

EG I PC → DSDM installation

Discussion about quality of movement

Discussion between : Bertha/Barbara/Sarah
Second version
third version

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We are talking about general quality of movement and not the one specific of every dancer. It's not about comparing the dancer to the movement of Emilio Greco, it's more about telling if his/her quality fits Emilio's guidance. It's a pedagogical perspective.

The use of such measure or descriptors is for the play mode of the Double Skin Double Mind interactive and **pedagogical** installation where the participant improvises regarding of the qualities he acquired during the professional (B1/B2/B3) modes of the DSDM installation. The system would then be able to recognize some qualities in the general path of the participant and give the corresponding sound feedback (in a further work the visual/graphic one as well).

You can find in the following chapters the different measures that give accurate information to the system about the qualities to recognize from the participant's performance.

1 Breathing

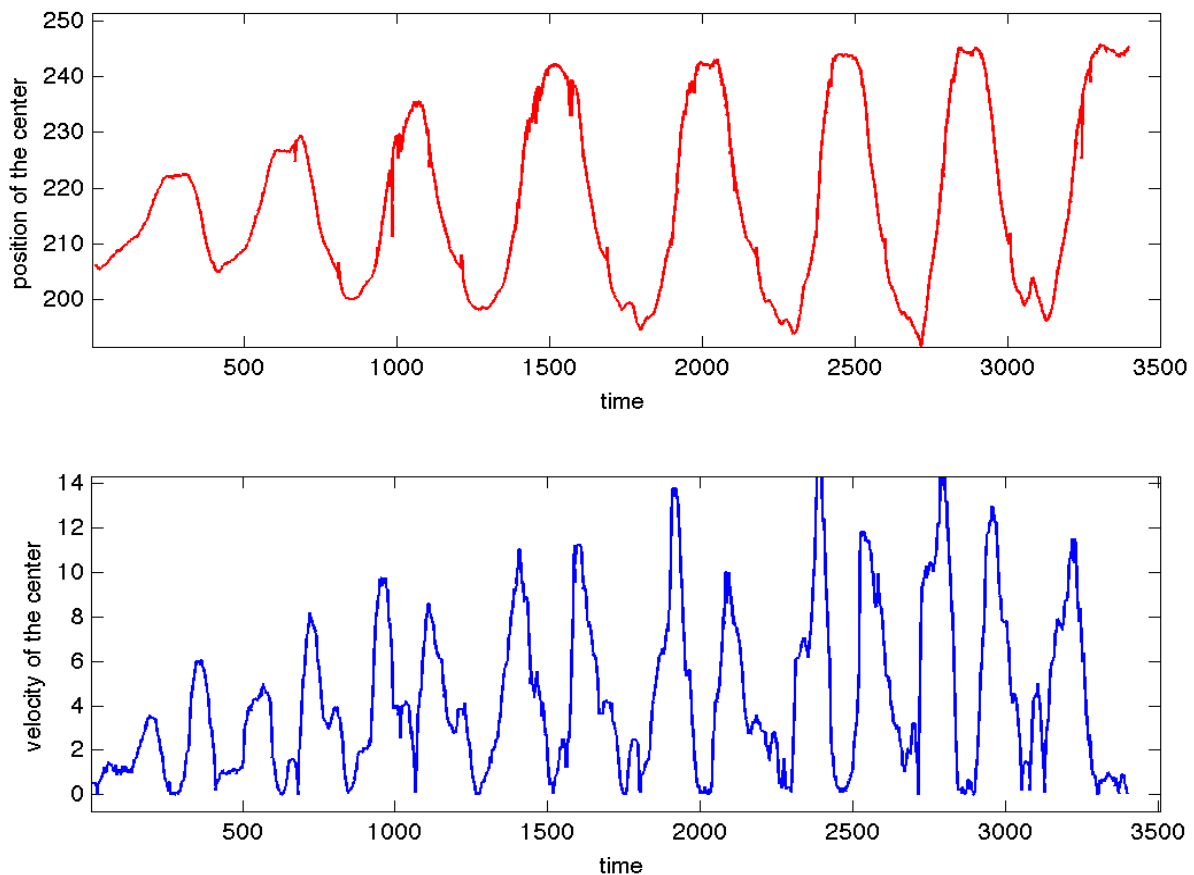
1.1 Growing

2.2.1 velocity of the movement (Temporal descriptor) cf G.Volpe Velocity feature.

- Dependance of the quality of the growing with the velocity of the center of mass
- Rule based feature : if the velocity of the the center of mass is bellow a certain fixed threshold then the slow quality of the growing is achieved.

$$velocity = ((V_x = \frac{x(i) - x(i+1)}{\Delta t}), (V_y = \frac{y(i) - y(i+1)}{\Delta t}))$$

Plot of the absolute value velocity of the center of mass of Emio. :



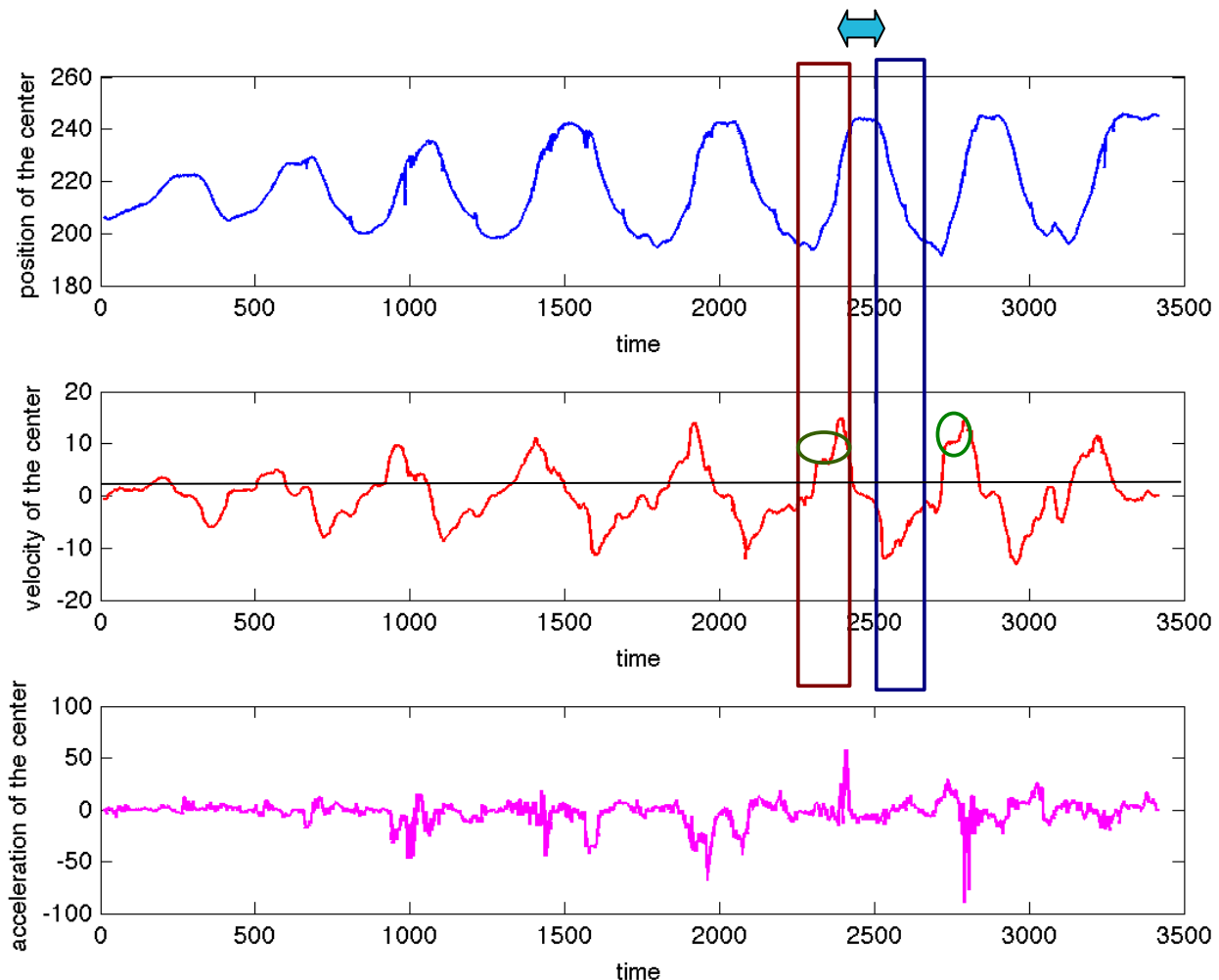
the arrow represent the moment when Emio is down → discontinuity (Emio is not mooving anymore)

2.2.2 Continuity (temporal descriptor)

- the couple surrounded by a scare represent the “breath in” and the “breath out” period of the movement.

