

REPRODUCING REALITY

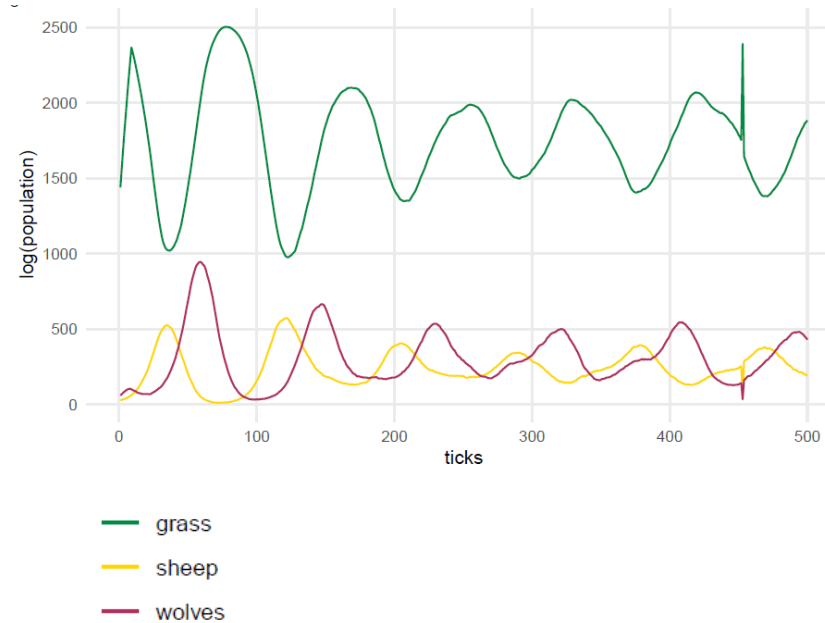
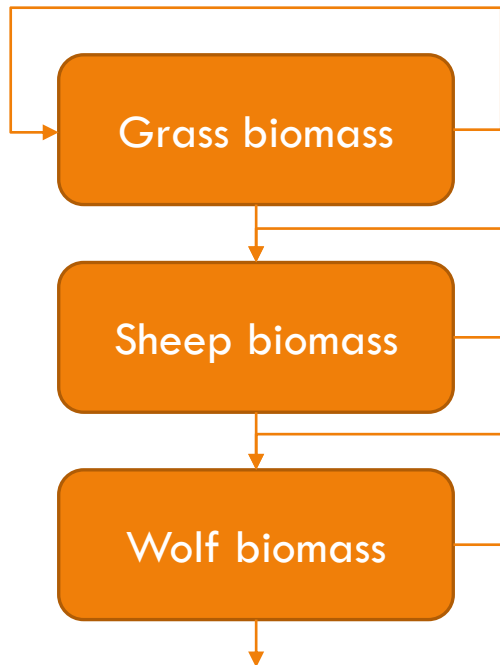
A COMPARISON OF METHODOLOGIES AND MACHINE LEARNING
ALGORITHMS FOR THE CALIBRATION OF AGENT-BASED MODELS
IN ECOLOGY

MSc thesis Leiden Universiteit
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University & Research

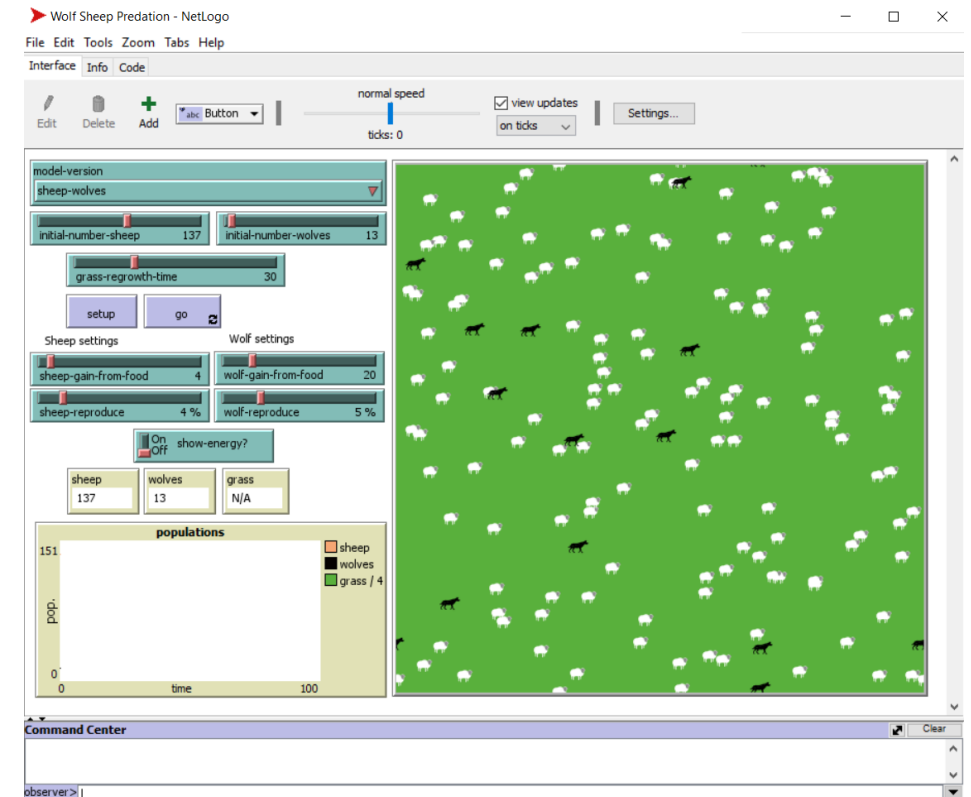
INTRODUCTION

ECOLOGICAL MODELS

Traditional differential equation models



Agent-Based Models



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Results

Discussion

Conclusion

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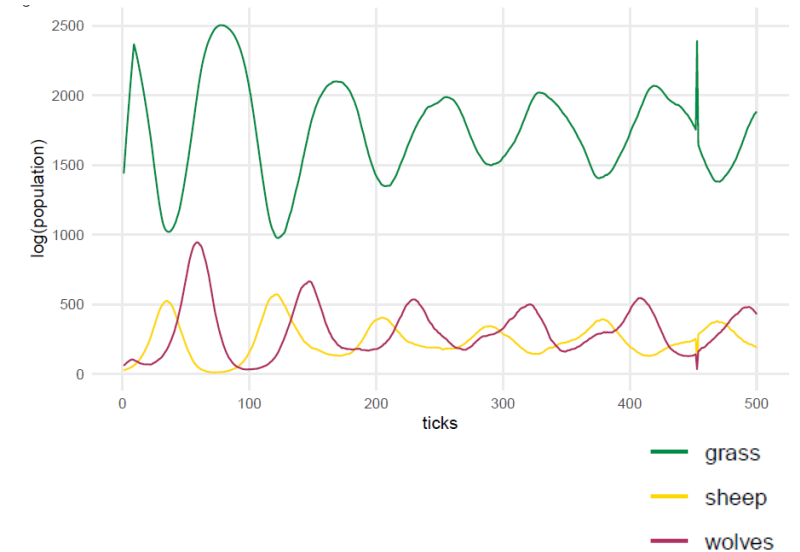
AGENT-BASED MODELS

parameters



ABM

output



```
ask wolves [  
  move  
  set energy energy - 1 ; wolves lose energy as they move  
  eat-sheep ; wolves eat a sheep on their patch  
  death ; wolves die if they run out of energy  
  reproduce-wolves ; wolves reproduce at a random rate governed by a slider  
]
```

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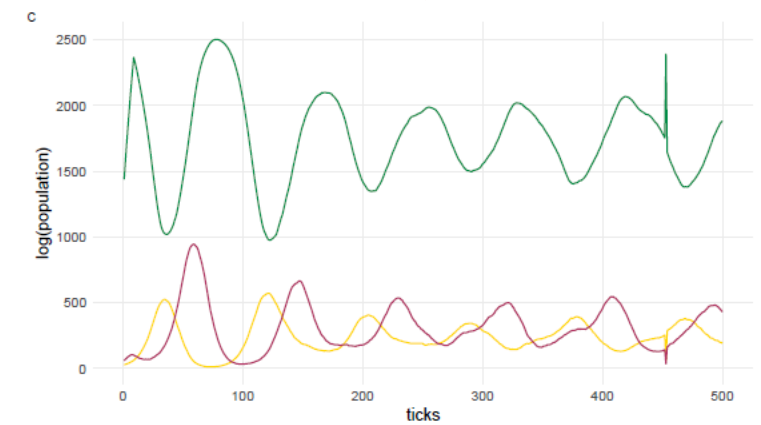
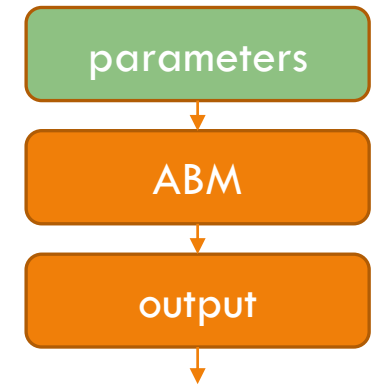
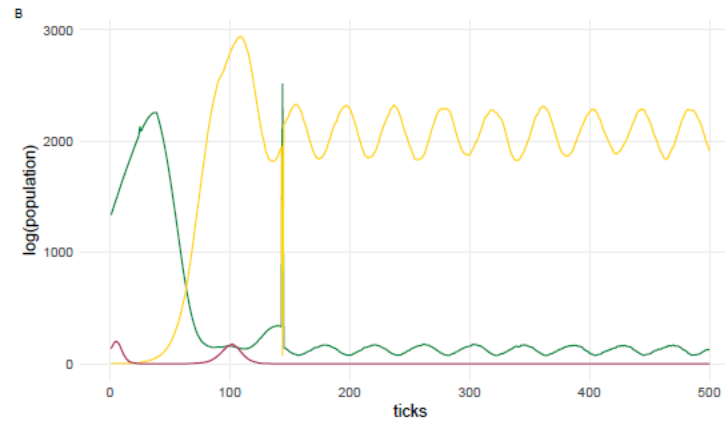
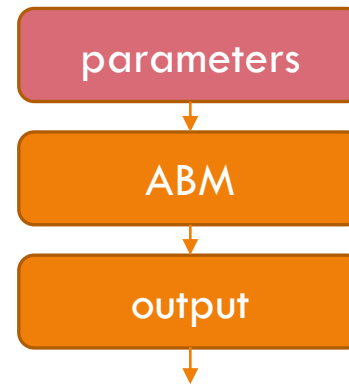
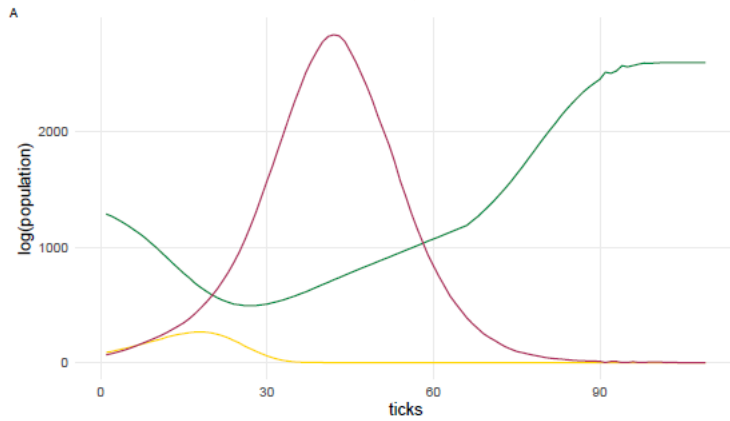
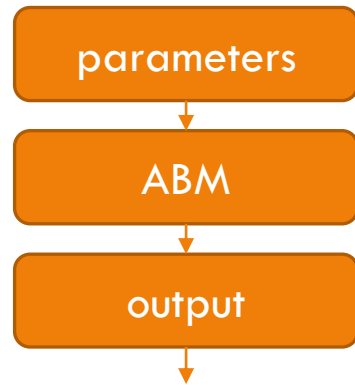
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AGENT-BASED MODELS



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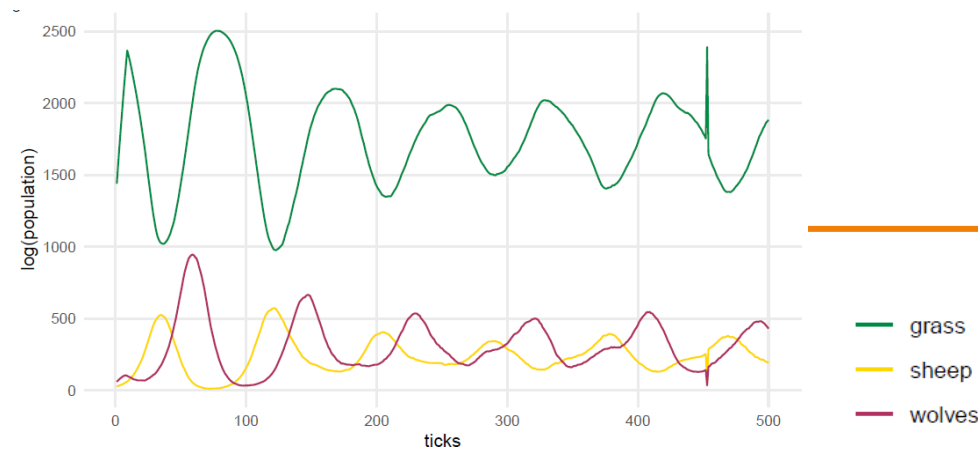
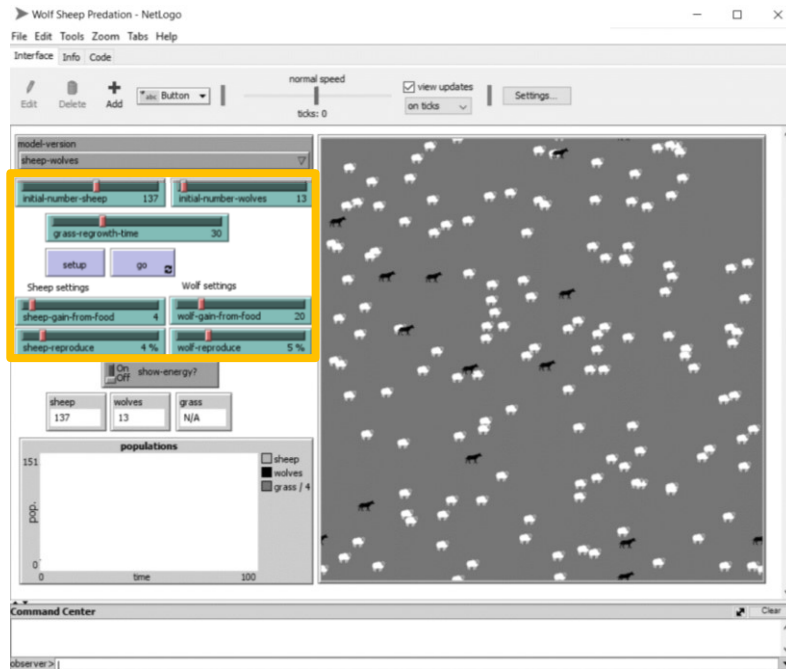
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CALIBRATION



