

SPDIM: Source-free Unsupervised Conditional and Label Shift Adaptation in EEG

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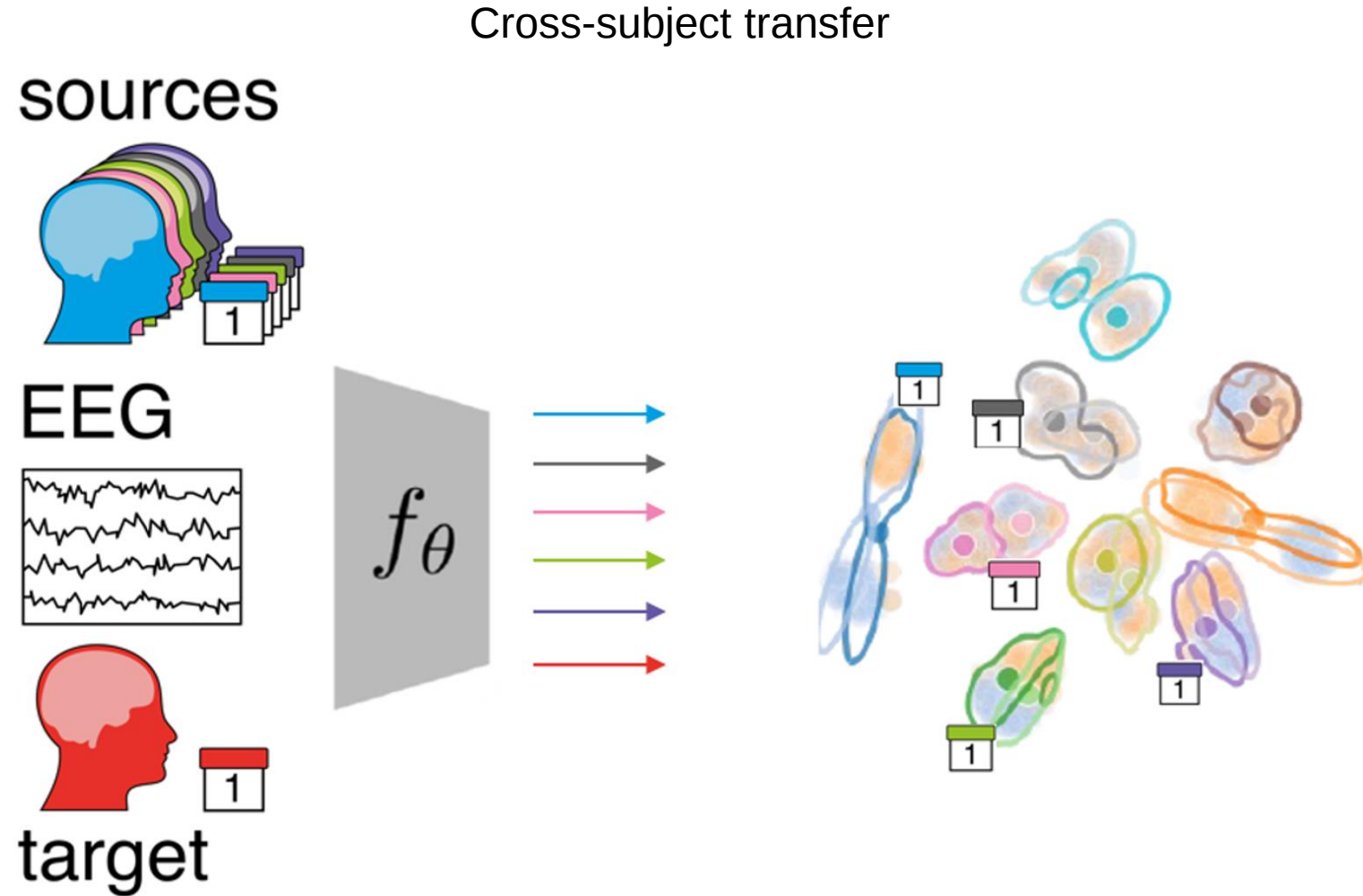
EEG-based neurotechnology

