



Cognitive Map Based Computational Framework for Experiment Type Prediction

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Data Science in Techno-Socio-Economic Systems

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Overview

- Concept of cognitive maps and reference frames
- Data sources: Experiments and computational model
- Objectives
- Methods
- Results
- Conclusions

Concepts



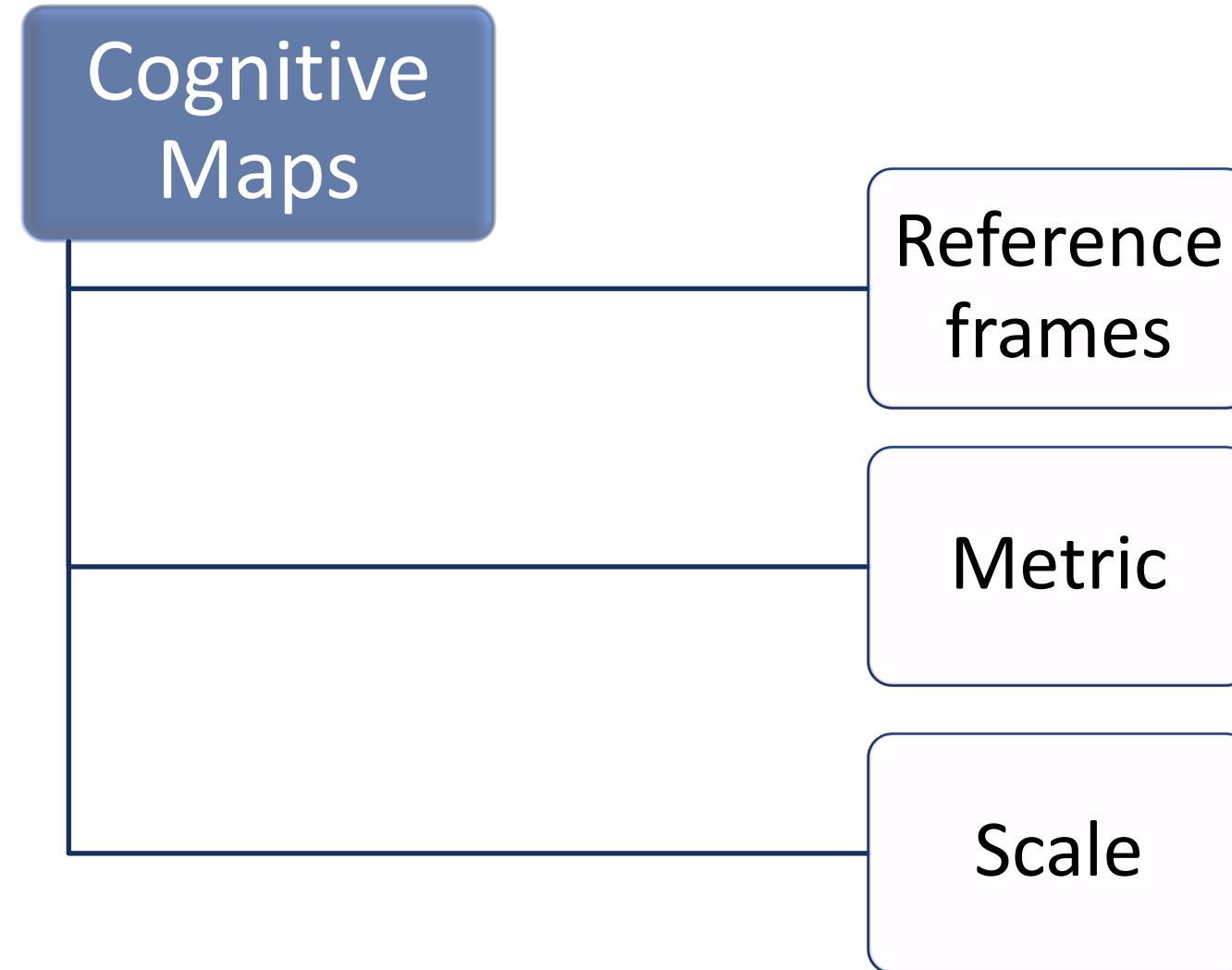
How do we learn to navigate in space?



