HUMAN DATA ANALYTICS

Deep Learning Techniques for Gesture Recognition: Dealing With Inactivity

Matteo Drago, Riccardo Lincetto
Dept. of Information Engineering, University of Padova, Italy

Prof. Michele Rossi

matteo.drago@studenti.unipd.it
riccardo.lincetto@studenti.unipd.it

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Outline

- Introduction
- Dataset description
- Related Work
- Our proposal
- Discussion of results
- Conclusion and future works

Introduction

Human Activity Recognition:

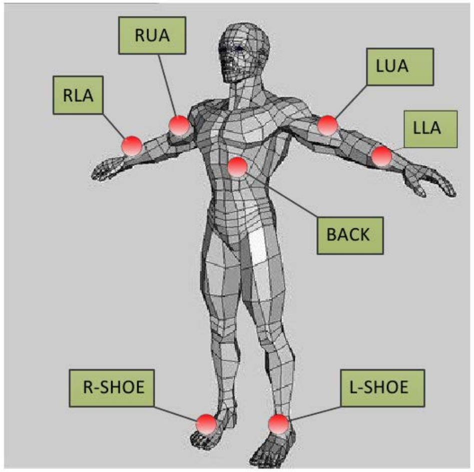
- Visual detection from images and video
- Gesture recognition from sensor-based data

In the past decade, many models have been designed for time series classification.

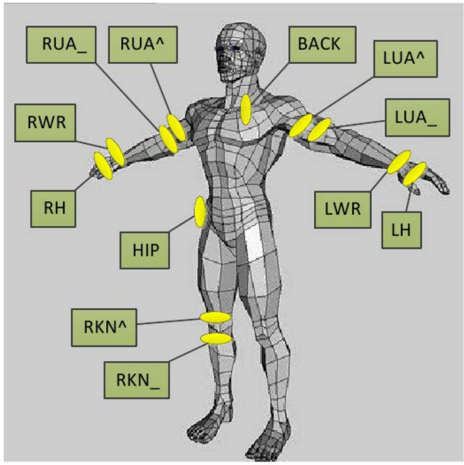
Main problems:

- LACK of BENCHMARKING DATASET to compare different solutions
- ABSENCE of DETAILS in most of the models presented in the literature

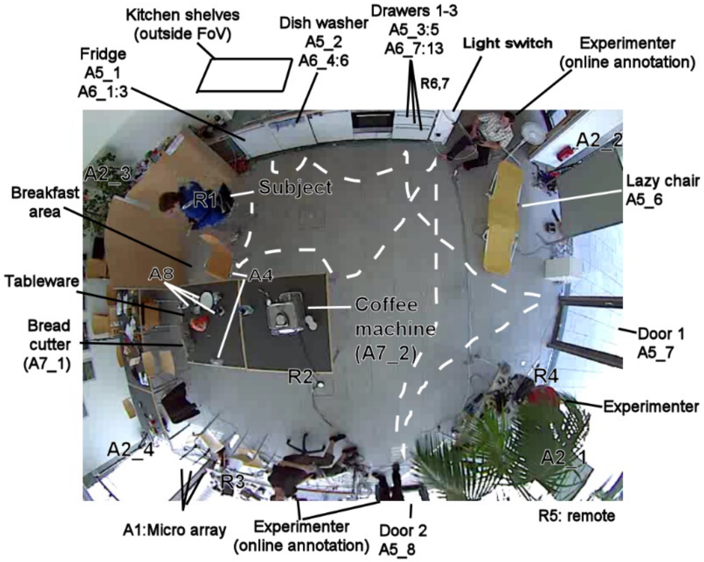
OPPORTUNITY DATASET



= Complete Inertial Measurement Unit



= Triaxial Accelerometer



[1] R. Chavarriaga, H. Sagha, A. Calatroni, S. T. Digumarti, G. Tröster, J. del R. Millán, and D. Roggen, "The opportunity challenge: A benchmark database for on-body sensor-based activity recognition," *Pattern Recognition Letters*, 2013.

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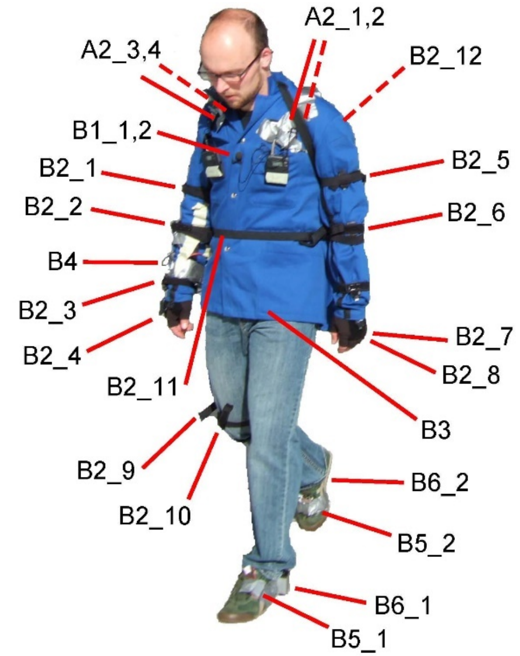
- 4 different subjects
- 7 Inertial Measurement Units
- 12 accelerometer sensors



113 channels of measurements

Data has been collected in two distinct modalities :

- 5 sessions of **Activity of Daily Living** (ADL)
- **Drill** : 20 repetitions of low level activities

Multiclass Classification Problem

TASK A:

- Classification of high level gestures / modes of locomotion

Standing, Walking, Lying, Sitting

TASK B2:

- Recognition of low level gestures (17 in total)

Open Dishwasher, Close Dishwasher, Open Fridge, Close Fridge,

Open Drawer 1, Close Drawer 1, Open Door 1, Close Door 1, …

Both tasks comprehend the *Null Class*, which represents inactivity.
A more detailed discussion on this in a couple of slides