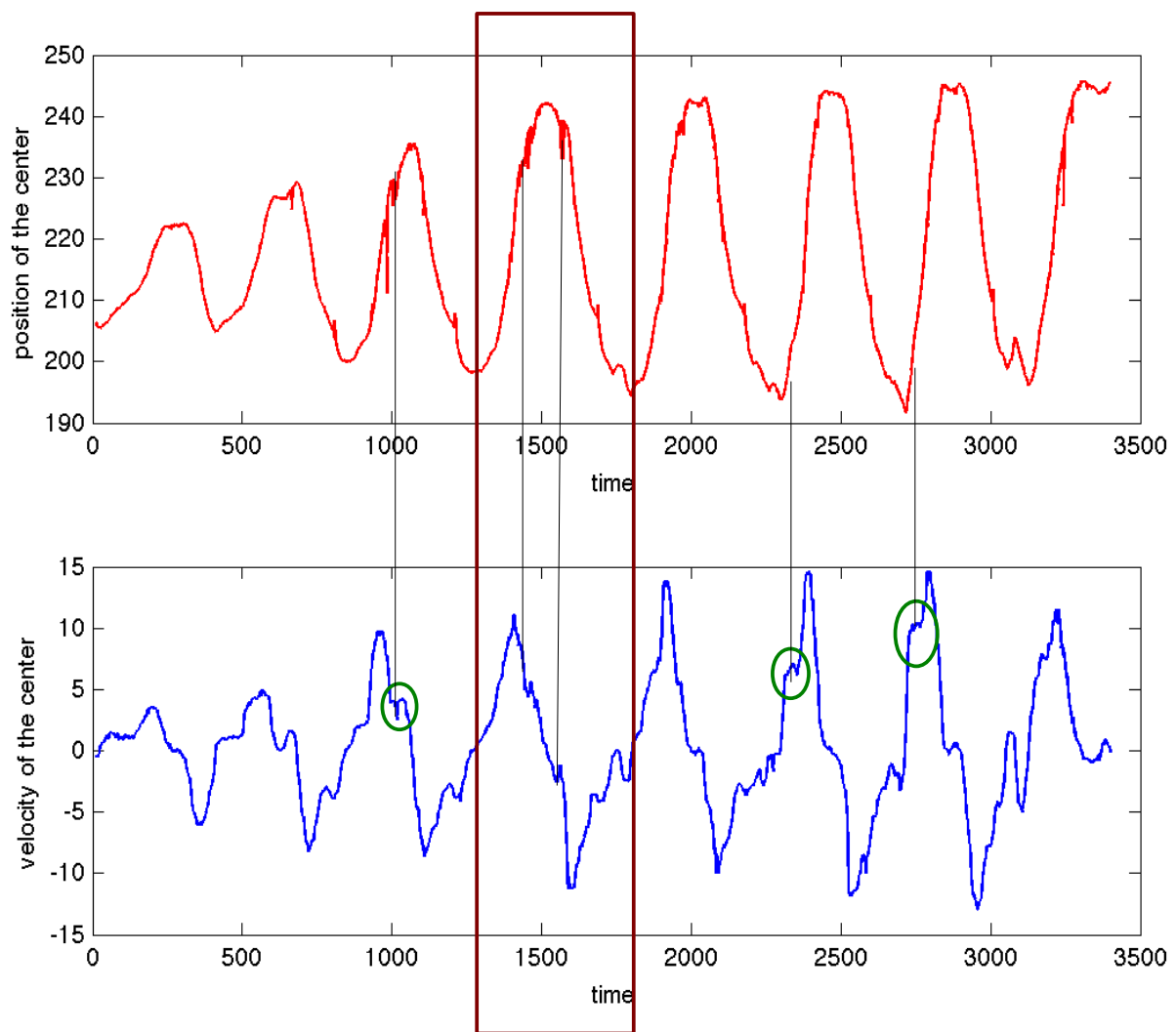
This movement is continuous at the exception of the moment where the stretching is almost maximum and the growing is inner to the dancer (physically it's a non-moving moment but the growing is still processing)

- Plot of the position velocity and acceleration of Emio during the breathing



- The arrow represent the sustain, the plot is characterized by an inflection point at that point. **This is a discontinuity in the movement.**
- The red scare is the “breath in” and the blue one is the “breath out”. The velocity at that two phases is almost symmetrical at the difference of **a little sustain that is present only during the “breath in” phase (the green circle) when Emio start raising his arms. This is a discontinuity of the movement.**

Question : Can we compare with the perception of the dancer ? Do they perceive this discontinuity ?



~~Maximum length feature (Shape and space based feature)~~

~~Rule based feature :~~ Calibrating the dancer, estimating the maximum length that he/she can achieve and the more he/she achieve it during the growing the best the quality is reproduced. If the maximum length feature as described bellow is near to 1 then the stretching quality in the growing phase is achieved.

~~This feature/descriptor is equivalent to the verticality one.~~

2.2.3 Verticality

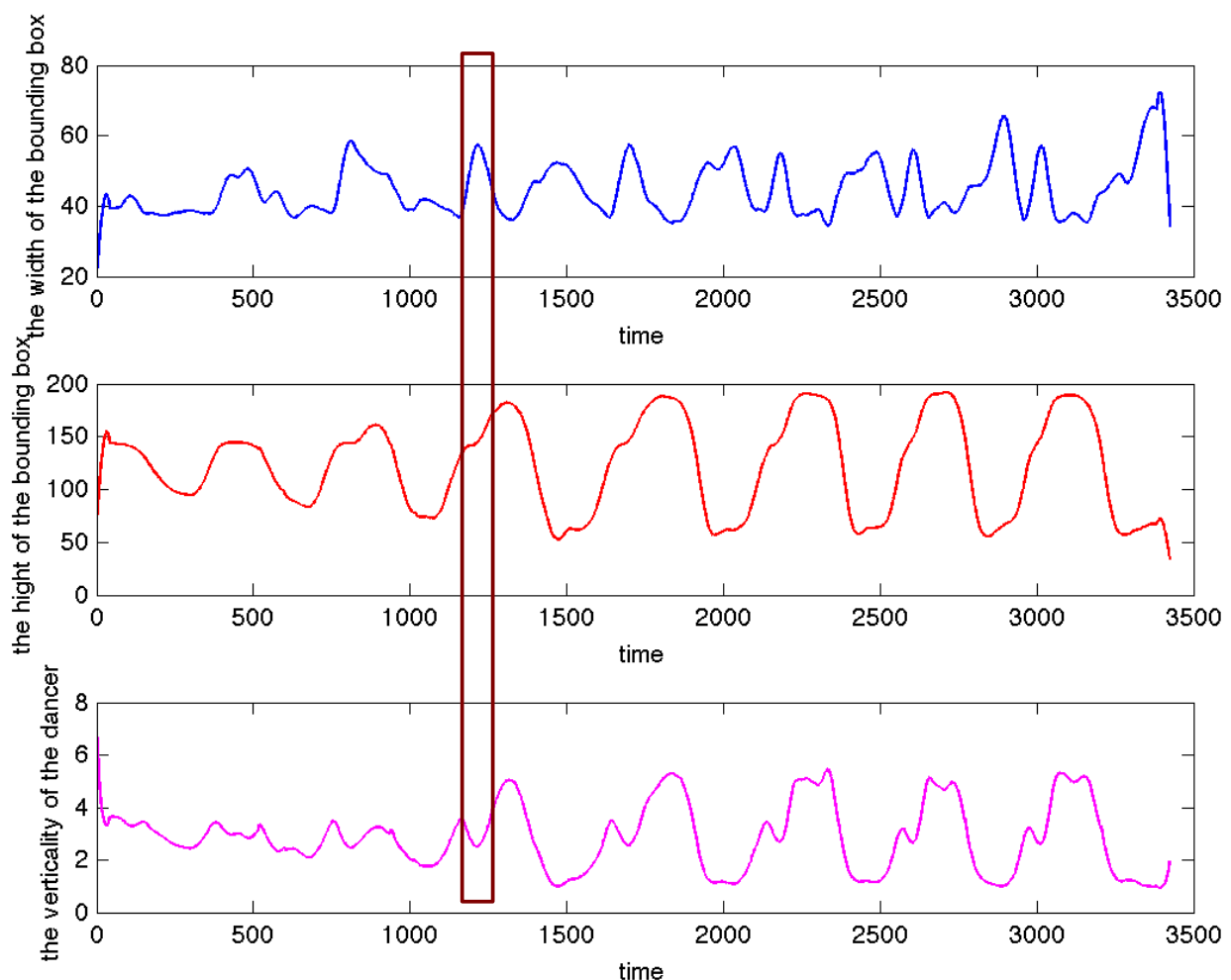
the bounding box have to stay narrow and the width of the bounding box shouldn't be beyond a certain threshold. **(Shape and space based feature)**

Rule based feature : At each frame, calculate the verticality index as follow and fix a threshold so that if the verticality is bellow a certain fixed threshold than the quality of verticality is achieved.

$$verticality = \frac{boundingboxlength}{boundingboxwidth}$$

- Plot of the width, length and the verticality of Emio during the breathing:

The maximum verticality corresponds to the moment Emio is at his maximum extension during the “breath out” and the minimum verticality to his minimum extension during the “breath in”.



