Experimental evaluation of a computer-vision based method to assess the aerodynamic drag of cyclists

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Context

- **Aerodynamic drag = 80-90% of resistive forces**

- **Effective Frontal Area (ACd) : $F = 0.5\ ACd\ \rho\ v^2$**
- **ACd should be reduced so must be quantified**

- **Existing Method :**
  - Wind tunnel
  - Dynanometric measurement
  - Deceleration + Linear regression
  - **Recently 3D digitilization + CFD**

3D + CFD : advantages

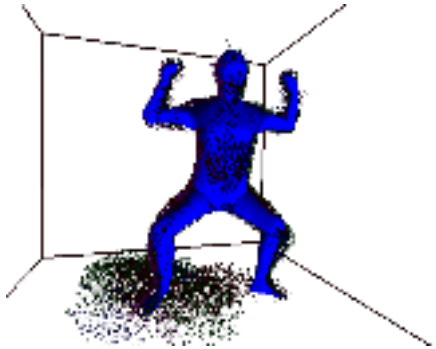
- **Low operating and equipment costs**
- **Measuring conditions closer to real world**
- **Many experiments are possible :**
  - Simulating different wind conditions
  - Simulating different cyclist speeds
  - Assessing different equipments (helmet,wheel, …)
  - Simulating team pursuit

Ergocycle method (1)

- **Set-up :**
  - 4 RGB-D Sensors
  - 4 Nano-computers (slaves)
  - 1 master computer (manage digitalization)
  - 4 calibration patterns

Ergocycle method (2)

- **Cyclist Digitalization using a Human Body Model :**
  - No pre or post-processing work
  - Model is composed of:
    - Anatomical features
    - Pose features
  - Steps :
    - Model initialization (find Anatomical Features)
    - Digitalization of the bike
    - Fit Cyclist in 3D Point Cloud (find Pose Features)



Ergocycle method (3)

- **OpenFoam solver**
  - Surface discretized with polyhedral surface mesh
  - k-ε turbulence model
  - Numerical wind tunnel = 20 m x 15 m x 50 m box

Experimental data (1)

- **Experimental conditions**
  - 200m indoor velodrome (Bourges-Fr)
  - Powermeter : Rotor 2INpower
  - Speed Sensor : Garmin 010-12103-00
  - Temperature & atmospheric pressure : Bosch BME280

- **Data processing**
  - Drag is processed by inverting a physical model

$$F_{cyclist} = F_{aero} + F_{roll} + F_{acceleration} \qquad F_{aero} = \frac{P_{sensor}}{V} - C_r mg - ma$$

  - Python code available here : https://github.com/ApeiraTechnologies/ConfSciCycling2019

Experimental data (2)

- **Subjects**
  - 4 athletes
  - 1 athlete for calibration and repeatability evaluation
  - 3 athletes for method evaluation
- **Conditions**
  - Each cyclist uses his own bike
  - 3 laps for each speed
  - Same sequence for 3 positions
- **Evaluated positions**
  - Uprigth position
  - Brake-hoods position
  - Dropped position
- **Evaluated speed**
  - 25 km/h
  - 30 km/h
  - 35 km/h
  - 40 km/h

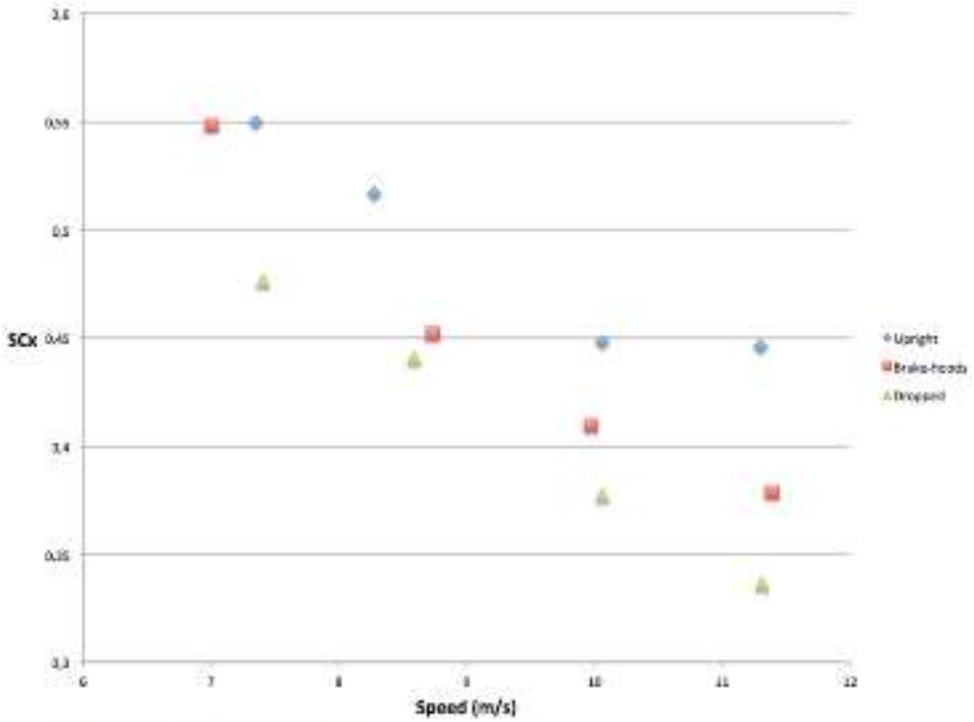
Results (1)