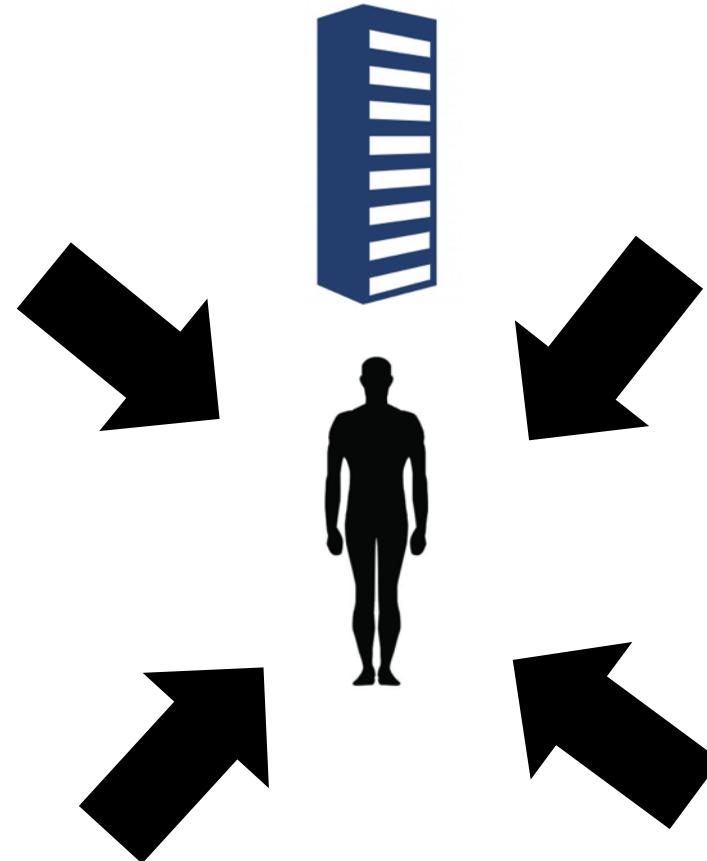
Cognitive Maps



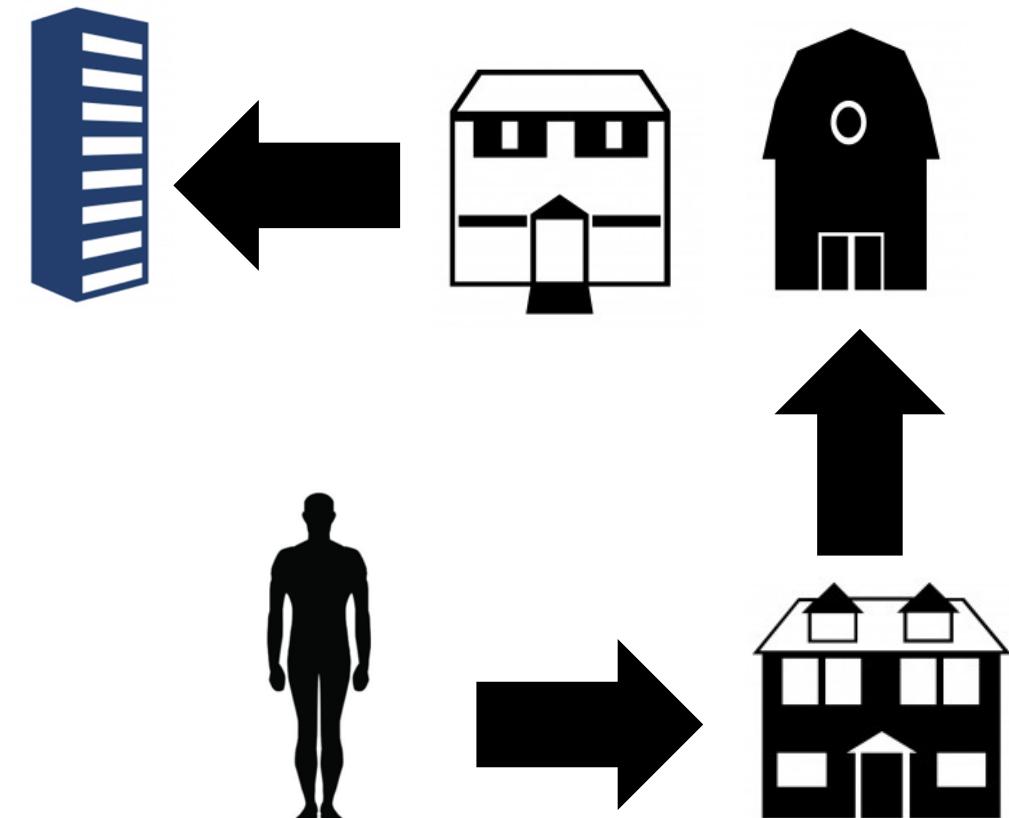
Cognitive Maps



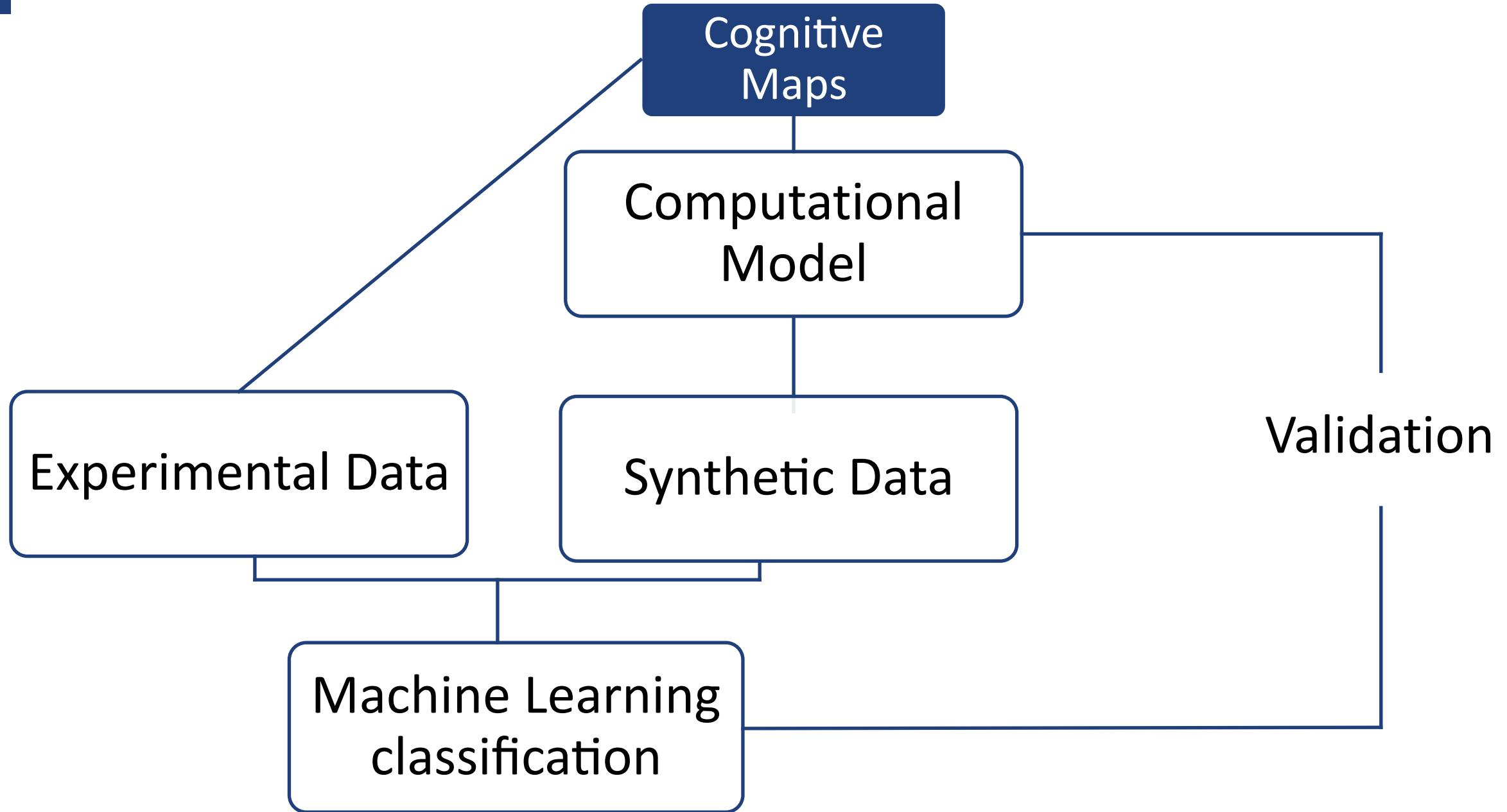
Reference frames



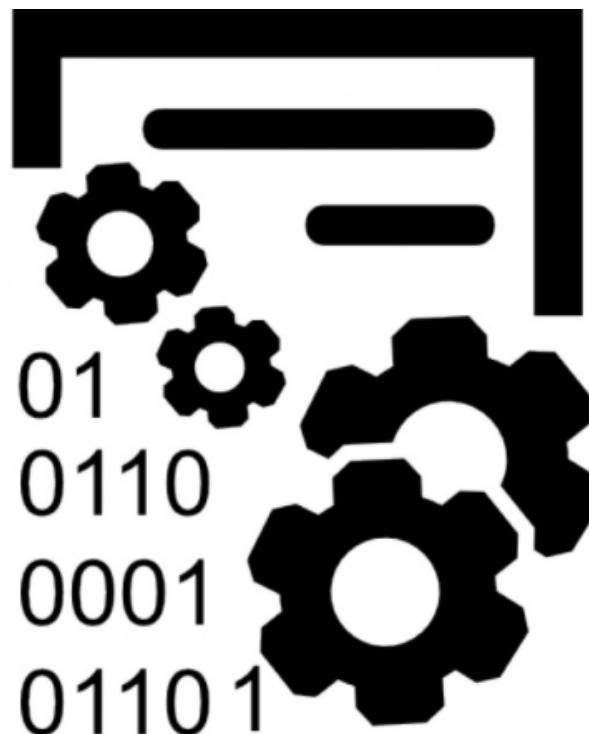
Egocentric



Allocentric



Data sources



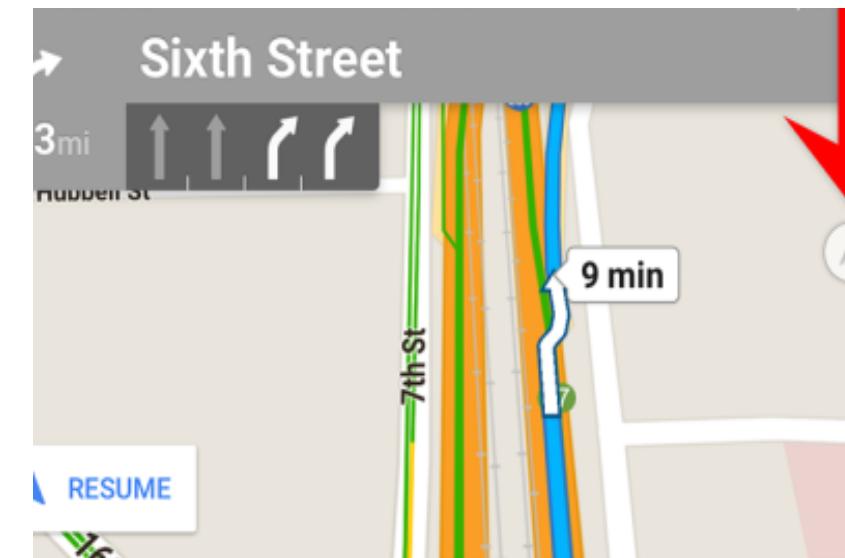
Experimental Data



Group A - Allocentric:
Navigation with a static
Map

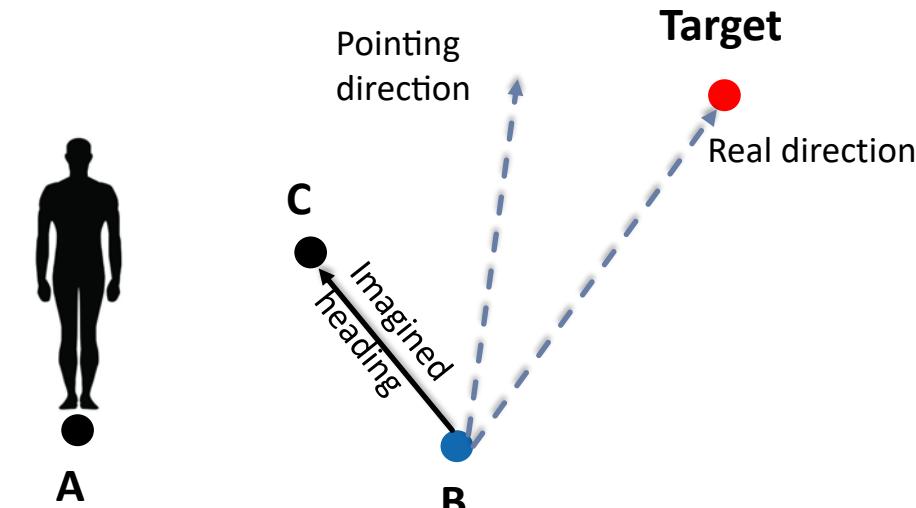


Group B - Egocentric :
Navigation with a map that
can rotate the direction
along with the perspective of
the participant.



Obtained Data

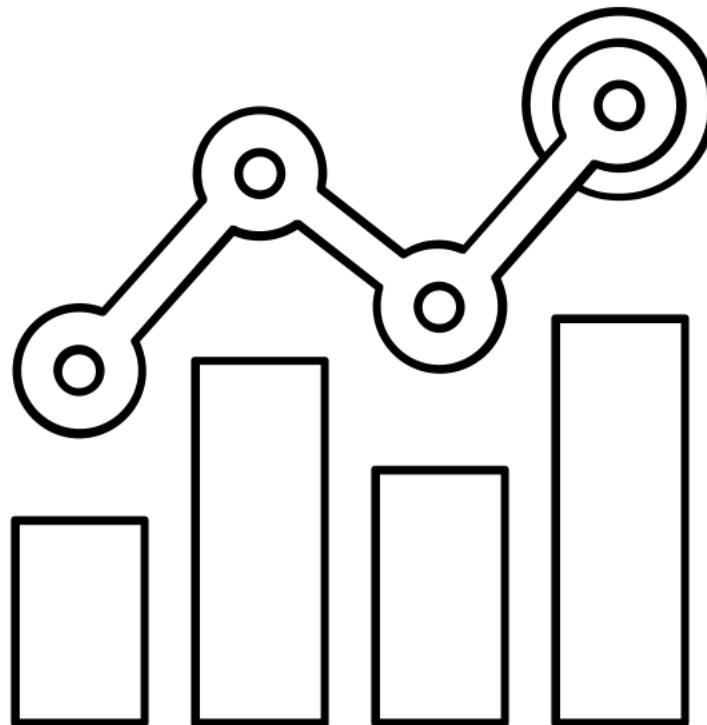
- Judgments of relative direction (**JRD**): **the error of the pointing angle** for each trial and each participant, after they navigate within the city.
- Simulator Sickness Questionnaire (**SSQ**).
