Clinical Gait Analysis

Artificial intelligence for data science
SIC7002

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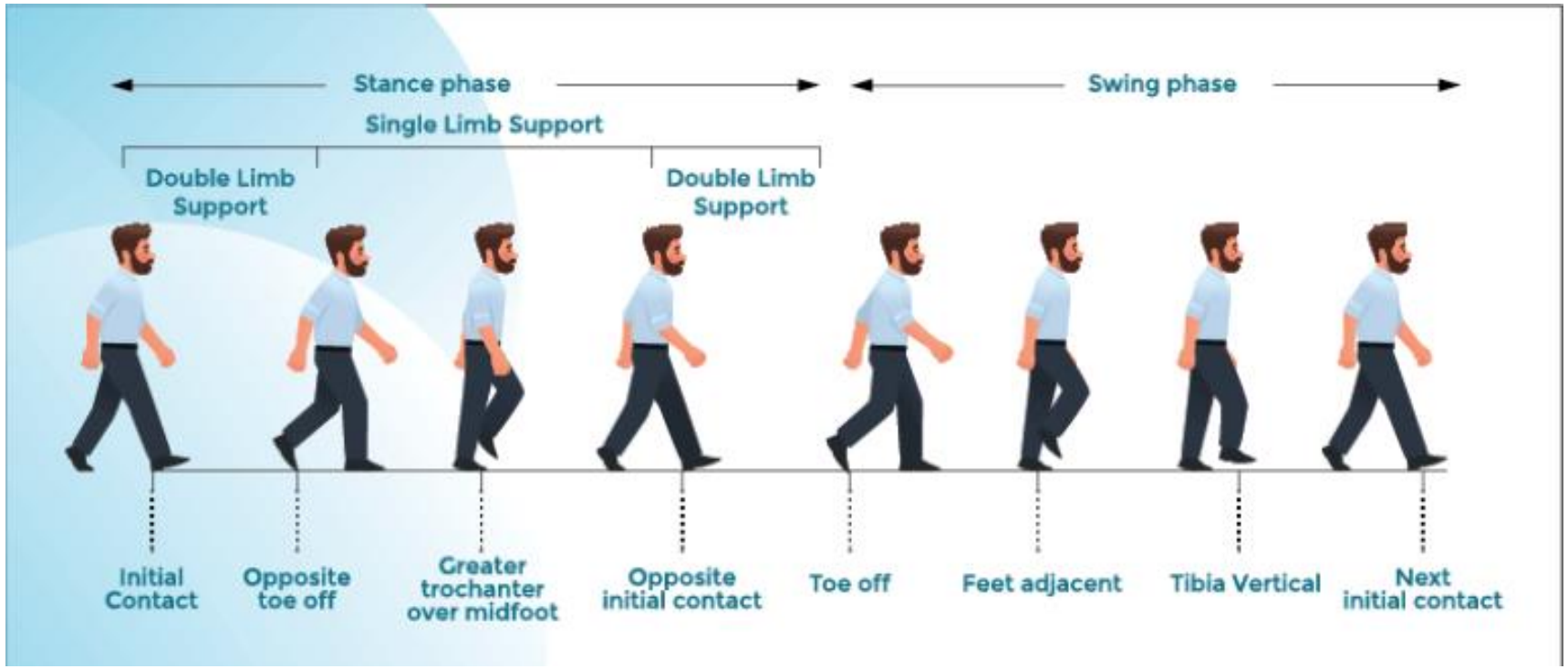
Introduction



Gait cycle

State of the art

Kinematics: study of motion without considering the forces that cause it

Kinetics: study of the forces and moments that cause motion

Measures for clinical gait analysis

→ Obtain information for establishing the level of functional limitation due to pathology

- Normalcy index (NI)
- Hip flexor index (HIP)
- Gait deviation index (GDI)
- Gait abnormality index (GAI)

Experiment

52 participants, with no neuro-orthopaedic troubles, has been asked to walk under five different speed constraints.