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Methodology

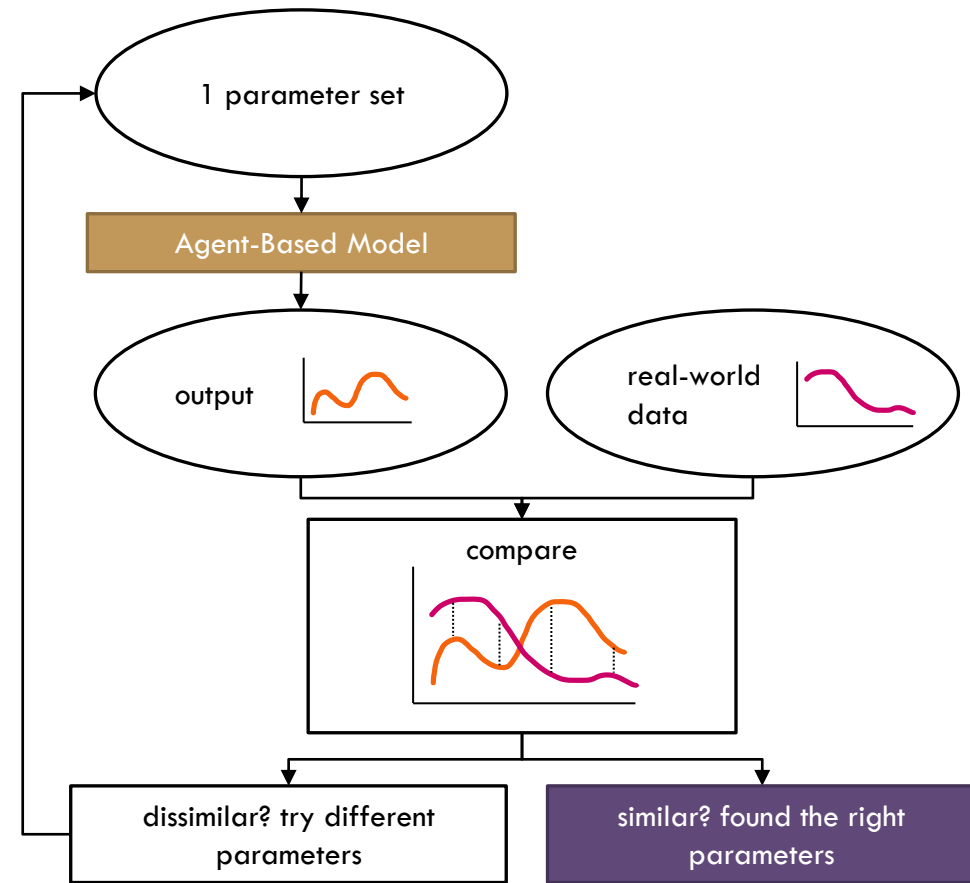
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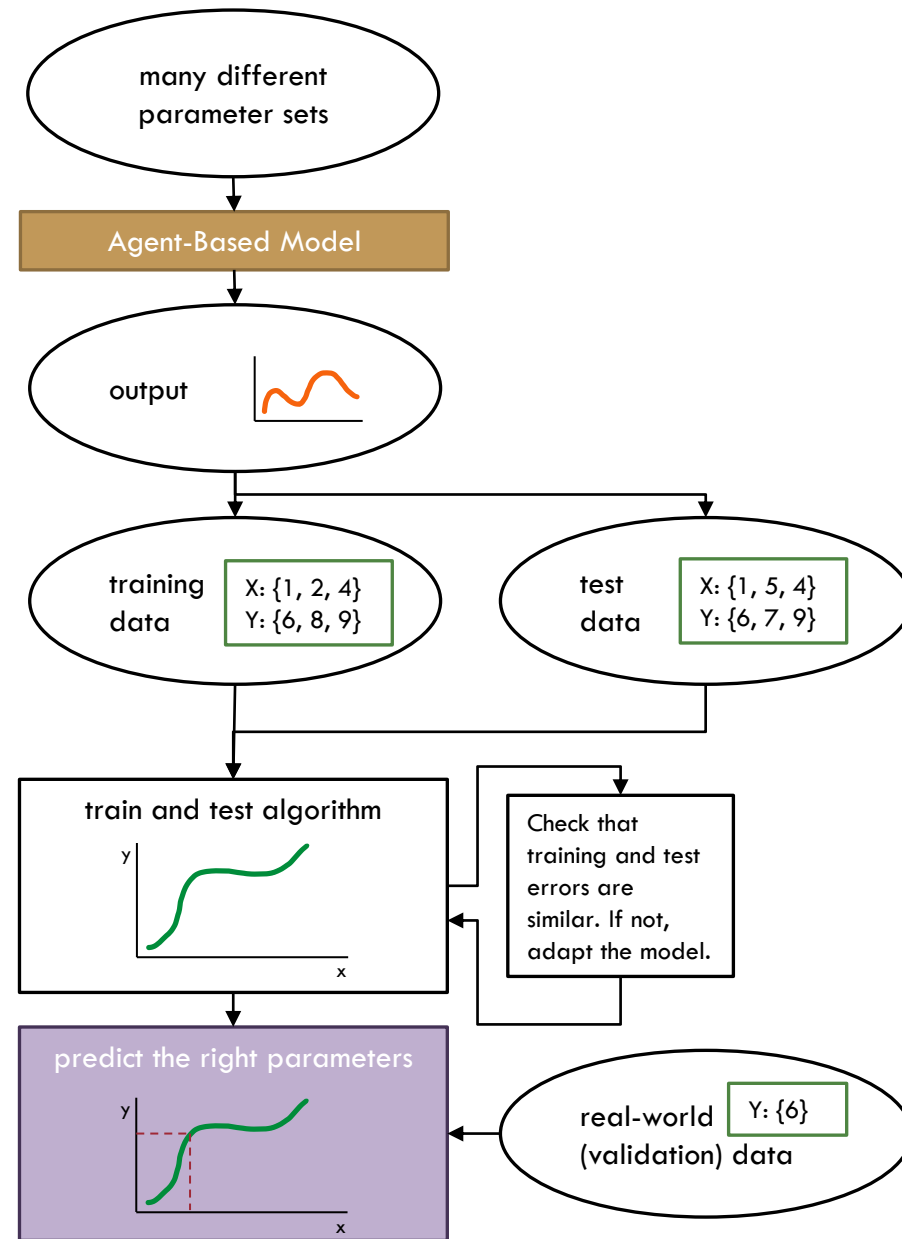
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INTRODUCTION

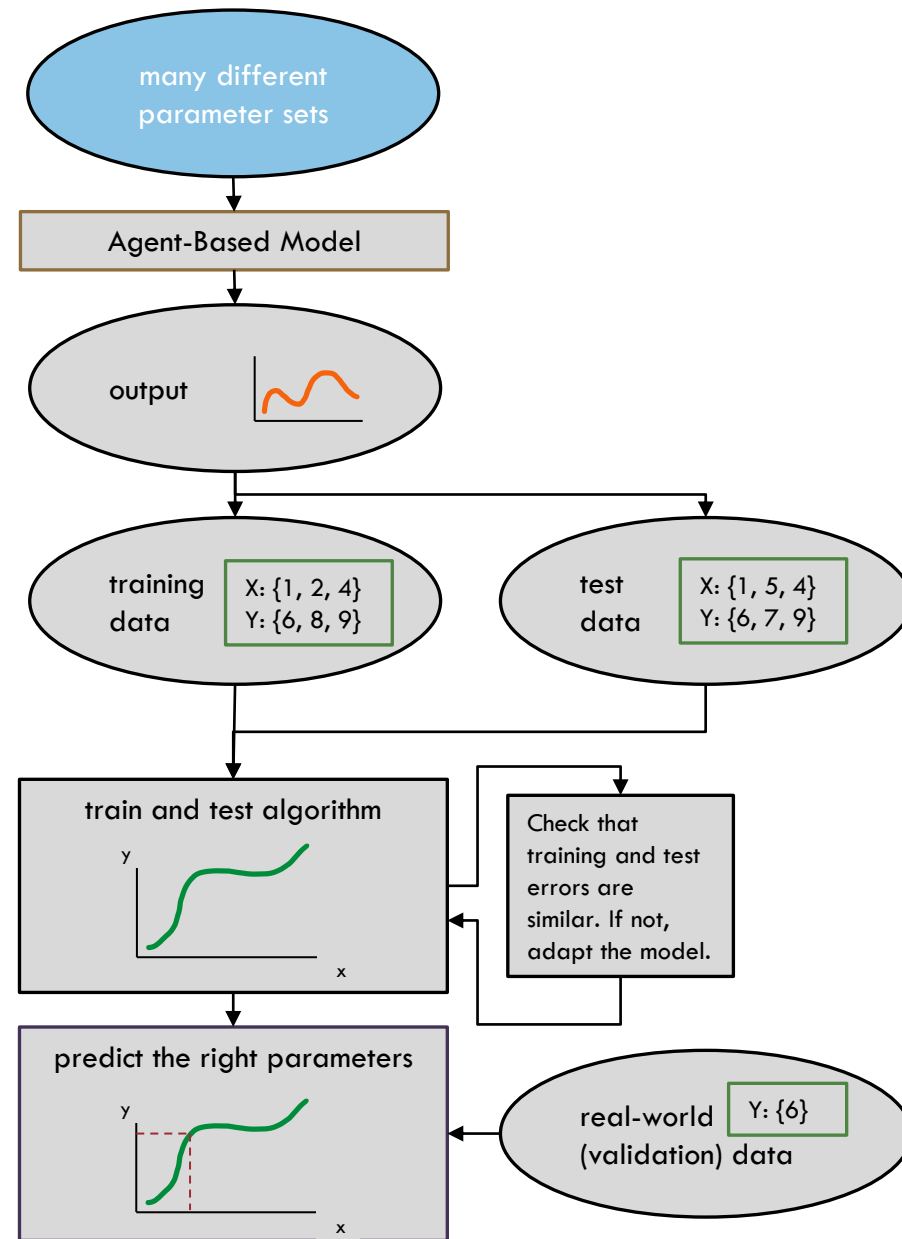
CALIBRATION



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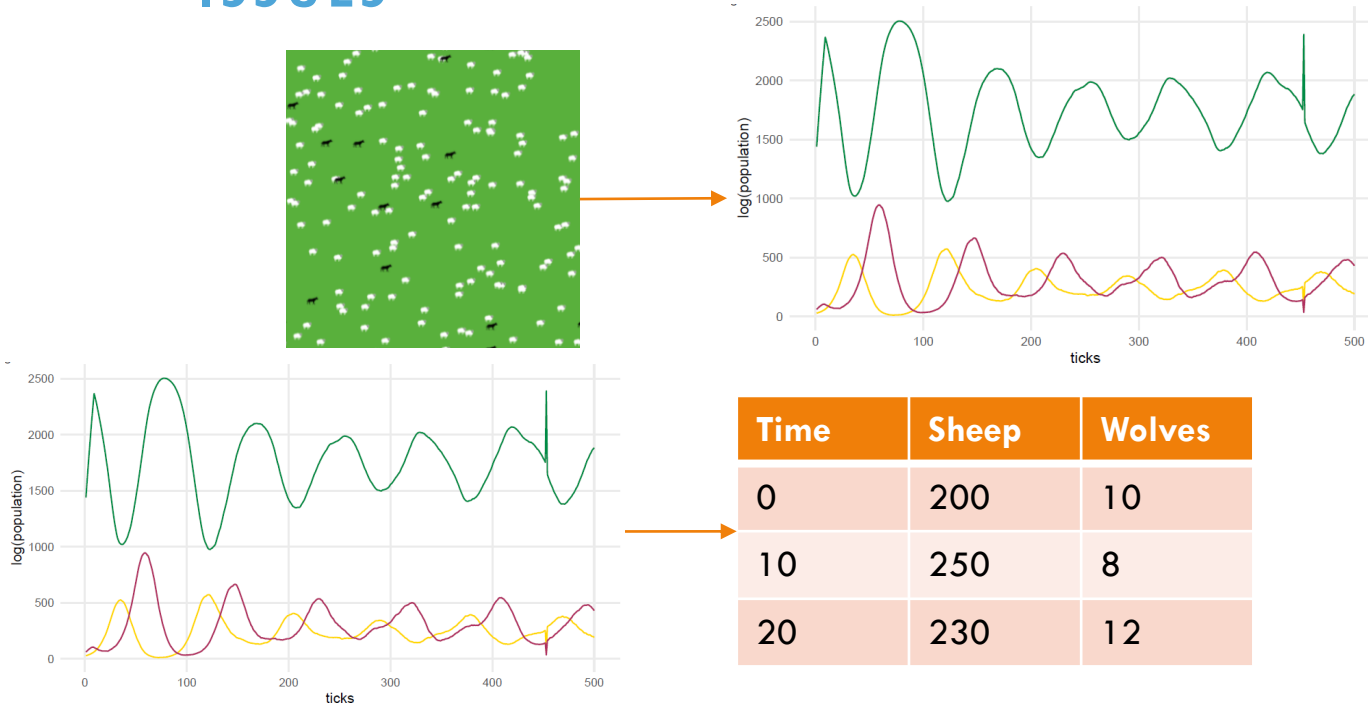
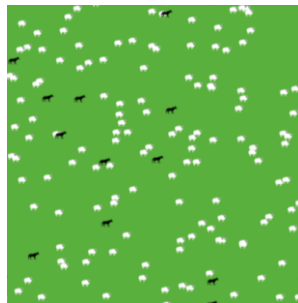
CALIBRATION STEPS & ISSUES