- **Task Completion time**: time in seconds spent for each task in the city.
- **Reading map time**: total time in seconds spent using the map in each task during navigation.
- **Task score**: the reward score of their navigation tasks.



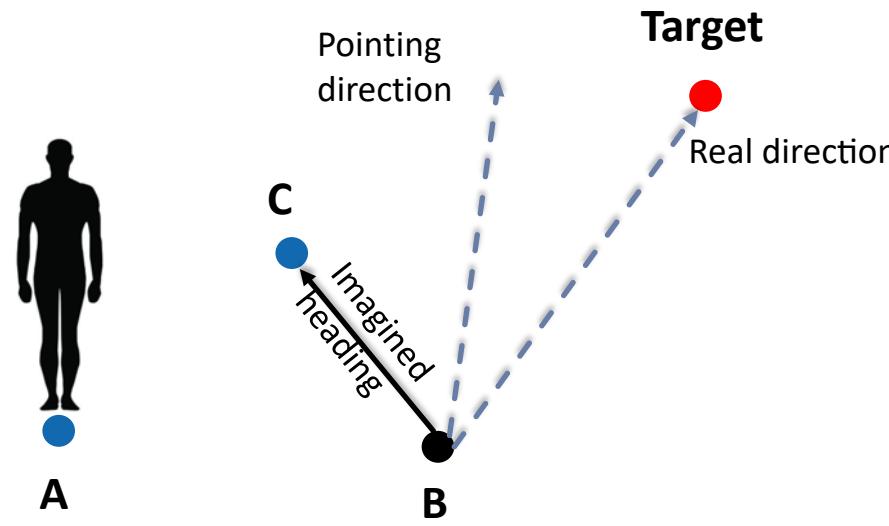
Objectives

- Train several machine learning algorithms (SVM, SVD, NBC, kNN, RF) and test its performance to classify experimental data into a given reference frame, i.e. allocentric and egocentric- based spatial representations.
- Validate the computational model by studying whether the synthetic data can be classified in a similar manner as the experimental data.

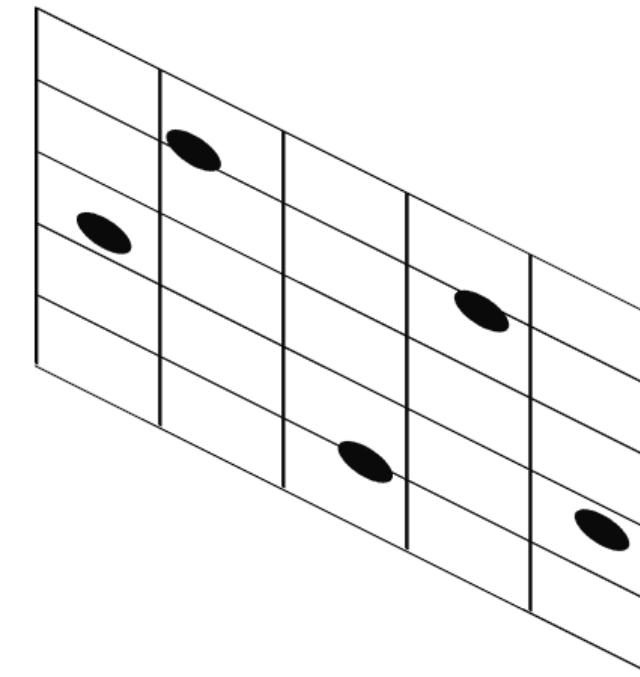
Method



Computational Model – JRD fixation



Judgments of relative direction (JRD)

