Cooperative Data-Driven Modeling

Aleksandr Dekhovich**, O. Taylan Turan*, Jiaxiang Yia** and Miguel A. Bessa***

*Pattern Recognition Laboratory, Delft University of Technology, Van Mourik Broekmanweg 6, Delft 2628 XE, The Netherlands

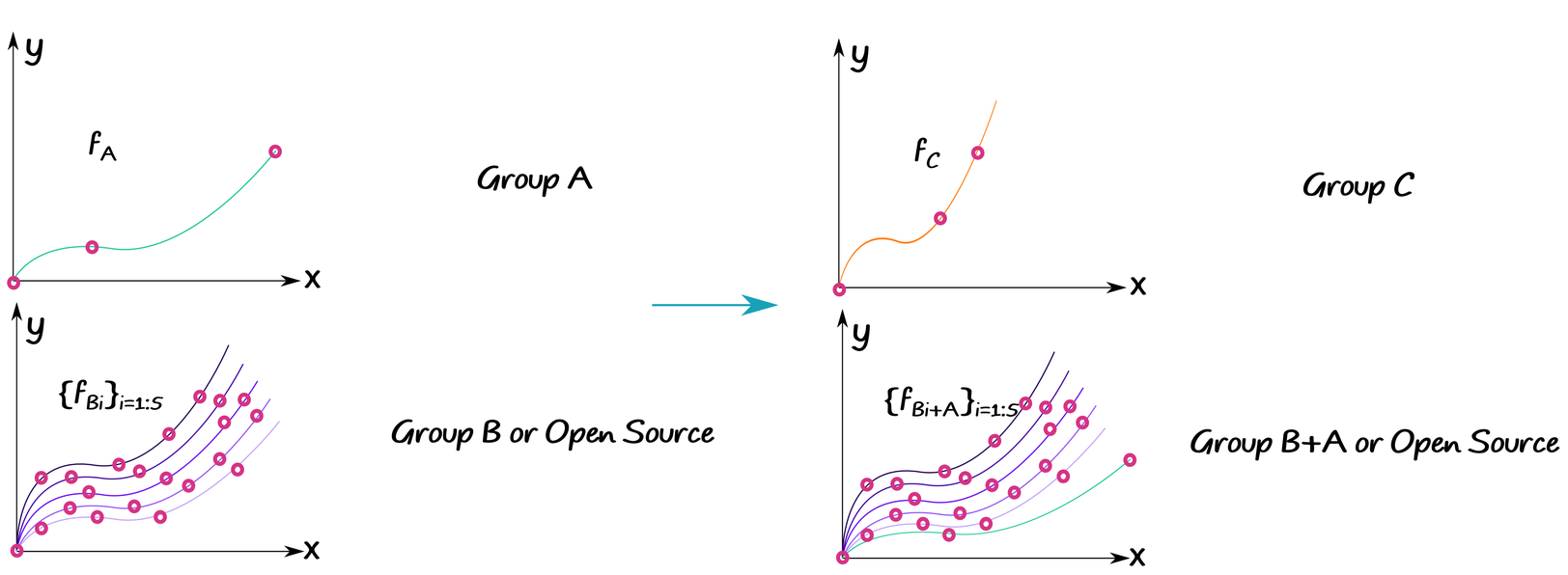
**Department of Material Science and Engineering, Delft University of Technology, Mekelweg 2, Delft, 2628 CD, The Netherlands