2.2.4 Correlation between the Emio's breathing sound and the periodicity of the movement. (Temporal descriptor)

indirect computation + Rule based feature : At each frame, if R is far from 0 with a certain threshold than the sound of breathing and the periodicity of the movement are correlated.

$$R = \frac{\sum_{i=1}^N (g_i - \bar{g})(s_i - \bar{s})}{\sqrt{\sum_{i=1}^N (g_i - \bar{g})^2} \sqrt{\sum_{i=1}^N (s_i - \bar{s})^2}}$$

→ NOTE : We should find a way to map the sound feedback to Emio's breathing sound or the evolution of the movement of the dancer

to think about it

1.2 Ramification / Exploring

The ramification = growing + different direction of the arms

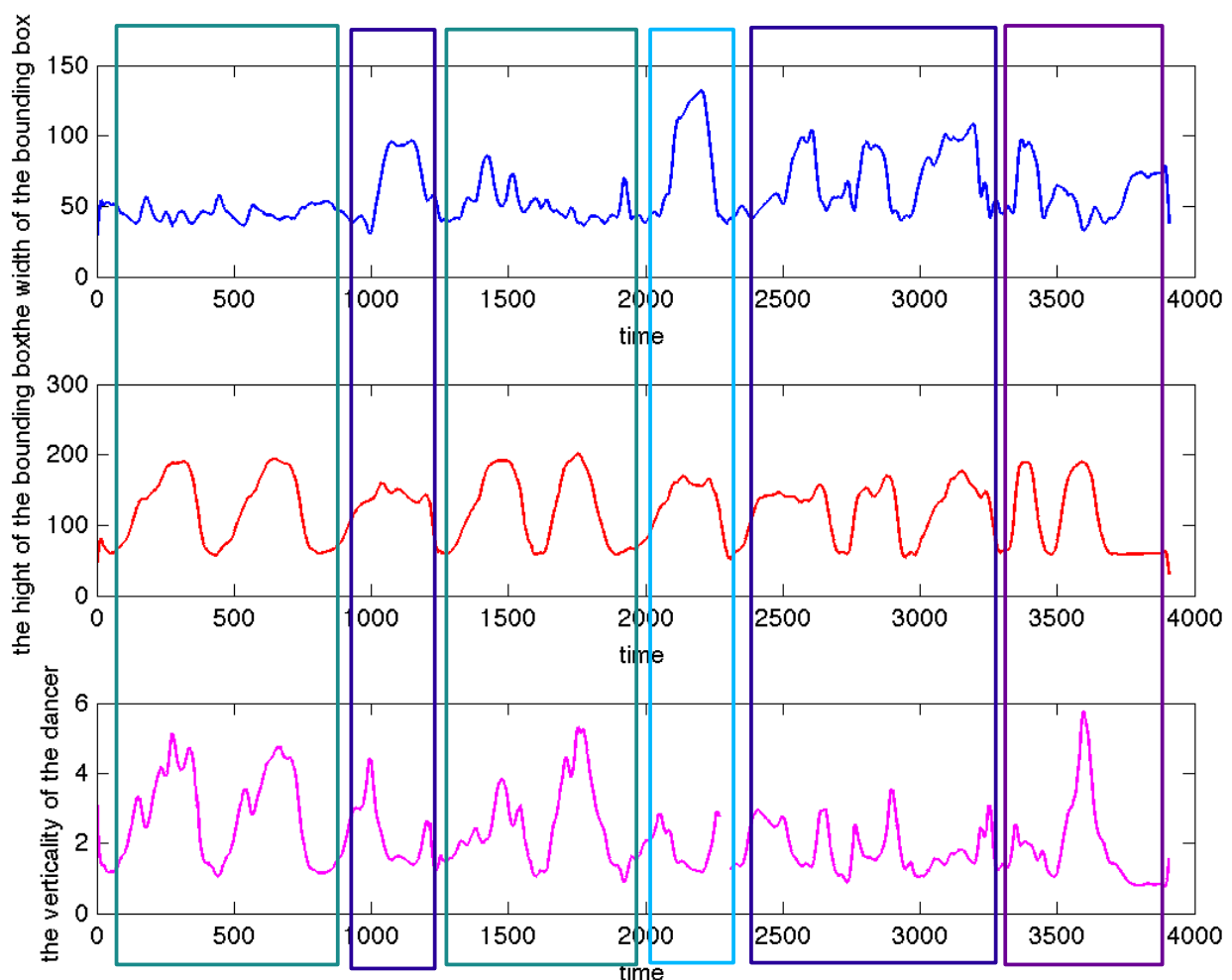
The same descriptors as for the growing but replacing the verticality feature by the maximum diagonal feature..

2.2.1 Verticality (Temporal descriptor)

- Plot of the verticality of Emio. :

Let us plot the verticality of Emio's movement during the breathing (with the width and the hight of the bounding box).

We can notice that the width of the bounding box can be much bigger than in the growing while the vertical extension is less important as shown on the plot of the hight of the bounding box. Indeed, the verticality is less visible during the ramification because the extension is to the side and not necessarily to the top.

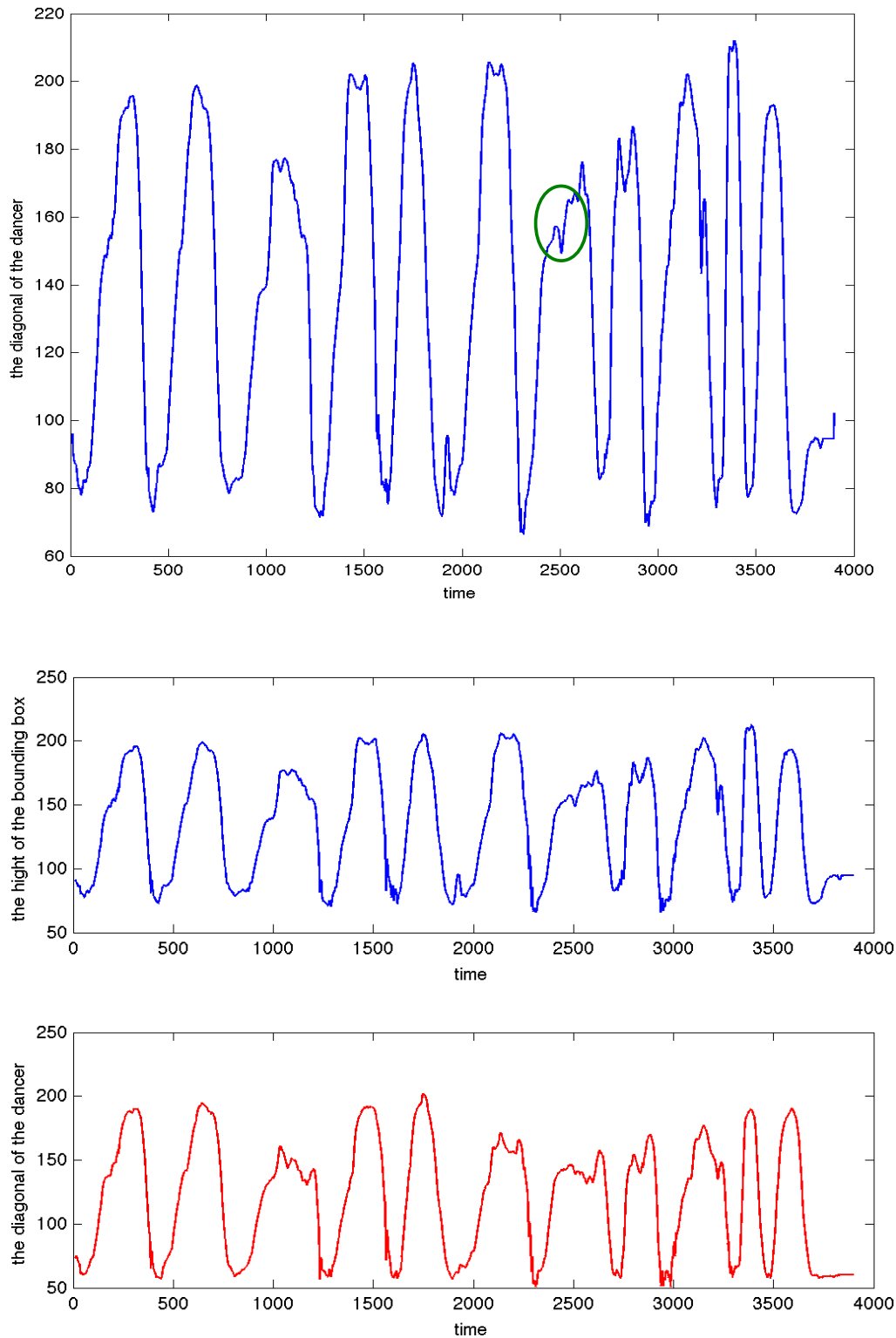


2.2.2 maximum diagonal length feature (Shape and space based feature)

Rule based feature : if the dancer acheives his maximum diagonal then the quality is achieved.