Dataset

The study focused on **knee flexion**, using 101 points to characterize each cycle, with 10 cycles per person

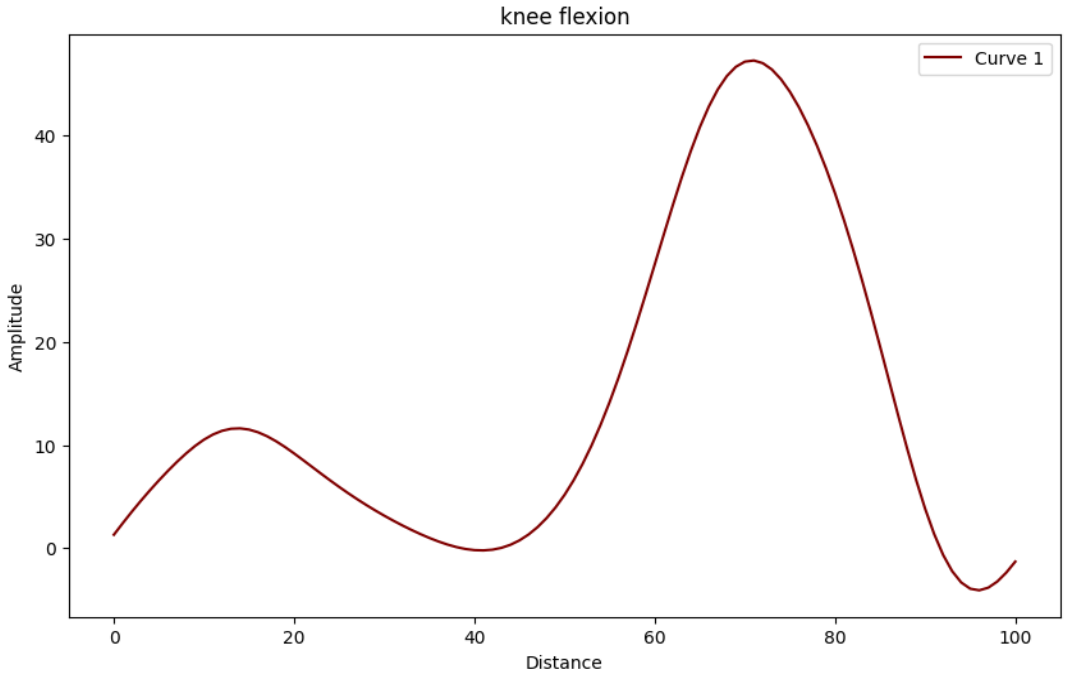
5 different speed conditions :

- Speed 1 : 0 - 0.4 m/s
- Speed 2 : 0.4 - 0.8 m/s
- Speed 3 : 0.8 - 1.2 m/s
- Speed 4 : Spontaneous
- Speed 5 : High

