Université de Montréal

S2M

Pyomeca
Biomechanical analysis

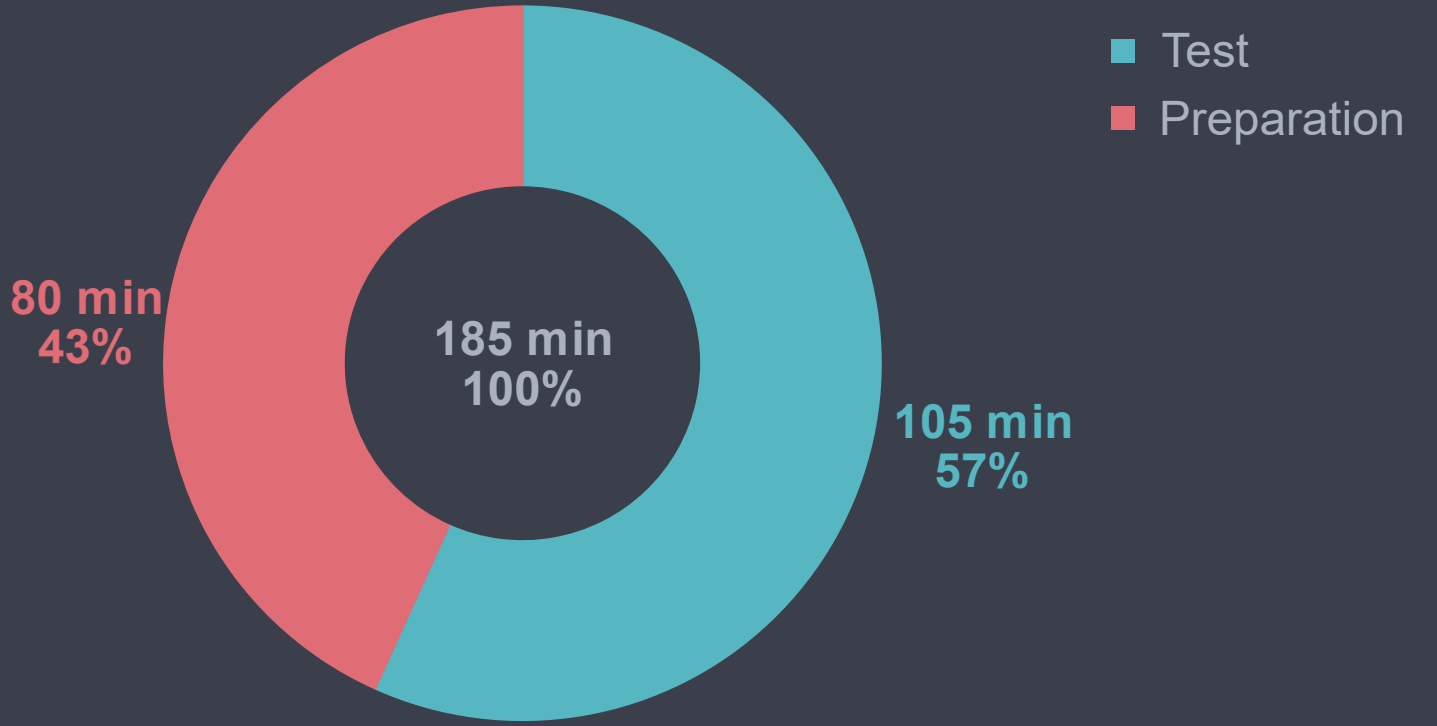
Machine learning reduces the amount of necessary maximum voluntary isometric contractions tests of the shoulder muscles

