

Problem

Machine learning in medical applications

- ▶ How to learn accurate results understandable by practitioners
- ▶ That capture the characteristics of underlying biological systems

Medical issue: Fall prevention in the elderly population

An important concern in public health [3]

- ▶ Each year more than a third of population older than 65 faces a fall
- ▶ Those falls can have devastating consequences
- ▶ Early detection of balance deterioration is crucial

Data

We consider 3 groups of subjects:

- ▶ Group 1 : **young healthy** individuals (67 signals).
- ▶ Group 2 : **healthy elderly non faller** individuals (60 signals).
- ▶ Group 3 : **elderly faller** individuals (56 signals).

Groups are ordered according to their supposed quality of balance

Romberg test

Each subject is recorded

- ▶ on a Wii balance board
- ▶ standing still
- ▶ arms laying on the side
- ▶ 25 seconds with open eyes
- ▶ 25 seconds with closed eyes

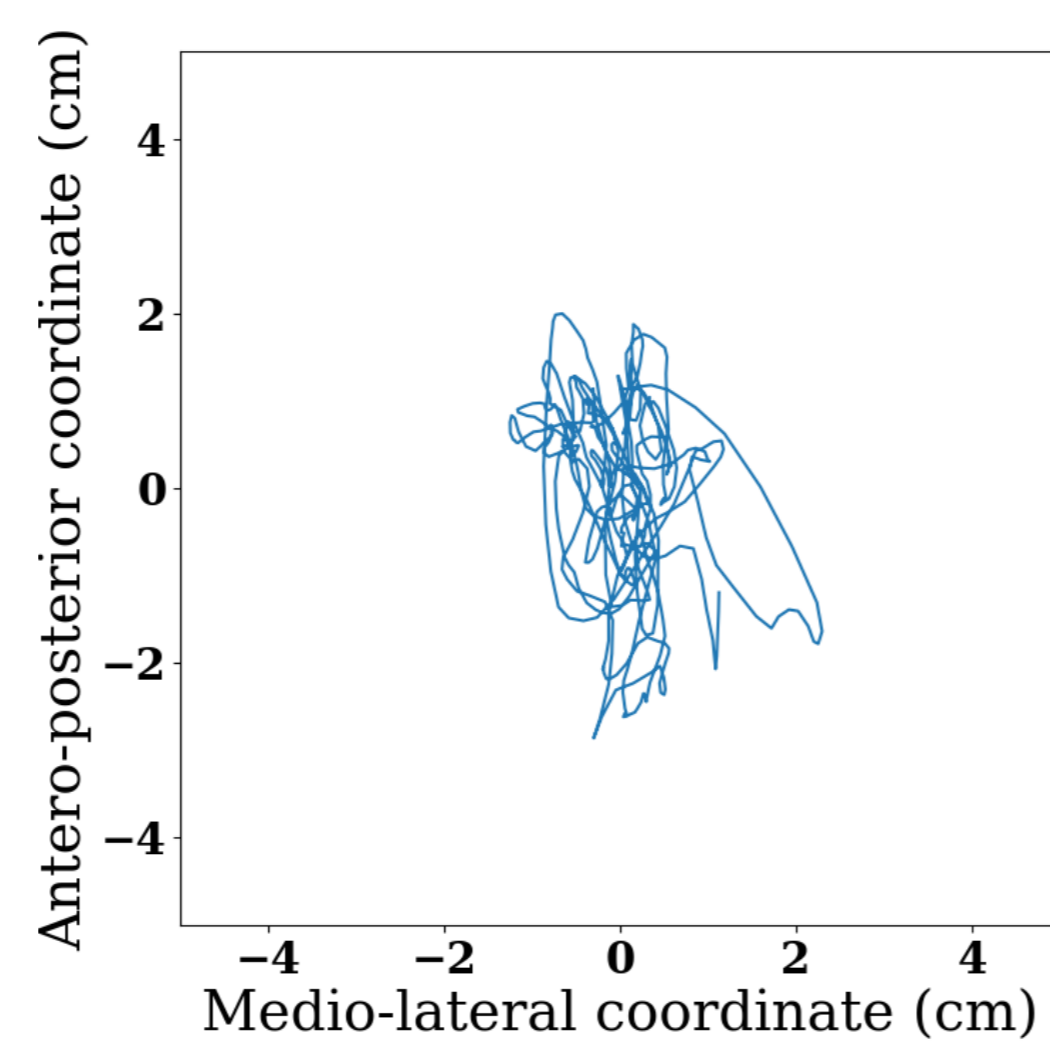


Figure: Trajectory of the CoP, open-eyes

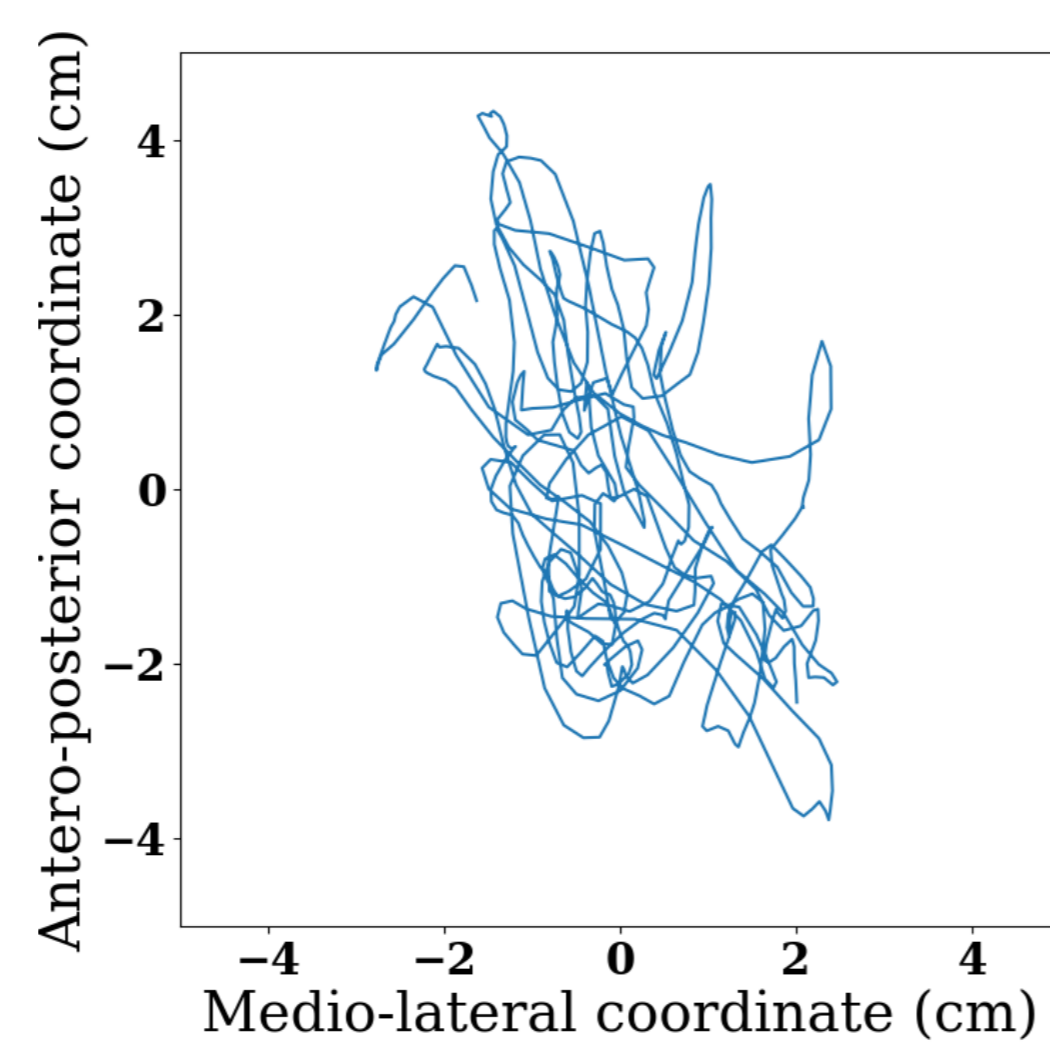


Figure: Trajectory of the CoP, closed-eyes

Measurements

- ▶ Displacement of the **center of pressure (CoP)** is recorded
- ▶ In medio-lateral and antero-posterior directions
- ▶ Resampled at 25 Hz

Noisy dataset

- ▶ Protocol related inconsistencies
- ▶ Intra-subject variability (tiredness)
- ▶ Sensor noise
- ▶ etc.