***School of Engineering, Brown University, 184 Hope St., Providence, RI 02912, US

o.t.turan@tudelft.nl github.com/taylanot

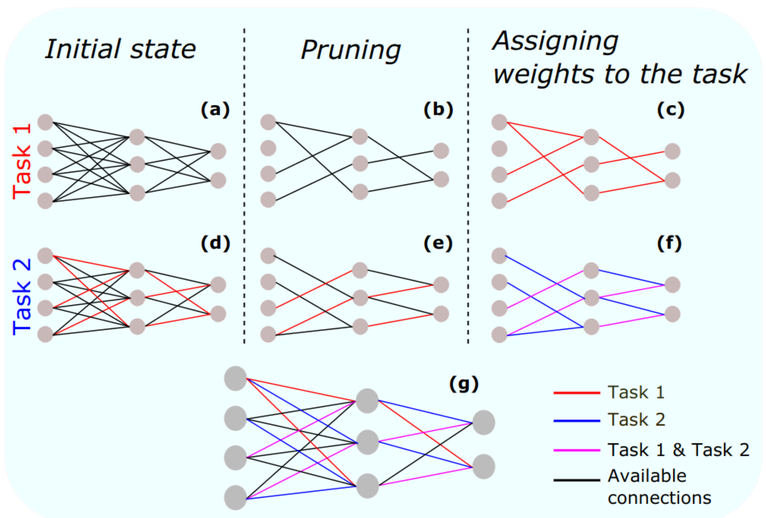
1. Introduction

- Continual-Learning: leverages similar learning problems (tasks) for a specific similar data-scarce target learning problem (task) in a setting where the tasks are observed consequently.
- AIM: Learning Constitutive Laws sequentially without catastrophic forgetting with Artificial Neural Networks.



2. Continual Prune & Select[2]

- Given a task $f_i : |\mathcal{X} \rightarrow \mathcal{Y}$ find sub-network $\mathcal{N}_i$ inside a given NN $\bigcup_{i=1}^{M} \mathcal{N}_i$
- Prune with NNRelief Method
- Fix the sub-network parameters and repeat the same procedure for f_{i+1}
- In the end you end up with task specific networks



3. NNRelief[1]

- Train your NN for a task of $f : \mathcal{X} \rightarrow \mathcal{Y}$
- Compute the importance scores of the activations
- Prune them with a pre-defined tolerance

Get-rid off redundant connections $\rightarrow$ decrease parameter overload.

5. Plasticity

Plastic Constitutive Law:

- Path dependent problem
- $\sigma = \mathcal{C}(\epsilon, t, \boldsymbol{\theta})$ with $\sigma \in \mathbb{R}^3$ and $\epsilon \in \mathbb{R}^3$

As a continual learning problem:

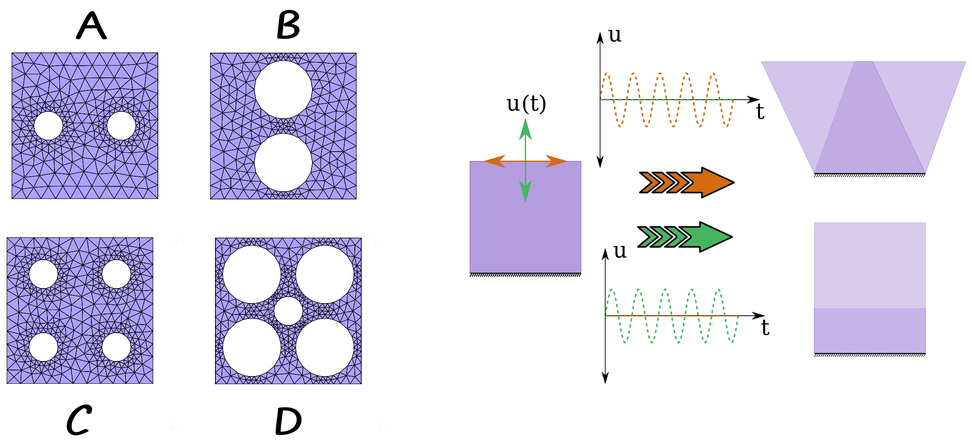
- $\boldsymbol{\theta}$ Determines the different tasks
- Try to learn $\mathcal{C}$
- Given $\{\sigma^{\boldsymbol{\theta}_i}_{t=1:T}, \epsilon^{\boldsymbol{\theta}_i}_{t=1:T}\}_i = 1, M$