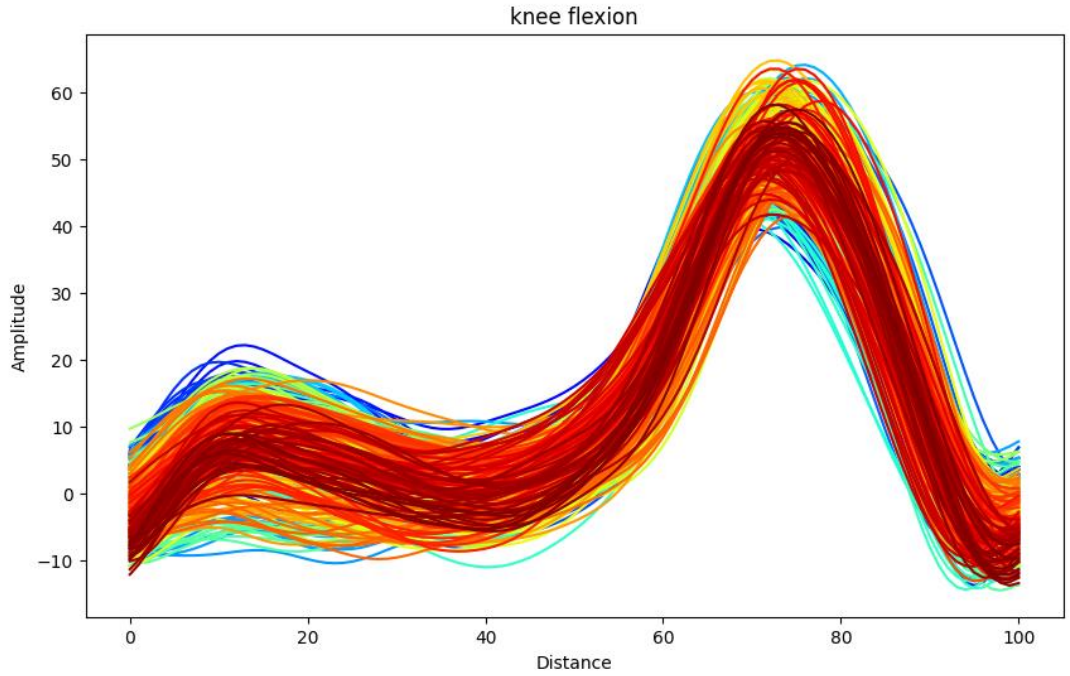
Objective → Study and analyse the impact of speed constraints on the gait

Visualization of the dataset

Example for Speed 3 :



One cycle



All cycles

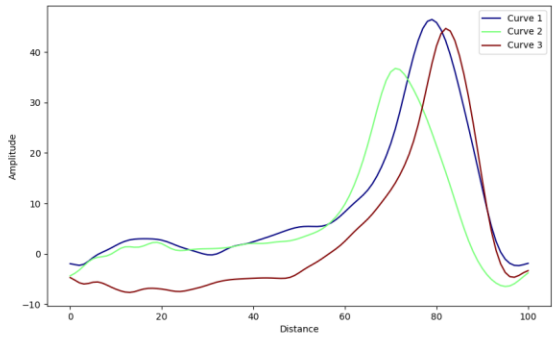
Methods

1. K-Medoids algorithm using DTW with k = 3.
2. 3D-visualisation of cycles based on a distance with a reference (Medoids of speed 4).
3. K-Means algorithm with k = 5 on the distances of each cycle with the reference .
4. Calculate the variance of one person's cycles and average over all persons for each speed.

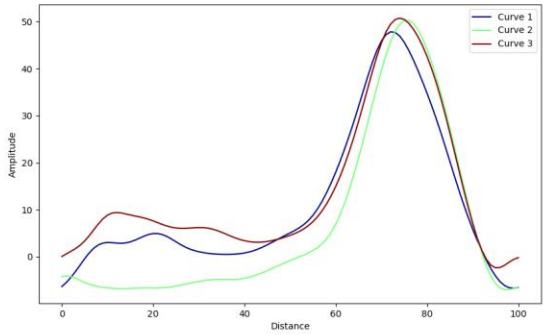
Results

K-Medoids algorithm using DTW with k = 3 for each speed.