- Sampling
- Sample size
- Repeated runs

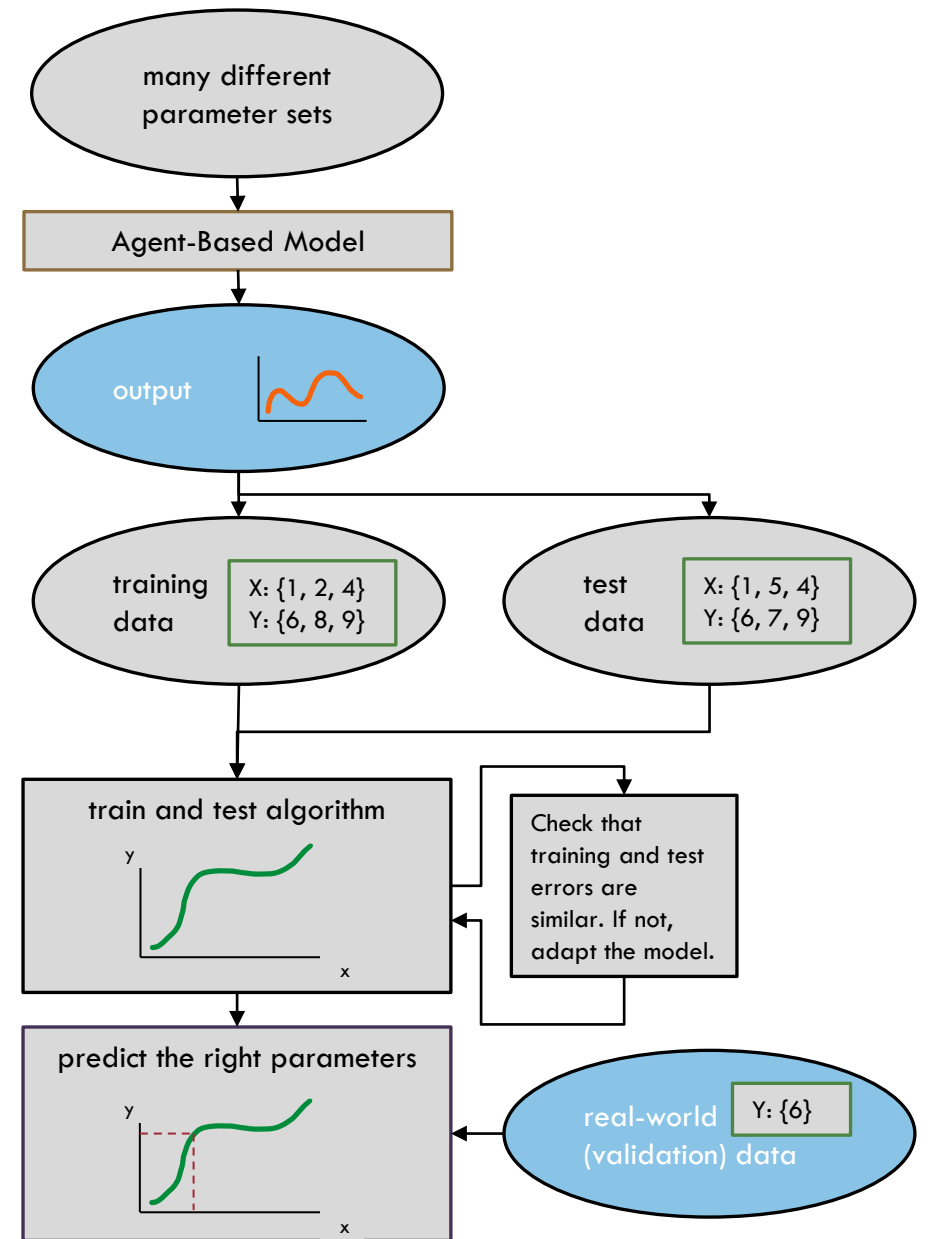


INTRODUCTION

CALIBRATION STEPS & ISSUES



Time	Sheep	Wolves
0	200	10
10	250	8
20	230	12



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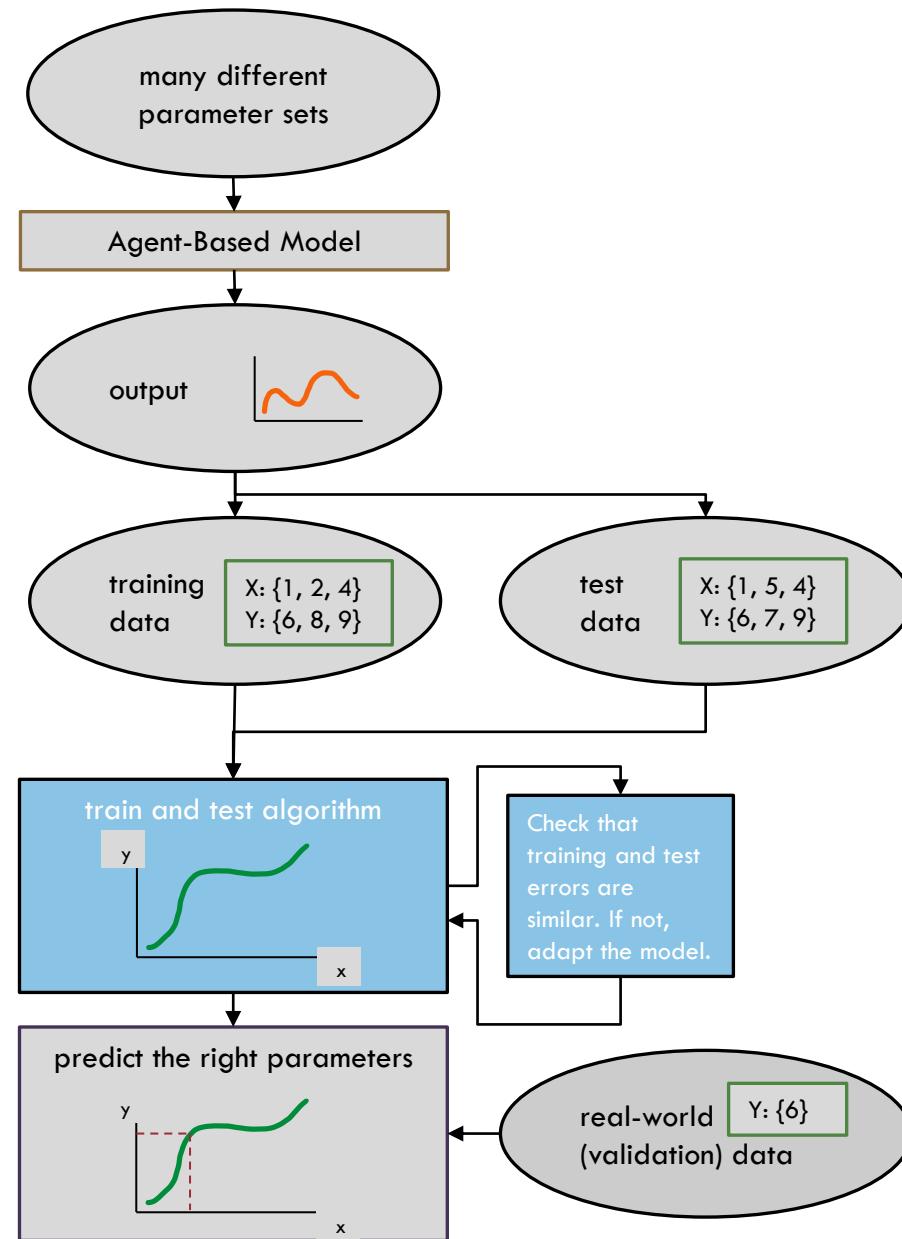
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CALIBRATION STEPS & ISSUES

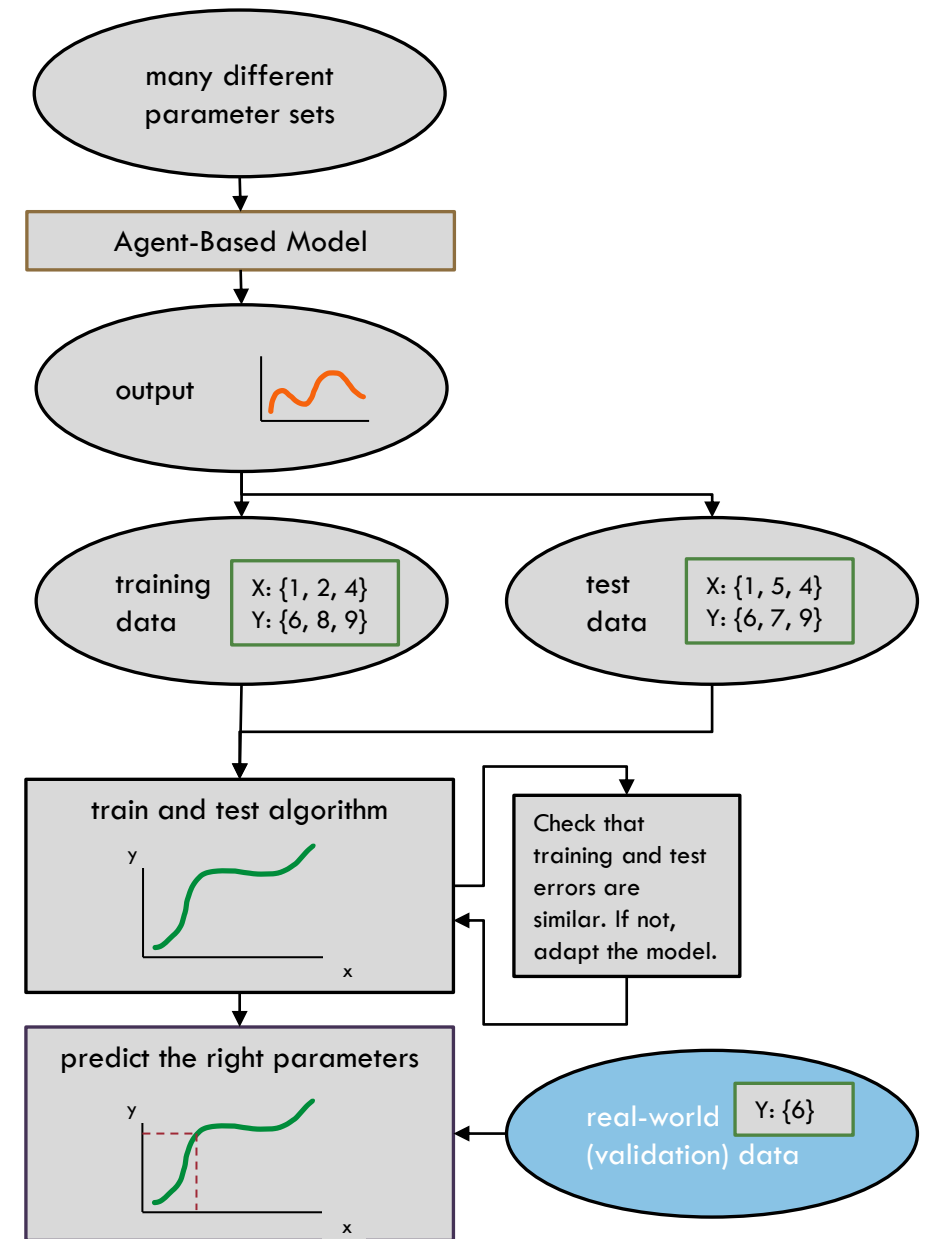
- Multiple parameters
- May need a lot of data
- Non-linear and dynamic relationships



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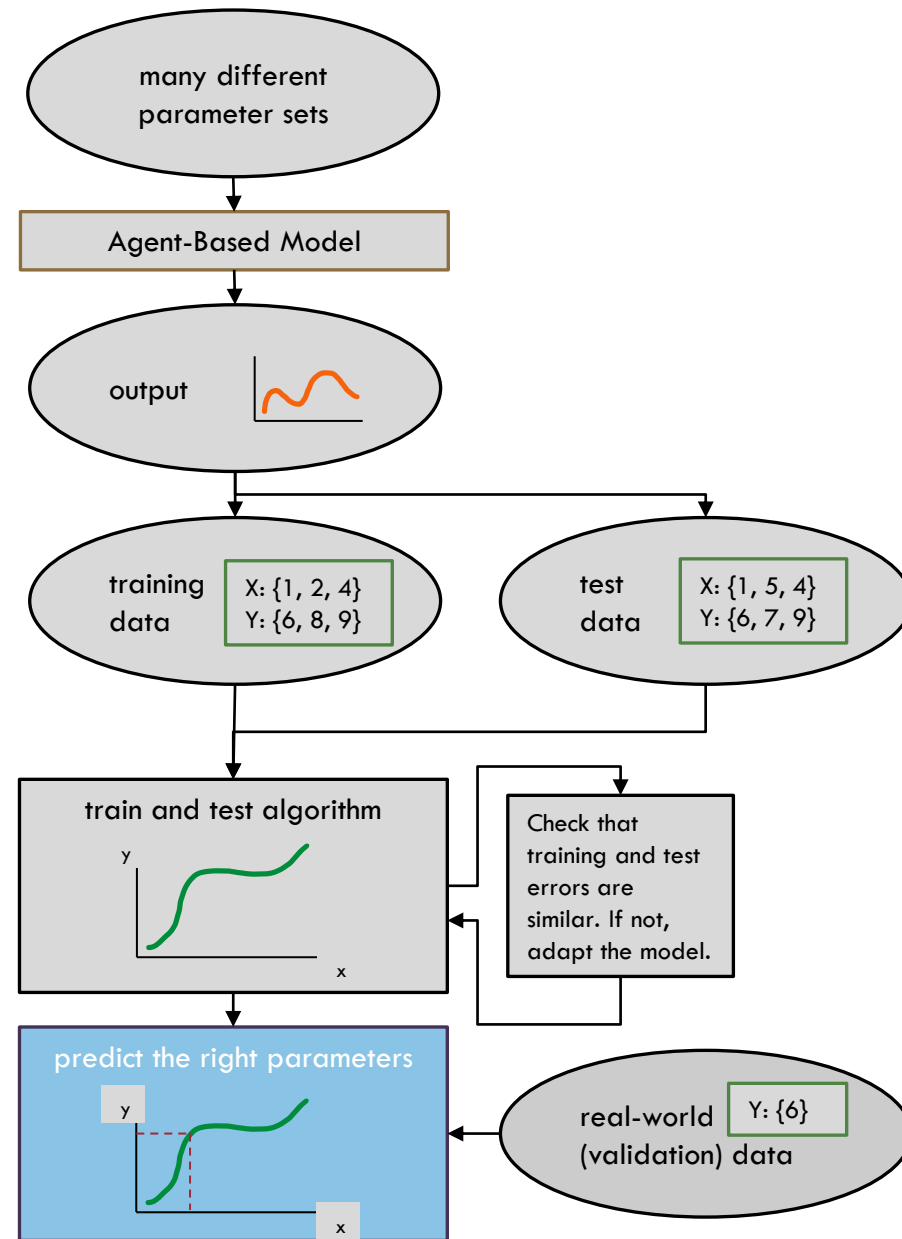
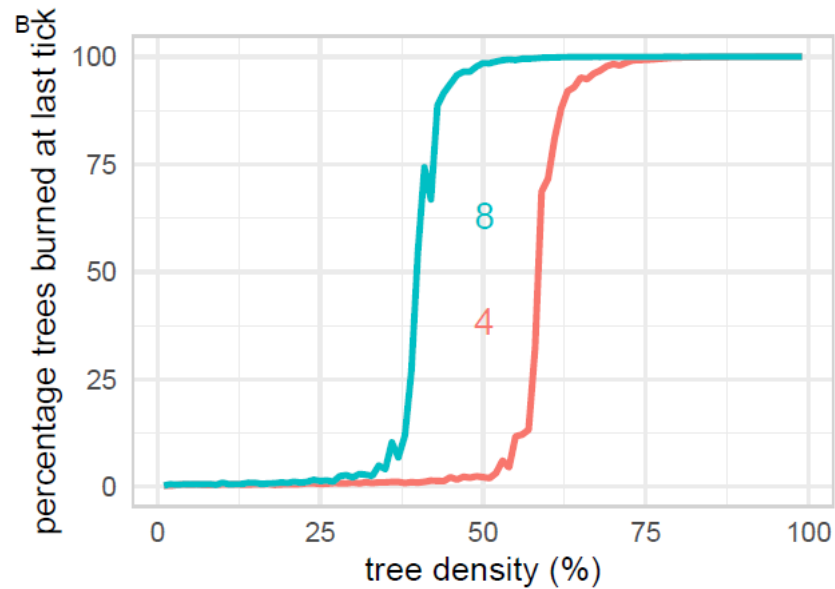
CALIBRATION STEPS & ISSUES