- **Repeatability of experimental data**
  - Weak repeatability
  - Further works to understand why

		Force(N)			
Position	**Speed (m/s)**	**Mean**	**Min**	**Max**	**Std**
Upright	7,5	15,17	12,53	17,58	1,93
Upright	9,9	26,29	23,93	28,23	1,70
Dropped	7,6	16,21	13,85	18,24	1,71
Dropped	10,4	27,49	26,30	28,70	1,10

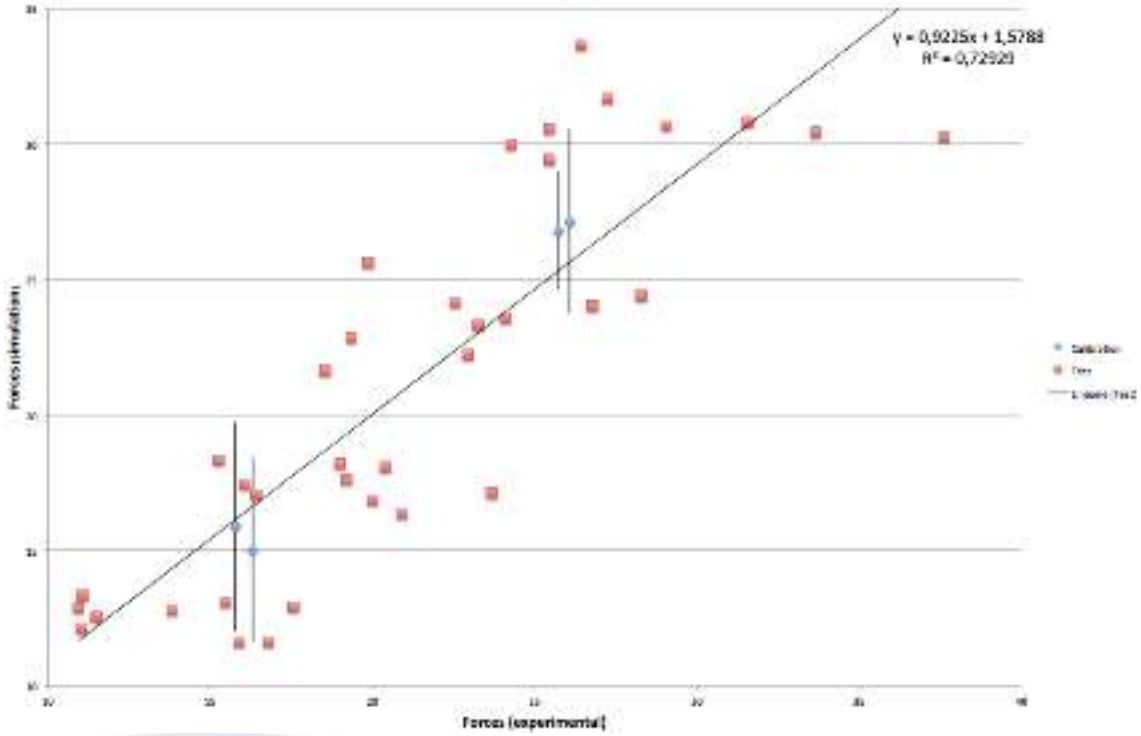
Results (2)

- **Experimental values of ACd**
  - Values for different positions are coherent
  - *ACd* is not constant when the speed changes



Results (3)