Growing market size

- Scalability: healthcare, home use
- Convenience: cheap, non-invasive

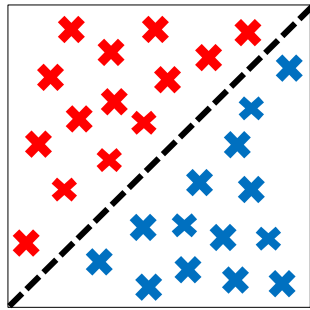
Current limitation

- Poor generalization across subjects due to distribution shifts



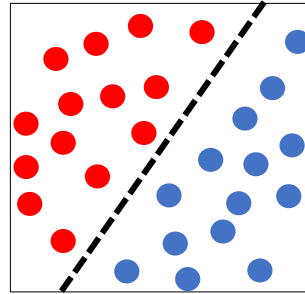
Conditional and Label shift

Source domain data



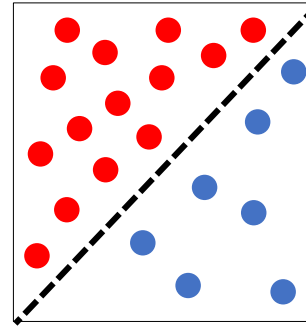
No data shift

Conditional shift



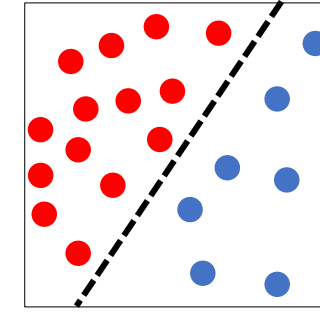
$p(y|X)$ changes

Label shift



$p(y)$ changes

Conditional and label shift



$p(y|X)$ and $p(y)$ changes

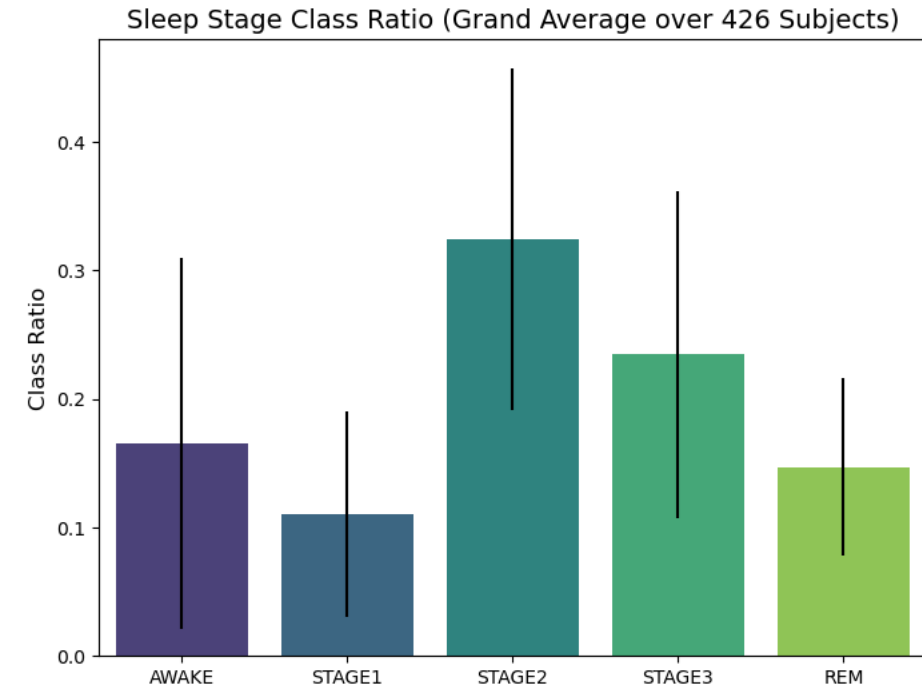
× × Source domains sample ● ● Target domains sample - - - Decision boundary