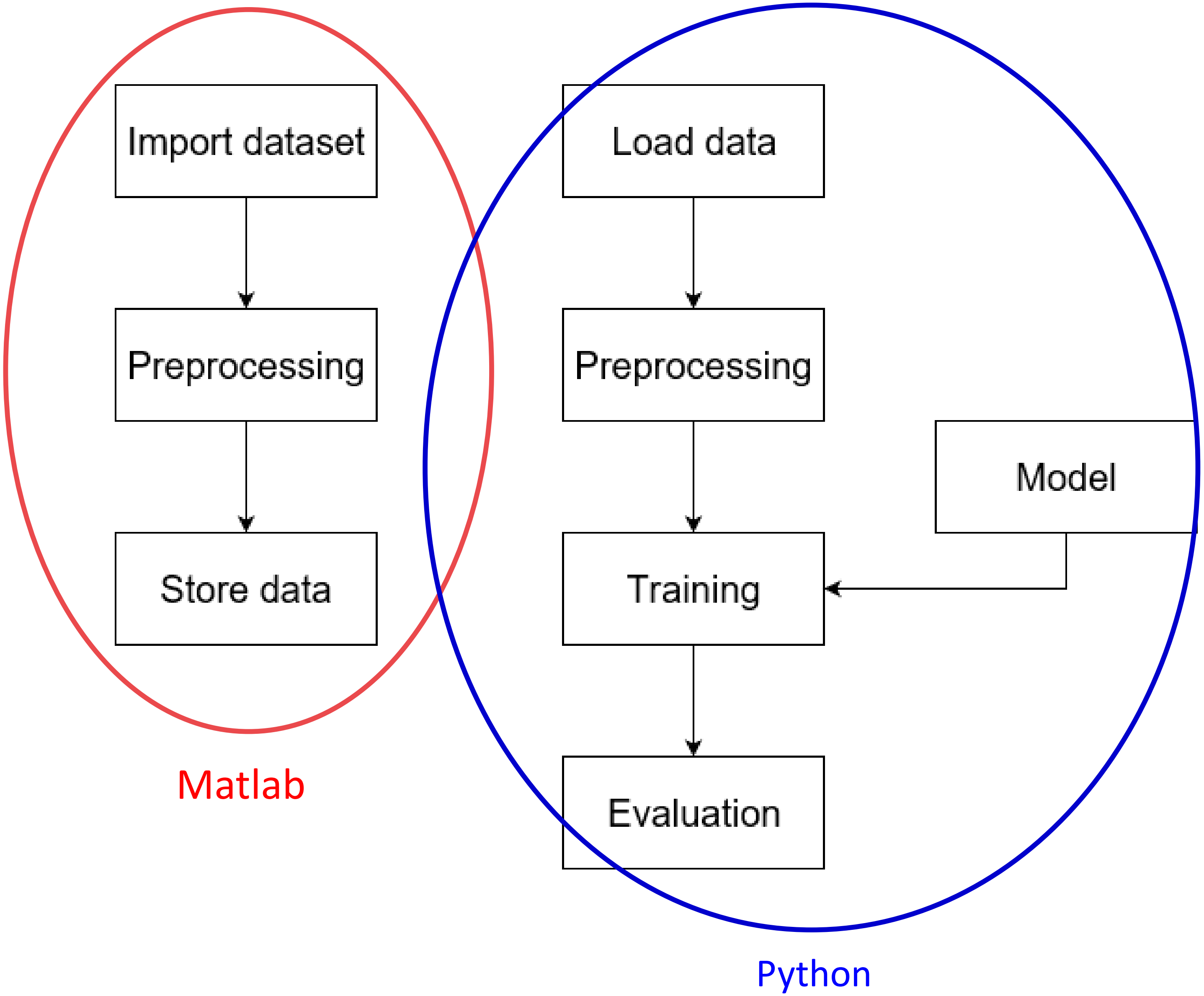
State of the Art

In the literature there’s no shortage of models trying to solve the problem. For example:

- Complete framework in [2] that performs interpolation in preprocessing and tries to cope with class imbalances (**1NN** and **SVM** as classifiers)
- **Convolutional layers** were implemented in NN along with **ReLU** and **pooling** layers in [3], in order to extract better features; they also segment the datasets into windows of samples
- A complete comparison can be found in [4] were they also implement a model comprehensive of both **convolutional** and **LSTM** layers, in order to extract sensible features and exploit the correlation among consecutive samples and independent windows

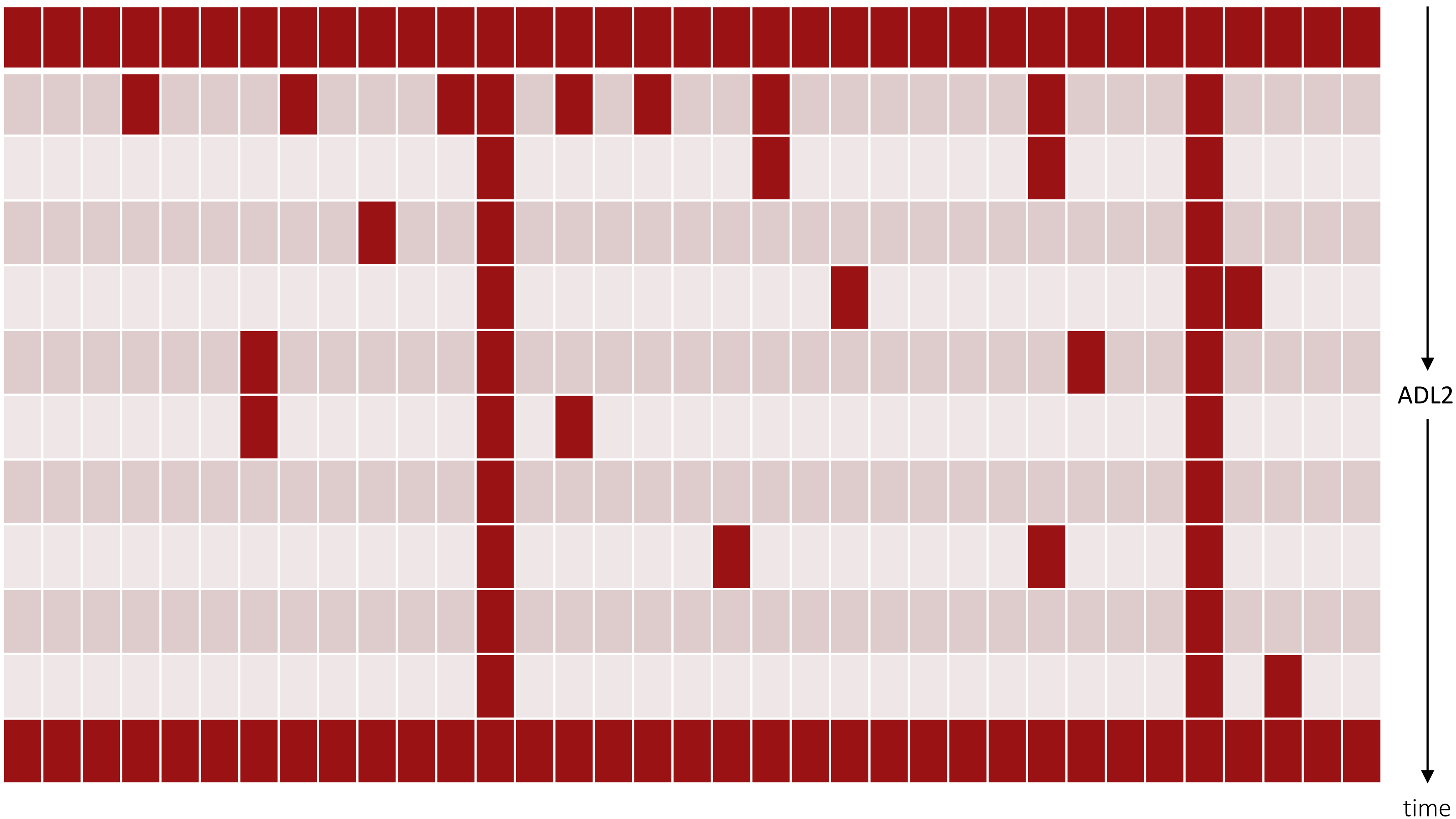
[2] H. Cao, M. N. Nguyen, C. Phua, S. Krishnaswamy, and X. Li, “An integrated framework for human activity classification.,” in *UbiComp*,pp. 331–340, 2012.
[3] J. Yang, M. N. Nguyen, P. P. San, X. Li, and S. Krishnaswamy, “Deep convolutional neural networks on multichannel time series for human activity recognition.,” in *Ijcai*, vol. 15, pp. 3995–4001, 2015.
[4] F. Li, K. Shirahama, M. A. Nisar, L. Köping, and M. Grzegorzek, “Comparison of feature learning methods for human activity recognition using wearable sensors,” *Sensors*, vol. 18, no. 2, p. 679, 2018.