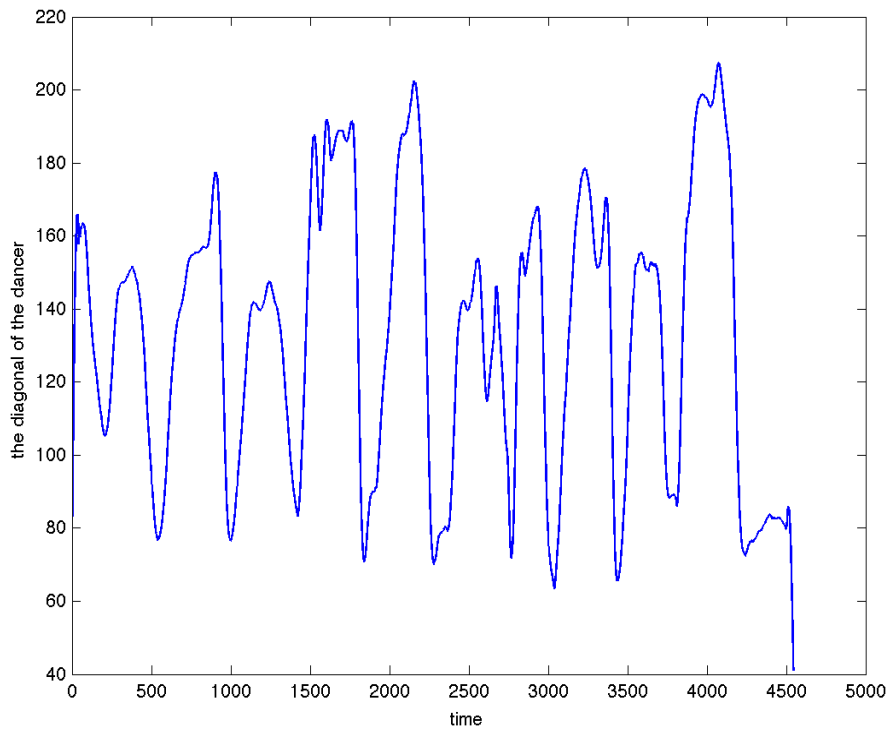
Since the Ramification and the exploring are no longer is a vertical extension, the measure that characterize the best the extension is the maximum diagonal length feature.

Let's plot the norm of the diagonal of Emio during the ramification part :



Let's plot the norm of the diagonal of Emio during the exploring part to compute the **maximum length in one of the diagonal**:

→ It is equivalent to the one of the ramification indeed.

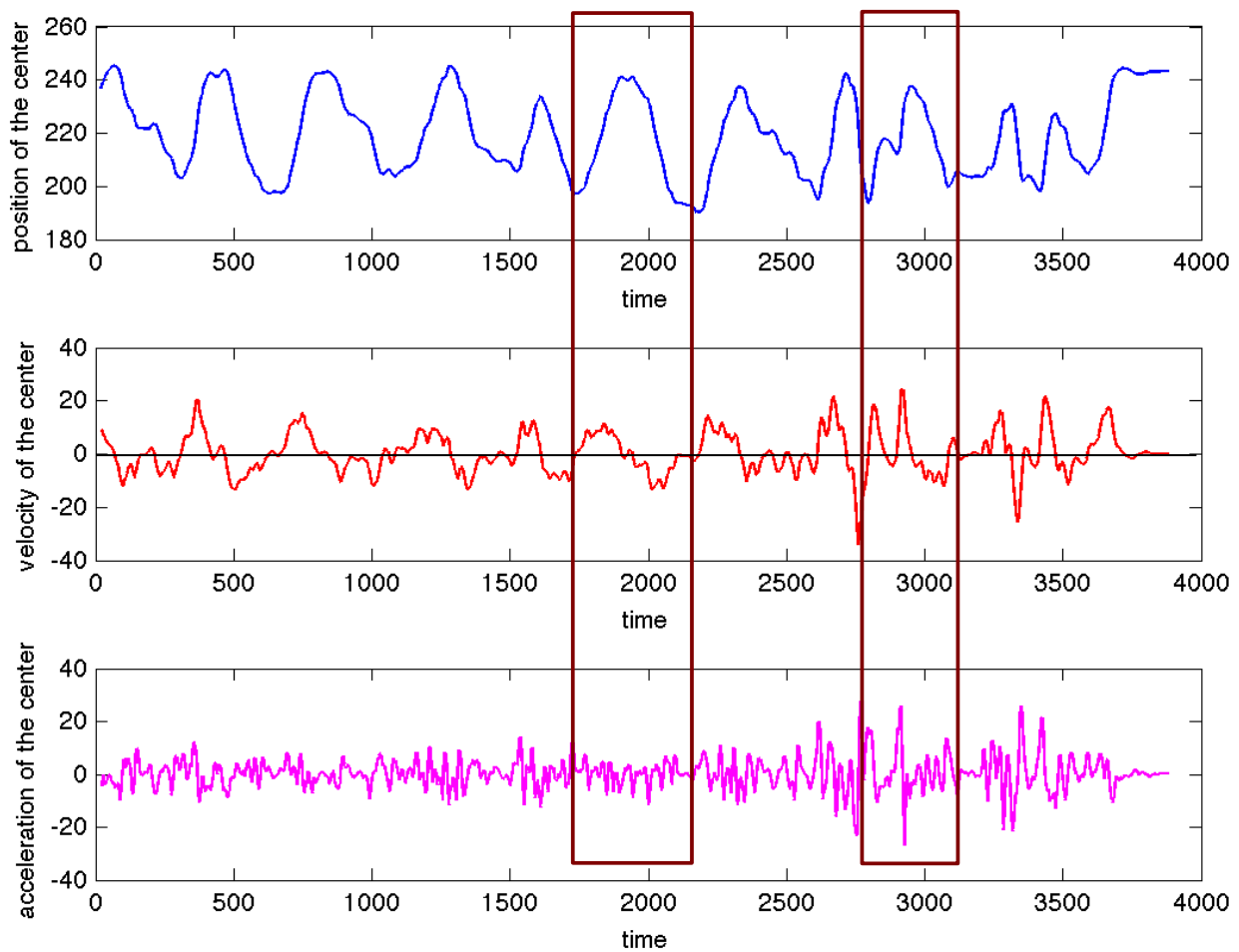


2.2.3 speed of the movement / continuity

- Dependence of the quality of the growing with the **speed** of the center of the mass

$$velocity = ((V_x = \frac{x(i) - x(i+1)}{\Delta t}), (V_y = \frac{y(i) - y(i+1)}{\Delta t}))$$

- Plot of the velocity of the center of mass for the center of mass of Emio. :

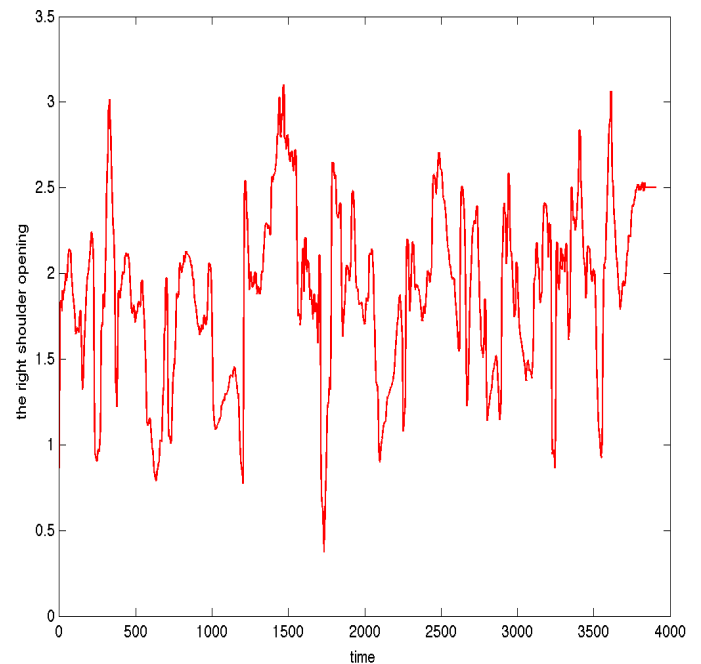
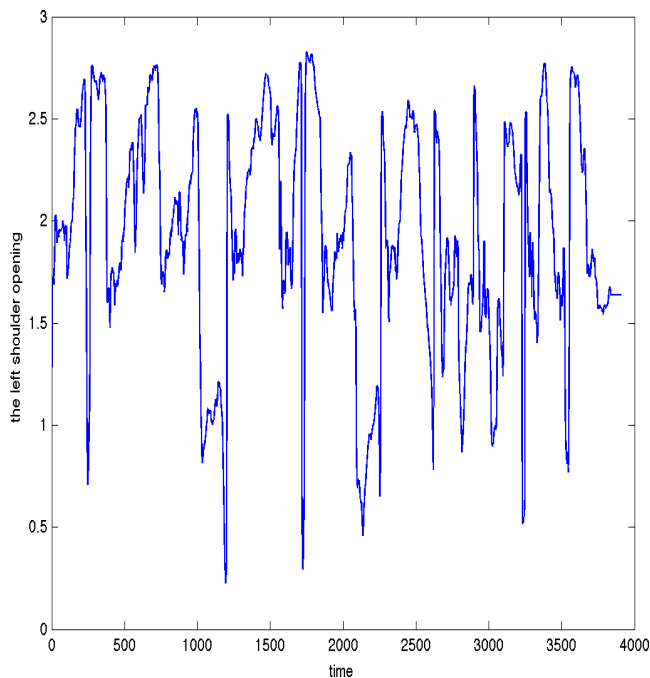


- the continuity is represented by the missing of the inflection points.

