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# SPEED PREDICTION OF THE SPORT HORSE FROM ACCELEROMETRIC AND GYROSCOPIC DATA

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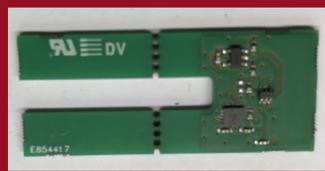
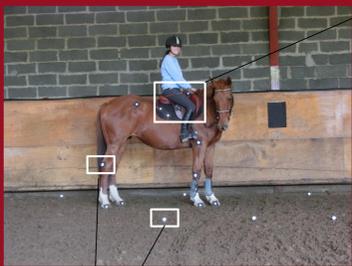
## Introduction & Objective

With the growth of connected and smart sport devices to improve performance, this kind of object is developed for equestrian sports. CWD put an accelerometer and a gyroscope on horse withers. It collects data from the 3 space directions (x, y, z) and it allows calculation of parameters that characterize motion like cranio-caudal, medio-lateral and dorsoventral energies or gallop frequency.

The objective is to predict the speed of the horse per second with an exactness of 0,6 m/s in order to have a new parameter characteristic of the horse movement.

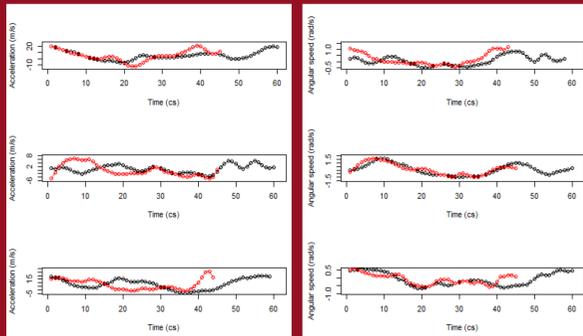
## Data

34 horses and 1905 strides



Accelerometer & Gyroscope

2D kinematics markers: instant speed is measured in a 26 meters field of vision with fast video acquisitions



One stride acceleration from 3 space directions

One stride angular velocity from 3 space directions

## Model

- ✓ In order to have the same signal length (101 points), one second of signal is kept for each stride from the beginning of the stride signal.
- ✓ Curves are registered by a warping function in a non-linear fashion using a basis of cubic B-splines (*register.fd* function from *fda* R package).
- ✓ An unsupervised clustering method for multivariate functional data based on a multivariate principal component analysis, called *Funclust*, is performed in order to get 2 groups (*funclust* function from *Funclustering* R package).
- ✓ Multivariate non parametric regression for functional data is performed on each group:

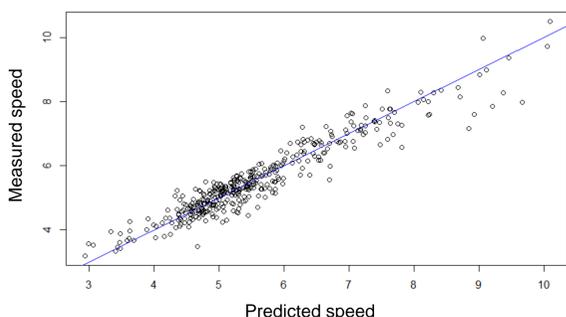
$$Y_i = r(X_i^1) + \dots + r(X_i^6) + \epsilon_i, \\ E(\epsilon_i | X_i^1), \dots, E(\epsilon_i | X_i^6) = 0$$

with Y the scalar response  
( $X^1, \dots, X^6$ ) the functional covariates  
r the functional operator

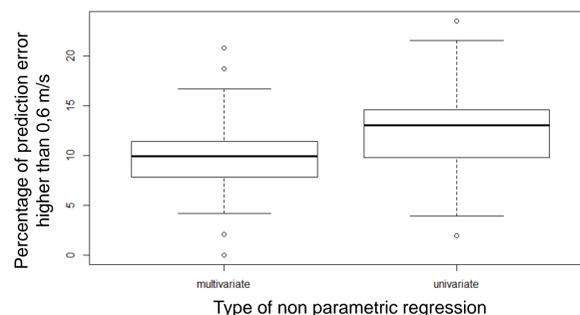
In practice we need to apply the function *funopare.knn.lcv* (npfda website) on the data with the first covariable, then get the residuals and apply *funopare.knn.lcv* on those residuals with the second covariate, and so on until all covariates are used.

## Results

- ✓ The database is cut into a training dataset (random sampling of 80% of the database) and a test dataset (20%).
- ✓ To evaluate the model quality, for each simulation the percentage of prediction error higher than 0,6 m/s is calculated.
- ✓ 500 simulations with a training and a test datasets, to estimate the variability of the multivariate non parametric regression in comparison with the univariate non parametric regression, are performed:



Predicted speed versus measured speed for the test dataset of one simulation



Percentage of prediction error for 500 simulations after clustering and functional multivariate non parametric regression (left) or clustering and functional univariate non parametric regression (right)

- ✓ The inclusion of multiple functional variables in the regression model makes the predictive error decreased in comparison with the univariate case.

## Conclusion

- ✓ Results are promising.
- ✓ Different ideas to improve results:
  - Improve *Funclust* speed because currently it could take a lot of time to cluster data.
  - Develop a multivariate non parametric regression for R which does not need to work iteratively.