Processing Pipeline of Our Proposal



Preprocessing

Original dataset (Dark squares = NaN values)



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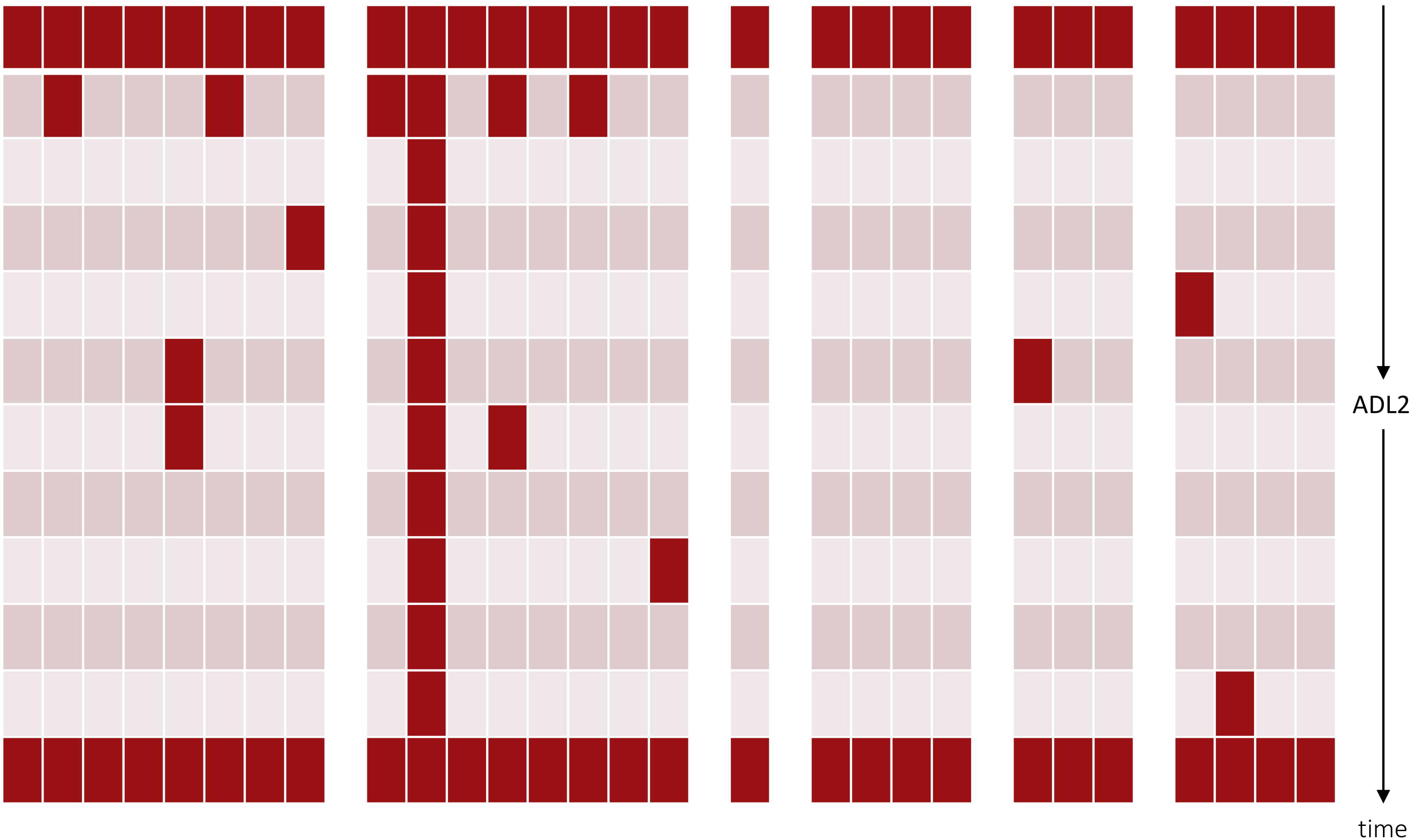
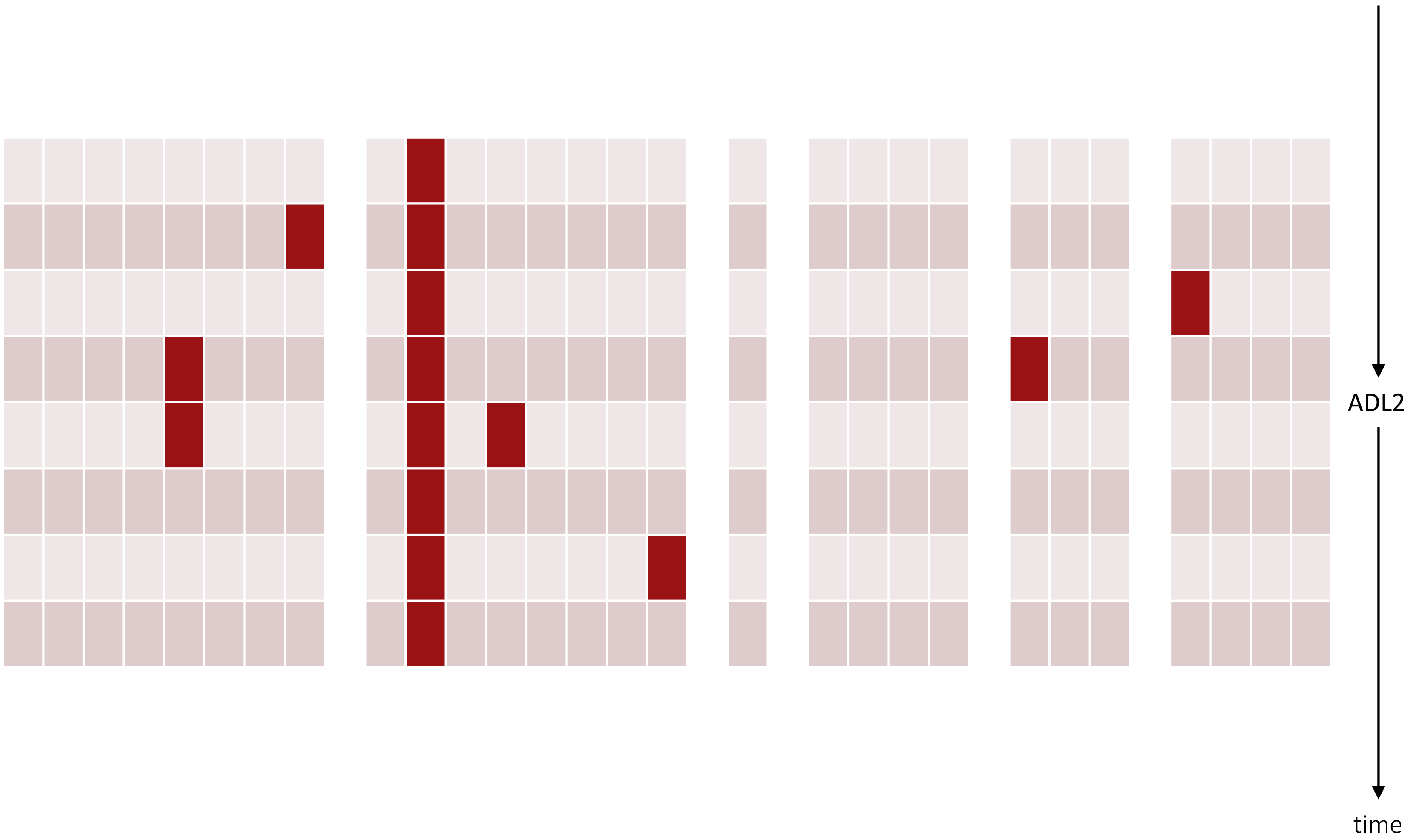
Preprocessing