Romain Martinez*, Jonathan Tremblay, Mickael Begon, Fabien Dal Maso

World Congress of Biomechanics 2018, Dublin

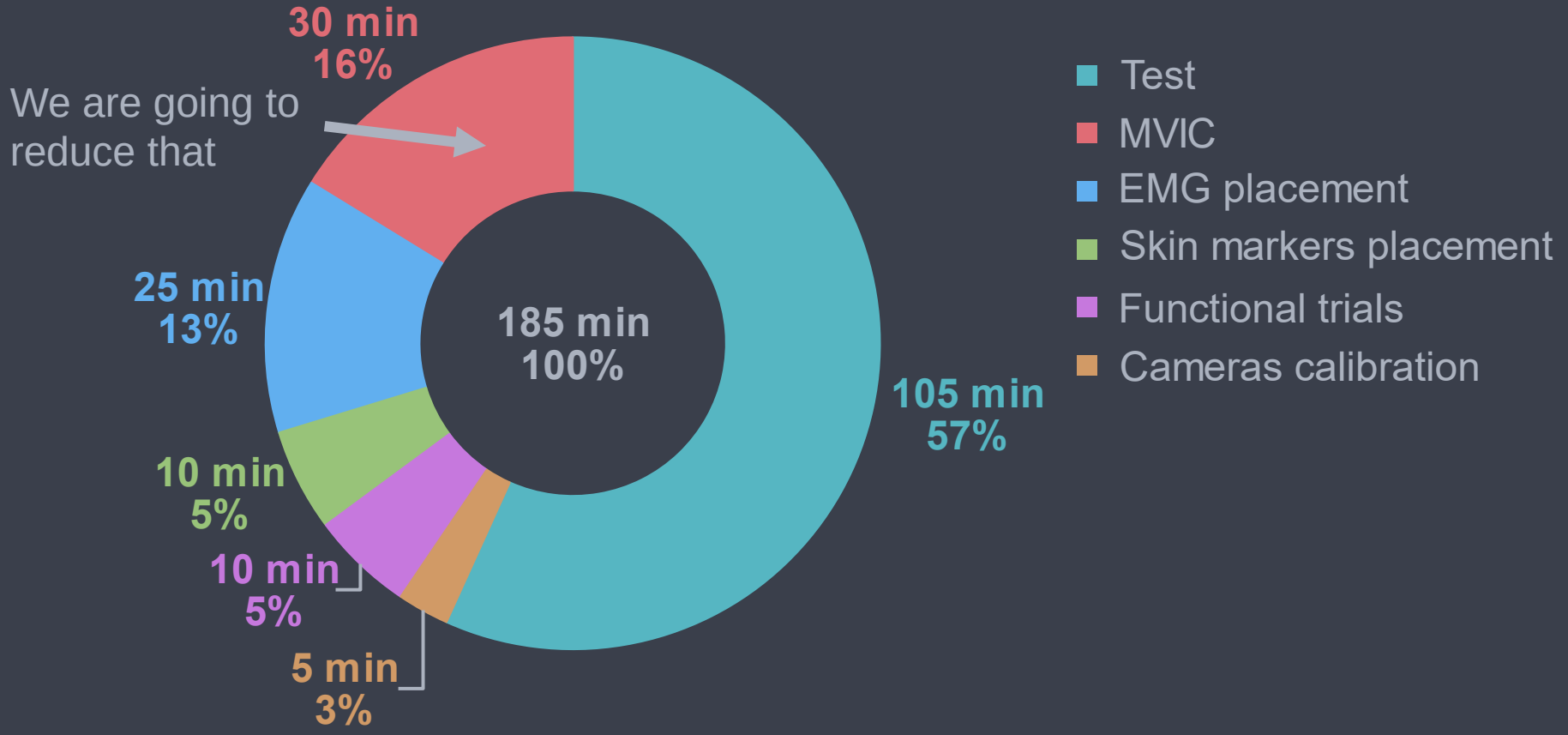
Introduction

We spend to much time preparing experiments



Introduction

We spend to much time doing *MVICs*



Introduction

What is *MVIC?*

Maximum **V**oluntary **I**sometric **C**ontraction (*MVIC*)
Test used to normalize an electromyographic signal