6. Conclusions

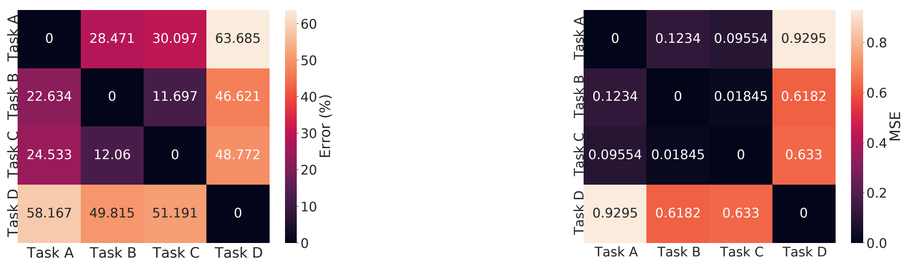
- Less number of parameters compared to standard learning.
- Better performance with less data.
- Sequential learning problem with transfer learning can enable cooperative data-driven modeling.

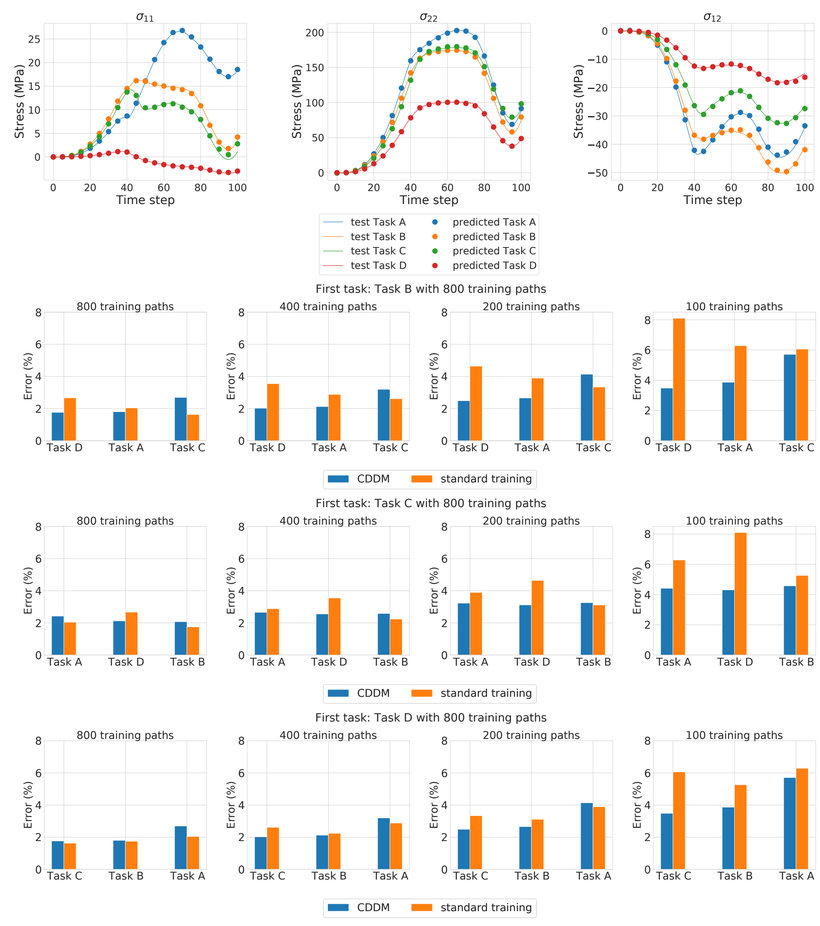
4. Learning Plastic Constitutive Models

- Von Misses Plasticity with changing geometries
- Continual Prune & Select with GRU's



Differences between tasks





7. References

[1] Aleksandr Dekhovich, David M. J. Tax, Marcel H. F. Sluiter, and Miguel A. Bessa. Neural network relief: A pruning algorithm based on neural activity, June 2022.

[2] Aleksandr Dekhovich, David M.J. Tax, Marcel H.F Sluiter, and Miguel A. Bessa. Continual prune-and-select: Class-incremental learning with specialized subnetworks. *Applied Intelligence*, January 2023.