2.2.4 The angle between the different direction of the arms (Shape and space based feature)

Rule based feature : Calculating the angle between the segment starting from the center of mass and finishing at the top right extremity of the hand and the segment starting from the center of mass and finishing at the top left extremity of the leg. If this angle is over a fixed threshold than the quality is achieved.

Let's plot the angle between the arm and the leg of the left and right part of Emio during the ramification :



We calculate this measure from the head, arms and legs approximation on the silhouette (eyeweb). These approximation have an small rate of accuracy and don't permit to see the real opening of the arm pet. These measures will be surely more accurate if we use a motion capture system.

We can still see that the angle oscillates from 0 to π for the 2 arms of Emio during the Ramification.

1.3 Exploring

Exploring = ramification + 3 dimensionality (!!! We have a 2 dimensional bounding box, the 3 dimensionality isn't possible to characterize) → **the exploring part is described exactly the same way than the ramification part.**

→ See ramification .

2 Jumping

2.1 *Gentle rebounding*

2.2.1 Auto-correlation between the extremities of the bounding box **(Temporal descriptor)** **and (Shape based feature)**

→ already done by Fred

2.2.2 Model of 2 masses interacting with a spring force between them. **(physical models based feature)**

Question : how is it possible to compare 2 qualities of 2 dancers by comparing the physical models they generated ?

→ Future work !!

2.2 *breaking action / Strenuous rebounding*

The movement of the legs alternating and using the knees is a model that the dancer should follow to get to the quality of the movement that is wanted.

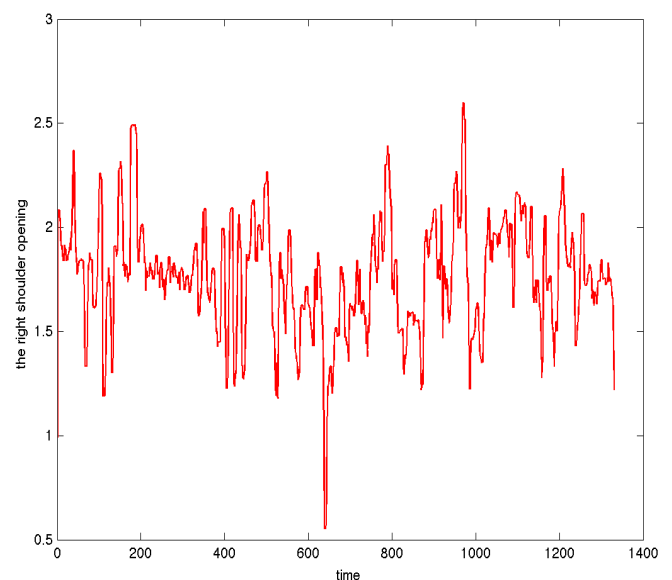
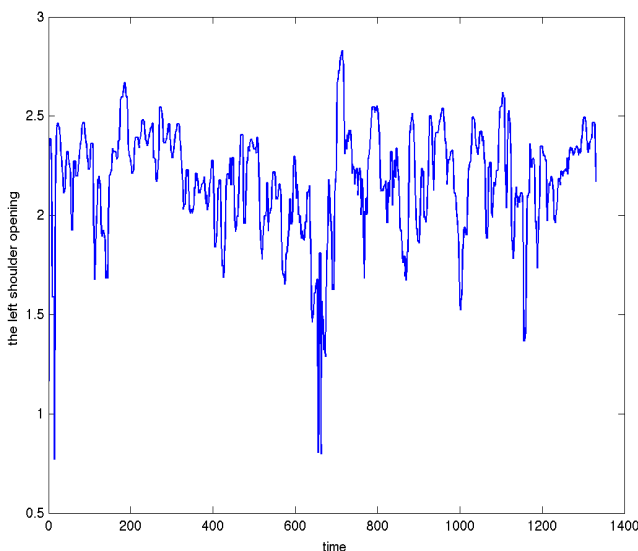
2.2.1 The movement of the legs is shape oriented. (Shape based feature)

Test of the Gesture Follower on this part of the Workshop

2.2.2 The angle between the center and the arms direction

- The arm pit are open → measuring the **angle between the center and the arms direction** shows the opening of the armpit (**Shape and space based feature**)

Rule based feature : Calculating the angle between the segment starting from the center of mass and finishing at the top right extremity of hand and the segment starting from the center of mass and finishing at the top left extremity of the leg. If this angle is over a fixed threshold than the quality is achieved.



We can see that this measure oscillates a lot because of the non stability of the data from the approximation algorithm of the head, the arms and the legs of the silhouette.

2.2.3 Correlation between the sound produced from the hands touching the thigh and the periodicity of the movement itself. (Temporal descriptor)

indirect computation + Rule based feature : At each frame, if R is far from 0 with a certain threshold than the sound of breathing and the periodicity of the movement are correlated.

$$R = \frac{\sum_{i=1}^N (g_i - \bar{g})(s_i - \bar{s})}{\sqrt{\sum_{i=1}^N (g_i - \bar{g})^2} \sqrt{\sum_{i=1}^N (s_i - \bar{s})^2}}$$

2.2.4 Different acceleration between the 4 extremities (the 2 hands and the 2 legs) even if their periodicity is the same.

2.2.5 Model of 2 masses interacting with a spring force (physical models based feature)

Question : how is it possible to compare 2 qualities of 2 dancers by comparing the physical models they generated ?

→ FUTUR WORK !!!

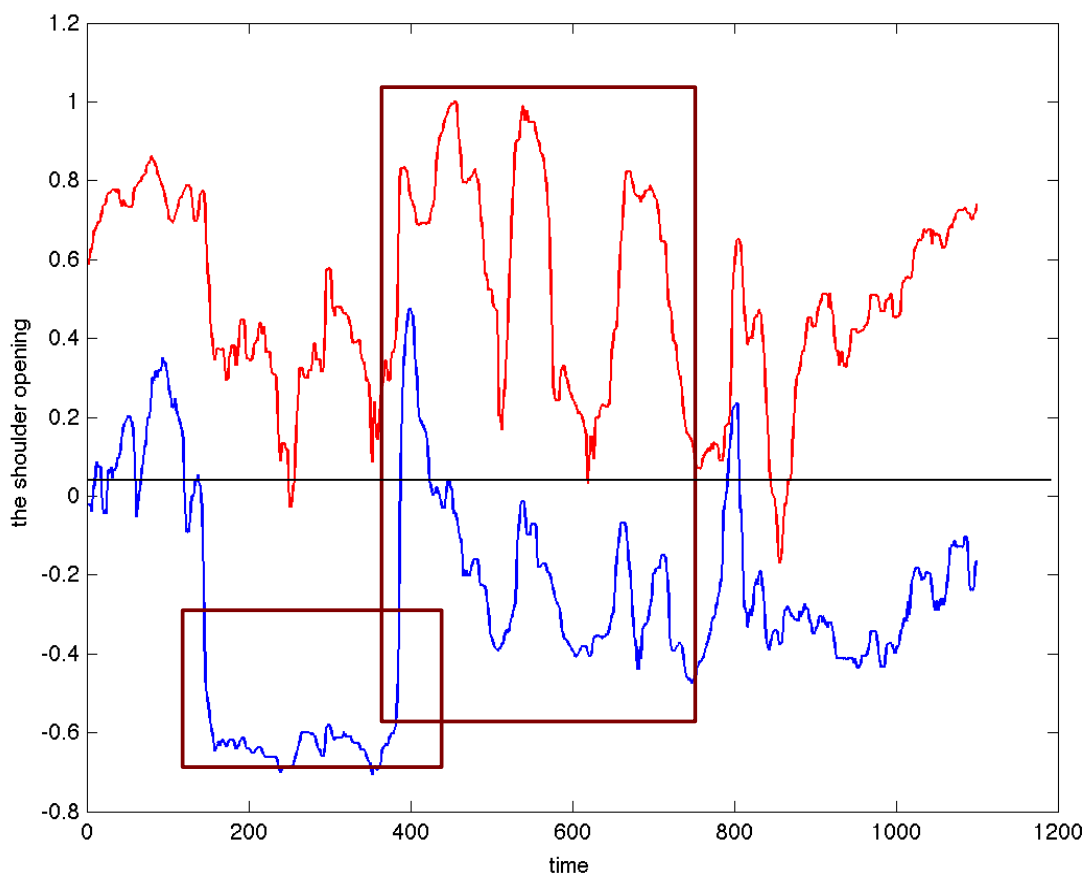
2.3 Shoulder breathing → clustered as part of the breathing

2.2.1 Angle between the center and the arm direction (Shape and space based feature)

- the space or the volume under the armpit should be measured as an **angle between the center and the arm direction** that shows the opening of the armpits.