Electro**M**yo**G**raphie (*EMG*)
Give an estimate of muscle activation

Warning
EMG ≠ muscle activation—but a *particular* voltage measured

Normalization
Required to reduce inter-individual variability

Introduction

What is *MVIC?*

Problem

No *MVIC* allows maximum contraction for a *set* of muscles

Shoulder complex

Boettcher et al., 2008

Combination of *4 tests* to normalize *12 muscles*

- ☑ Few tests required
- ☒ Unrepresentative

Dal Maso et al., 2016

Combination of *12 tests* to normalize *12 muscles*

- ☒ Large number of tests
- ☑ Representative

Introduction

Objective

Boettcher et al., 2008

Combination of *4 tests* to normalize *12 muscles*

- ☑ Few tests required
- ☒ Unrepresentative

Dal Maso et al., 2016

Combination of *12 tests* to normalize *12 muscles*

- ☒ Large number of tests
- ☑ Representative

Martinez et al., 2018

Predictive approach

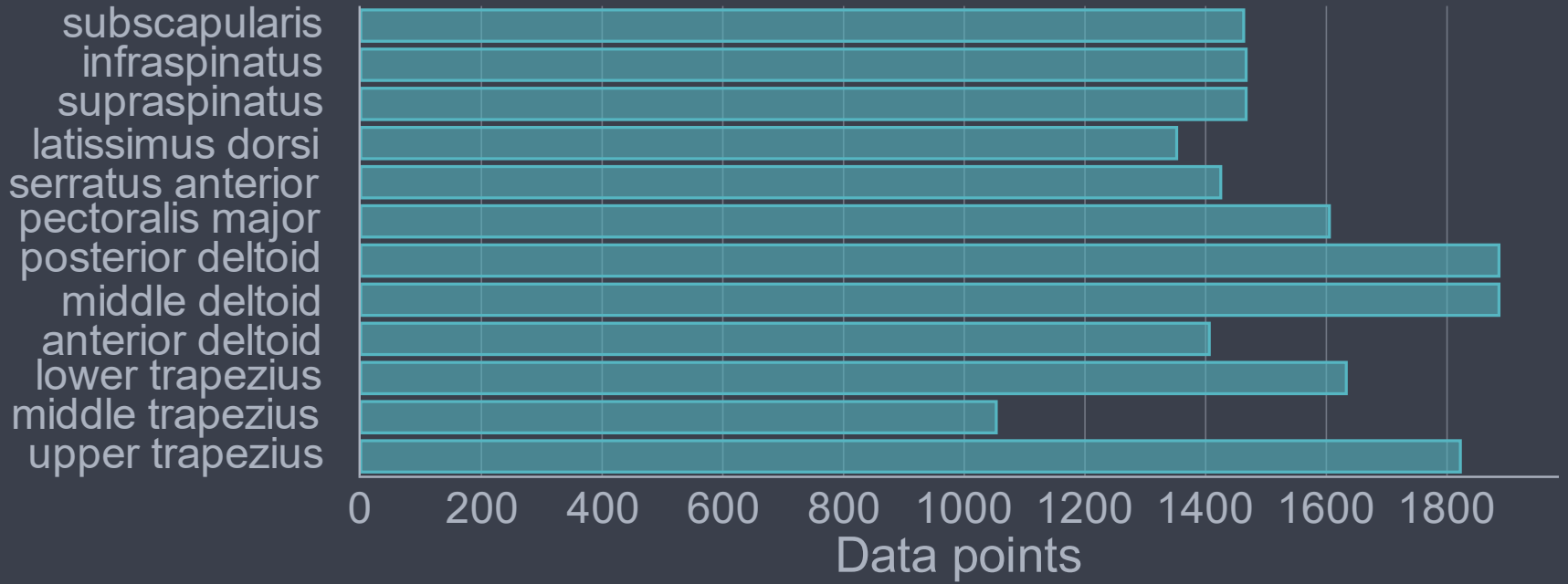
- ☑ Few tests required
- ☑ Representative

Methods

Data collected

18,465 data points

≈ 12 shoulder muscles × ≈ 16 *MVICs* × 184 participants



Methods

Data processing

1. **Raw** data

Muscle	Participant	Test 1	Test 2	Test 3	⋯	Test 16
1	1	0.127825	0.124255	0.146927	⋯	nan
2	1	0.179864	0.294909	0.295846	⋯	0.199097
3	1	0.078753	0.106490	nan	⋯	0.272709
...	...	...	...	...	...	...
12	184	0.150353	0.104654	0.115272	⋯	0.150641

Methods

Data processing

2. **Normalization** based on test # 2

Muscle	Participant	Test 1	Test 2	Test 3	···	Test 16
1	1	72	100	130	···	nan
2	1	64	100	91	···	37
3	1	76	100	nan	···	168
...	...	...	...	...	...	...
12	184	105	100	57	···	110