Contribution

- ▶ New postural control model
- ▶ White-box fully interpretable algorithms
- ▶ Regularization that embeds heuristics into models

Postural control model

Model: Hypothetical Posturographic Target (HPT)

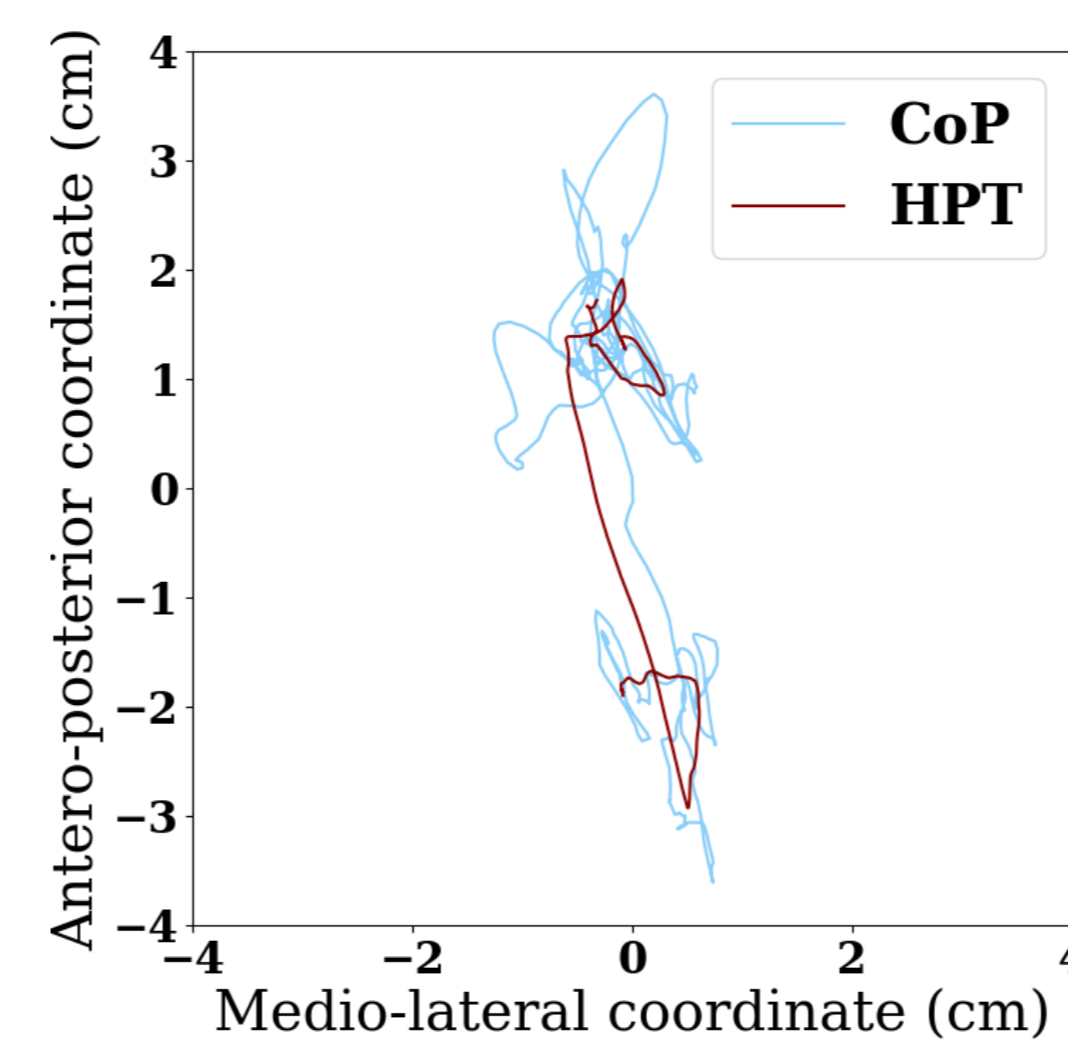


Figure: Trajectories of CoP and HPT

Concept of Posturographic Target (PT) based on [1]

Alternating phases of

- 1) oscillations around a PT
- 2) rapid movement to the next PT

We compute an hypothetical continuous approximation of the PT

Scoring algorithms and model-space regularization

Two key guidelines :

- ▶ The use of simple models that are more robust and interpretable
- ▶ A regularization specifically designed for this medical application