Label shift

- A shift in the output distribution

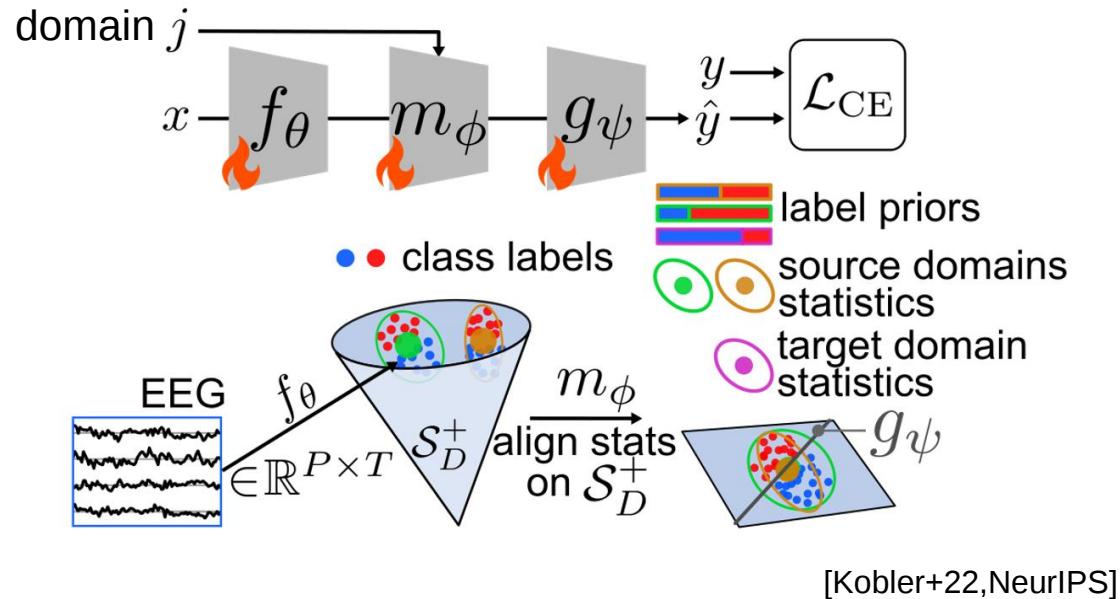
Label shift in EEG

- Sleep staging classification



TSMNet framework

Source domain training



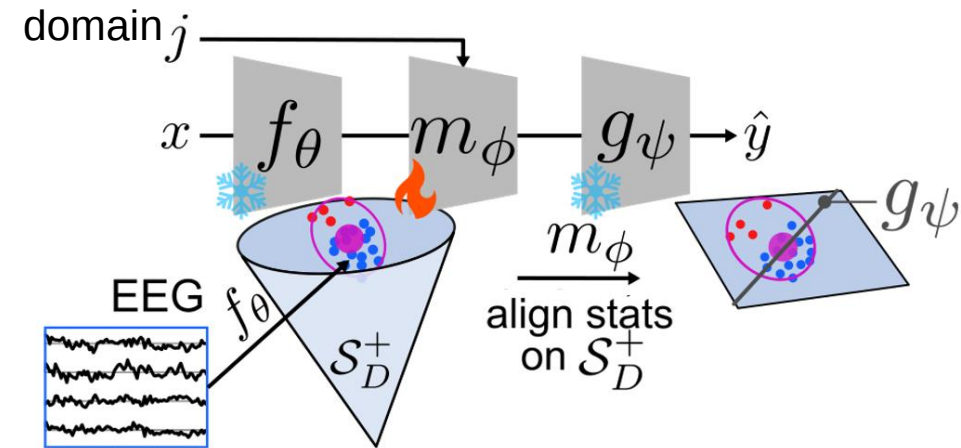
Architectures

- f_θ : Feature extractor to map observations to the latent space on symmetric positive defined (SPD) manifold.
- m_ϕ Alignment domain statistics on the SPD manifold
- g_ψ : A shared classifier

End to end learning of $\{\theta, \phi, \psi\}$

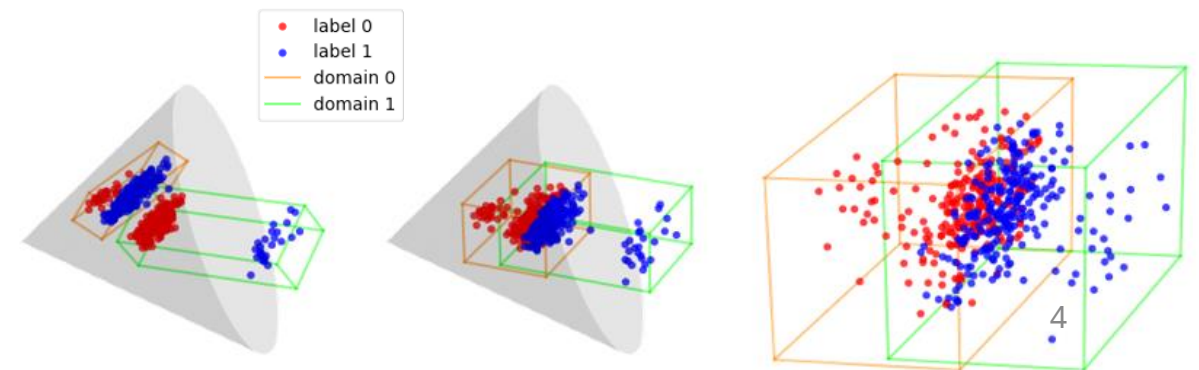
Objective: cross-entropy error (supervised learning)