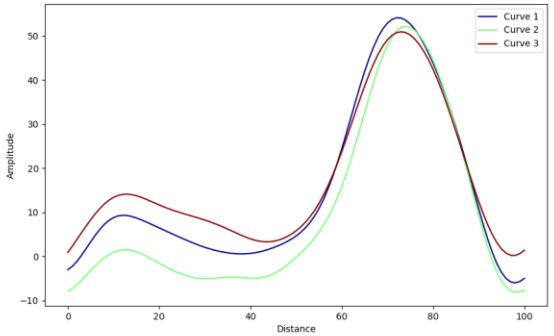
Speed 1 : 0 - 0.4 m/s



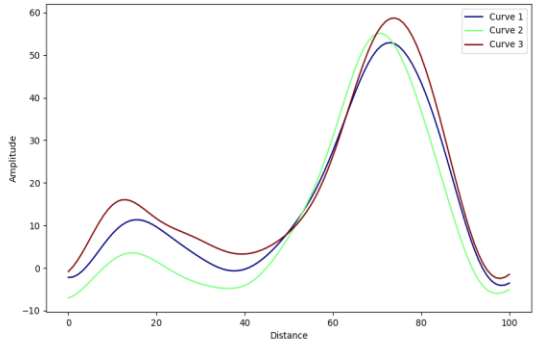
Speed 2 : 0.4 - 0.8 m/s



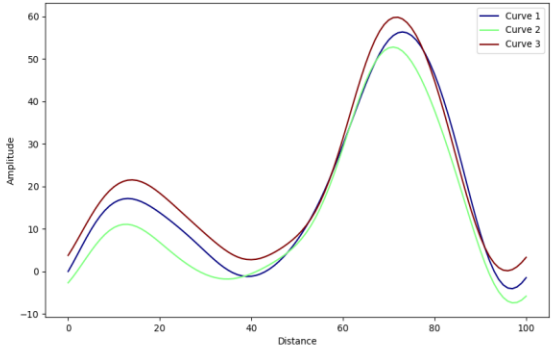
Speed 3 : 0.8 - 1.2 m/s



Spontaneous Speed



High Speed

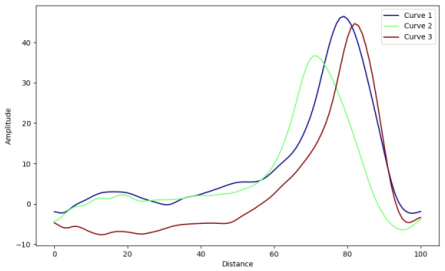


Interpretation

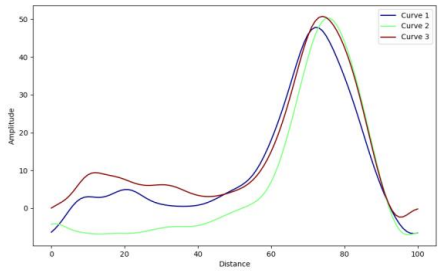
- The slower the speed constraint, the smaller the first bump.