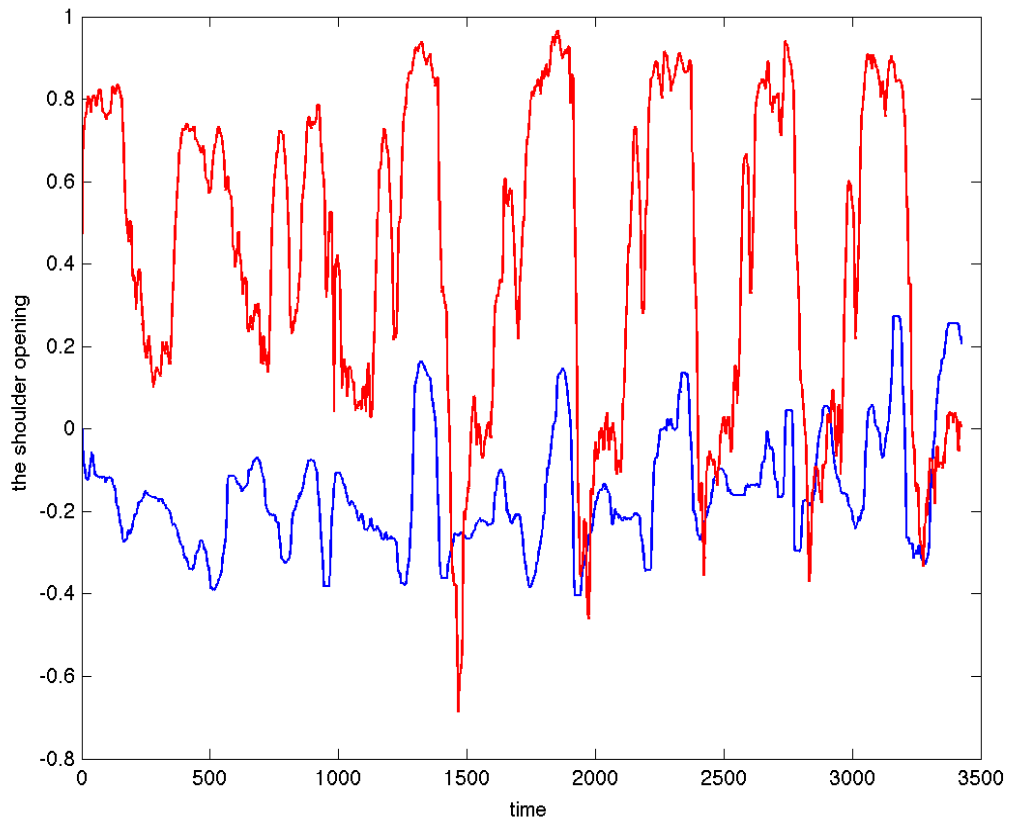
Rule based feature : Calculating the angle between the segment starting from the center of mass and finishing at the top right extremity of the hand and the segment starting from the center of mass and finishing at the top left extremity of the leg. If this angle is over a fixed threshold than the quality is achieved.

Let us plot the diagonal of Emio during the shoulder breathing part :



- the first scare represents the part of the video where Emio has his arm on his head with an extreme shoulder breathing.
- The second scare, where the two plots are almost simetrical, Emio is deploying his two arms is the shoulder breathing.
- PS : the red plot represents his right arm and the blue one represents his left one.

Let's compare with the plot of the shoulder angle for the growing part :



In fact the shoulder opening (the angle) quality is present in all the parts of this workshop in the exception of the reducing one. So this quality is absolutely not exclusive of the shoulder breathing part.

2.4 Strenuous rebounding

Strenuous rebounding = breaking action + 3 dimensionality

→ See breaking action

2.5 Walking

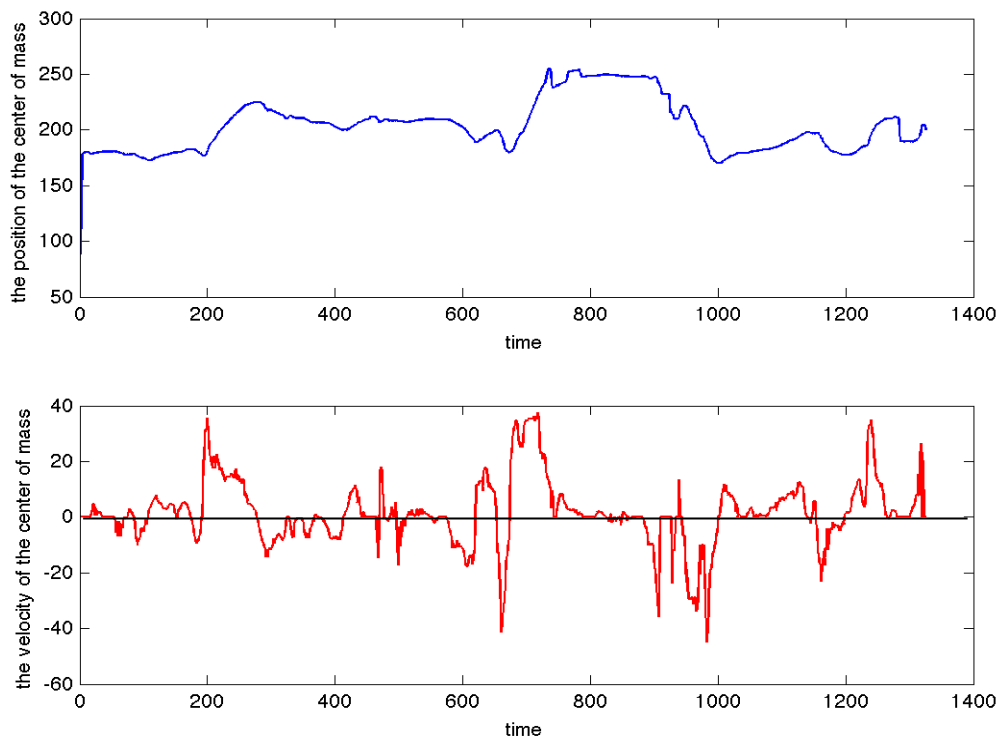
No interactivity and no feedback !

3 Expanding

In the expanding section, the exact same quality is performed in the 2 first sub sections. For a pedagogical reason, this quality is first presented as opening of the boundaries and then transfer of balance.

3.1 Open boundaries /transfer of balance :

2.2.1 Continuity = no acceleration. (temporal descriptor)



The continuity is characterized by the absence of inflexion point. The position of the center of mass is smooth.

2.2.2 shifting of the weight (Shape based feature)

The shifting of weight is measurable as the **distance between** the plan passing by the **center** of the 2 foot and the **center of mass**

Rule based feature : if the distance between the center of mass and the segment dividing the extremities of the 3th and the 4th bounding boxes in 2 is over a certain threshold than the quality is achieved.