- Availability
- Scale
- Information
- Noise



INTRODUCTION

CALIBRATION STEPS & ISSUES



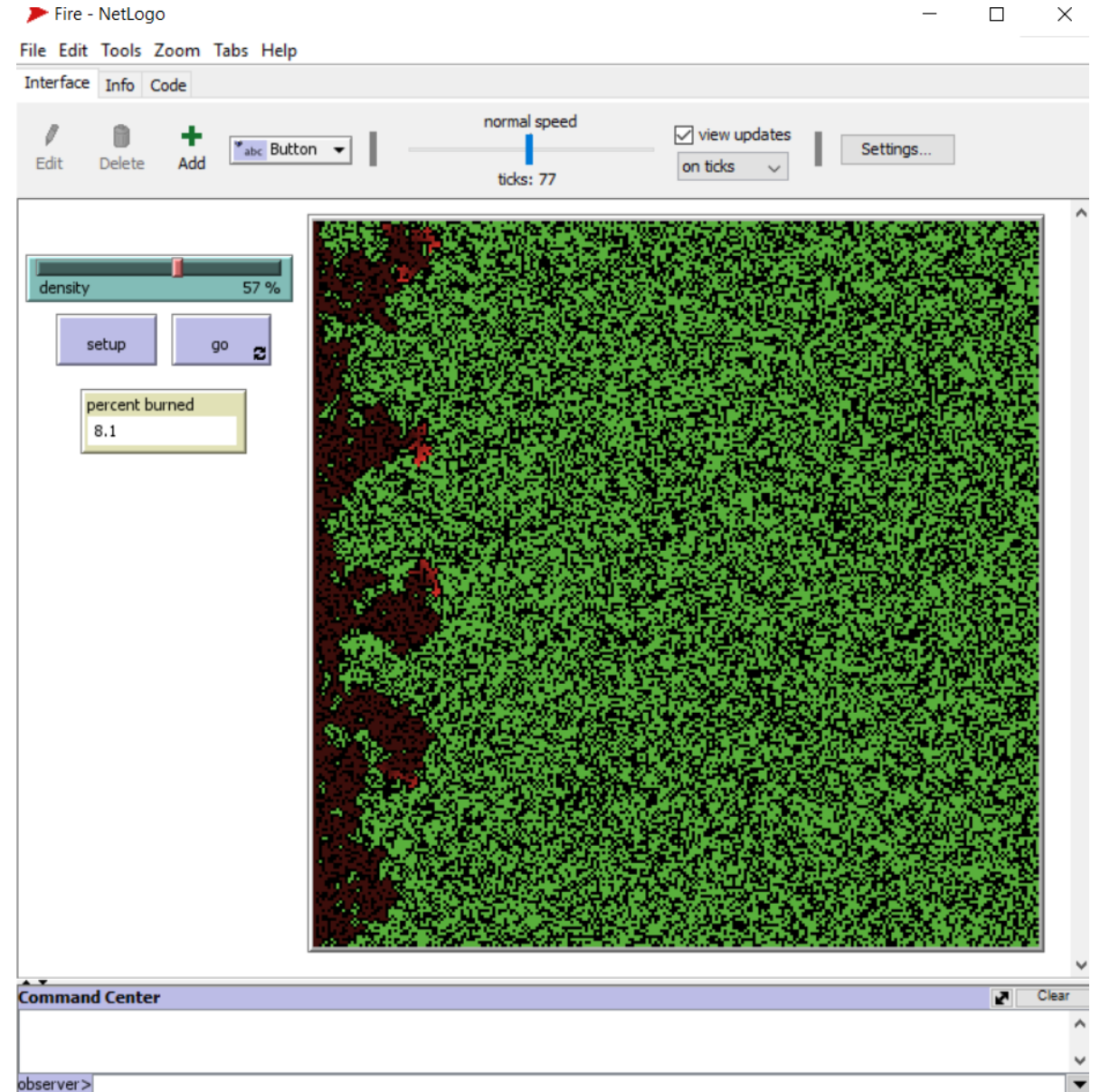
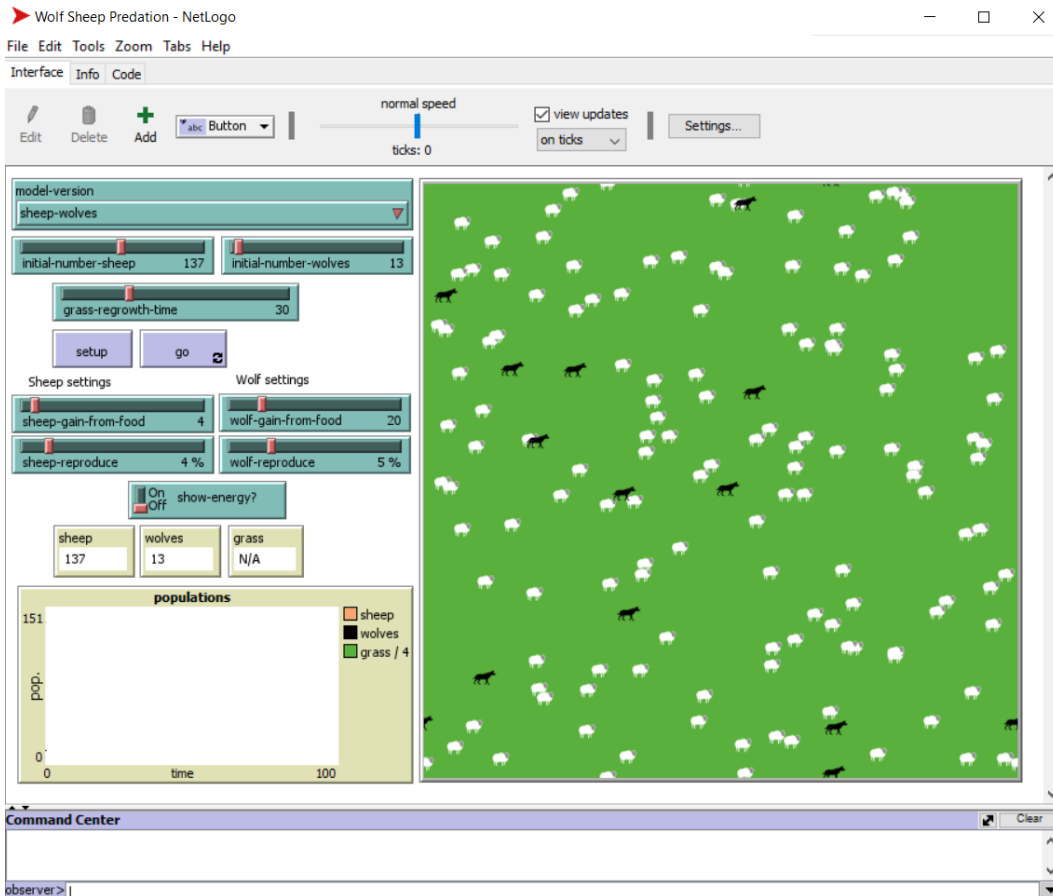
INTRODUCTION

RESEARCH QUESTIONS

1. Identify calibration issues
2. What is the influence of ...
 - a) Using a full time series vs. using time points
 - b) Summarising vs. not summarising repeated runs of the same parameter combination
 - c) Noise in the real-world data... on calibration performance (i.e., the ability to deduce the input parameters correctly)?
3. Which algorithm most successfully calibrates ABMs?
 - a) A univariate or multivariate algorithm?
 - b) A linear or non-linear algorithm?