Results

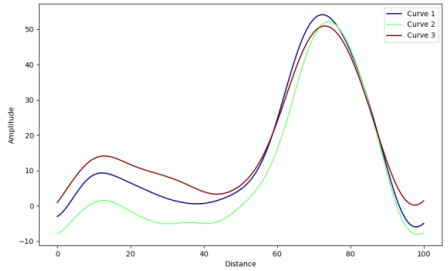
3D-visualisation of cycles



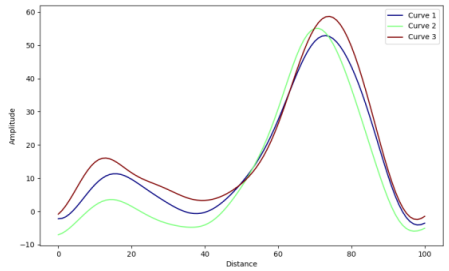
Speed 1



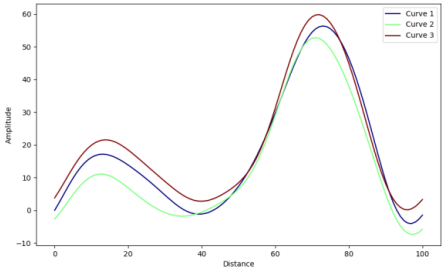
Speed 2



Speed 3

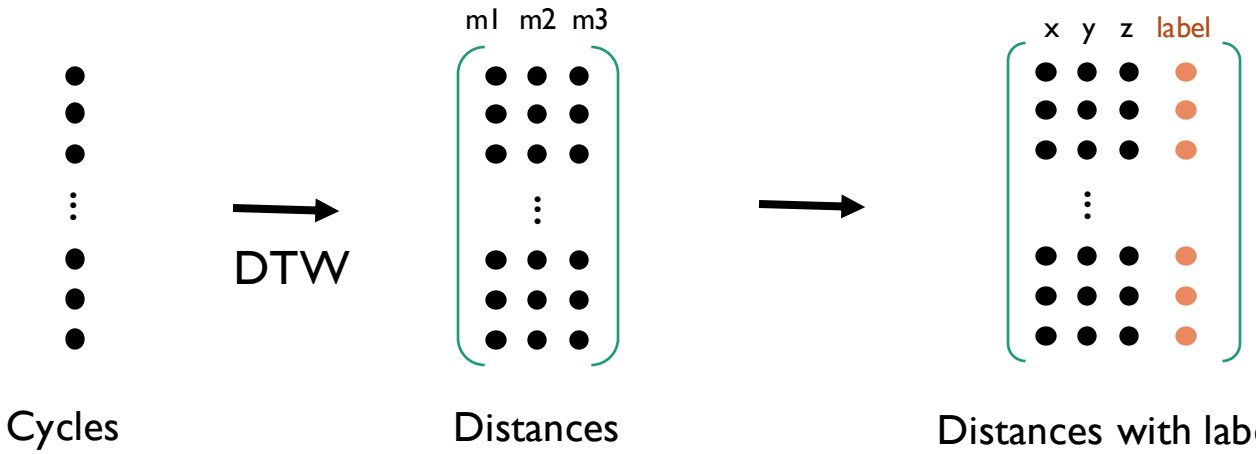


Spontaneous Speed



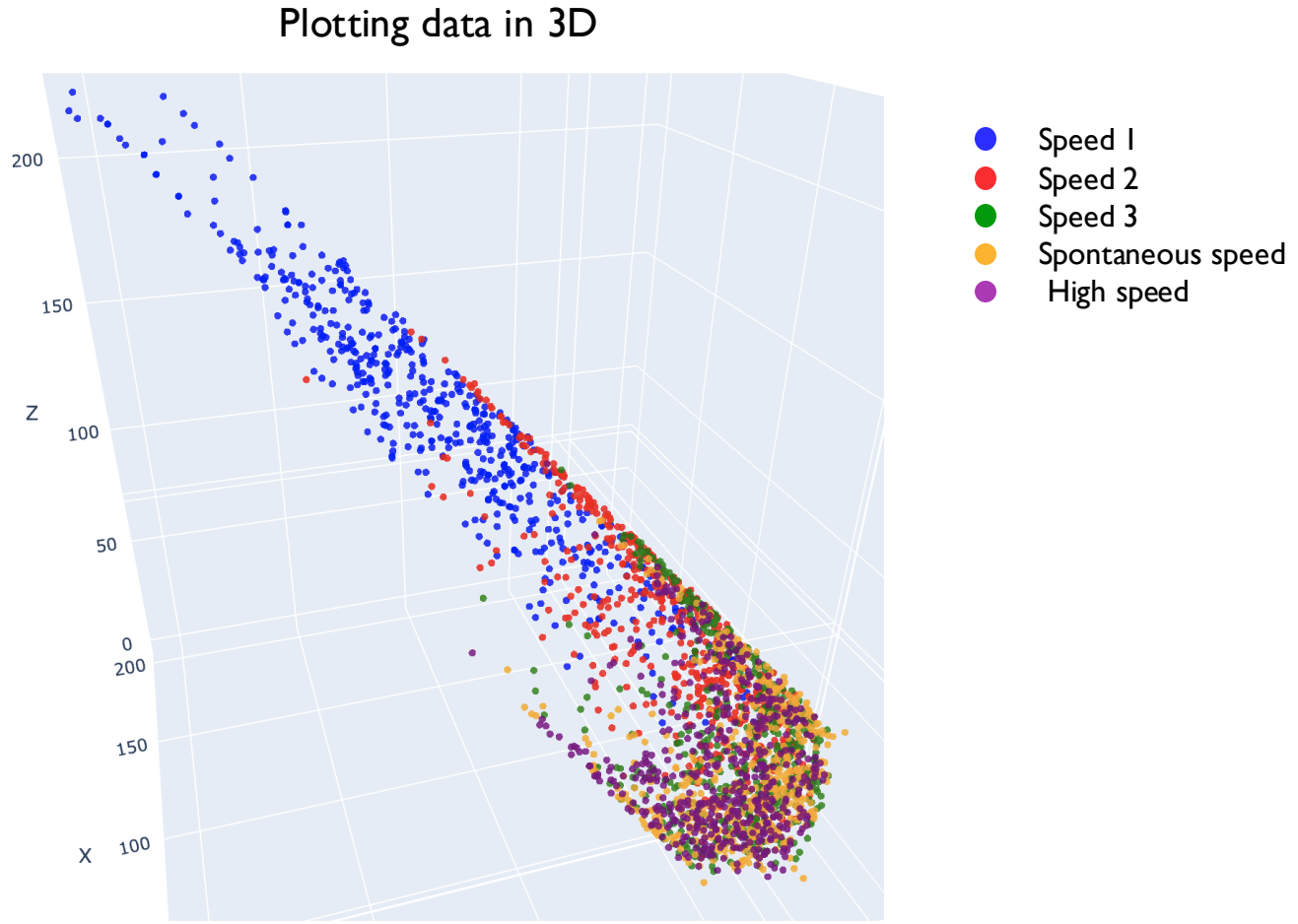
High Speed

