time windows
 $\text{sign}(\cdot)$: sign function

Spatial information of EEG signals

- 2-D input to consider **spatial information** through CNN (convolutional neural network)



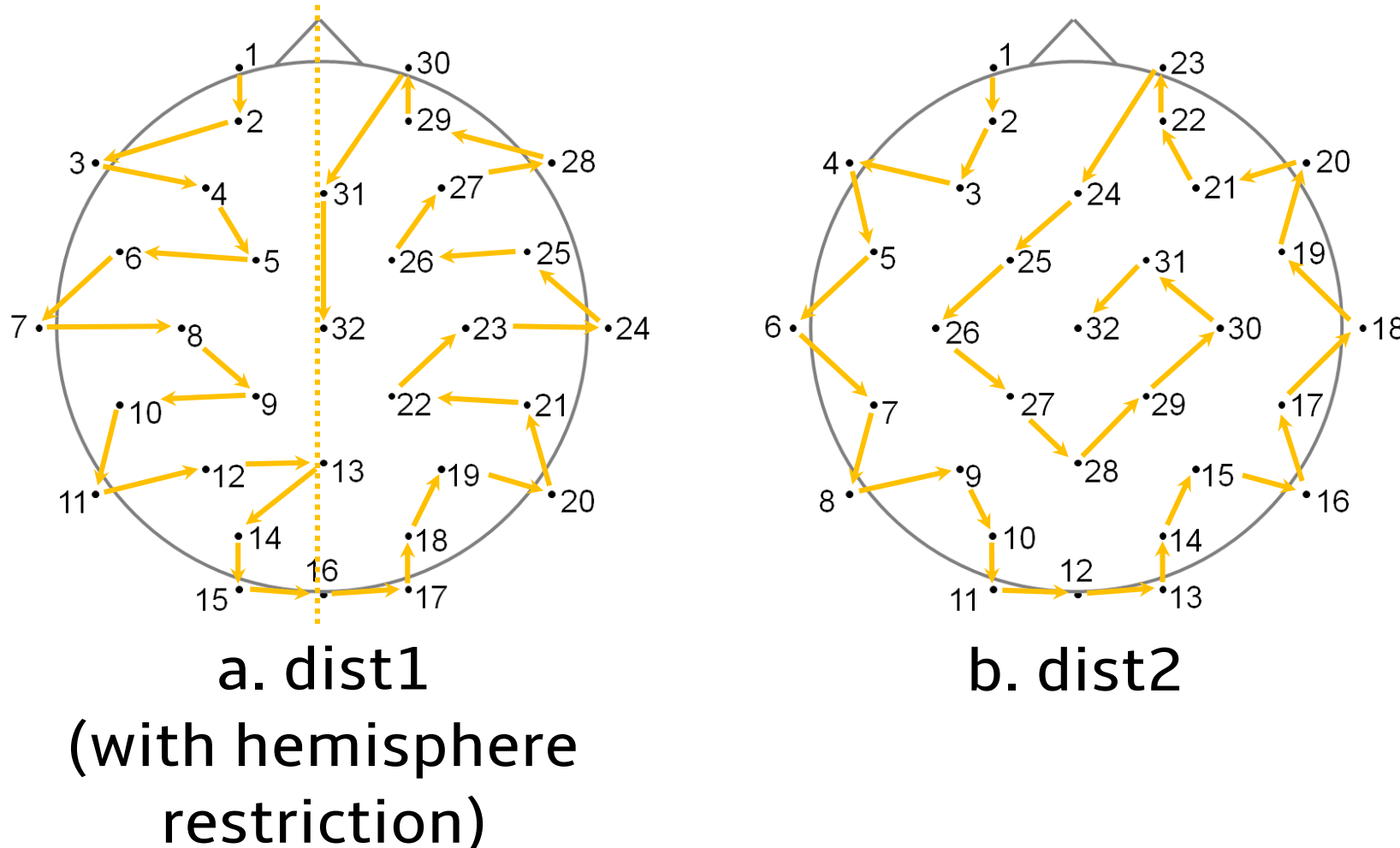
a. dist1



b. dist2

Locations of connectivity features

- Electrode ordering methods considering **hemispheric asymmetry**



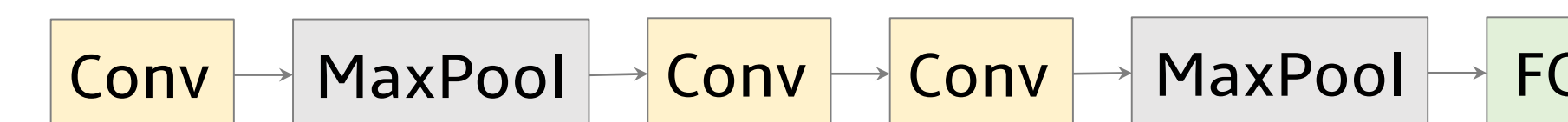
- We propose a **new CNN-based approach for emotion recognition using EEG** for considering brain connectivity and spatial information
- Cross-regional relationship** and **spatial information** (asymmetric activation pattern between hemispheres) of EEG signals improve emotion recognition performance