Discard of useless columns, keeping on-body sensor signals



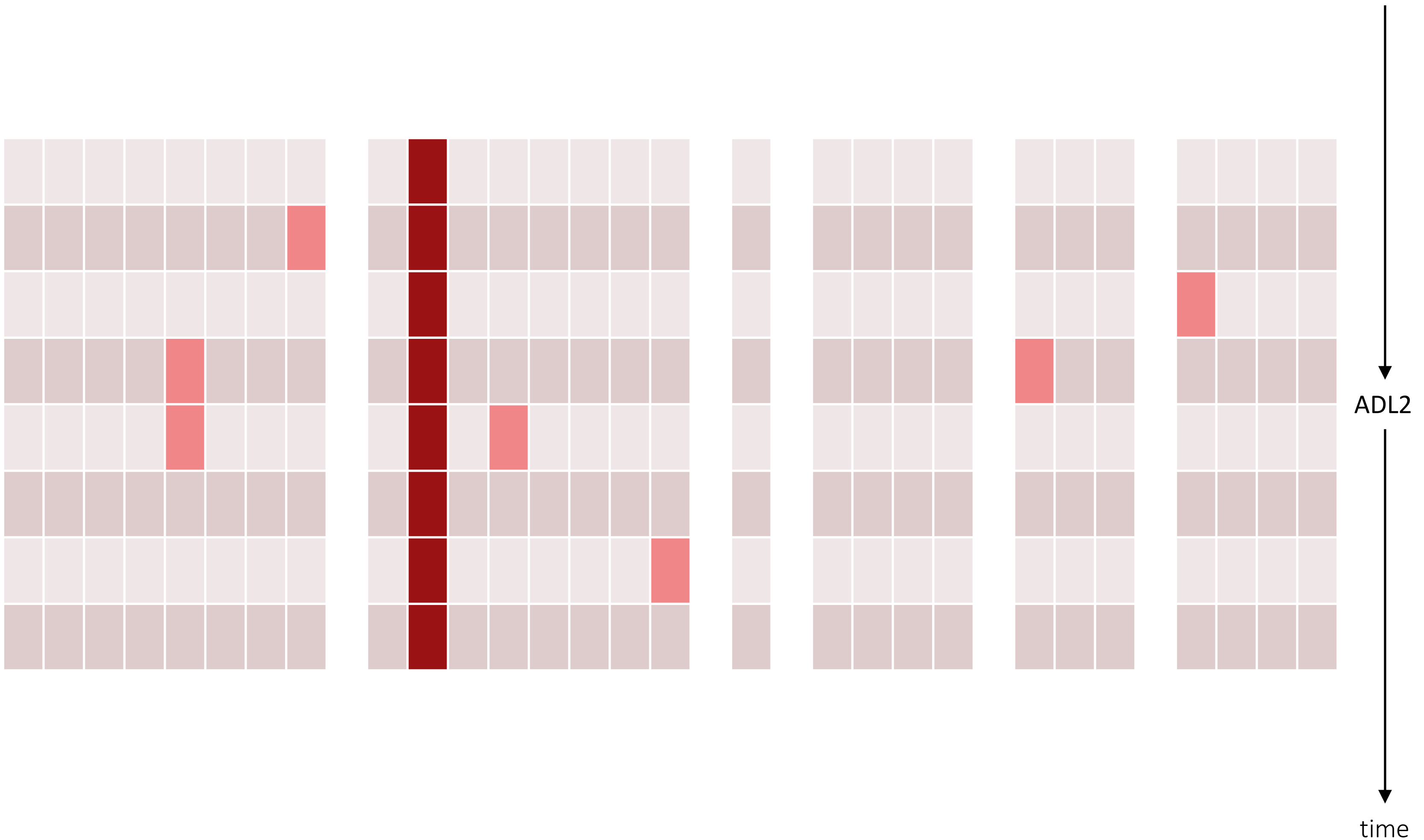
Preprocessing

Cutting of initial and final NaNs



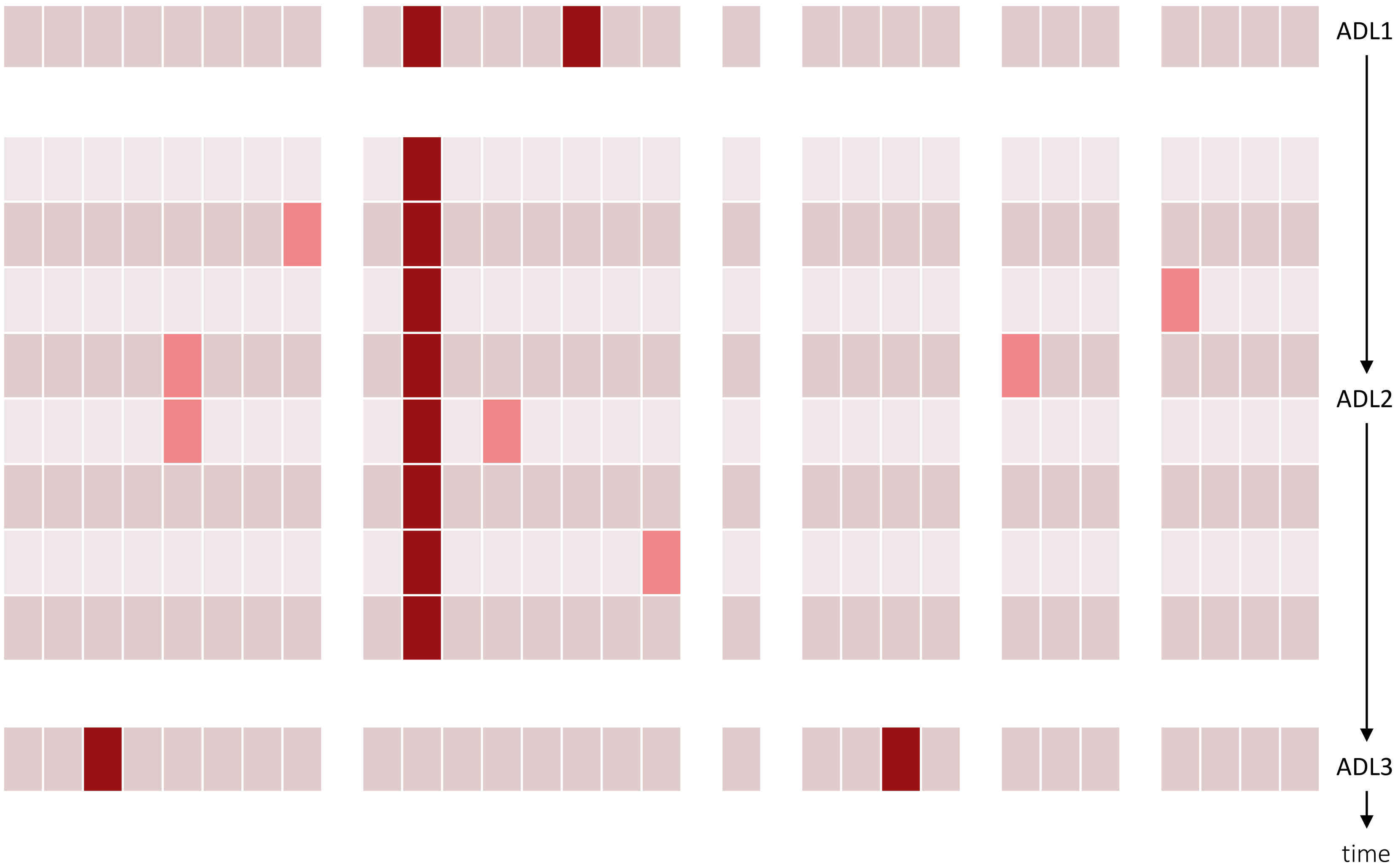