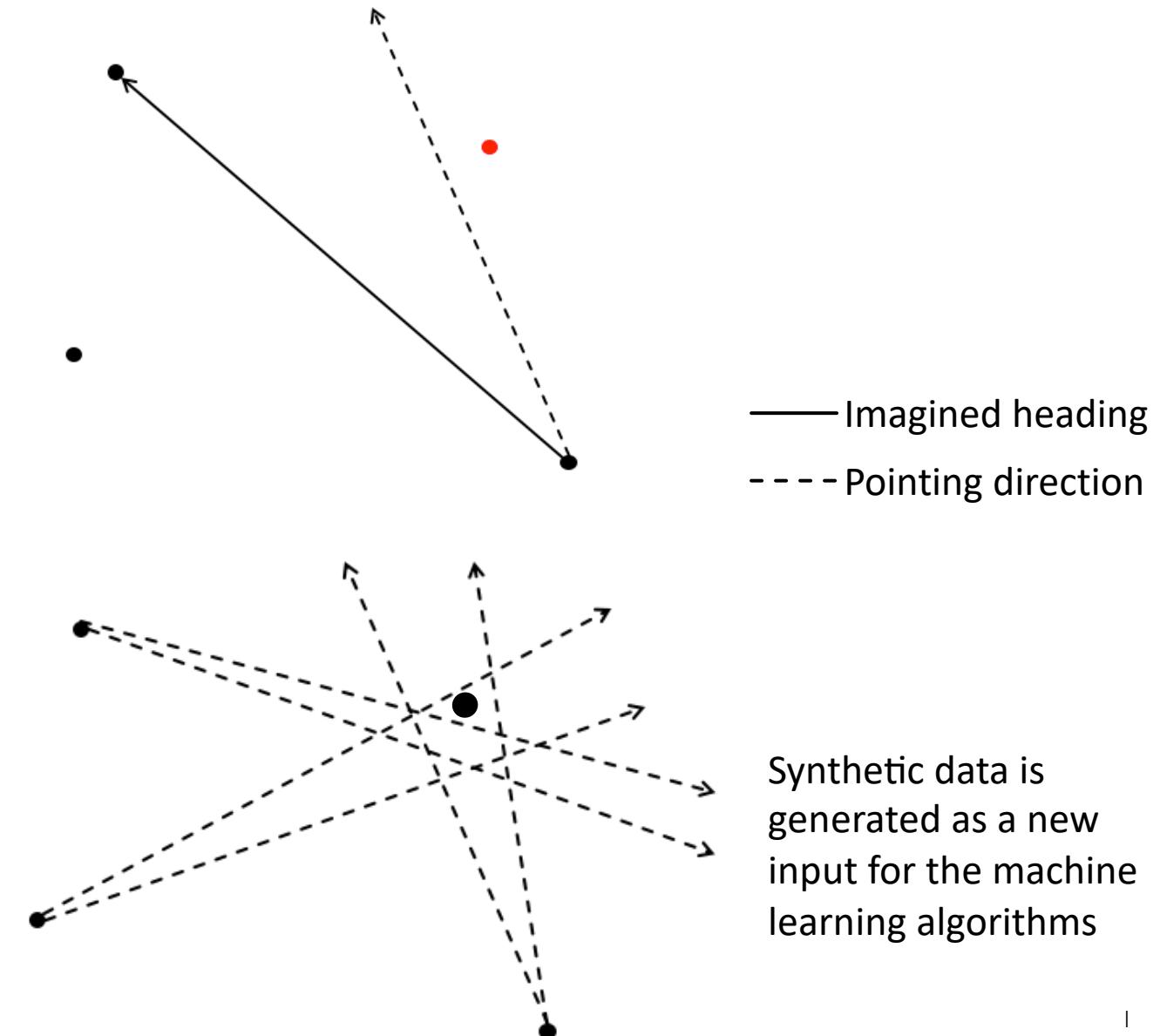


Virtual space with random locations

JRD fixation (continue)

Experimental JRD

Optimize x- and y-coordinates of each location to fit experimental JRD data



Genetic algorithm – JRD fixation

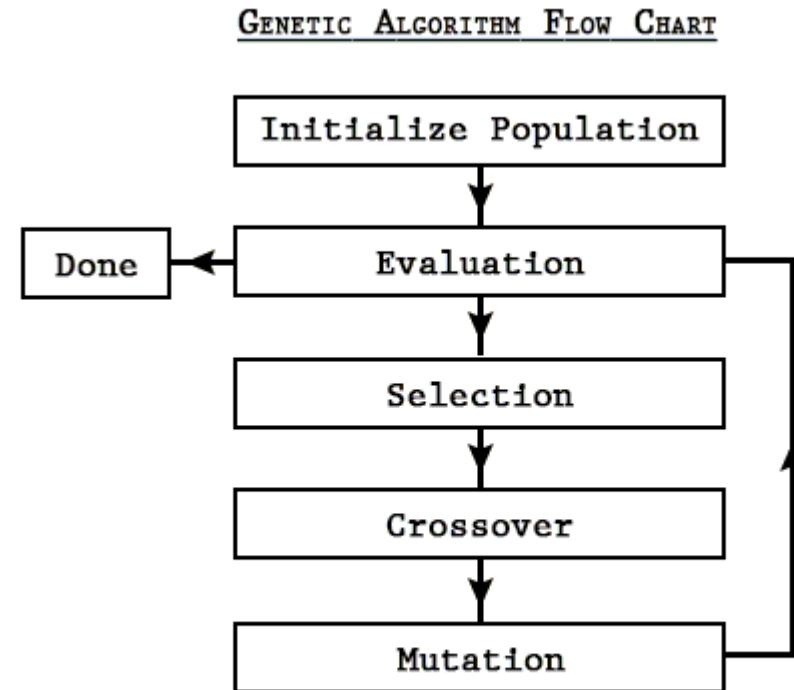


Figure 1 Genetic algorithm .Source: <http://3.bp.blogspot.com/>

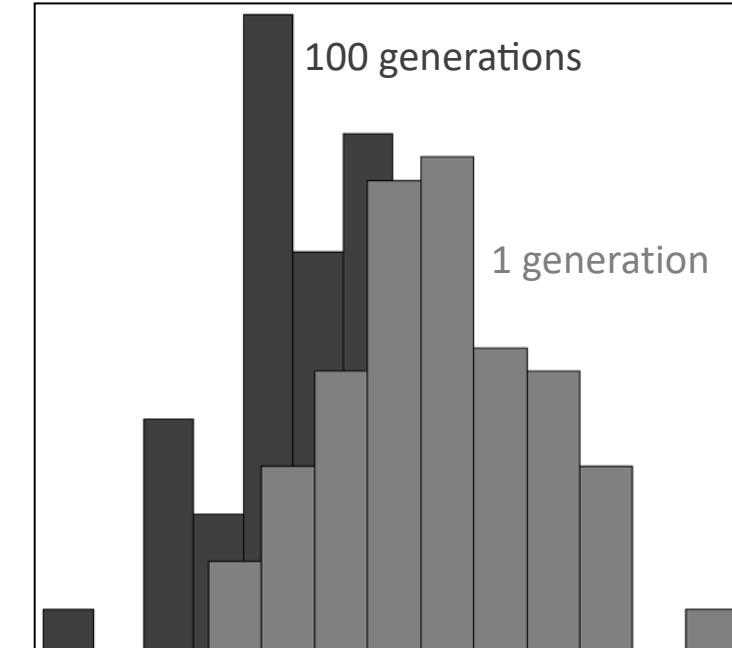
Three operators

Selection: Kept one of every eight organisms

Crossover: Exchanged bits between pairs of organisms

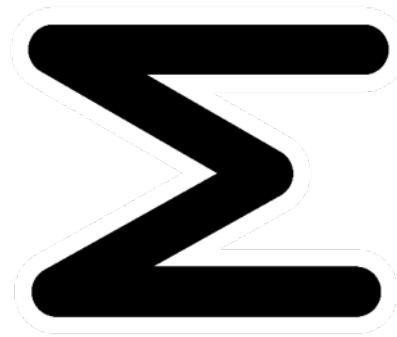
Mutation: Randomly switched individual bits from 0 to 1 or vice versa