Methods

Data processing

3. Compute **maximum** of each row

Muscle	Participant	Test 1	Test 2	Test 3	⋯	Test 16	Max.
1	1	72	100	130	⋯	nan	130
2	1	64	100	91	⋯	37	100
3	1	76	100	nan	⋯	168	168
⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯
12	184	105	100	57	⋯	110	110

Methods

Data processing

4. **Predict** the maximum based on a subset of tests

Inputs

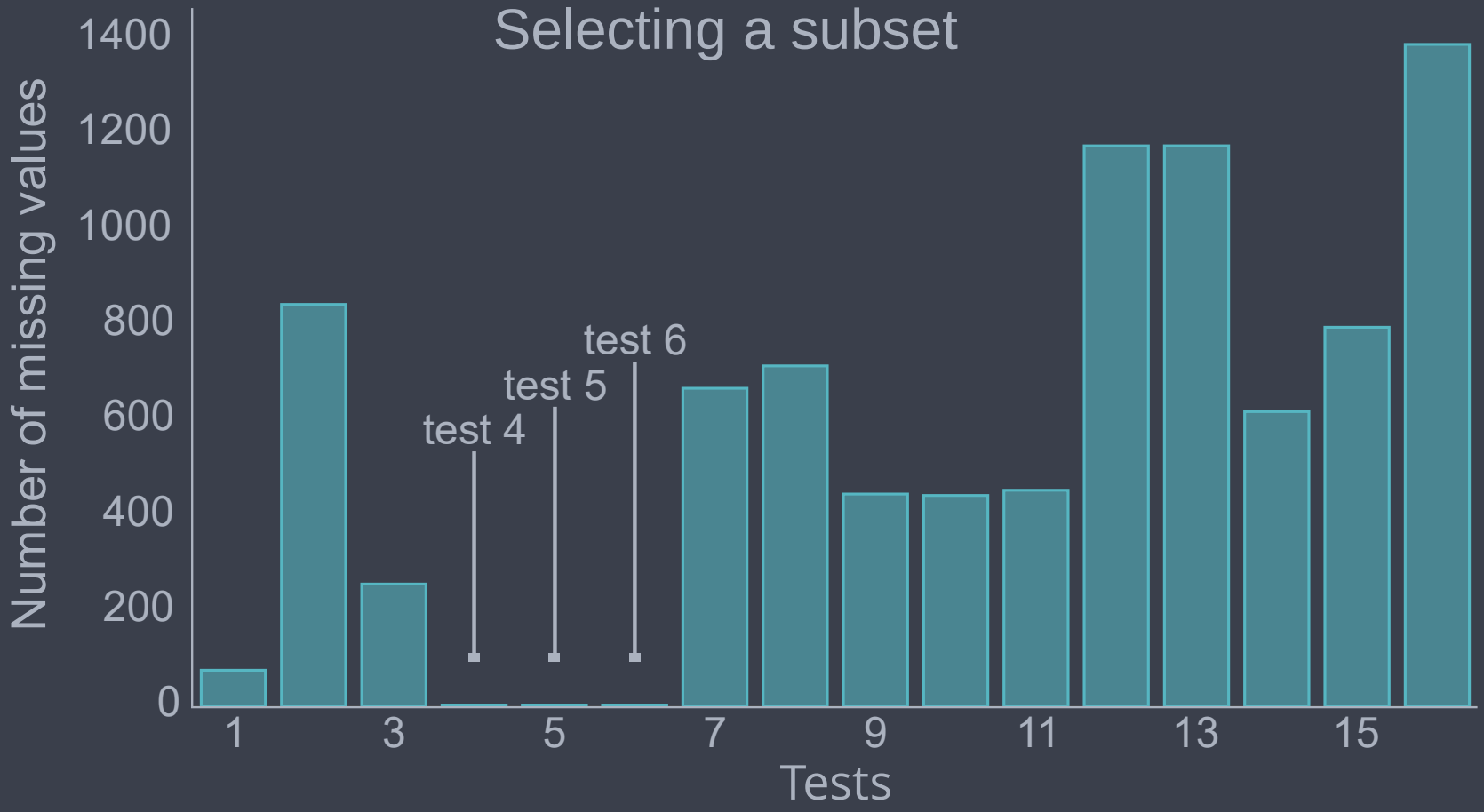
Muscle	Participant	Test 1	Test 2	Test 3
1	1	72	100	130
2	1	64	100	91
3	1	76	100	nan
...	...	...	...	...
12	184	105	100	57