Preprocessing

Interpolation



Preprocessing

Concatenation



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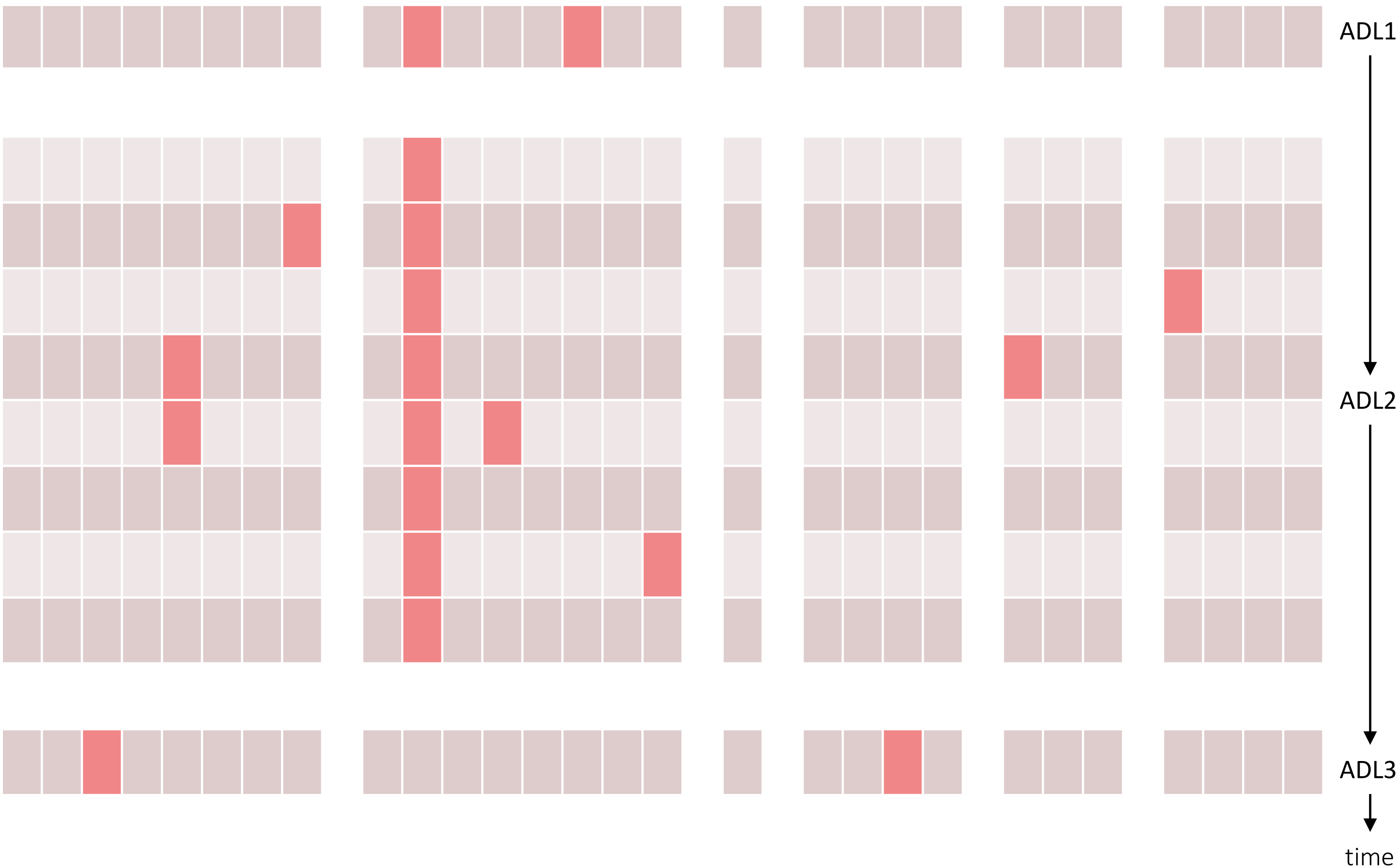
Preprocessing