METHODOLOGY

ABMS



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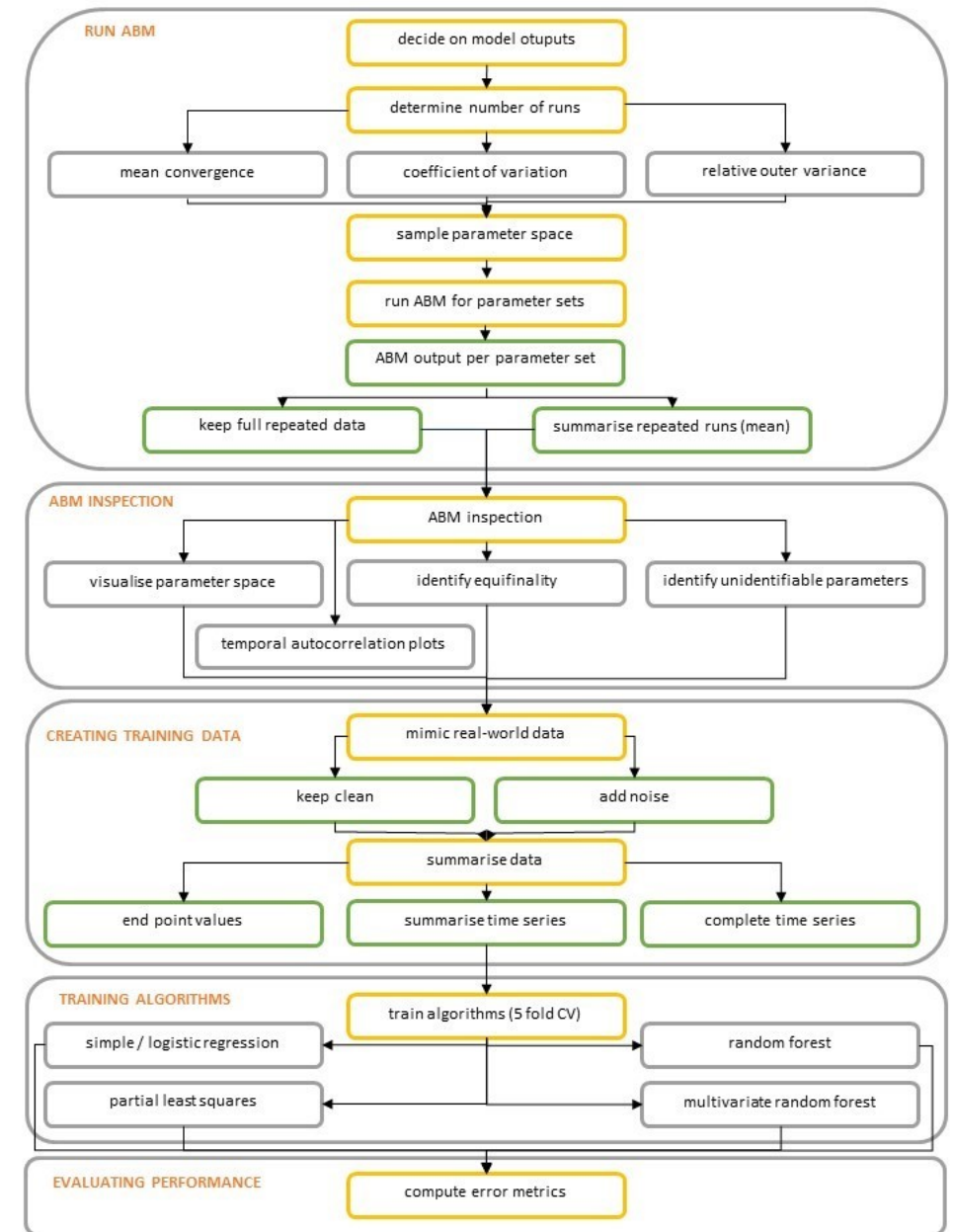
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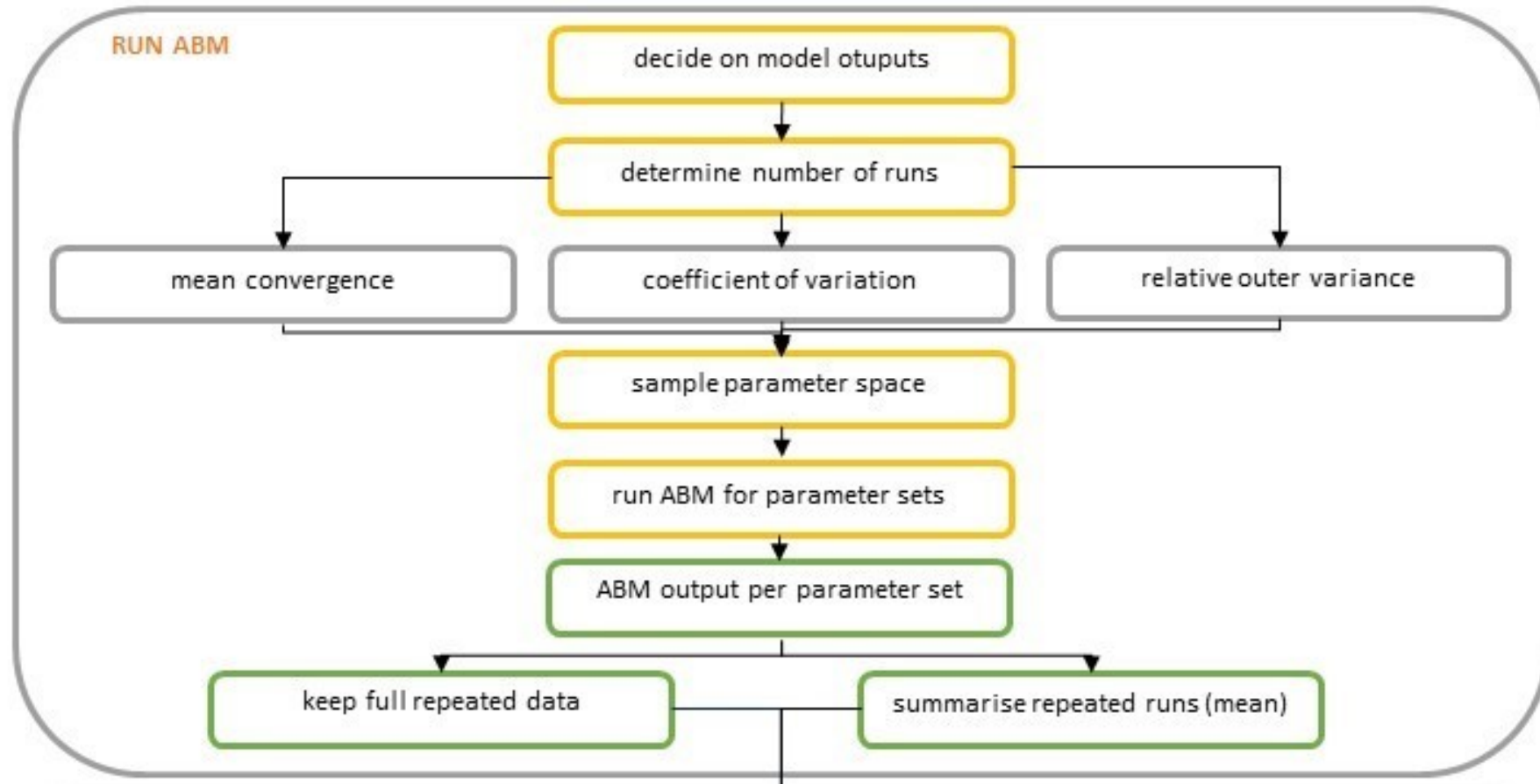
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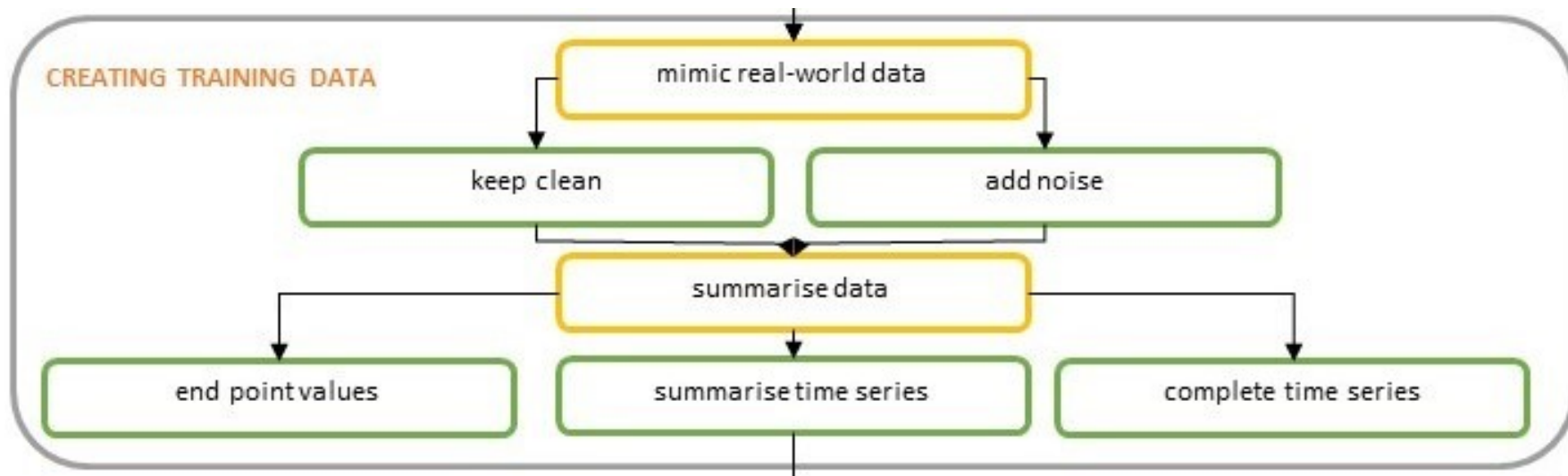
Discussion

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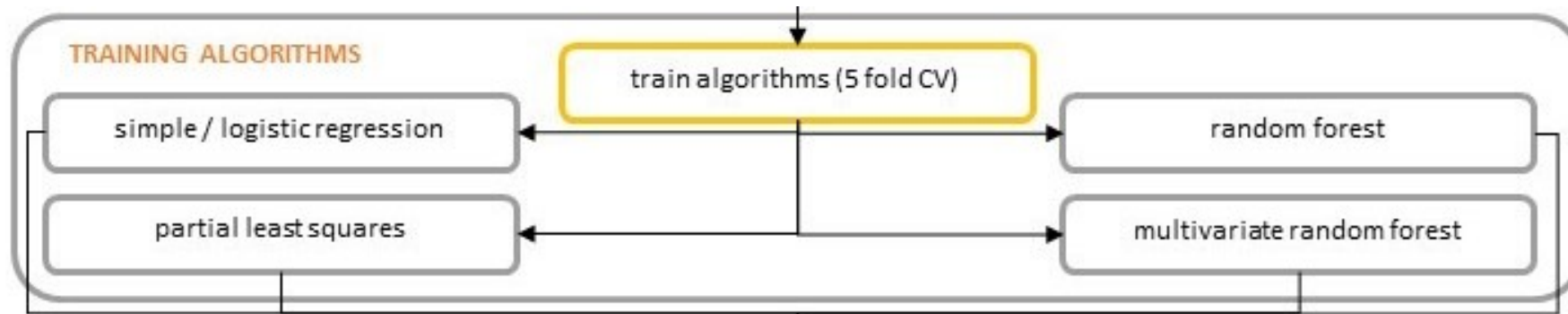
METHODOLOGY



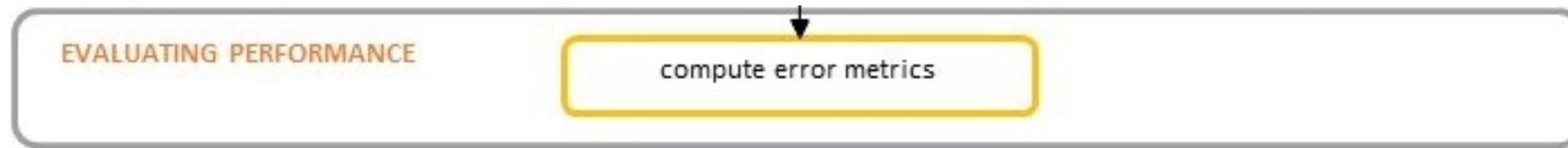
METHODOLOGY



METHODOLOGY



METHODOLOGY



Continuous parameters

- RMSE
- NRMSE
- Point prediction performance
- % estimated correctly

Discrete parameter

- Cohen's kappa
- F1 score
- Matthew's correlation coefficient
- % estimated correctly

RESULTS

OBSERVATIONS & ISSUES



Linear regression

Random forest

Partial least squares

Multivariate random forest

rank deficiency

excessive run-times

Introduction

Methodology

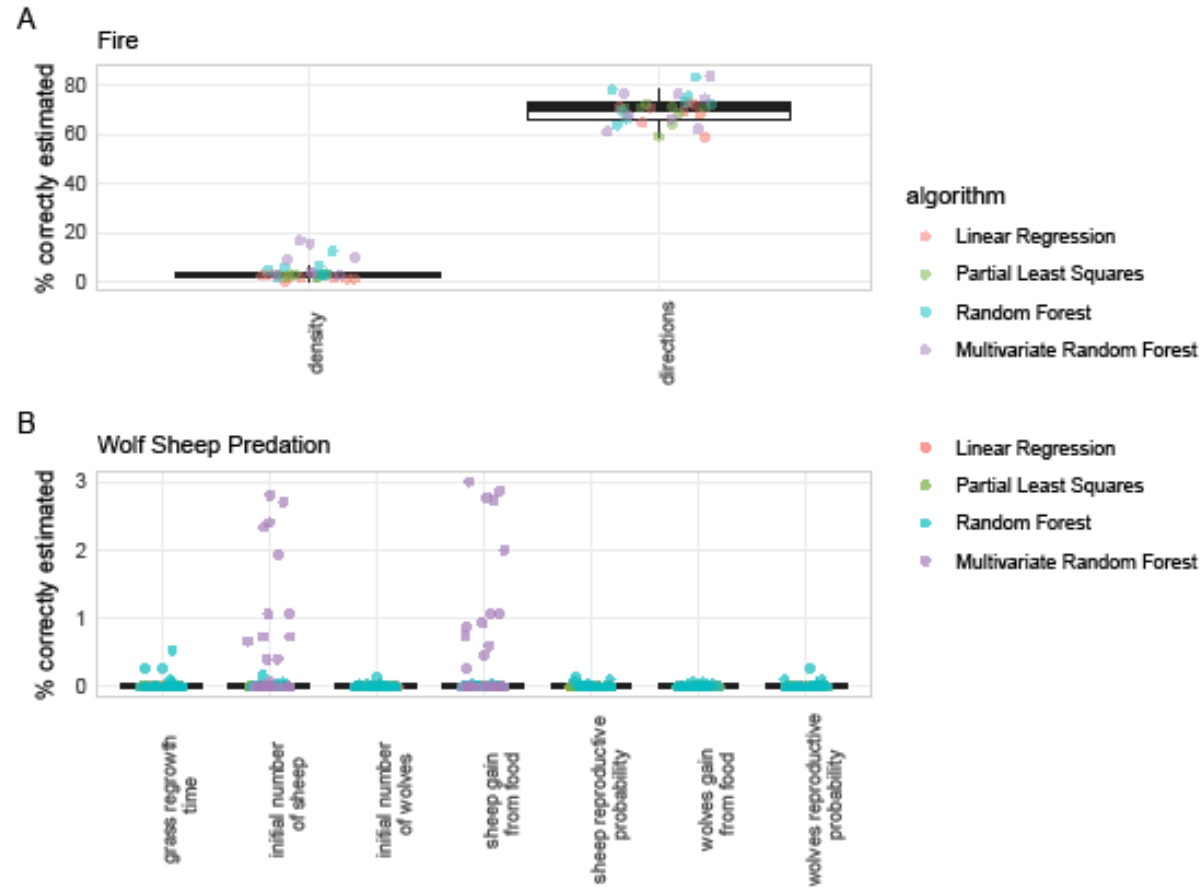
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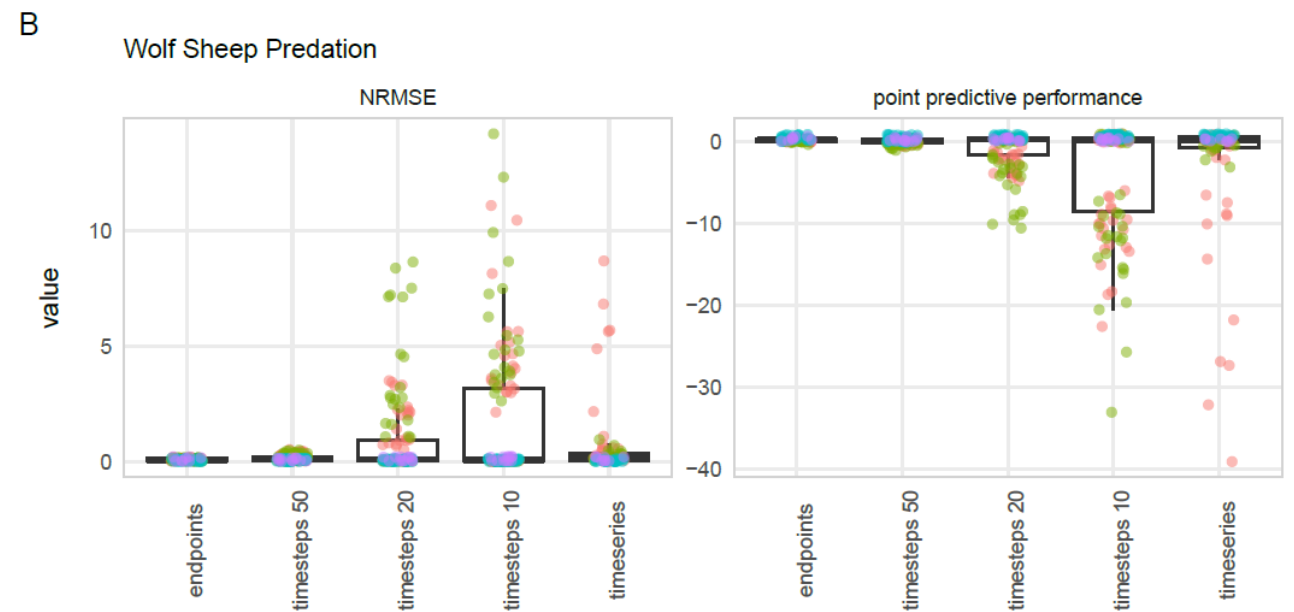
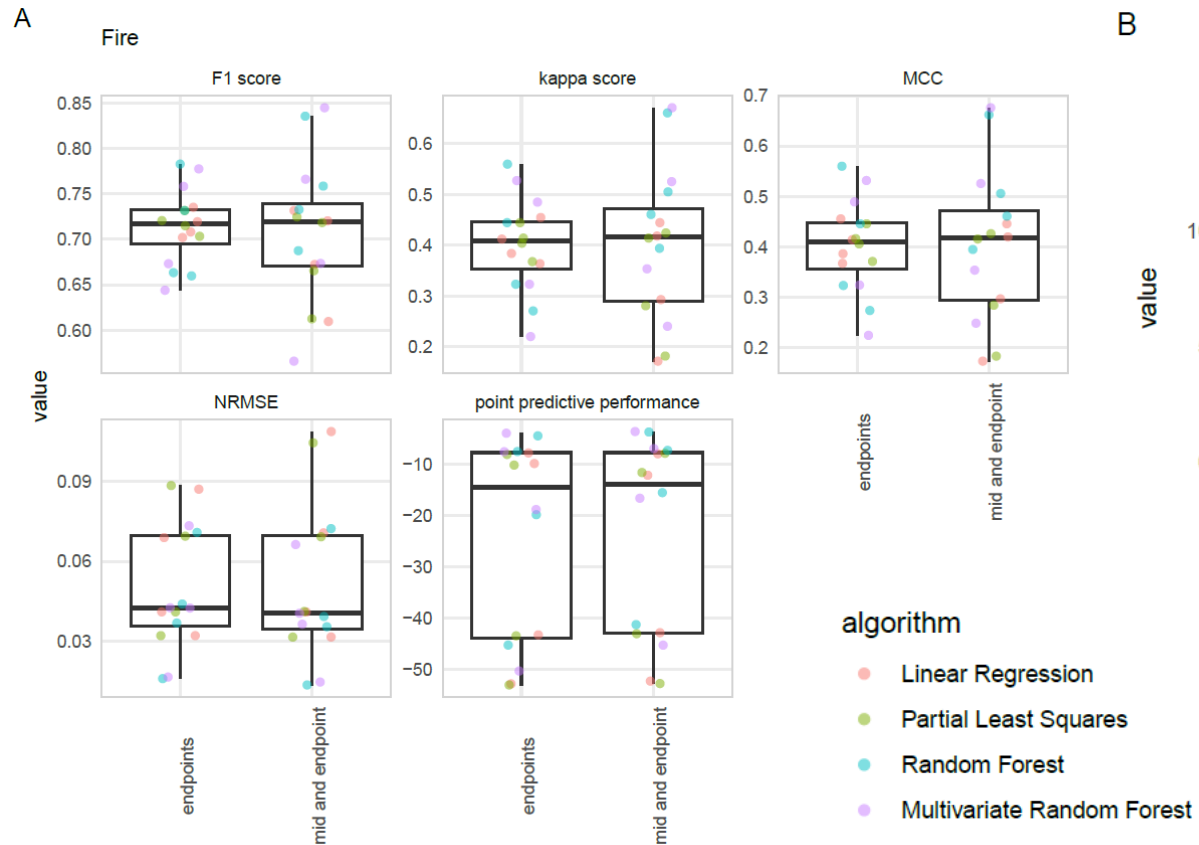
RESULTS