Calculate the **DTW distance** of all cycles to the 3 medoid cycles (m1, m2 and m3) of the spontaneous speed.



Results

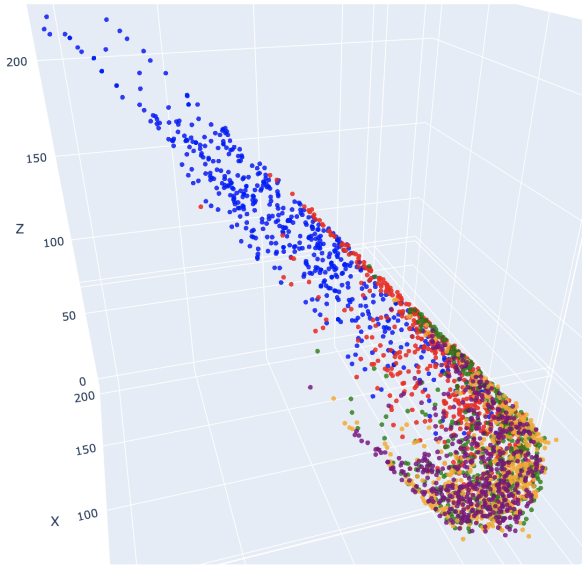
3D-visualisation of cycles



Results

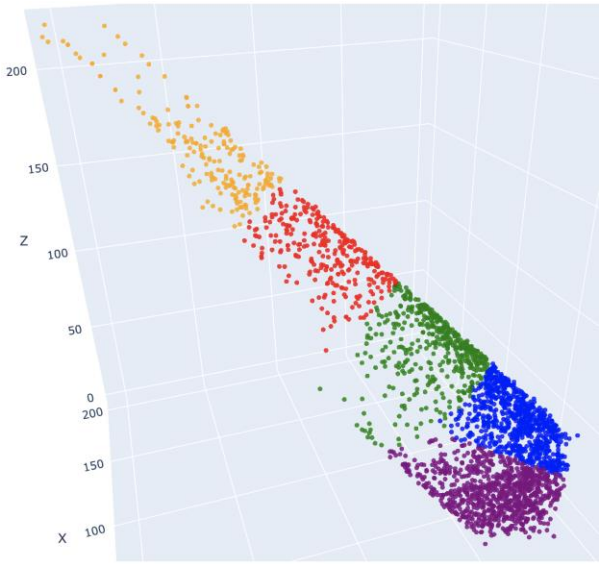
K-Means algorithm

Plotting data in 3D



- Speed 1
- Speed 2
- Speed 3
- Spontaneous speed (Ref)
- High speed

K-Means (k=5)