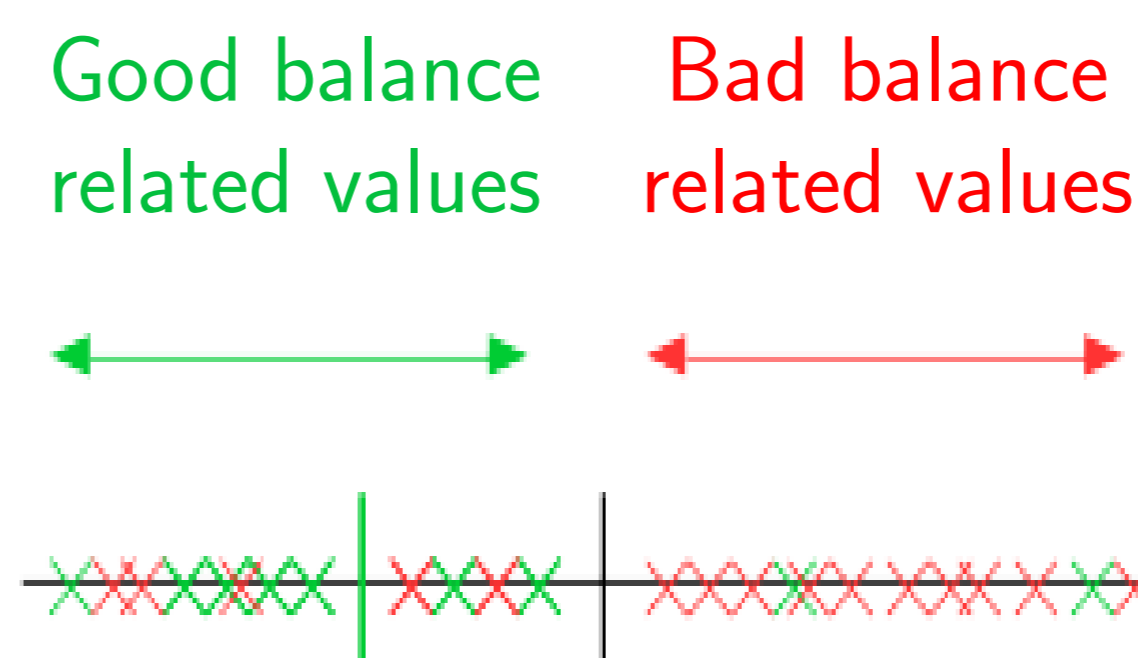


Figure: Heuristic based Weak Classifiers

Bad balance related values are constrained to be below the threshold and vice versa.

By limiting the number of possible classifiers, this constraint acts as a model-space regularization.