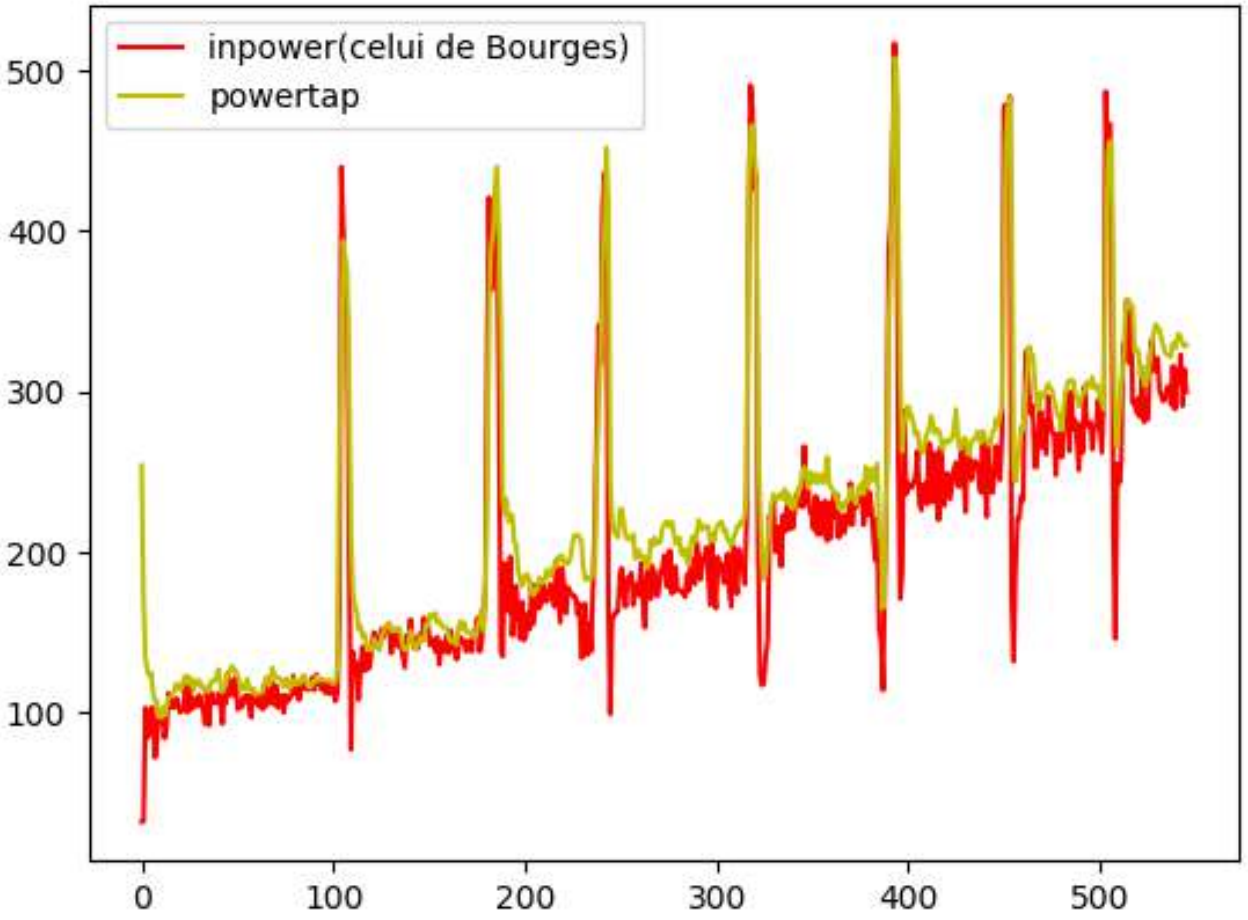
- **Validation of our method**
  - Good correlation with experimental data
  - But correlation is limited by the weak repeatability