CNN structures

- CNN-2



- CNN-5



- CNN-10

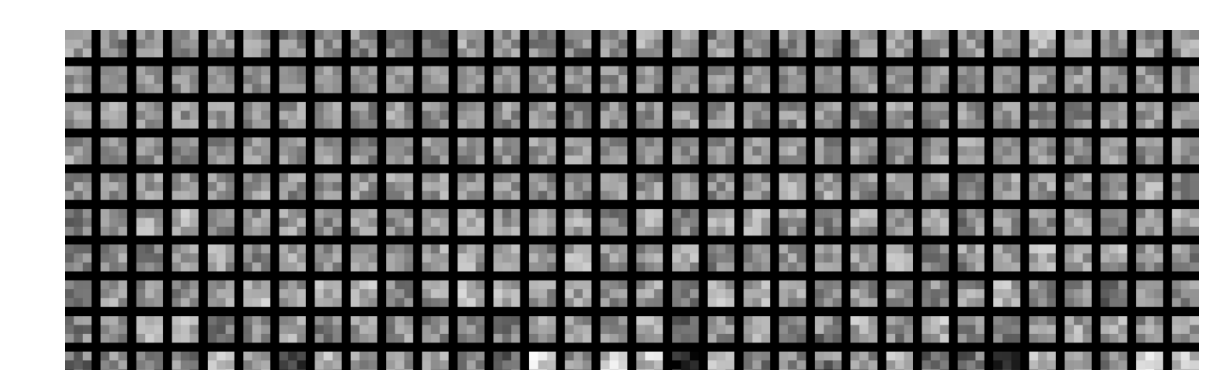


Experiment

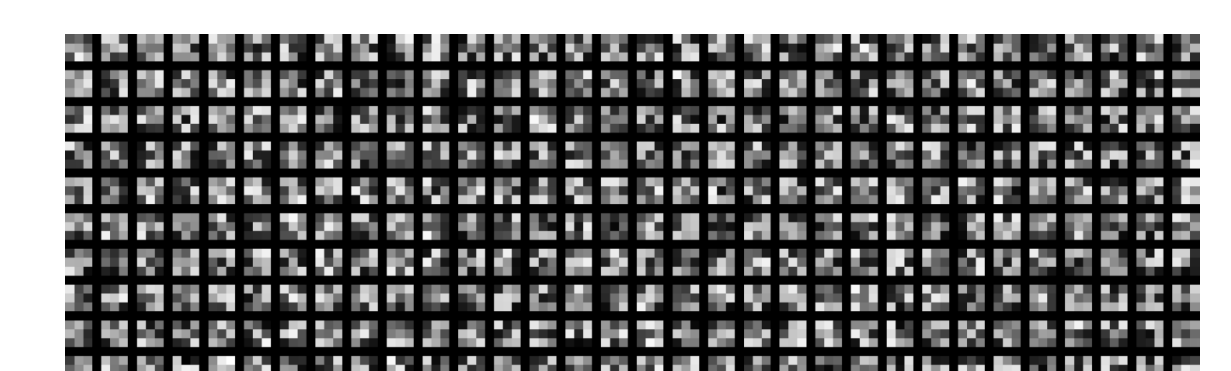
- Classification problem
low valence (negative emotion) vs. high valence (positive emotion) EEG signals from DEAP database
- Preprocessing
 - temporal segmentation (3 seconds with 2.5 seconds overlap)
 - bandpass filtering (delta, theta, low alpha, high alpha, alpha, low beta, mid beta, high beta, beta, and gamma)
- Comparison
 - PSD (power spectral density) features: max. **80.86%** with CNN-5
 - SVM (support vector machine): **55.42%** with PSD features

Classification accuracies [%]

	Ordering method	CNN-2	CNN-5	CNN-10
PCC	random	93.82	94.44	91.48
	dist1	93.80	94.17	92.18
	dist2	93.57	94.30	92.68
PLV	random	96.50	97.13	89.93
	dist1	96.62	97.11	91.30
	dist2	98.58	99.72	90.92
PLI	random	85.00	74.52	59.29
	dist1	85.03	78.17	61.48
	dist2	84.98	77.48	61.24



a. PSD



b. PLV-dist2

Filter weights of first conv. layer of CNN-5