Setting Nan columns to zero



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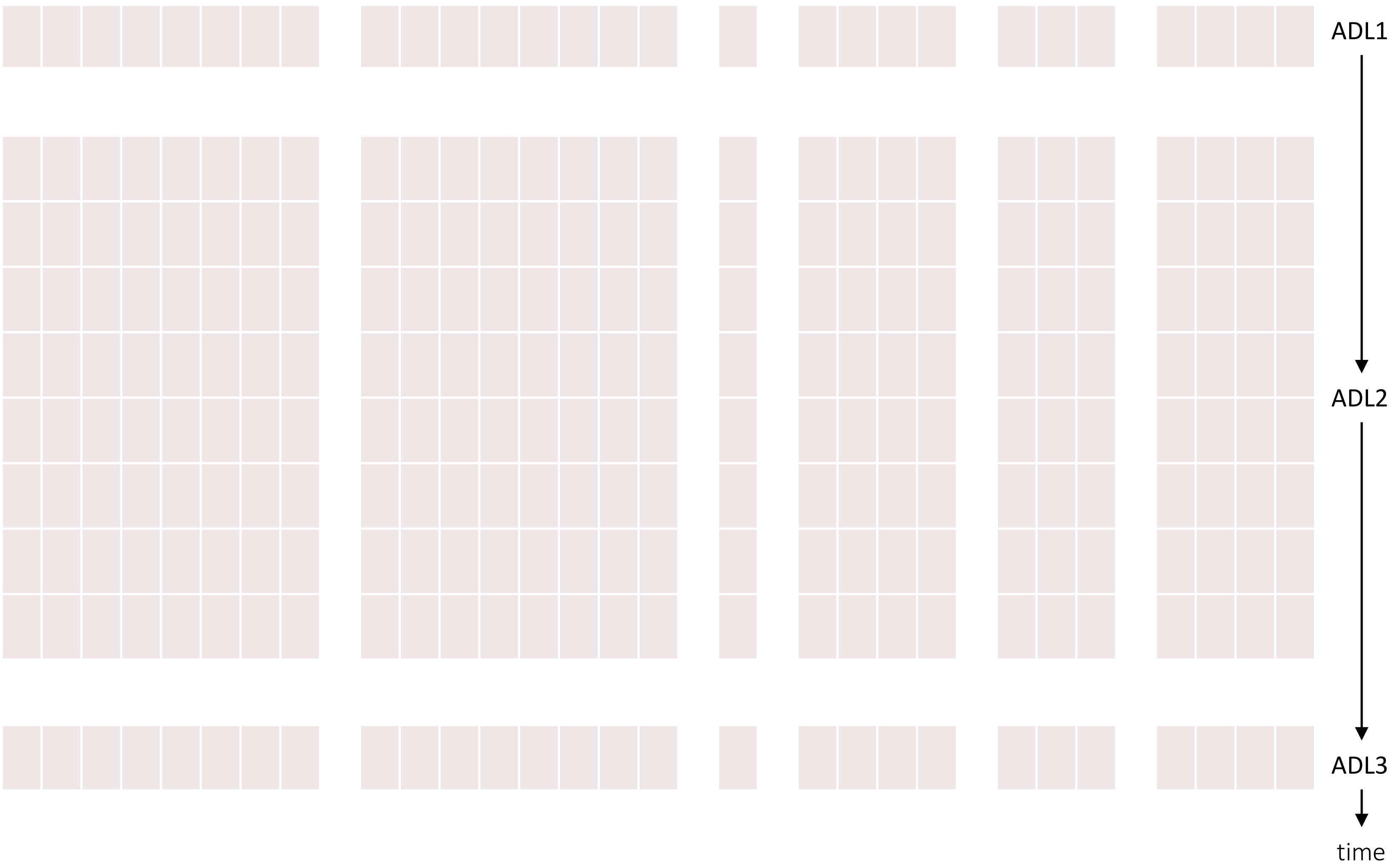
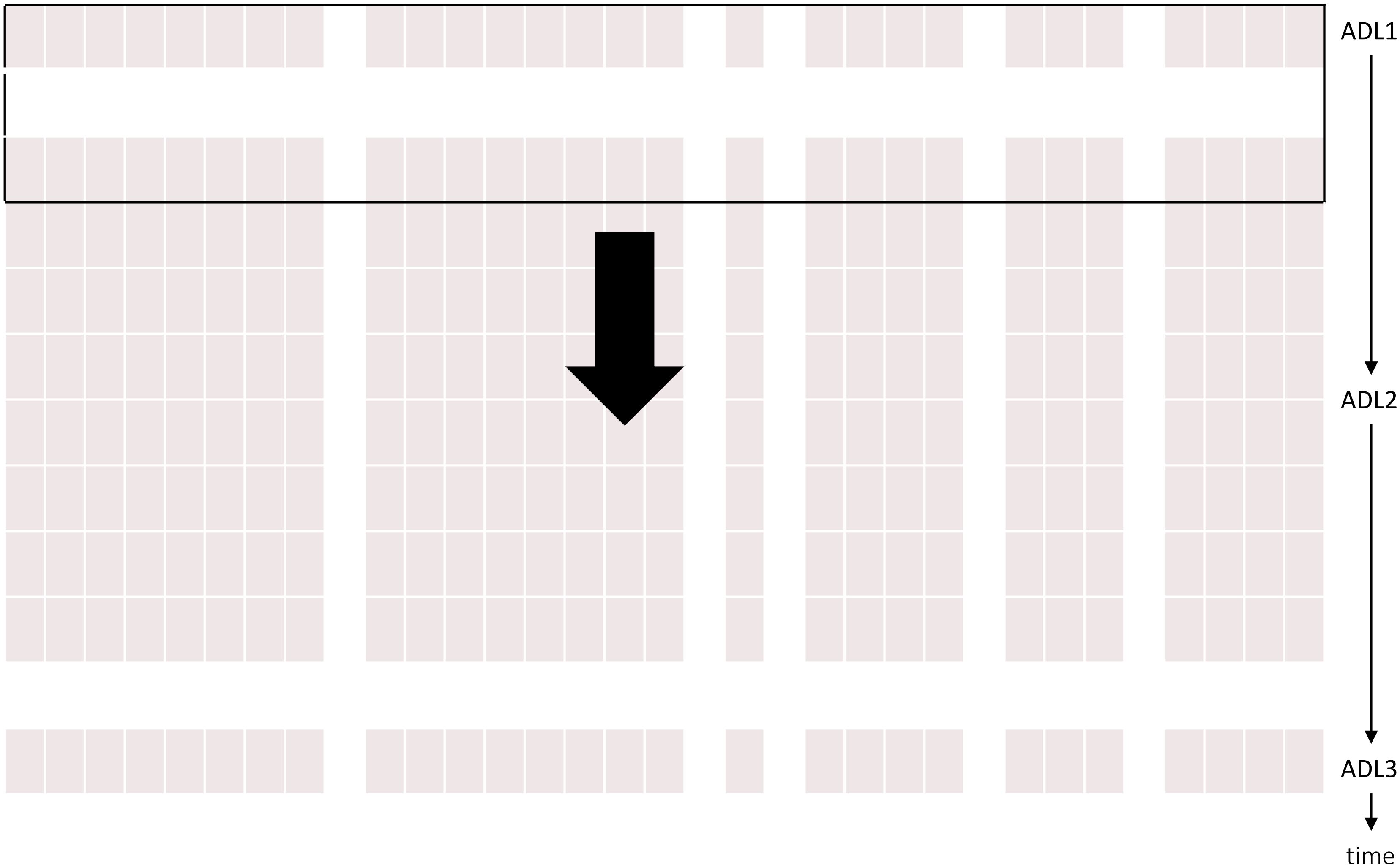
Preprocessing

Normalization



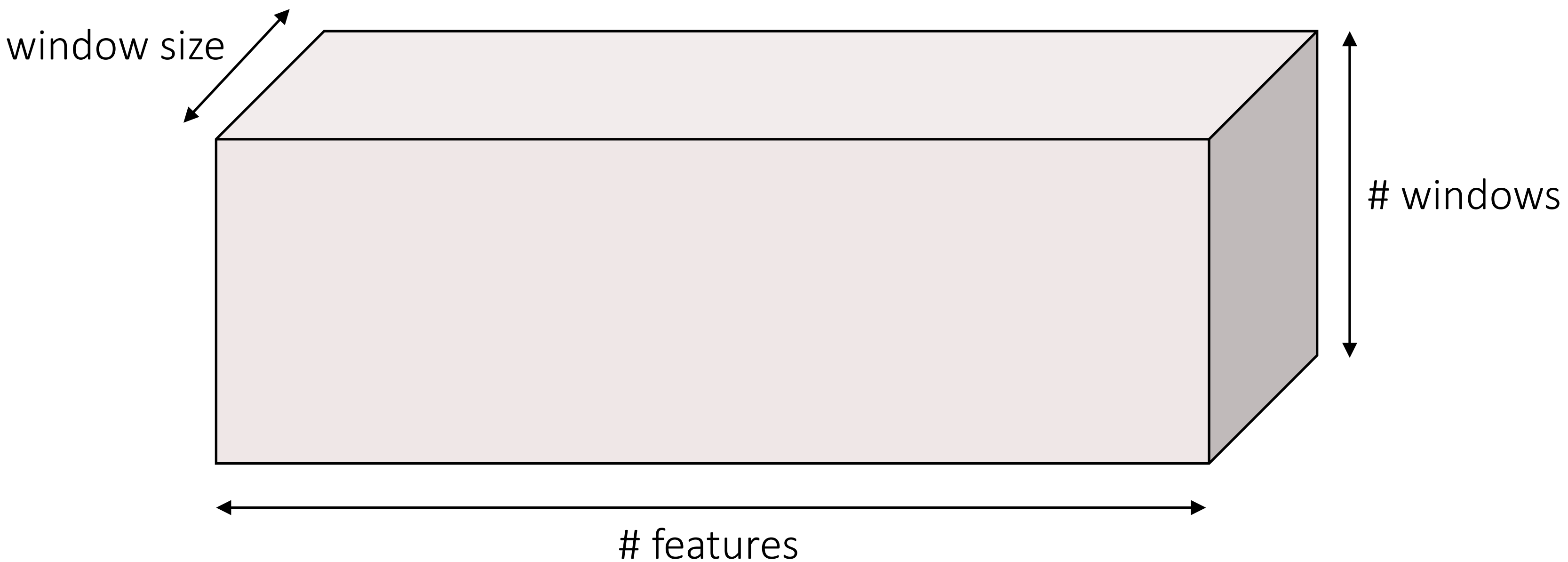
Preprocessing

Shaping (windowing)