Genetic algorithm validation



Sum of squared errors between JRDs from derived locations and observed JRD data

Data analysis pipeline



Sampling

- Randomized sampling
- X 10 times

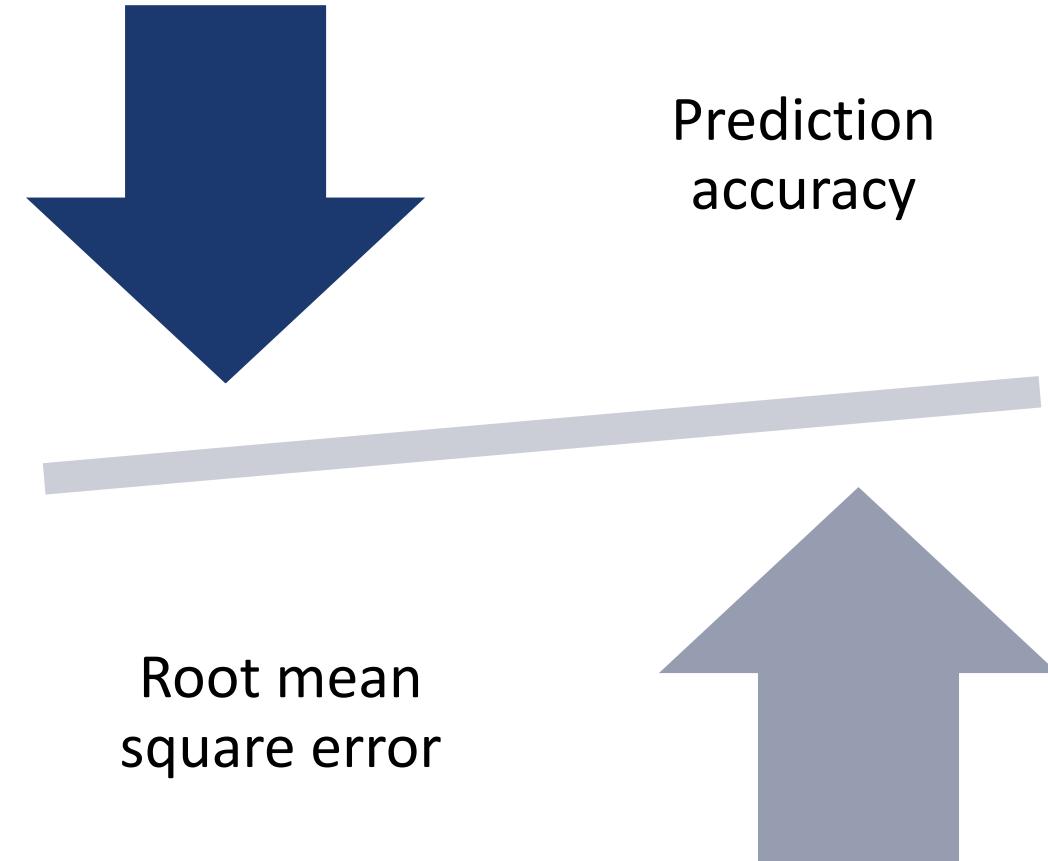
Training

- Varied training percentage
- 50%, 60%, 70%, 80%, 90%