Prediction

Output

Max.
130
100
168
...
110

Methods


Selecting a subset
Number of missing values
1400
1200
1000
800
600
400
200
0
test 4
test 5
test 6
1
3
5
7
9
11
13
15
Tests

Methods

MVIC 1

MVIC 2

MVIC 3

MVIC 4

MVIC 5

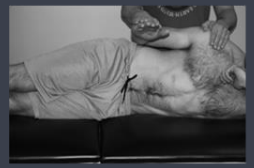
MVIC 6

MVIC 7

MVIC 8

MVIC 9

MVIC 10



MVIC 11

MVIC 12

MVIC 13

MVIC 14

MVIC 15

MVIC 16

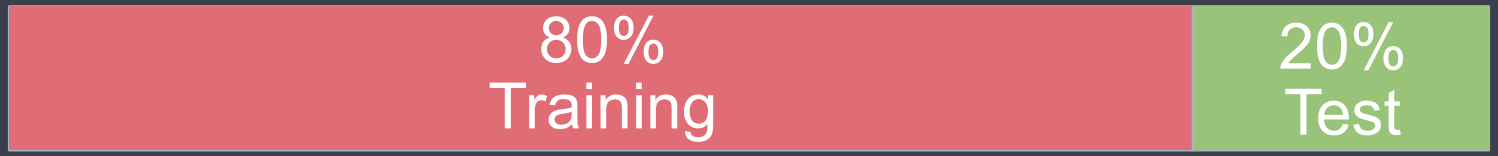
- Martinez
- Boettcher
- Dal Maso

Methods

Model evaluation

Training - test sets

To make sure that the model will **generalize well**



Non-parametric T-tests on relative error

$$\left\| \frac{\text{real} - \text{prediction}}{\text{real}} \right\| \times 100$$