GENERAL PERFORMANCE



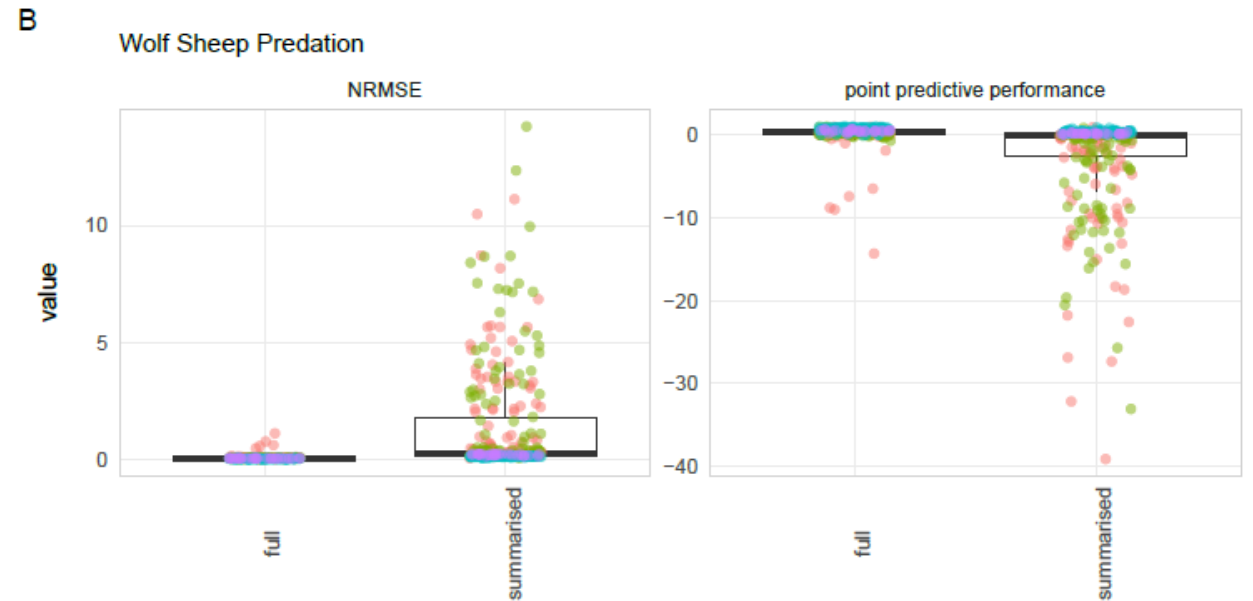
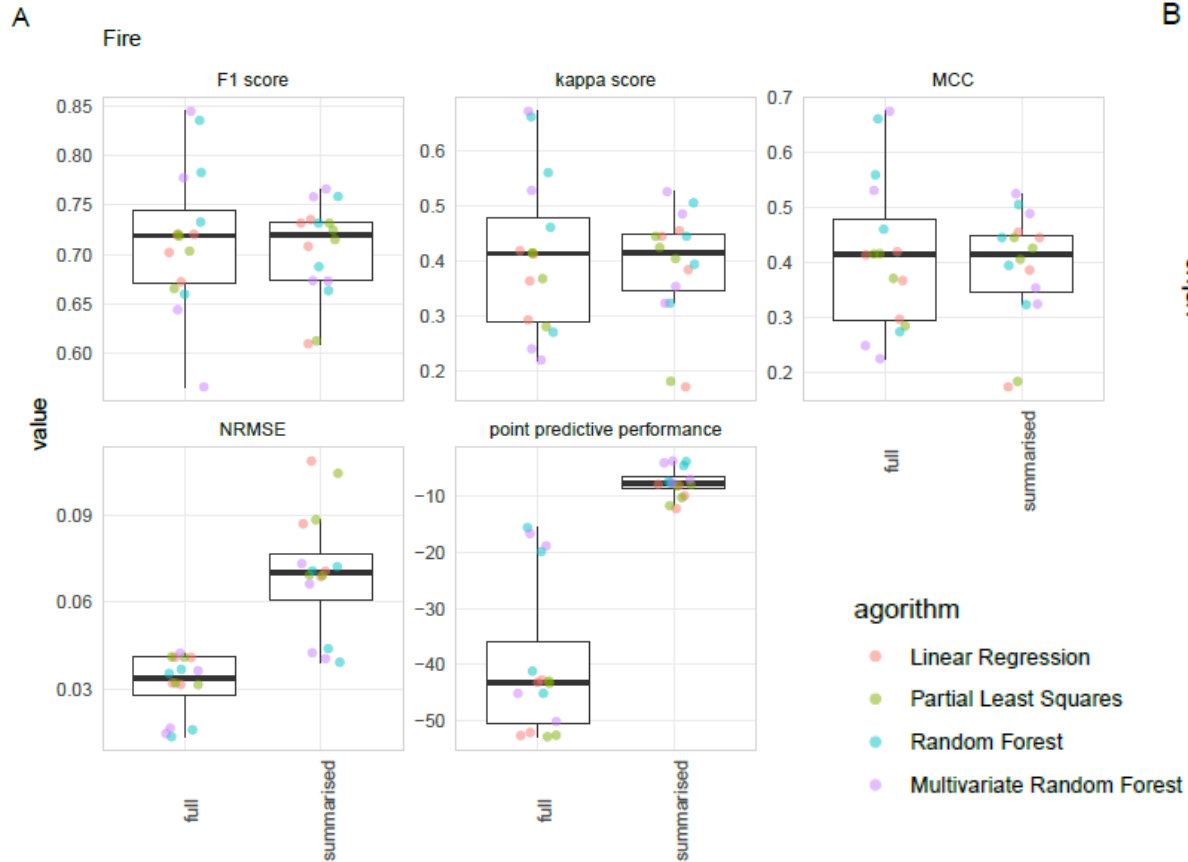
RESULTS