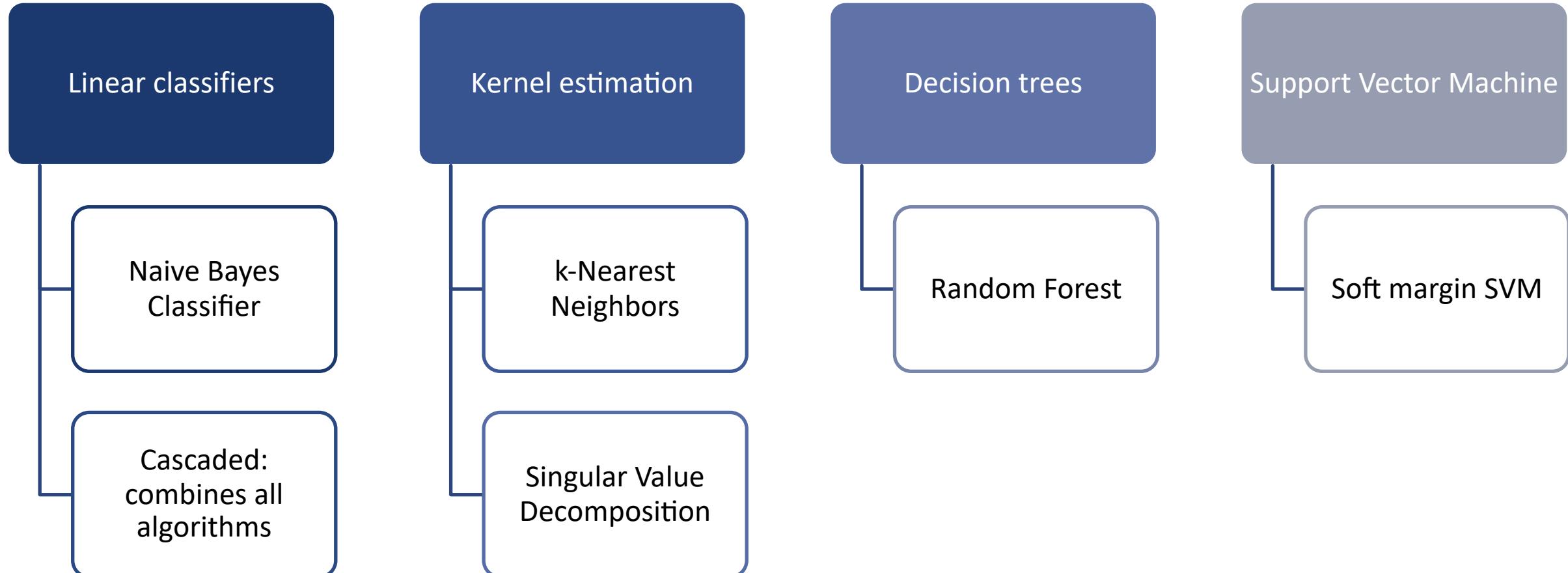
Predicting

- Classification
- Ego V Allo

Evaluation metrics



Classification algorithms



Model tuning

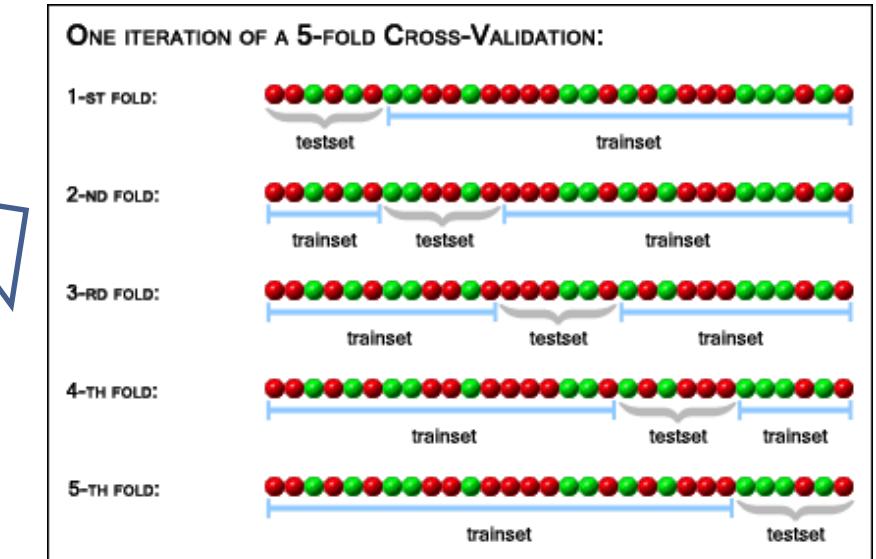
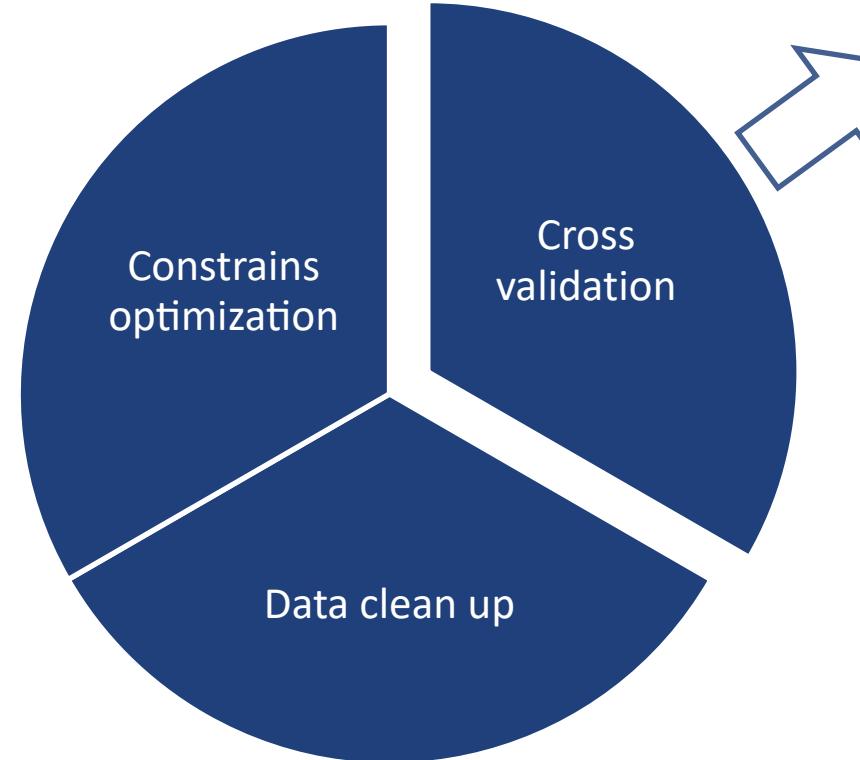
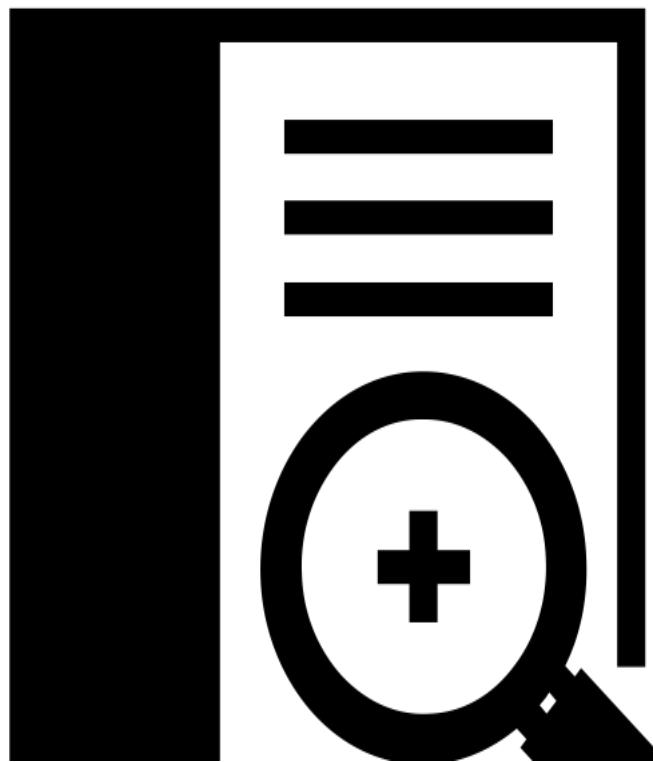
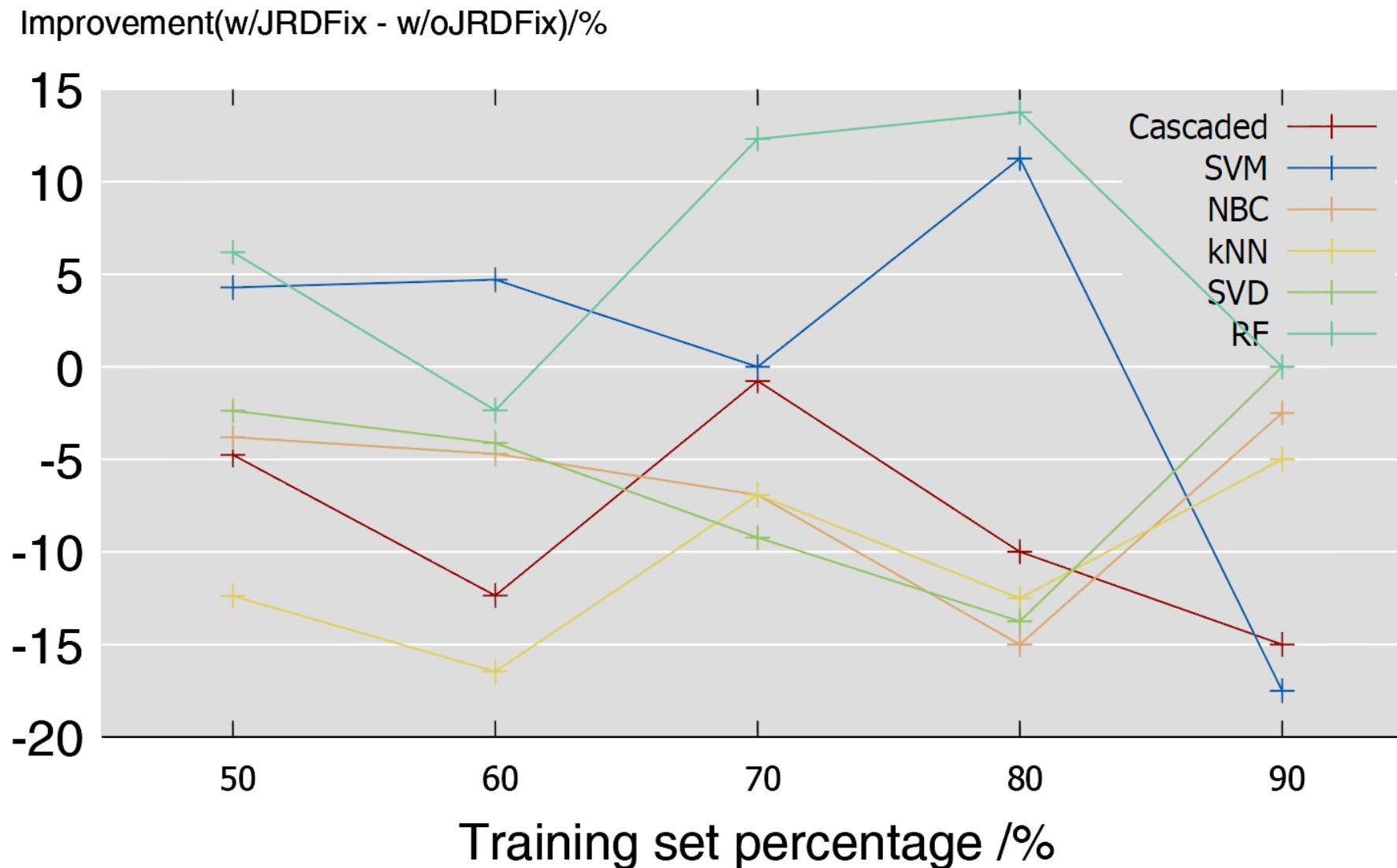