4 methods: Martinez, Boettcher, Dal Maso, Dal Maso updated

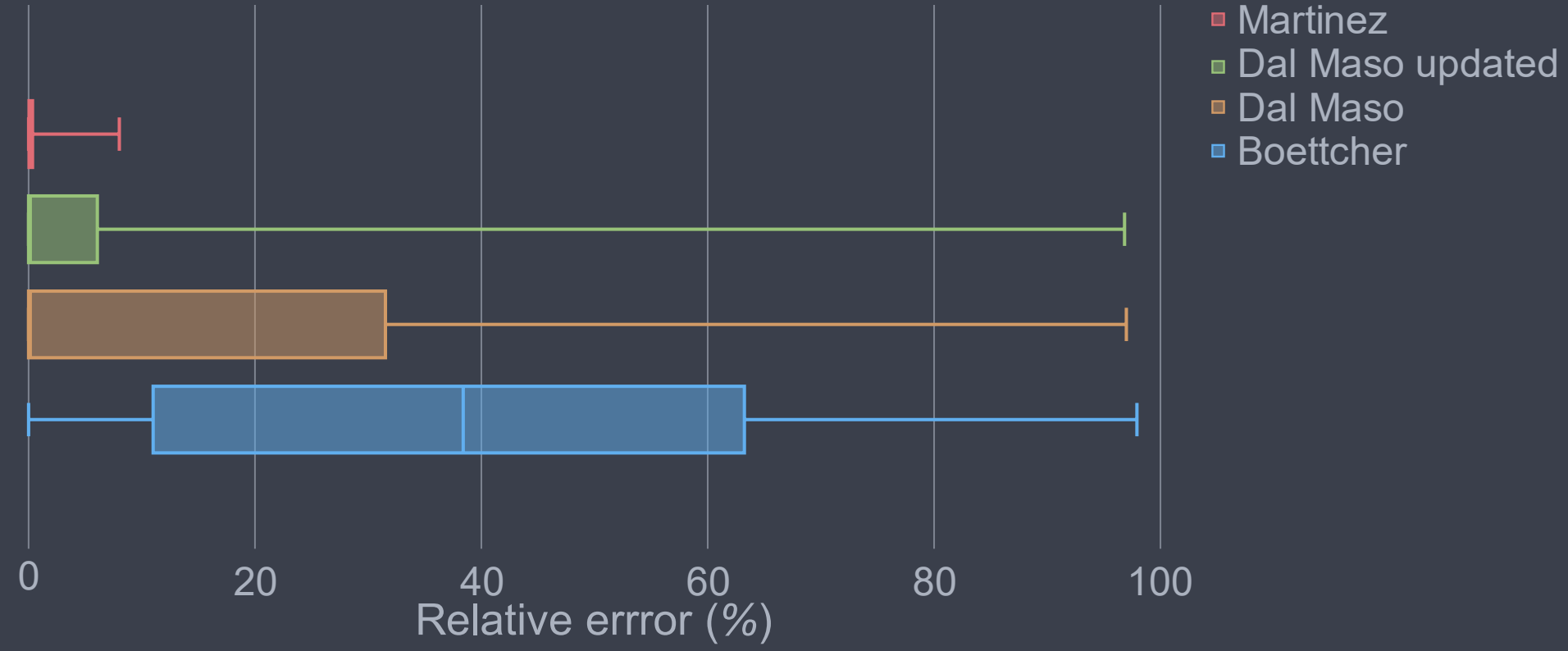
Results

Model performance

Average = 0.37%

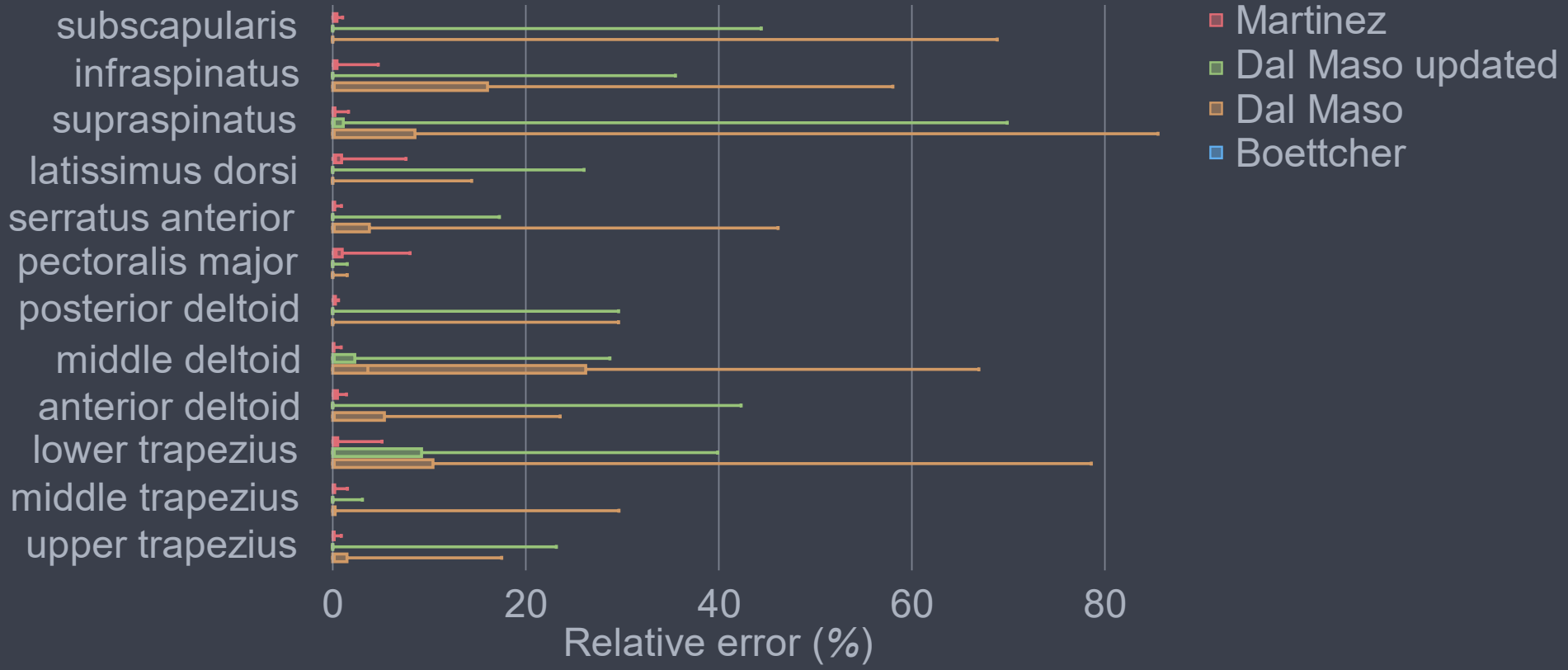
Results

Comparison with other methods



Results

Comparison with other methods



Discussion

Reducing time – increasing performance

Reducing Time

5 minutes (*3 tests*) *vs.* 22 minutes (*12 tests*)

Increasing performance

Small relative error (*0.37%*)

Method	**Relative error** (%)	**Execution time** (*min*)
Boettcher	**40.30**	6.67
Dal Maso	20.00	**22**
Dal Maso updated	9.36	**22**
Martinez	**0.37**	**4.7**