Distribution of cycles

Clusters	Speed 1	Speed 2	Speed 3	Ref	High speed
●	0	42	**224**	**293**	**306**
●	11	**185**	**207**	**191**	**151**
●	88	**211**	76	30	46
●	**229**	71	3	0	1
●	**192**	3	0	0	0

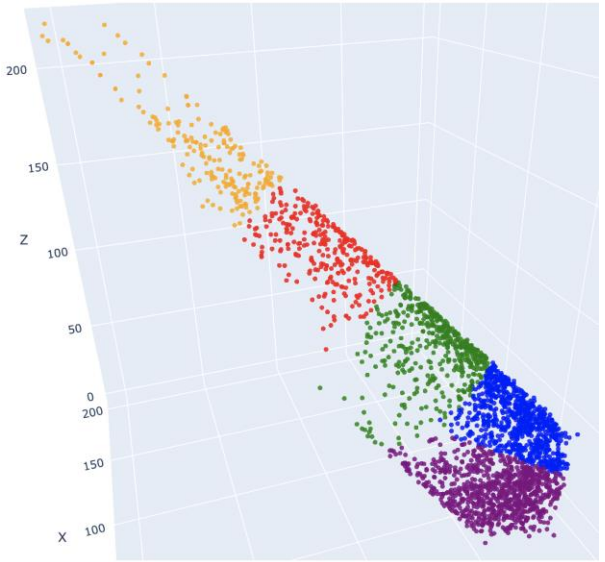
Interpretation

- The slower the gait is imposed, the more the cycles are distant from the cycles of spontaneous walking.
- With the constraint of slow speed, cycles become more individual-specific and different from one another.

Results

K-Means algorithm

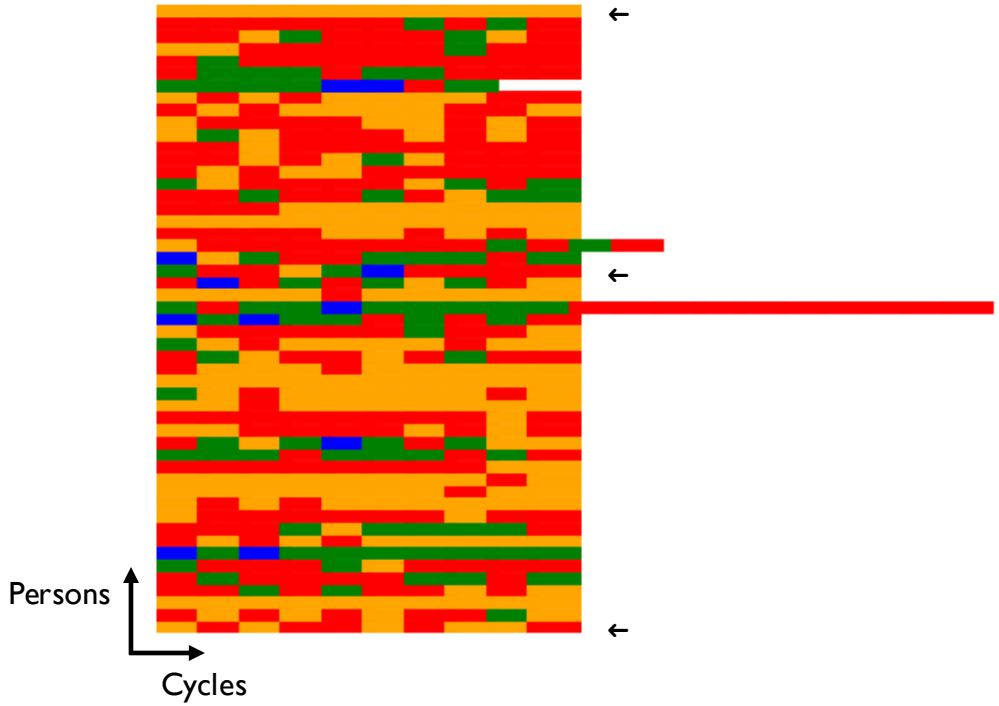
K-Means (k=5)



Distribution of cycles

Clusters	**Speed 1**
●	0
●	11
●	88
●	**229**
●	**192**

For the slowest speed



Interpretation

- With the slow speed constraint, individuals do not have similar cycles.