Inference to new target domains



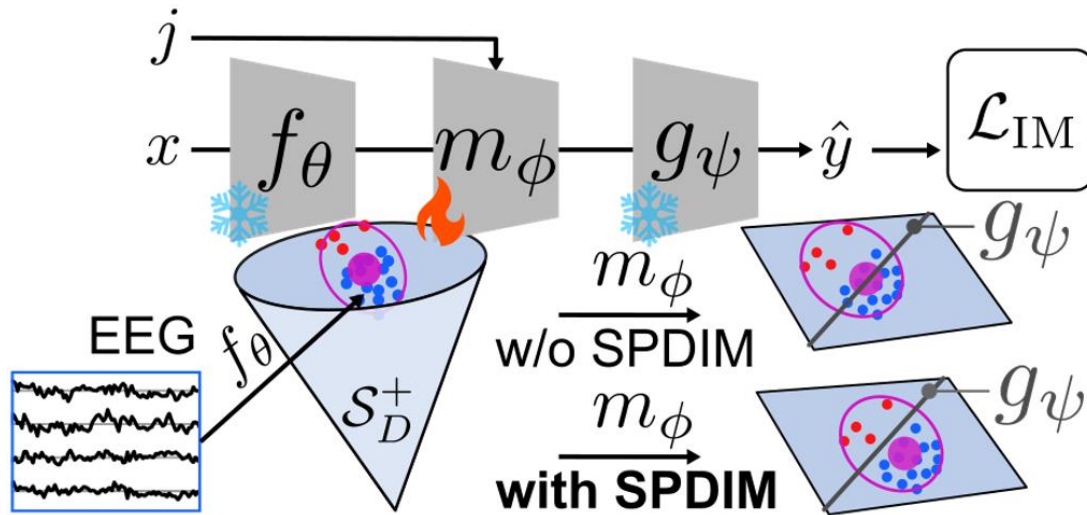
- Keep parameters in f_θ and g_ψ fixed
- Latent space projection + **Alignment** + Classification
- Source-free, Unsupervised domain adaptation (SFUDA)

Label shift effect



SPDIM Framework

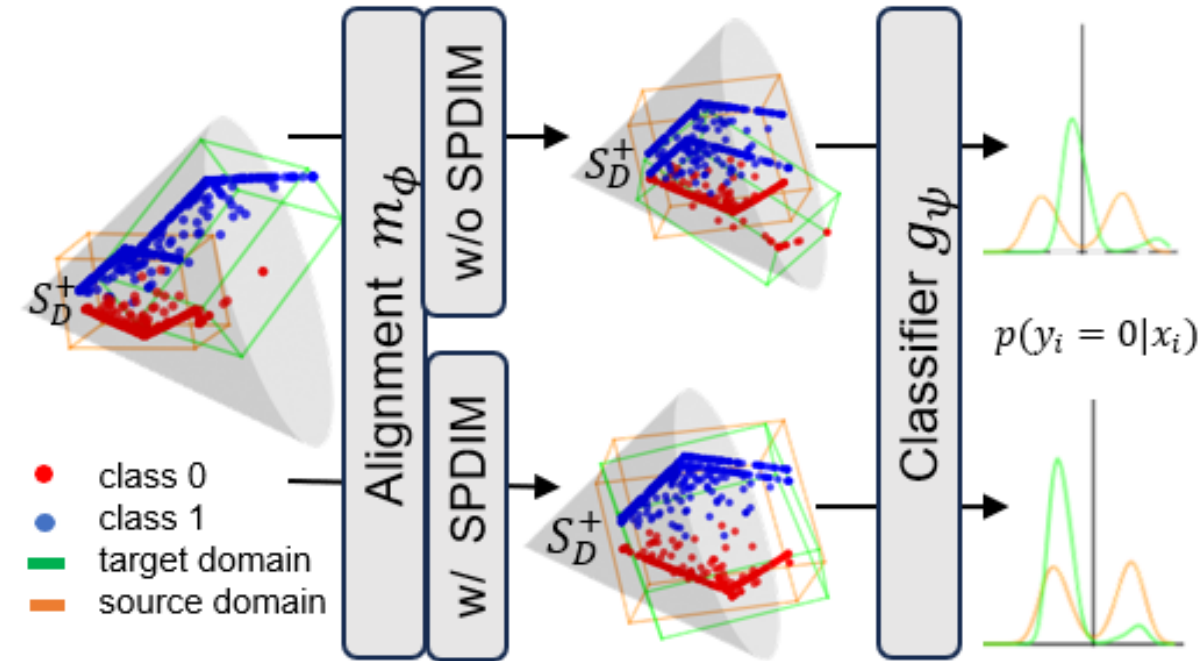
Target domain alignment with SPDIM



- Keep parameters in f_θ and g_ψ fixed
- Latent space projection + **SPDIM Learning a bias point** + Classification