RQ 1: FULL TIME SERIES VS. TIME POINTS



RESULTS

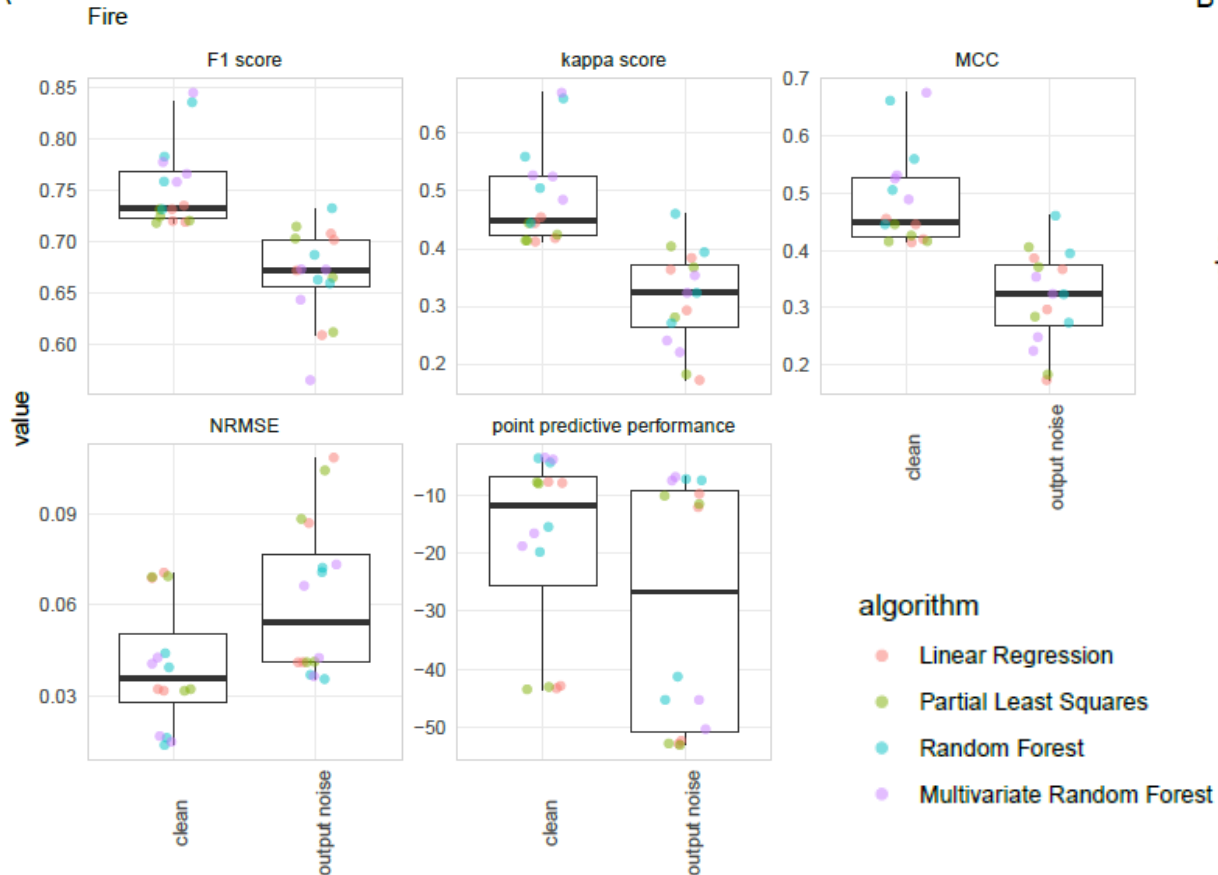
RQ 1: SUMMARISING REPEATED RUNS



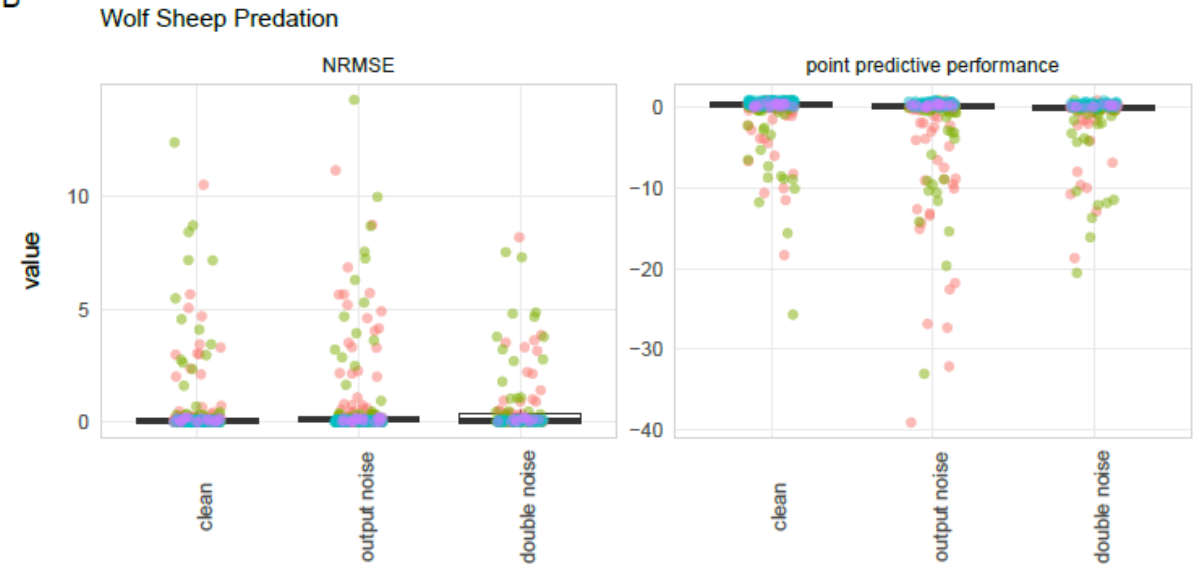
RESULTS

RQ 1: NOISE IN DATA

A



B



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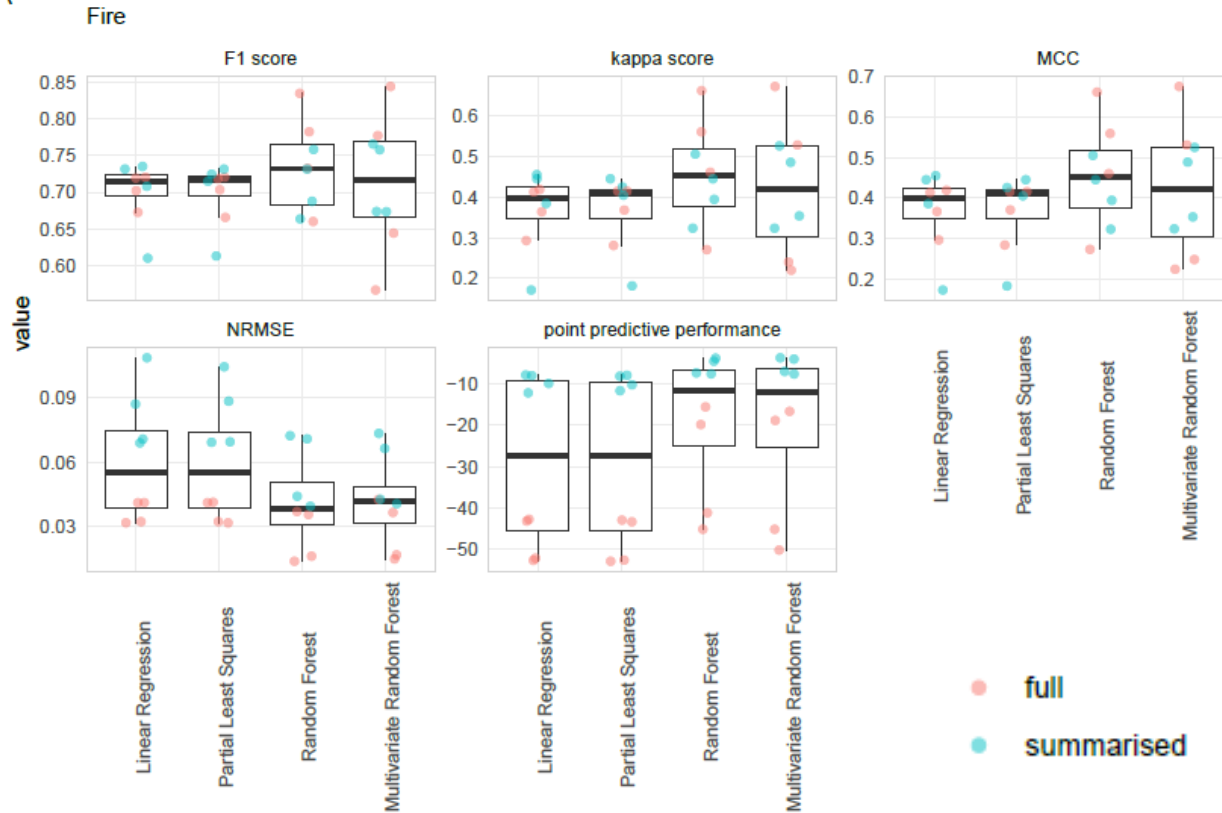
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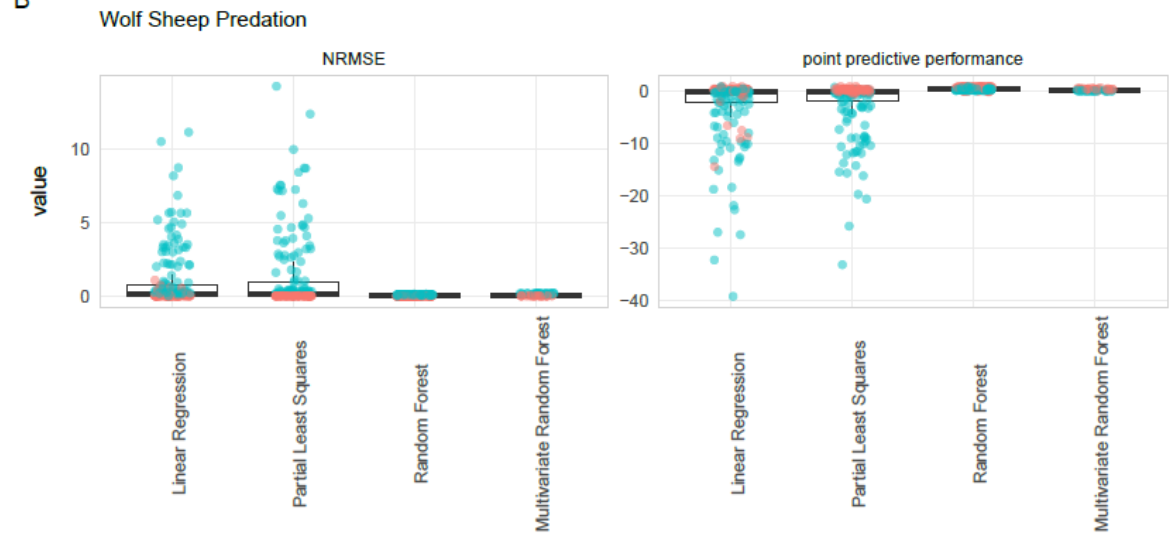
RESULTS