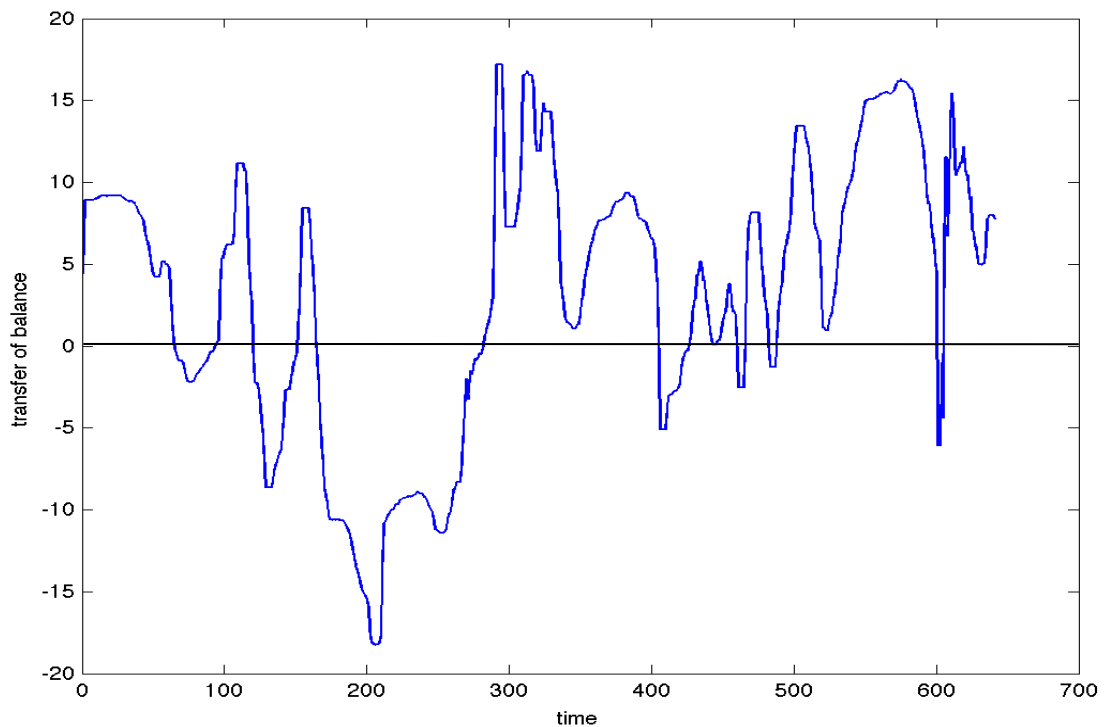
the plots of the transfer of balance can take into account

1) the distance between the center of mass and the medium of the extremities of the 2 bottom sub bounding boxes:

2) The distance between the center of mass and the center of the 2 legs as computed in eyesweb :

→ **These two ways of describing this quality are quasi equivalent plot.**

let's plot the shifting of weight for the transfer of balance part.



2.2.3 the extension

The extension is measurable with the **distances** between every ones of the 5 points defined by the 4 extremities (of the bounding box) and the center of mass (**Shape and space based feature**)

1) Rule based feature : if the maximum of the combination of the different distances separating the 4 extremities and the center of mass from each other is over a certain fixed threshold than the quality is achieved.

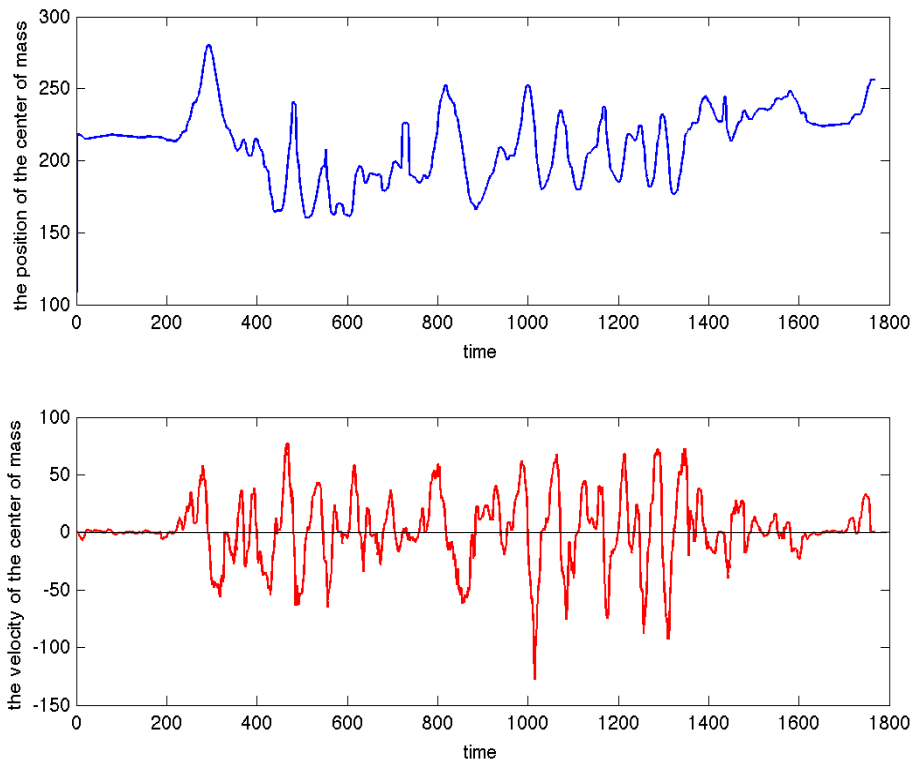
PS : This descriptor is equivalent to the combination of the verticality descriptor and the maximum diagonal length one

3.2 articulated rhythm

- The same descriptors as for the open boundaries and the transfer of balance part at the exception of the continuity of the speed.

2.2.1 No “continuity”

The speed is **no** longer **continuous** = the acceleration variates. **(temporal descriptor)**



The position of the center varies much more than in the open boundaries part and the velocity oscillates a lot. This characterizes the fact that the accelerations are different and the velocity is not continuous.

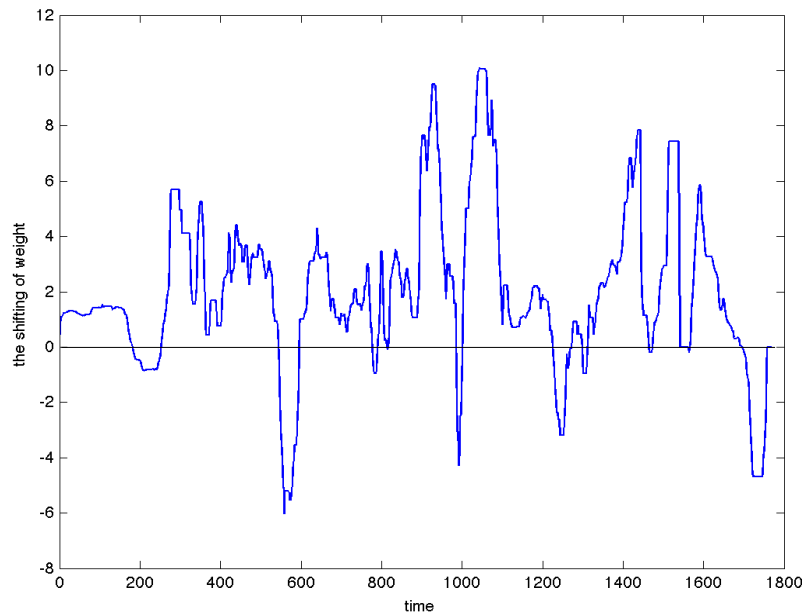
2.2.2 shifting of the weight (Shape based feature)

The shifting of weight is measurable as the **distance between** the plan passing by the **center** of the 2 foot and the **center of mass**

Rule based feature : if the distance between the center of mass and the segment dividing the extremities of the 3th and the 4th bounding boxes in 2 is over a certain threshold than the quality is achieved.

The plots of the transfer of balance tacking into account

the distance between the center of mass and the medium of the extremities of the 2 bottom sub bounding boxes and the distance between the center of mass and the medium of the 2 legs (in X-coordinate)



2.2.3 the extension

The extension is measurable with the **distances** between every ones of the 5 points defined by the 4 extremities (of the bounding box) and the center of mass **(Shape and space based feature)**

1) Rule based feature : if the maximum of the combination of the different distances separating the 4 extremities and the center of mass from each other is over a certain fixed threshold than the quality is achieved.