Preprocessing

Shaping (windowing)



Training set	ADL1	Test set	ADL4
	ADL2		ADL5
	ADL3		
	Drill		

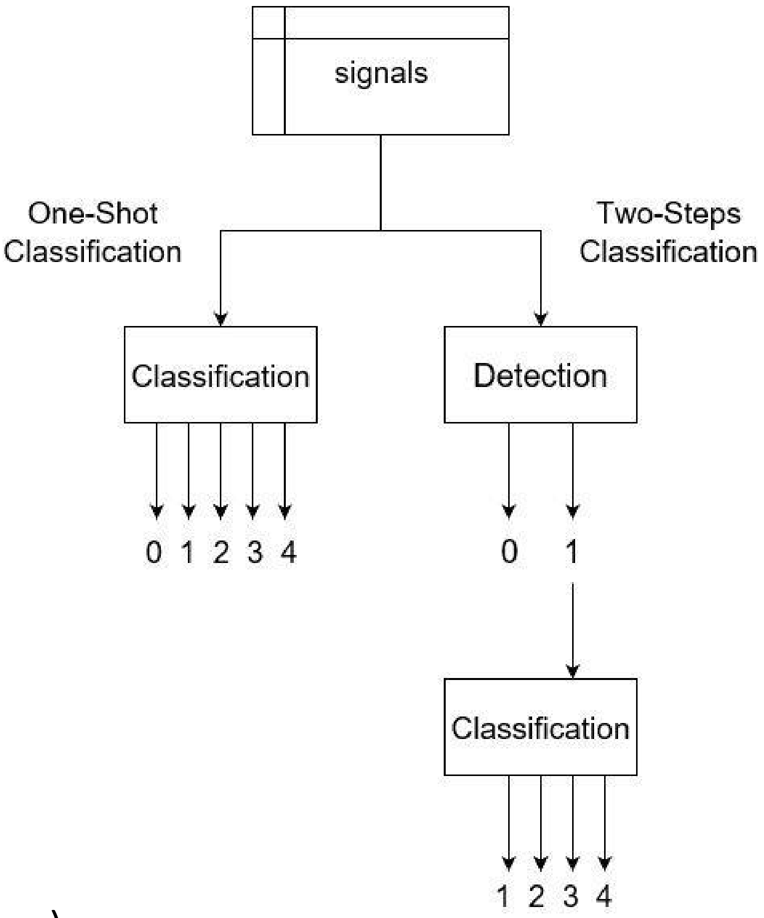
Models

Layer type \ Model name	Convolutional	Recurrent (LSTM)	Fully connected
Conv	3	0	2
Conv1DRec	1	2	2
Conv2DRec	1	2	2
ConvDeepRec	3	2	2

In our code:

Conv → Convolutional
Conv1DRec → Convolutional1DRecurrent
Conv2DRec → Convolutional2DRecurrent
ConvDeepRec → ConvolutionalDeepRecurrent

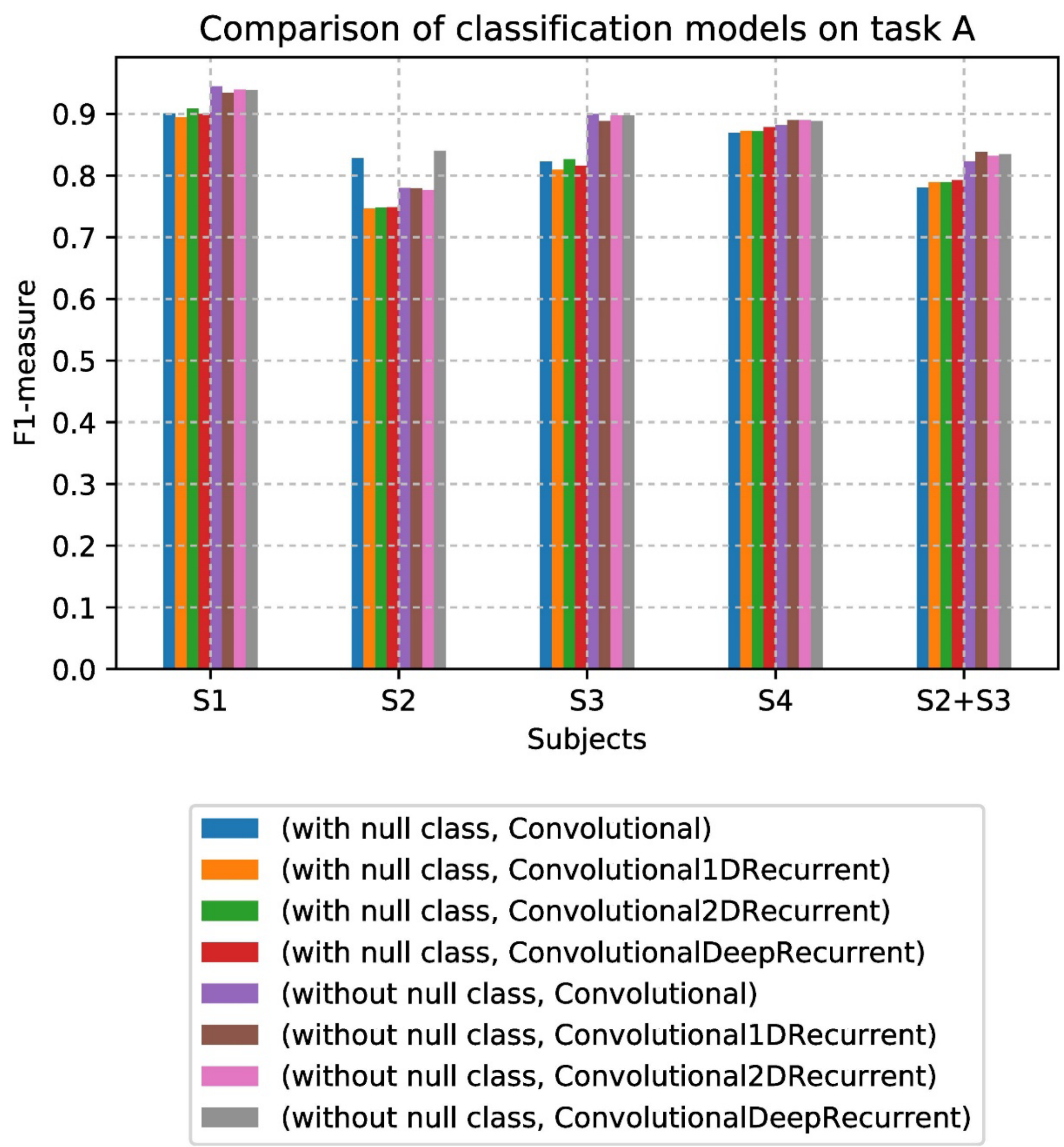
Pipelines



3 types of classification for each model:

- One-Shot
  - Classification (n+1 class)
- Two-Steps
  - Activity detection (binary)
  - Activity classification (n-class)