RQ 2: UNI-VARIATE VS. MULTI-VARIATE LINEAR VS. NON-LINEAR

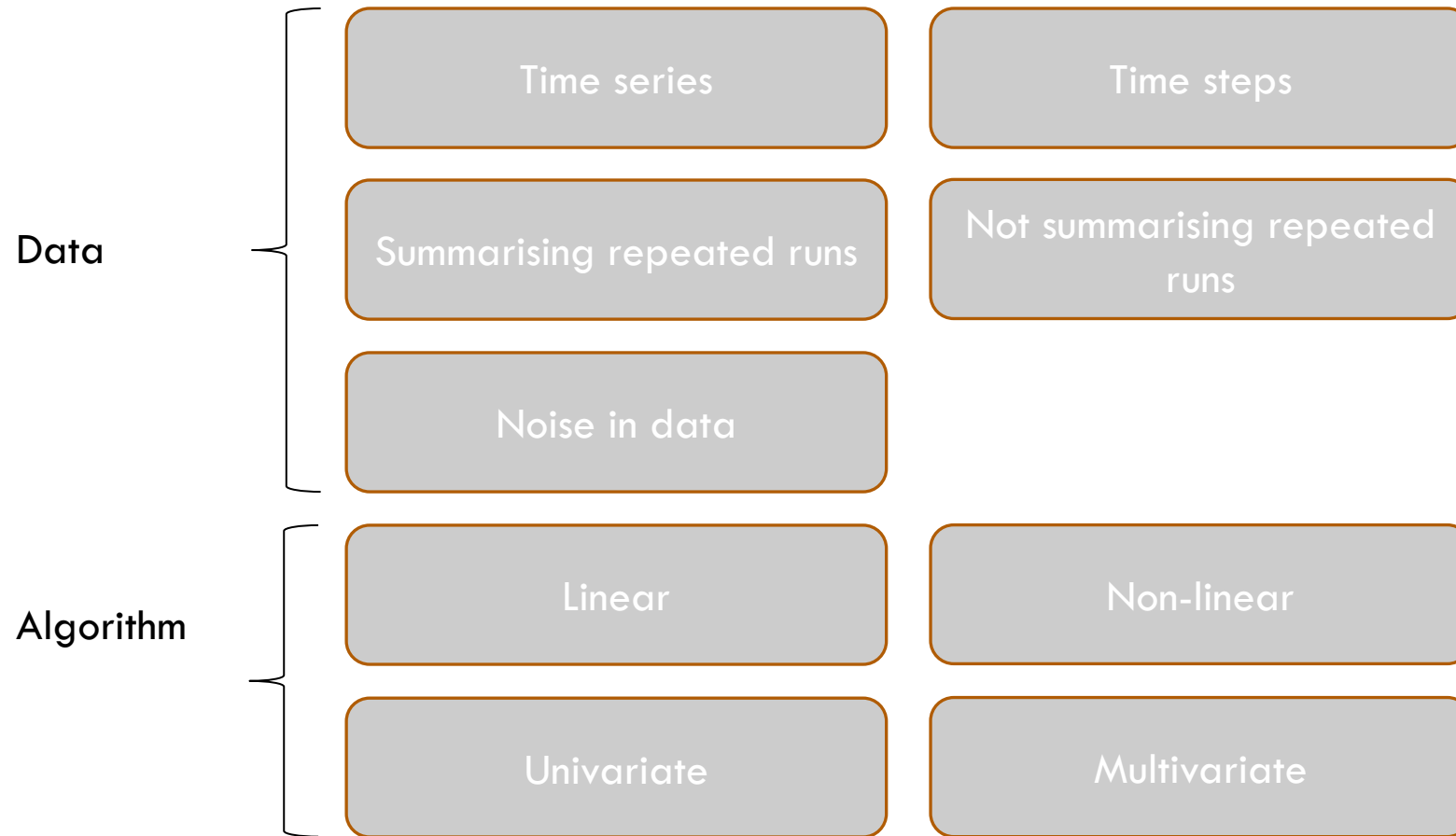
A



B



DISCUSSION RESULTS



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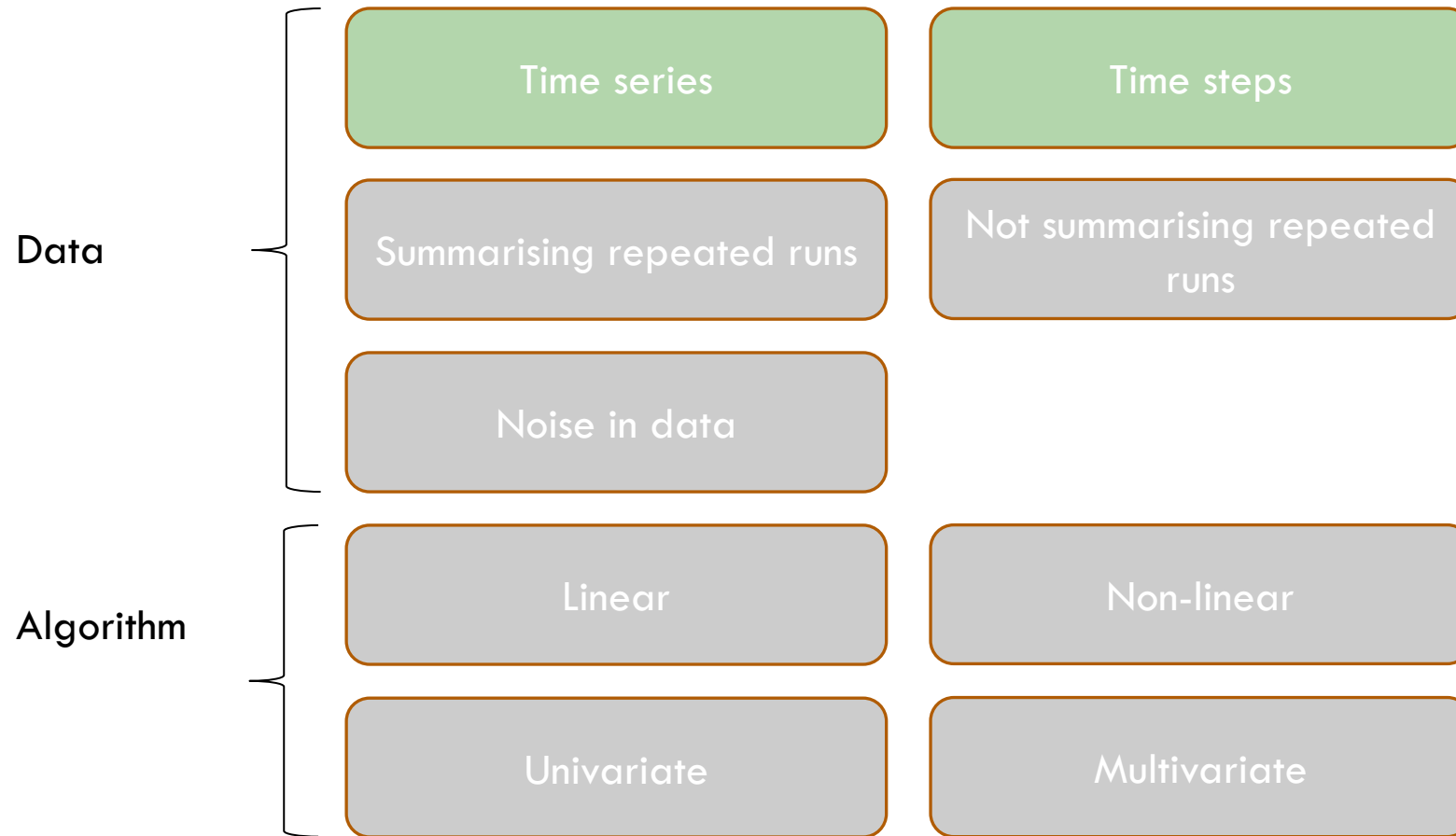
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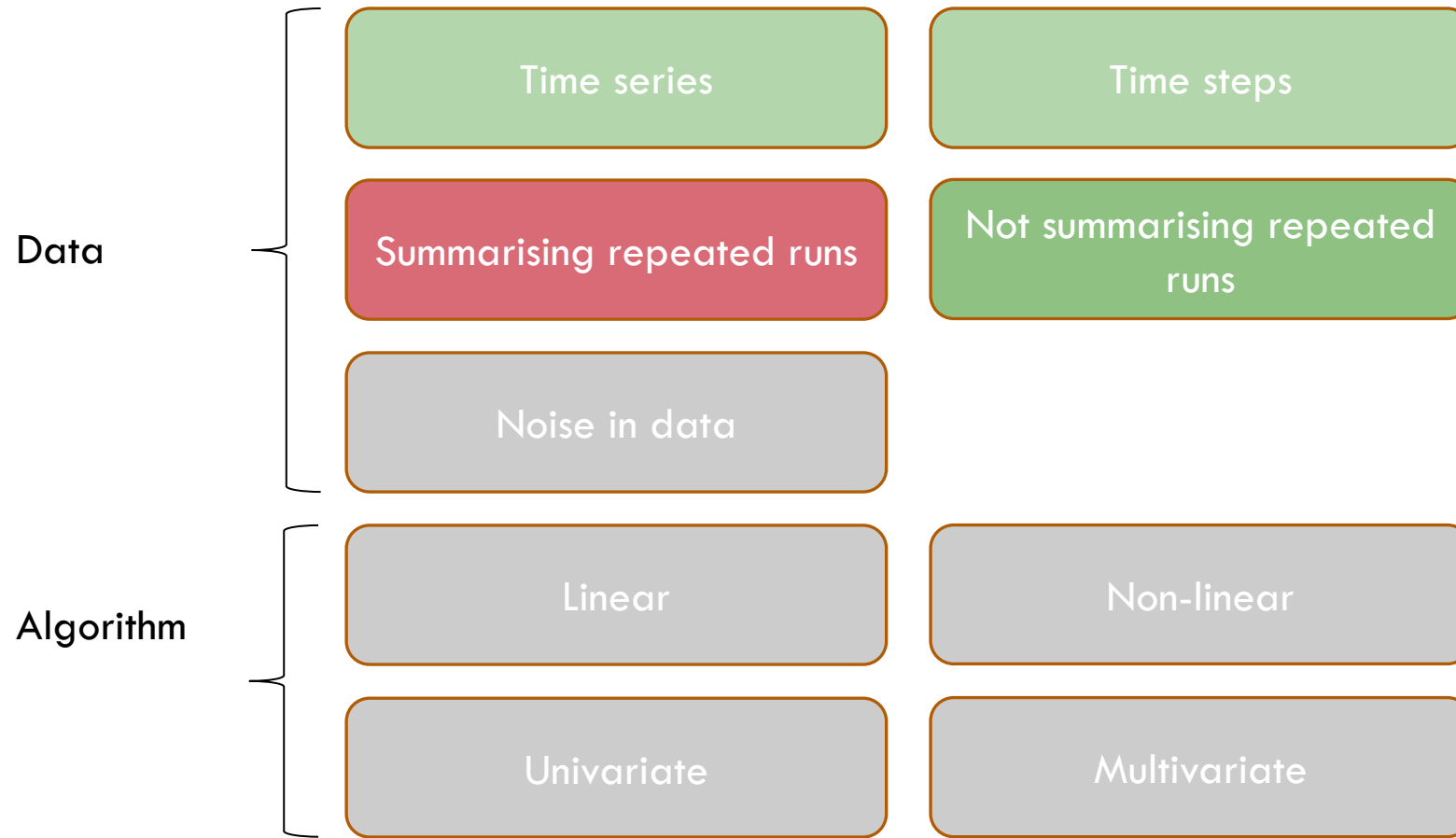
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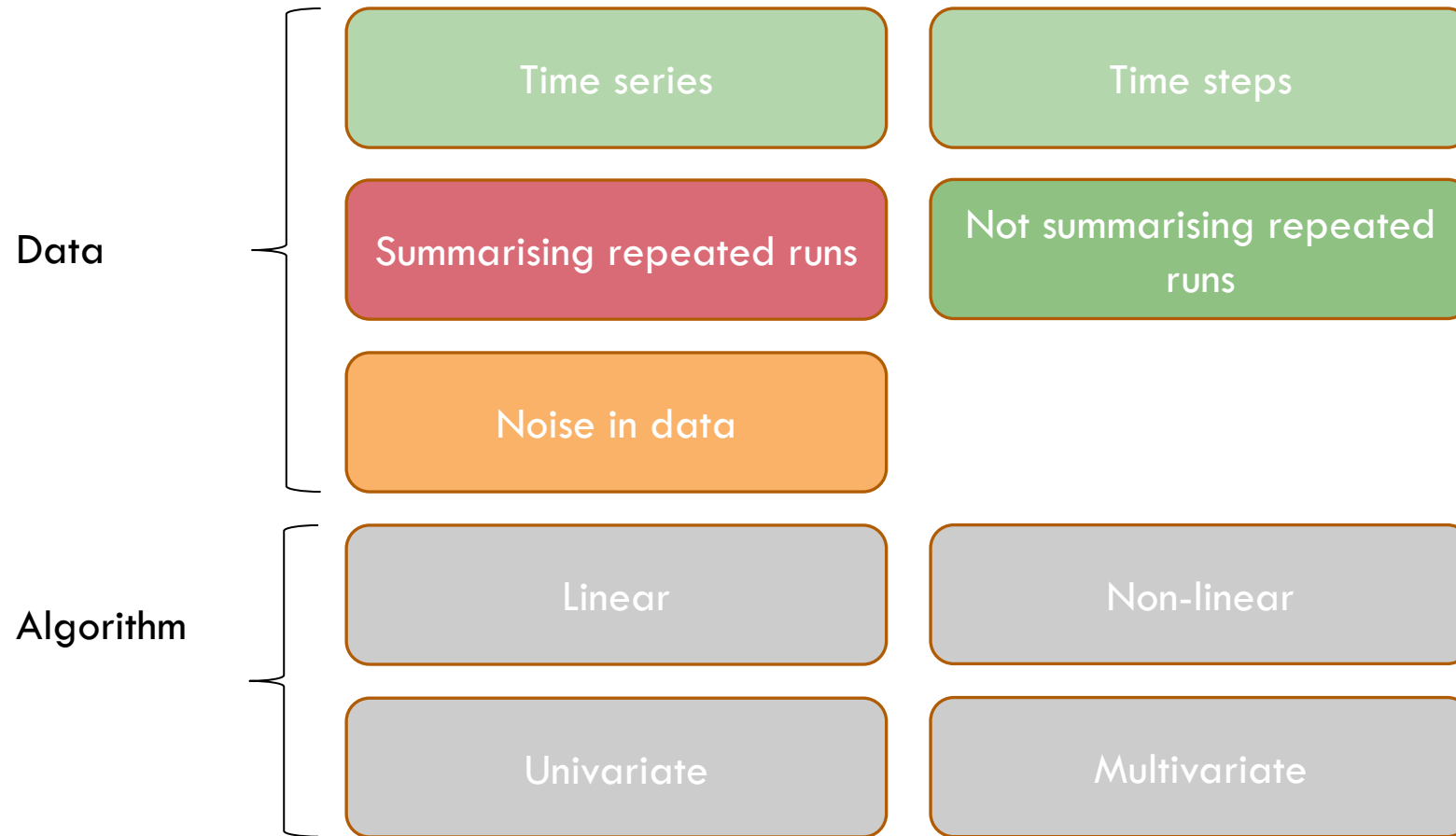
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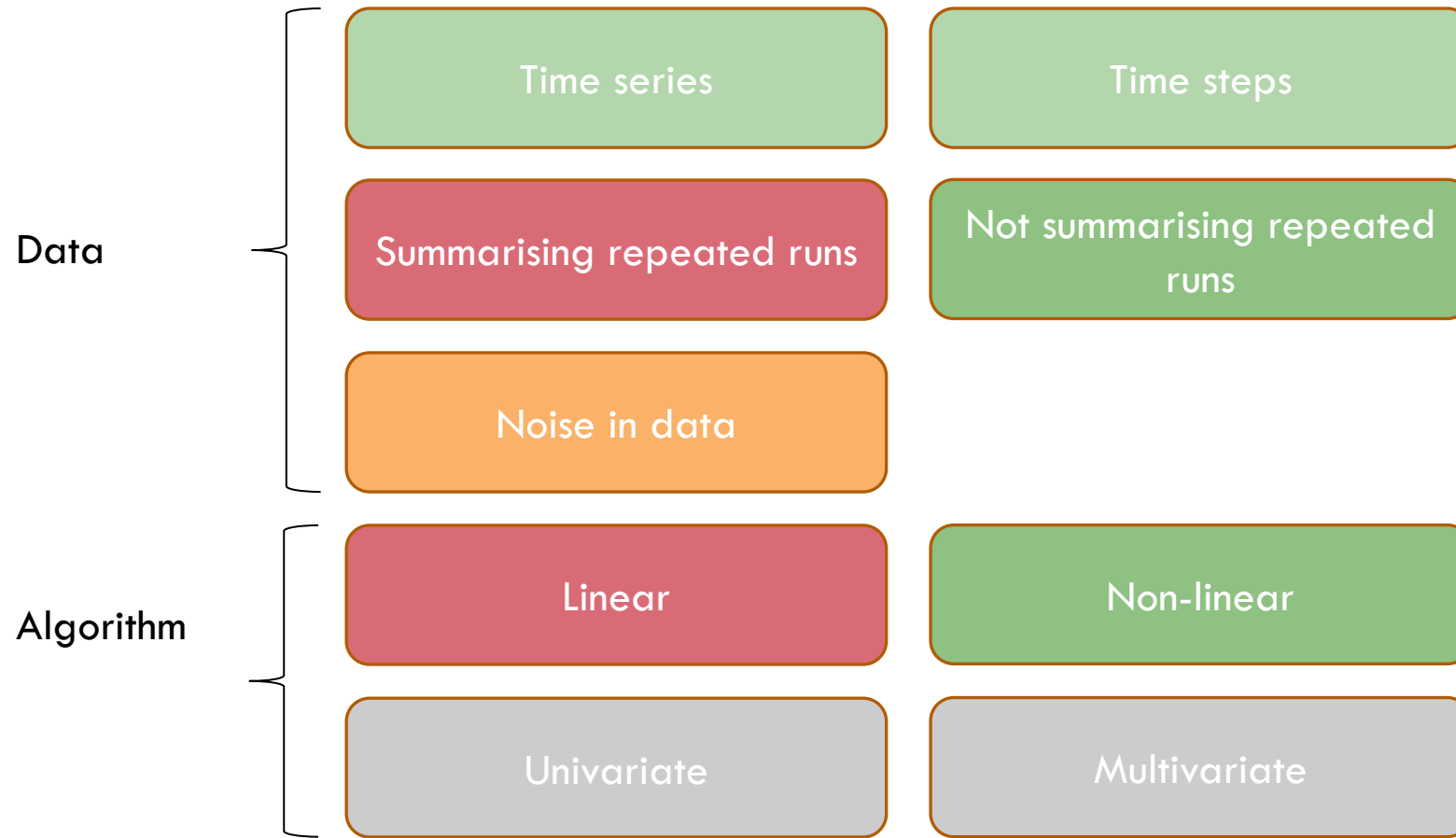
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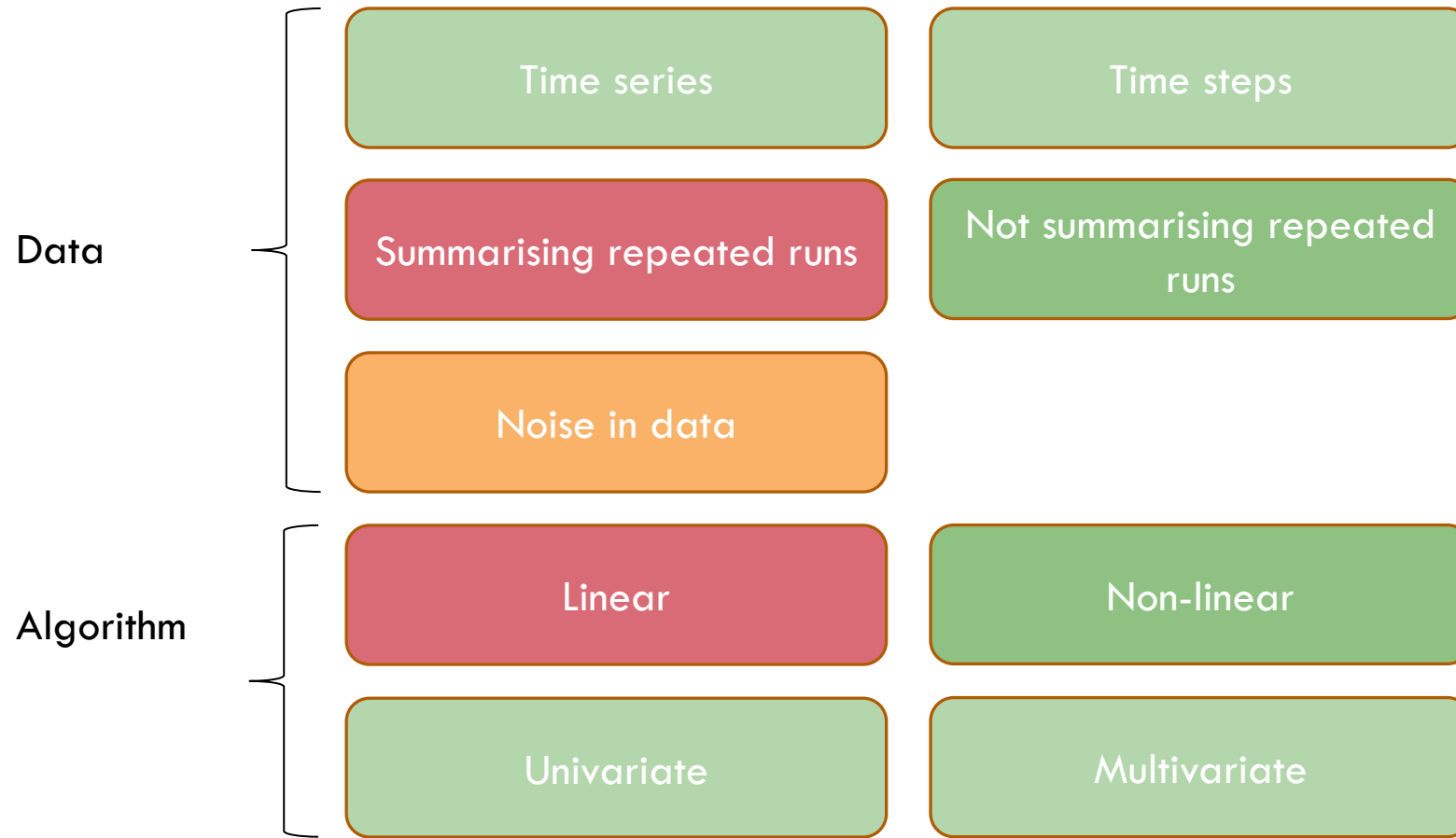
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DISCUSSION

STRENGTHS & LIMITATIONS

Strengths

- Overview of calibration steps
- Started to identify which steps may be influential

Limitations

- Computational limitations
 - Parameters as a set
 - Time points

DISCUSSION

IDEAS FOR FUTURE RESEARCH

- Sampling
- Evaluating performance
- Algorithms
- Expanding methodological questions
- Expanding the study

CONCLUSION

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THANK YOU

QUESTIONS?

BIBLIOGRAPHY

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