Tracking Functional Changes in Nonstationary Signals with Evolutionary Ensemble Bayesian Model for Robust Neural Decoding

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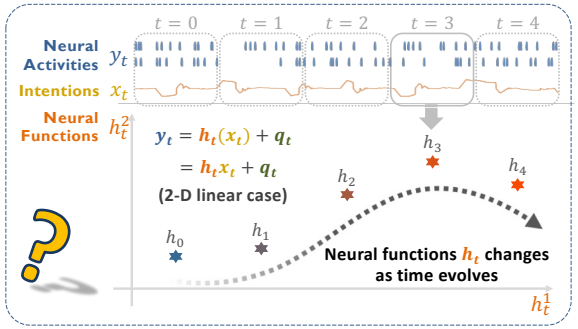
PROBLEM AND CHALLENGE

Problem: How to achieve **robust control** in brain-computer interface (BCI) systems ?
Challenge: The **changing** neural functional **mappings** between **neural activities** and the **intentions**.

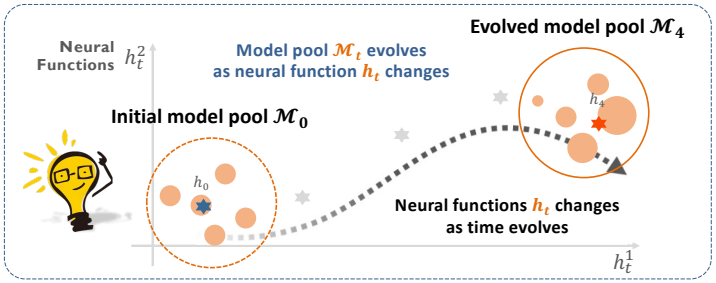


How to cope with neural functional changes to achieve robust online control?

THE MAIN INSIGHTS

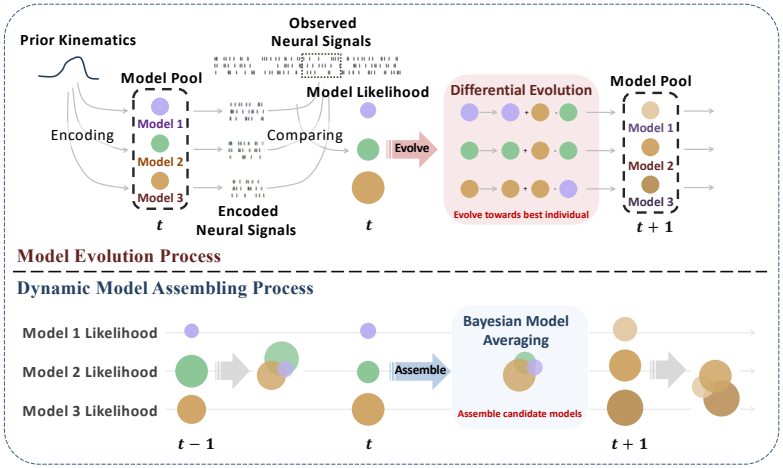
The idea

- Using a pool of models to describe different neural functions
- Dynamically changing the model pool to cope with neural changes
  - ✓ Tuning the **model weights**
  - ✓ Evolving the **model parameters**



Enabling model evolving with changes in functions.

EVOLUTIONARY ENSEMBLE MODELING

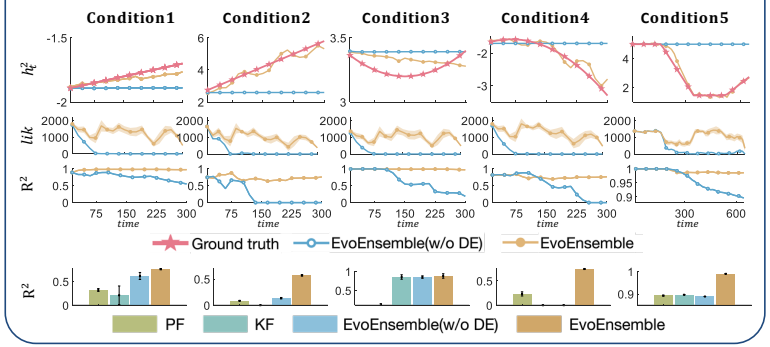


The framework of EvoEnsemble

EXPERIMENTS AND RESULTS

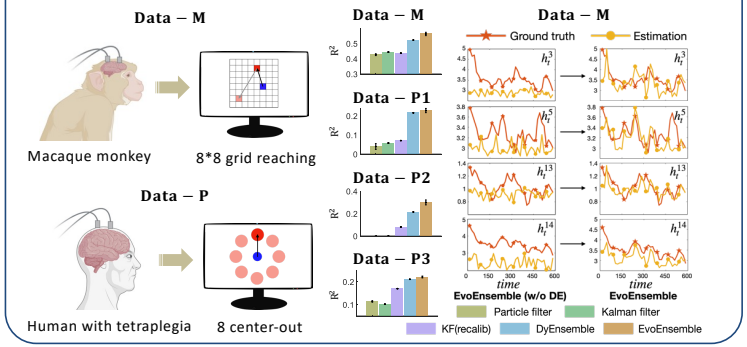
Simulations

EvoEnsemble successfully tracks the functional changes and obtains better state estimation in all five simulated conditions.



Neural datasets with a macaque and a paralyzed man

EvoEnsemble outperforms other neural decoding methods and tracks the neural functions closer than that without evolution.



CONCLUSIONS

- ✓ **Dynamic** modeling is essential to robust online control in BCI systems.
- ✓ EvoEnsemble can adaptively **change model weights** and **evolve model parameters** to cope with the functional changes in neural encoding.
- ✓ EvoEnsemble provides a **flexible** adaptive neural decoding **framework**.

Please find details in our papers:

[1] Tracking Functional Changes in Nonstationary Signals with Evolutionary Ensemble Bayesian Model for Robust Neural Decoding, ***NeurIPS 2022***
[2] Dynamic Ensemble Bayesian Filter for Robust Control of a Human Brain-machine Interface, ***IEEE Trans. BME 2022***
[3] Dynamic Ensemble Modeling Approach to Nonstationary Neural Decoding in Brain-Computer Interfaces, ***NeurIPS 2019***

https://arxiv.org/abs/2204.11840
https://papers.nips.cc/paper/2019/file/3f7bcd0b3ea822683bba8fc530f151bd-Paper.pdf

36th Conference on Neural Information Processing Systems (NeurIPS 2022)