Contributions: SPDIM learning a domain-specific bias parameter

- Learnable parameters: a bias parameter $\Phi \in \mathbb{R}^{20 \times 20}$, constrained to the SPD manifold
- Optimizer: batch gradient descent
- Loss: the information maximization loss (Minimize the uncertainty)



EEG Experiments- Sleep Staging Classification

Deep learning models

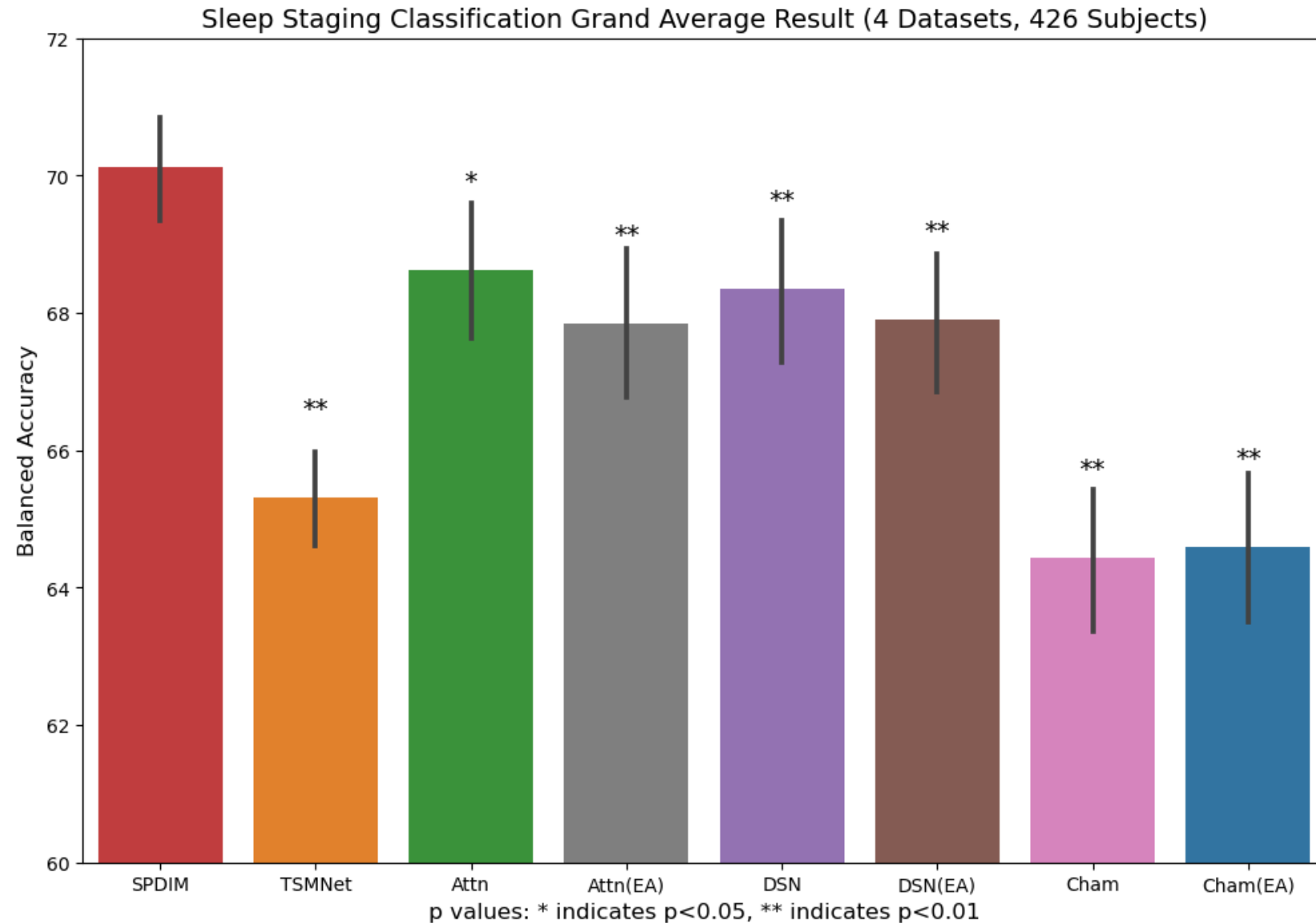
- Chambon (Cham)
- DeepSleepNet (DSN)
- AttnSleep (Attn)

SFUDA method

- Euclidean alignment (EA)

Highlights

- Attain State-of-the-art result
- 5% performance gain to standard TSMNet
- Theoretical analysis



Thanks For Watching