Results on locomotion



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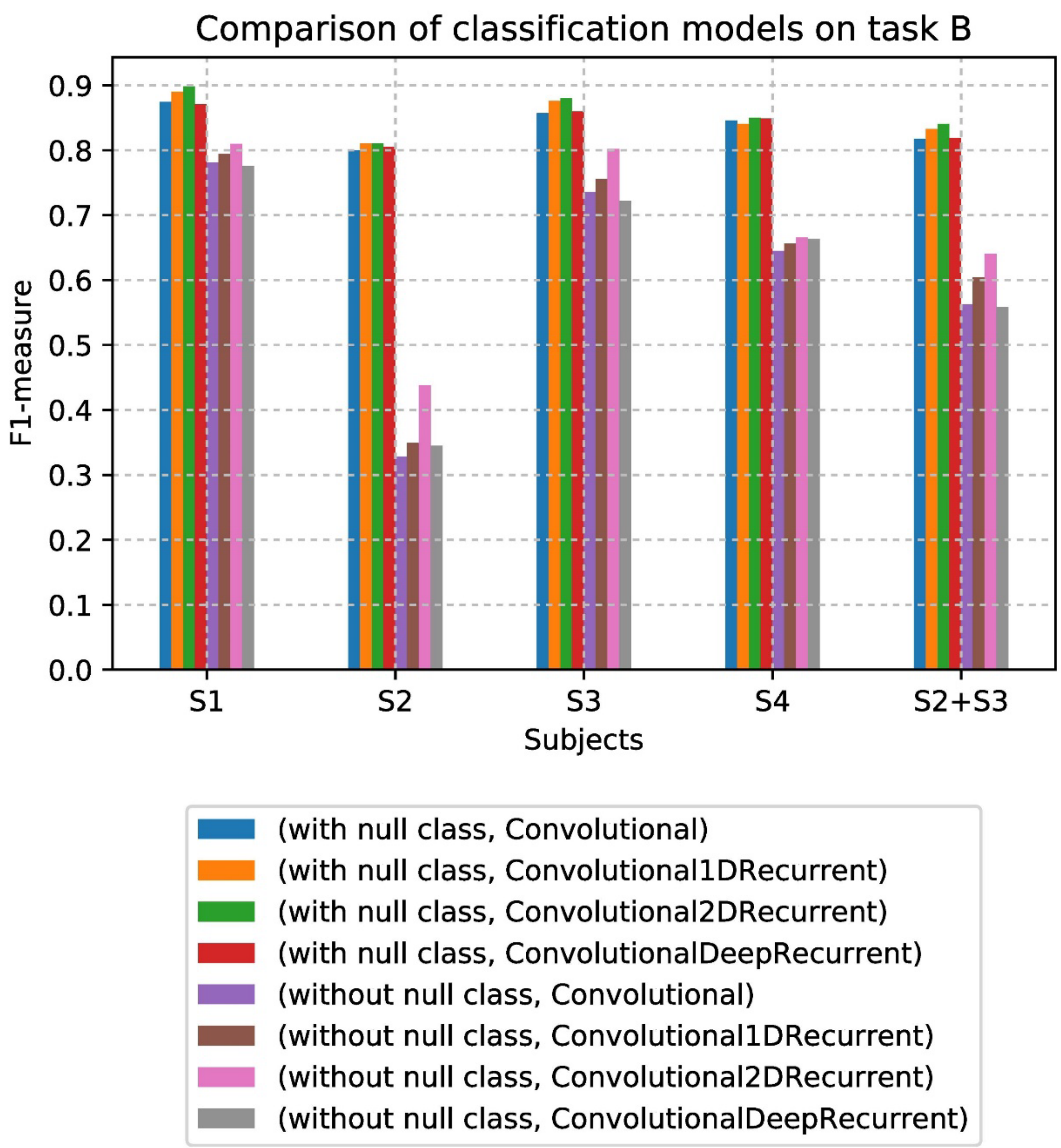
Results on gestures



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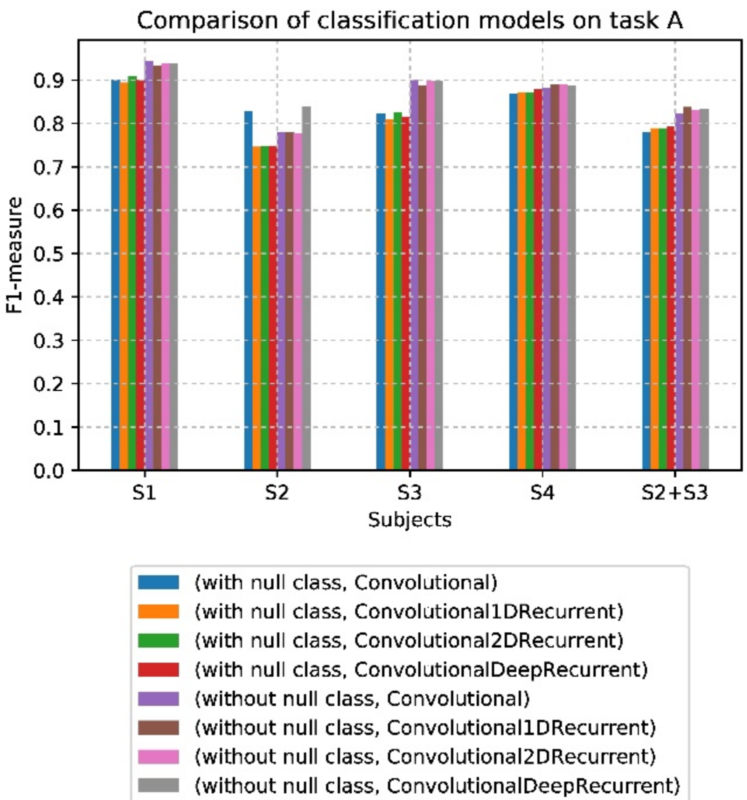
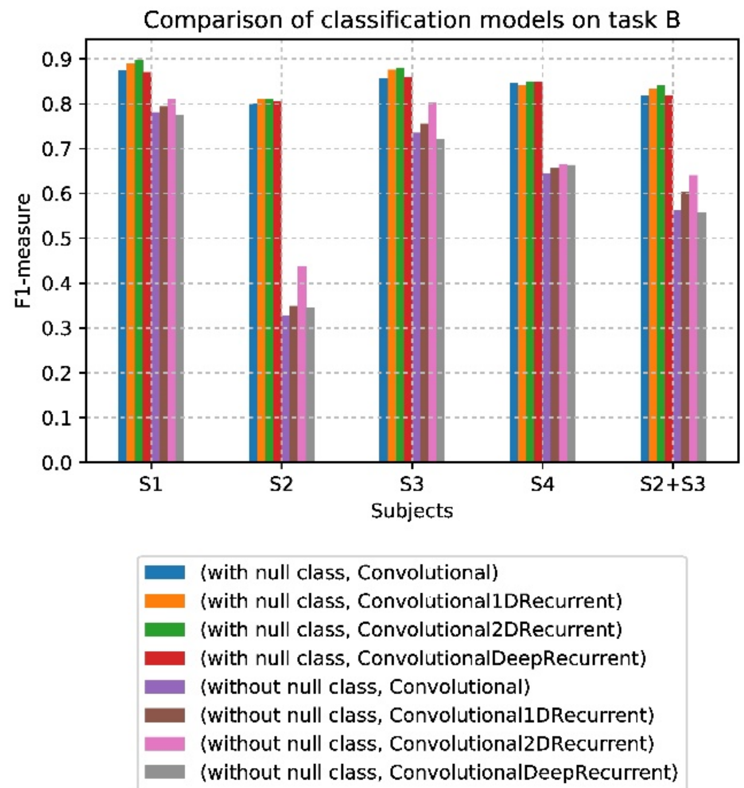
Conclusions





- No clear best choice
- Class imbalance
- Cascade implementation … notebook

These problems could be addressed in future work

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