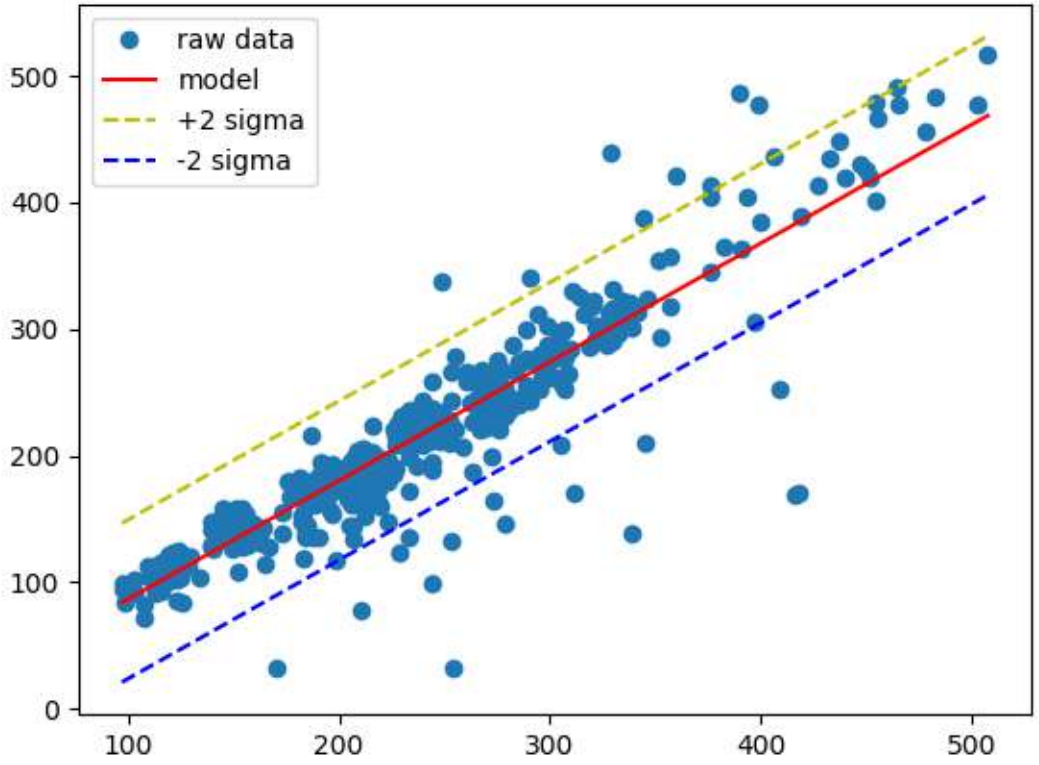


Conclusion

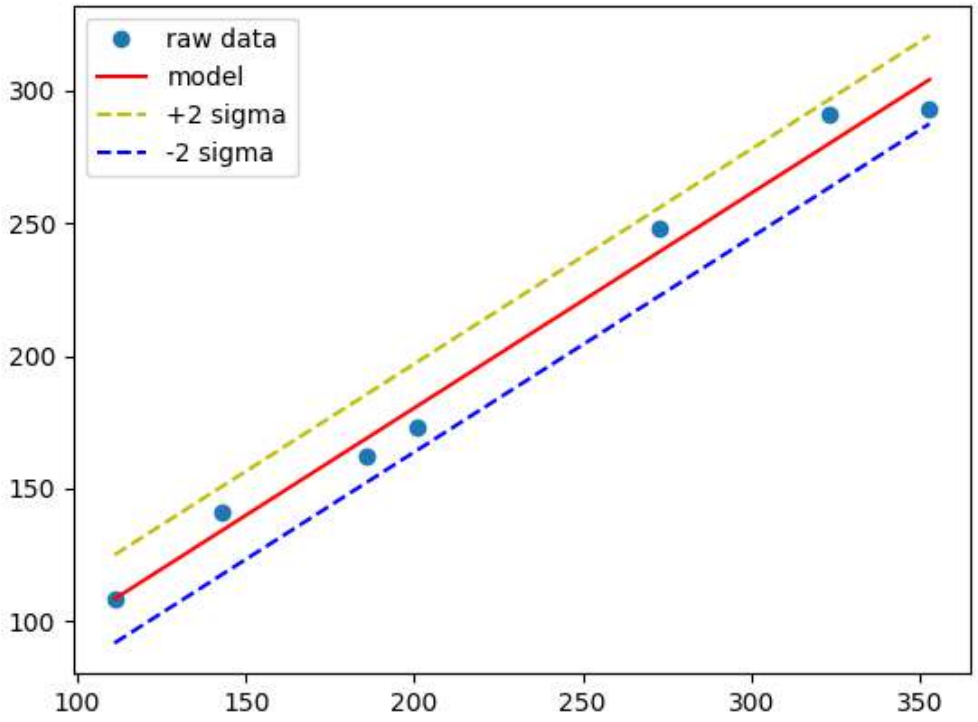
- **A new drag assesment method based on computer vision**
- **Experimental data based on well-known method**
- **Results**
  - Good correlation between our method and experimental data
  - But weak repeatability of experimental data
- **Future works**
  - Improve experimental conditions
  - Obtain better repetability of vedrome measurement
  - Definitive validation of our method

Questions ?





- **Poor correlation**
  - R2 = 0.863



- **Great correlation**
  - R2 = 0.987