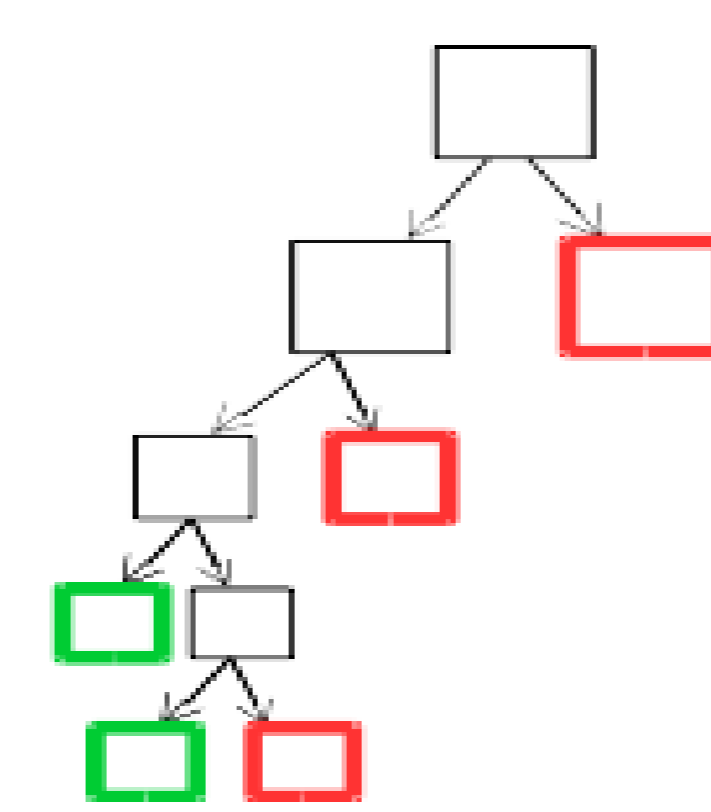


Figure: Heuristic based Decision Tree

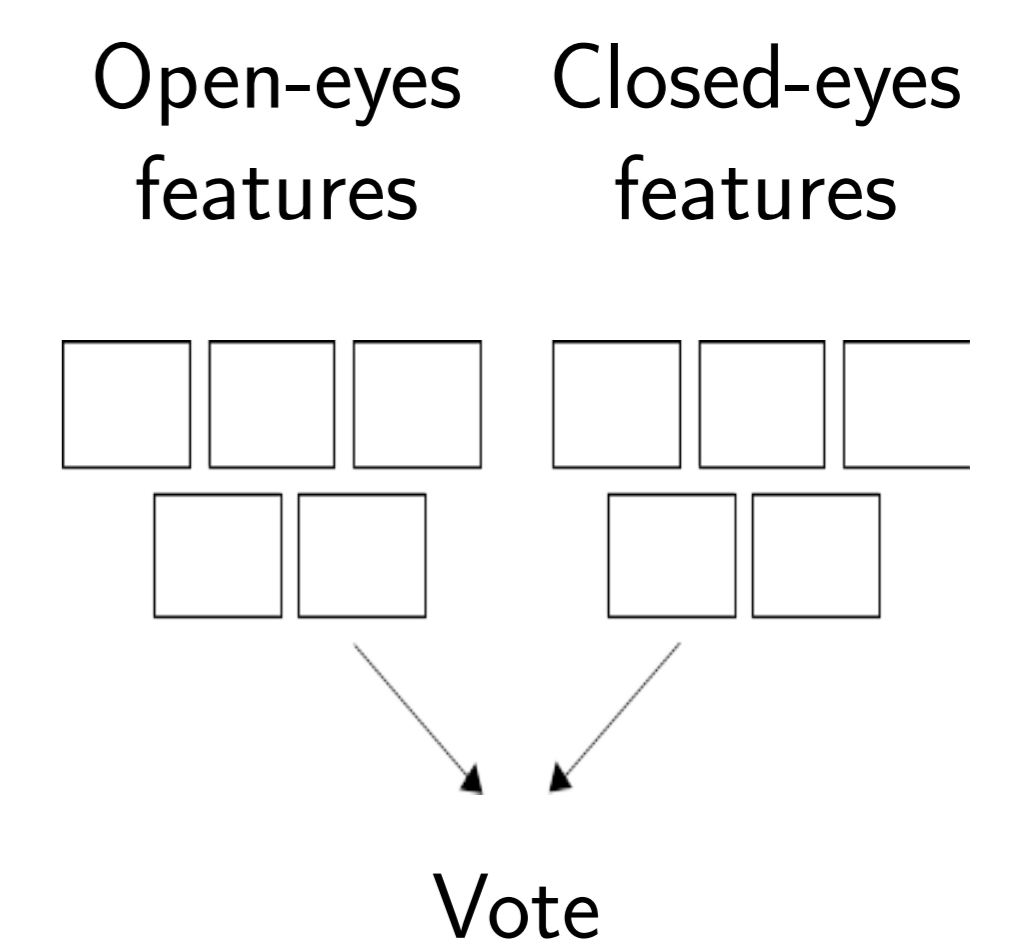


Figure: Heuristic based Bagging

Results

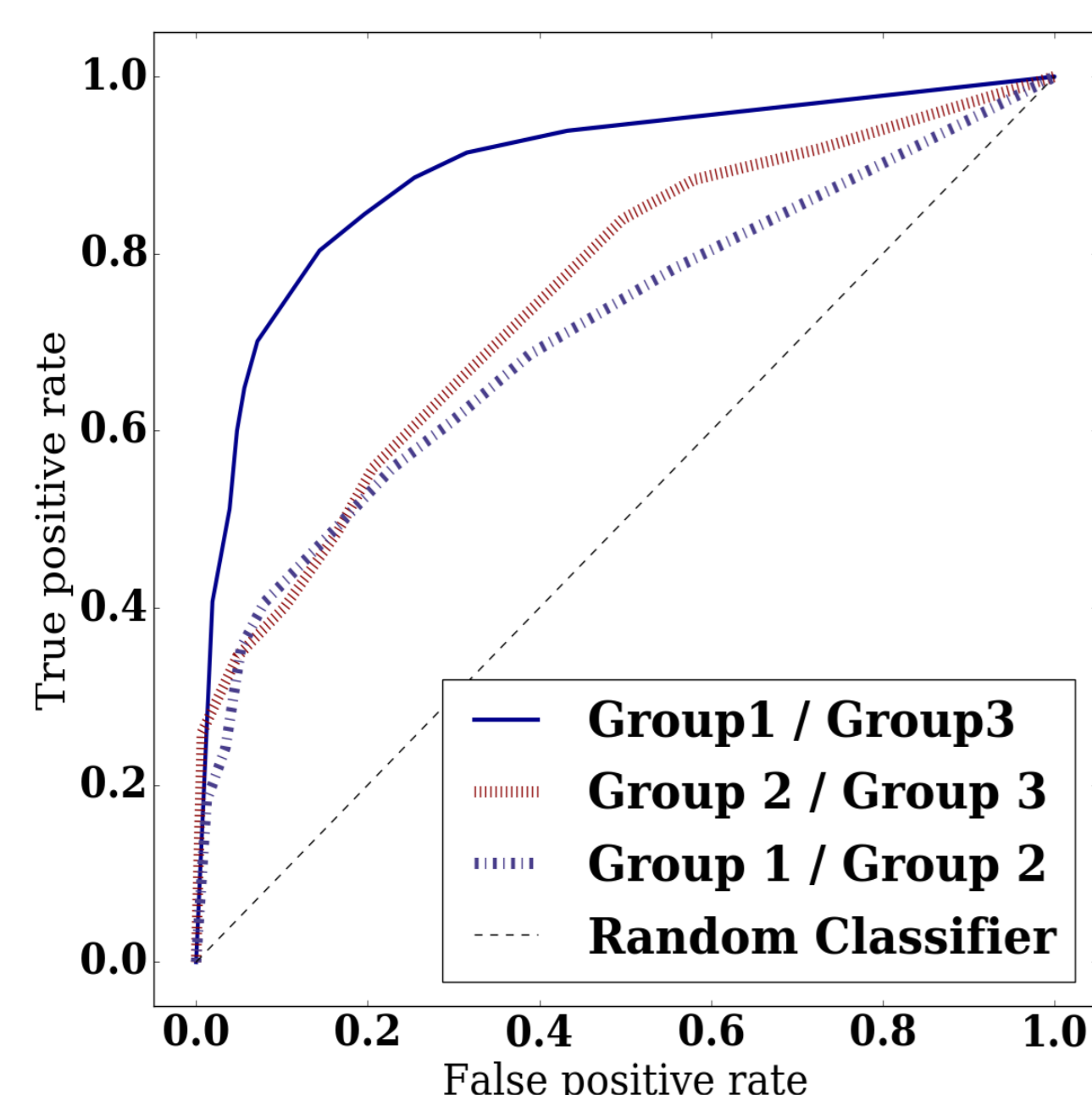


Figure: inter-groups ROC curves

Groups	1-2	2-3	1-3
RF	0.70(±0.08)	0.65(±0.06)	0.85(±0.04)
Adaboost	0.74(±0.06)	0.60(±0.08)	0.86(±0.06)
HBagging	0.72(±0.07)	0.75(±0.07)	0.90(±0.05)
HDTrees	0.69(±0.08)	0.70(±0.07)	0.88(±0.05)
HAdaboost	0.69(±0.07)	0.73(±0.08)	0.90(±0.05)

Table: Mean and standard deviation of AUC of the different algorithms for each pair of groups.

Group	1	2	3
Mean(std)	0.09(±0.14)	0.23(±0.21)	0.37(±0.21)

Table: Mean and standard deviation of group scores with HBagging.

- ▶ Simple models show the best performances
- ▶ Regularization based on heuristics improve model performances
- ▶ HBagging captures the Dose effect

References

- [1] L. Baratto, P. G. Morasso, C. Re, and G. Spada. A new look at posturographic analysis in the clinical context: sway-density versus other parameterization techniques. *Motor control*, 6(3):246–270, 2002.
- [2] A. Nicola and J. Audiffren. Model-space regularization and fully interpretable algorithms for postural control quantification. In *COMPSAC*, 2018.
- [3] W. H. Organization. Who global report on falls prevention in older age. *WHO reports*.