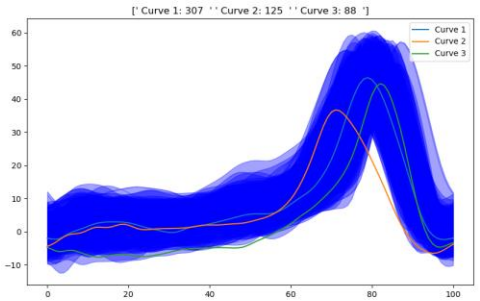
Results

Variance of cycles

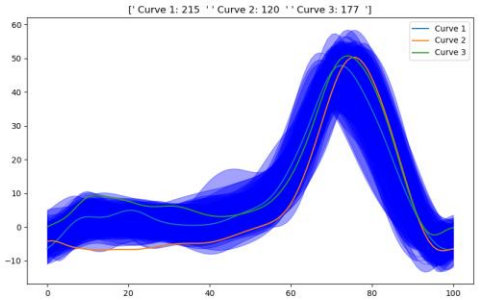
Speed	Variance
0-0.4 m/s	26.88
0.4-0.8 m/s	17.67
0.8-1.2 m/s	18.21
Spontaneous	13.56
High	8.31

Variance of one person's cycles and average over all persons for each speed

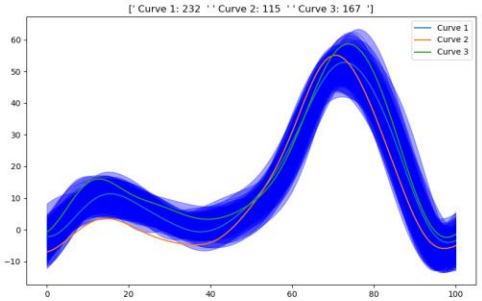
Speed 1



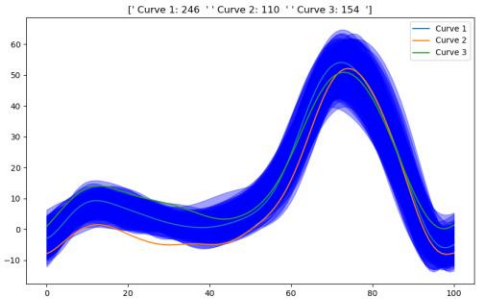
Speed 2



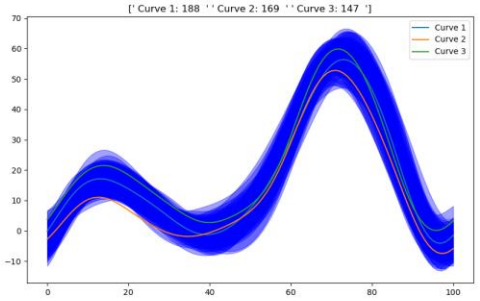
Speed 3



Spontaneous Speed



High Speed



Area of all cycles within a cluster found with K-Medoids

Interpretation

- The speed constraint weakened the walk. The slower the speed, the more different a person's cycles.
- It looks like the stance phase is the most disturbed. Search of balance ? The walker has to force the process which highlights his gait flaws.

Conclusion

Main results

- Deformation of cycle shape under speed constraint
- With the constraint of slow speed, cycles become more individual-specific and different from one another.
- To discriminate pathologies in diseased people, it is useful to apply stresses with slow speeds

Future research

- Take into account individual characteristics such as size and age to assess whether they influence cycle variability.

Thank you for your attention

Feel free to ask questions !