Figure 1 Cross validation Source <https://i.stack.imgur.com/YWgro.gif>

Results

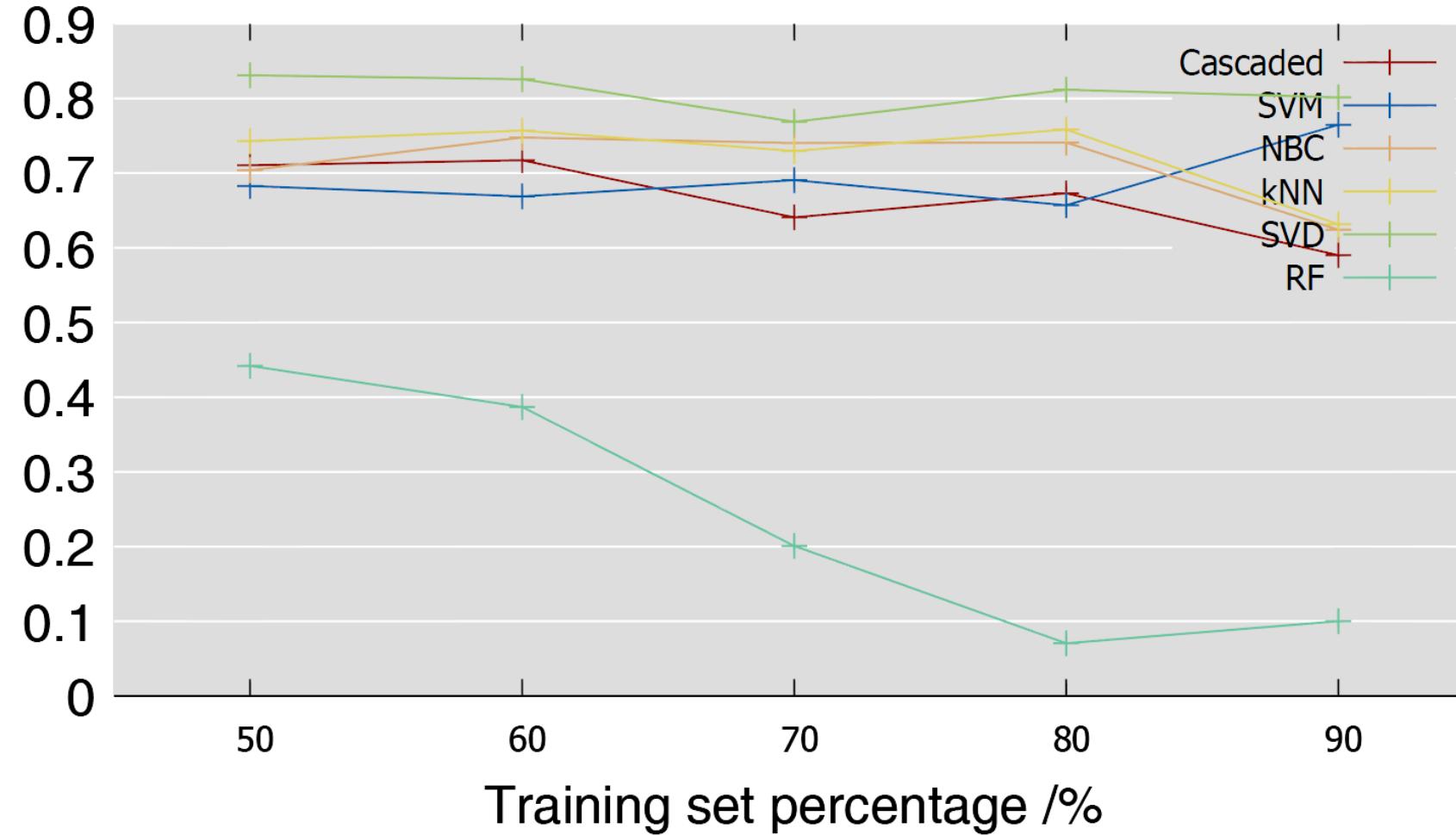


JRD fixation improvement

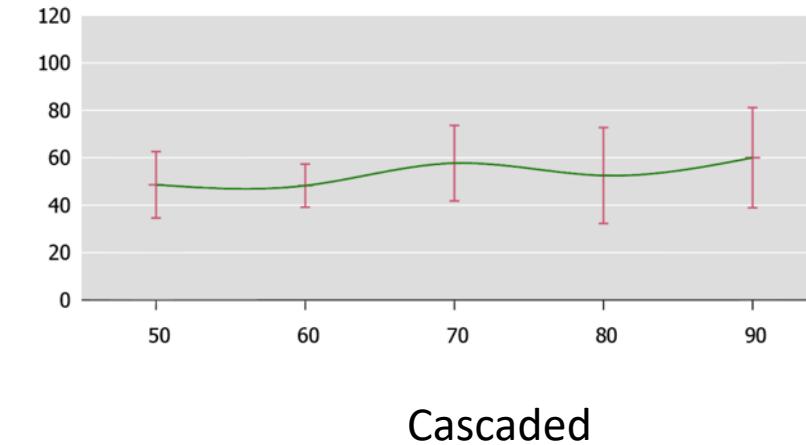
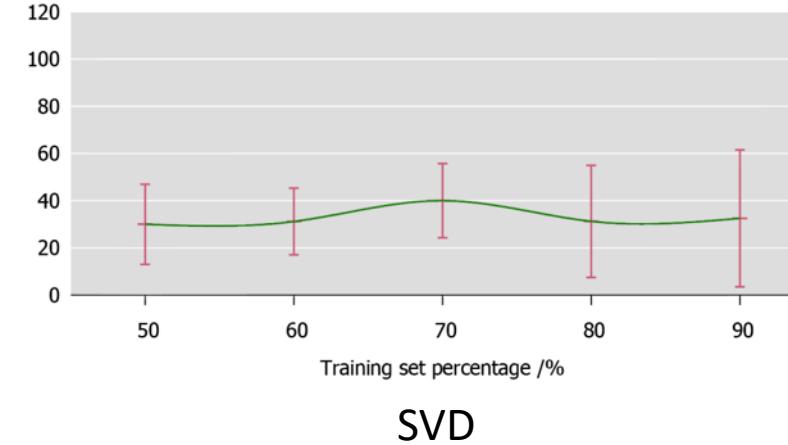
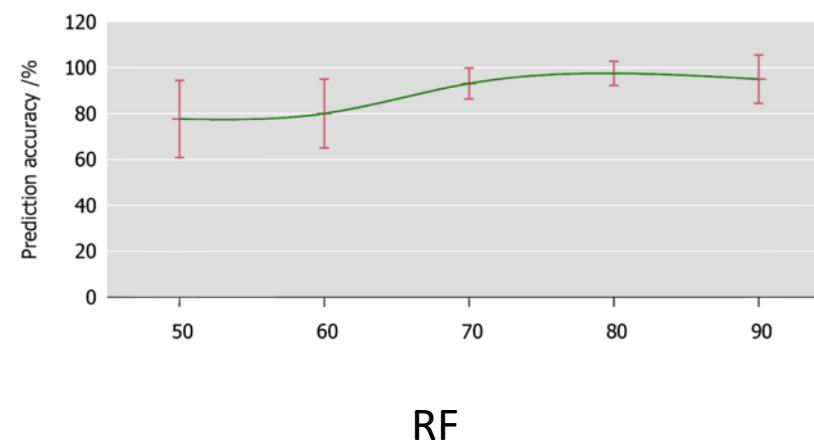
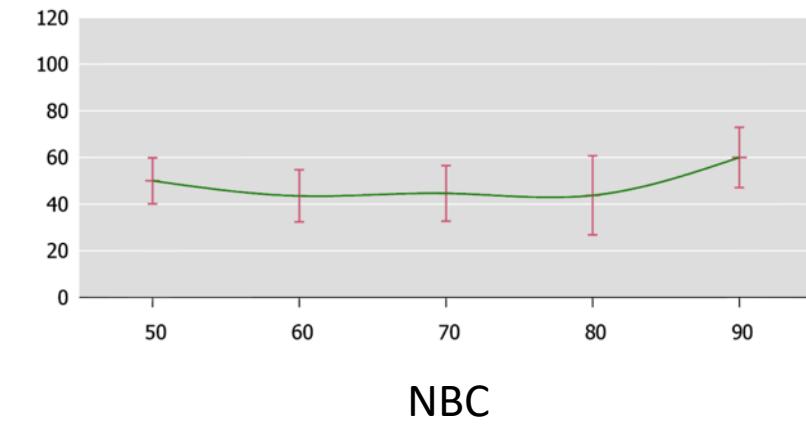
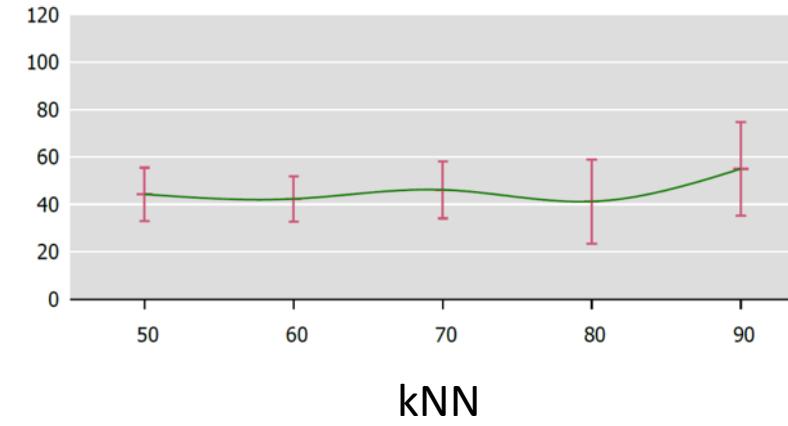
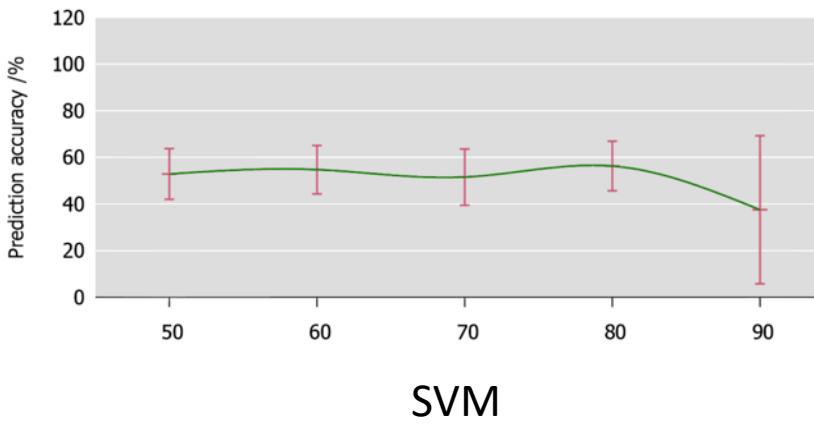


RMSE

Prediction Root Mean Square Error



Prediction accuracy



Conclusions



Conclusions

Performance

- Random Forest and Cascaded algorithm are **Best**
- RF - when training set is over eighty percent, **90 - 95%** accuracy

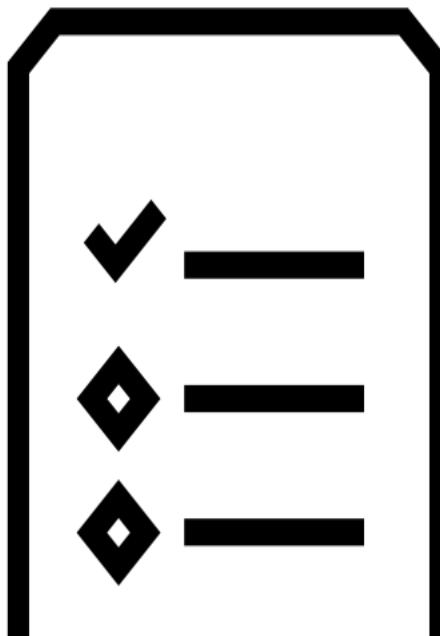
Training ratio

- Hard to generalize