Discussion

Practical application

Usage
Pre-trained model available for the community

1. Download the model from `github.com/romainmartinez/mvc`

2. Install `Python` and the `Scikit-learn` library

3. Make a prediction from your data

```
from sklearn.externals import joblib
x = joblib.load('my_data.pkl')
model = joblib.load('model.pkl')
prediction = model.predict(x)
```

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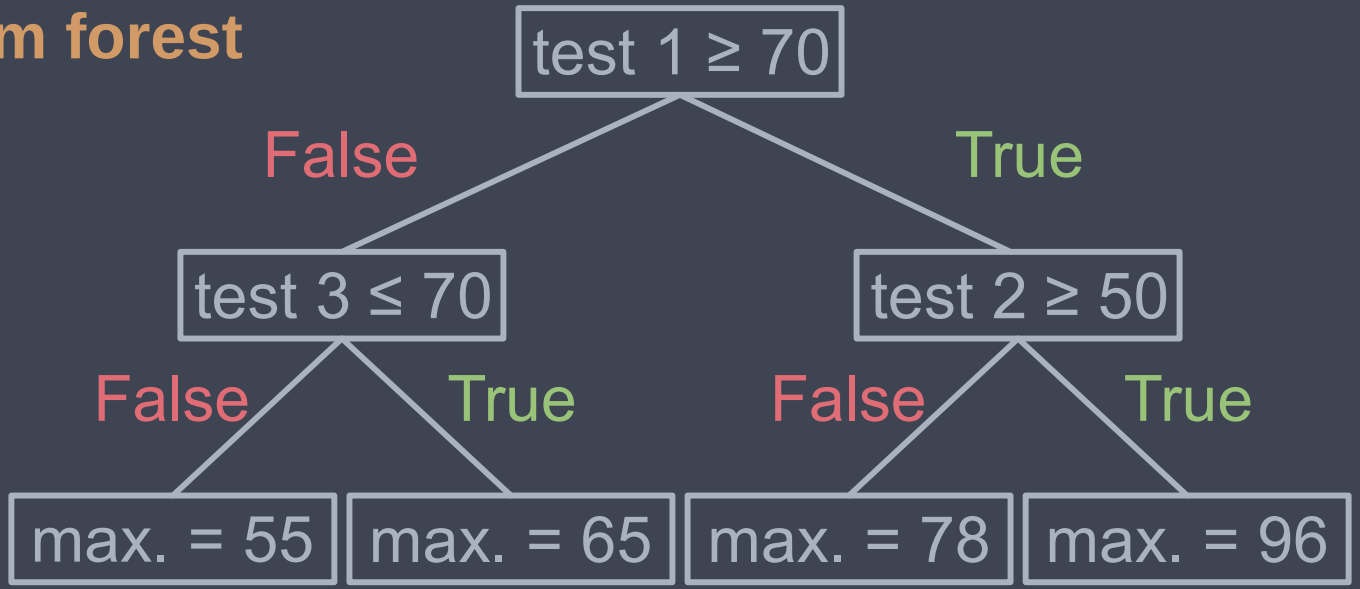
Methods

Choosing a model

Random forest



« Wisdom of the crowds »

Averaging a large number of novices is better than one expert