- Sometimes higher the better, sometimes reverse

Transitivity

- Very hard to transfer; depending on the experiment type
- **Underfitting**

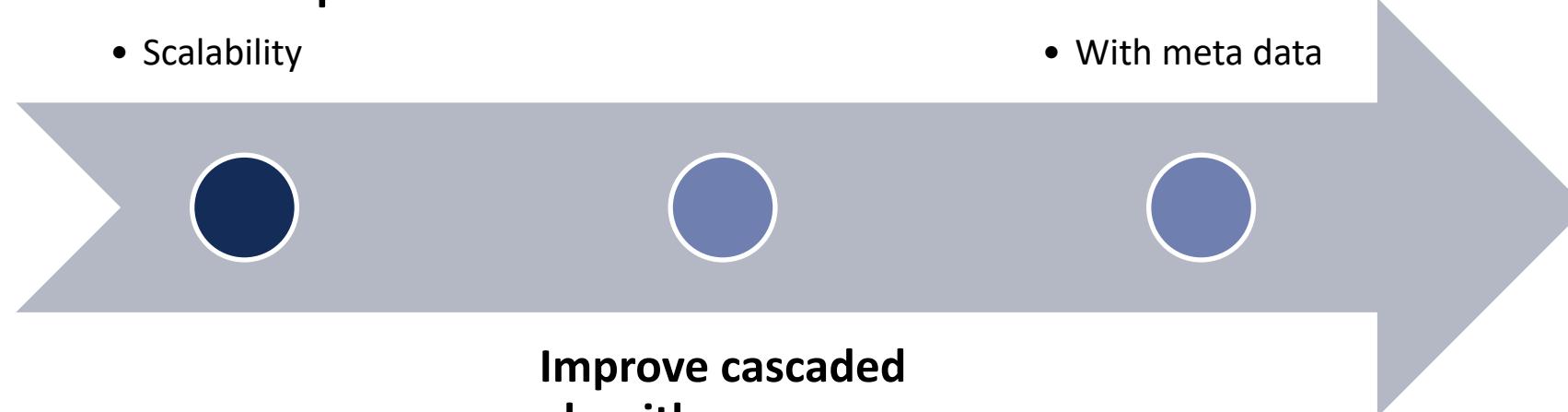
Future works



Future works

Small sample

- Scalability



Neural network

- With meta data

Improve cascaded algorithm

- Combine algos meaningfully

Thank you!

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Steps

- **Computational model** to distinguishing between different aspects of cognitive maps.
- **Machine learning** algorithms to classify experimental data into a given reference frame.
- **Machine learning** algorithms to classify computed-generated data.
- **Validation** of the computational model.