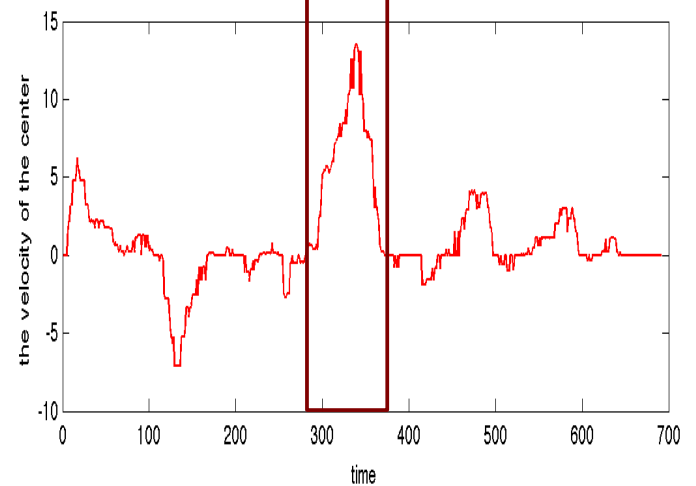
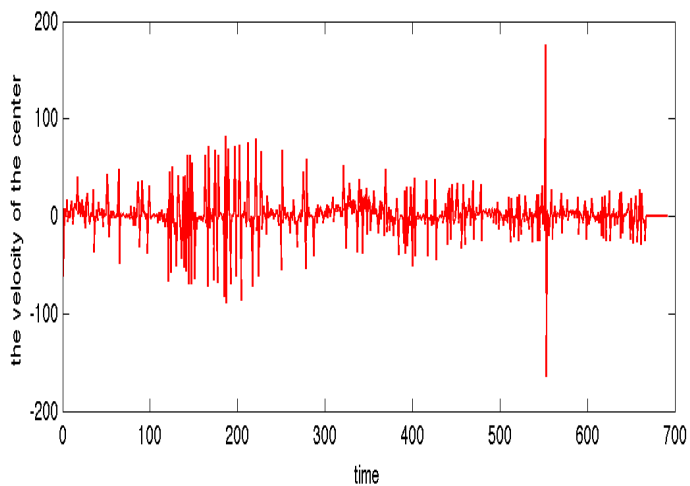
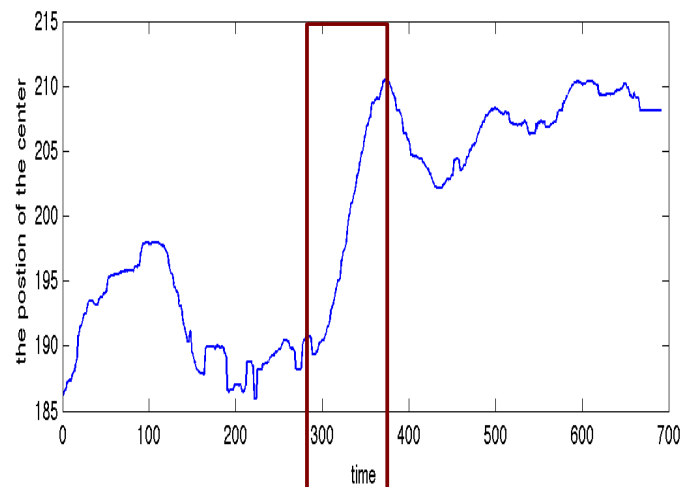
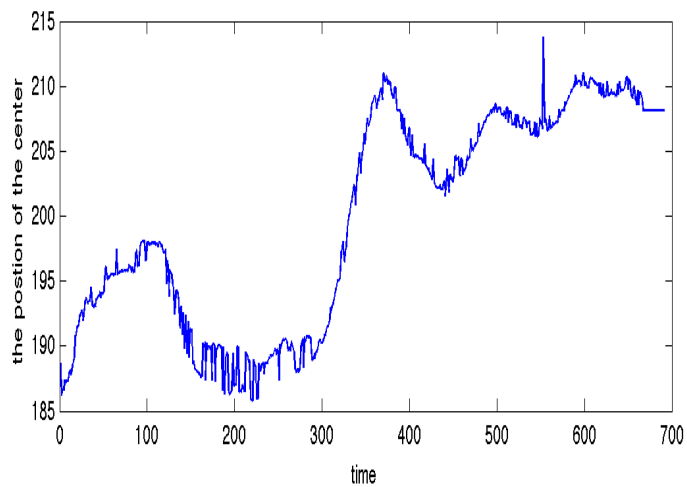
4 Reducing

4.1 *thick air*

2.2.1 speed calculation → model already existent in DSDM installation

the velocity must be bellow a certain threshold.

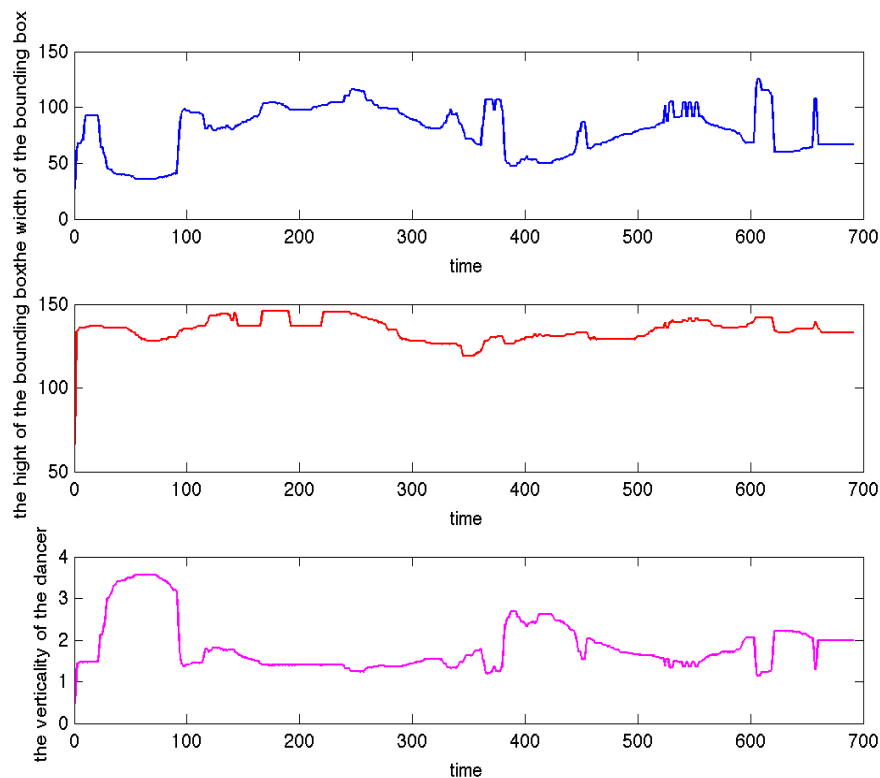
Plot of the position of the center of mass and bellow the velocity of the center of mass :



2.2.2 the volume of the bounding box is reduced.(Shape and space based feature)

Rule based feature : cf *G.Volpe contraction index*. If the maximum reducing feature is near to 0 then the reducing quality in the thick air phase is achieved.

$$\text{maximumreducingfeature} = \frac{\text{silhouette surface}}{\text{bounding box surface}}$$



The verticality in this case is low.

2.2.3 viscosity.

It immerse the participant in a viscous universe. Model the thick air as :

- for the motion of a particle of the viscous liquid
- for the motion of an object in a viscous liquid surrounding.

(physical models based feature)

Question : how is it possible to compare 2 qualities of 2 dancers by comparing the physical models they generated ?

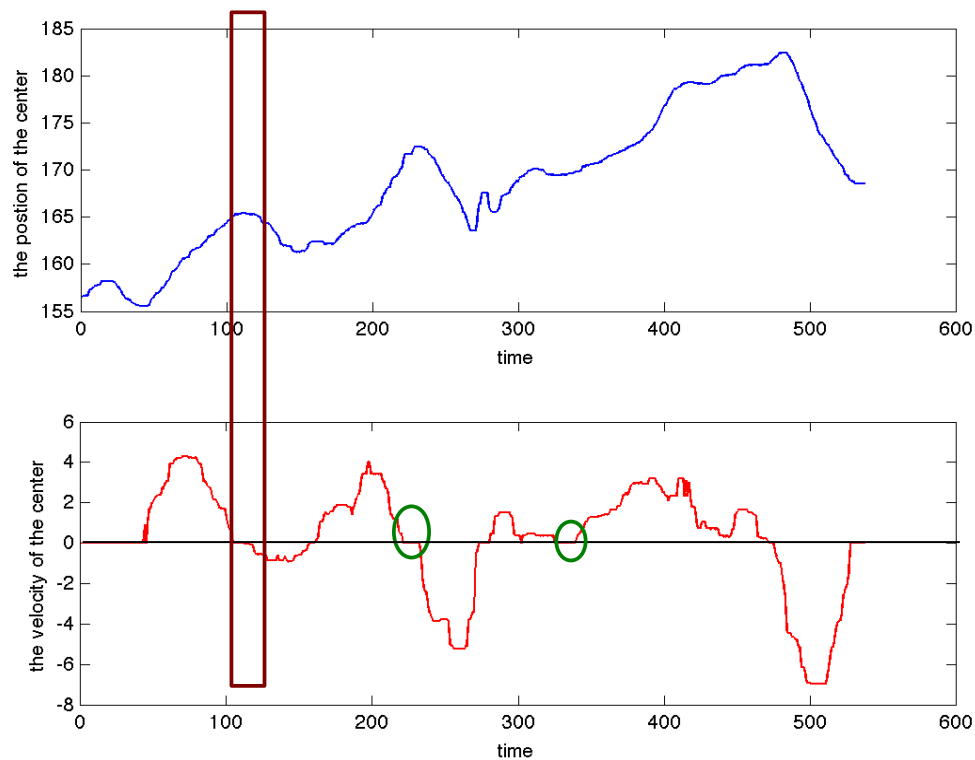
4.2 Floating

No resistance = no model from a viscous universe

2.2.1 Slow / continuity

→ speed calculation only → model already existent in DSDM installation

- the quality of slow is when the velocity is bellow a certain threshold.
- There are technically **discontinuities** (circle in green) where the velocity is null during a certain amount of frames.



4.3 freezing

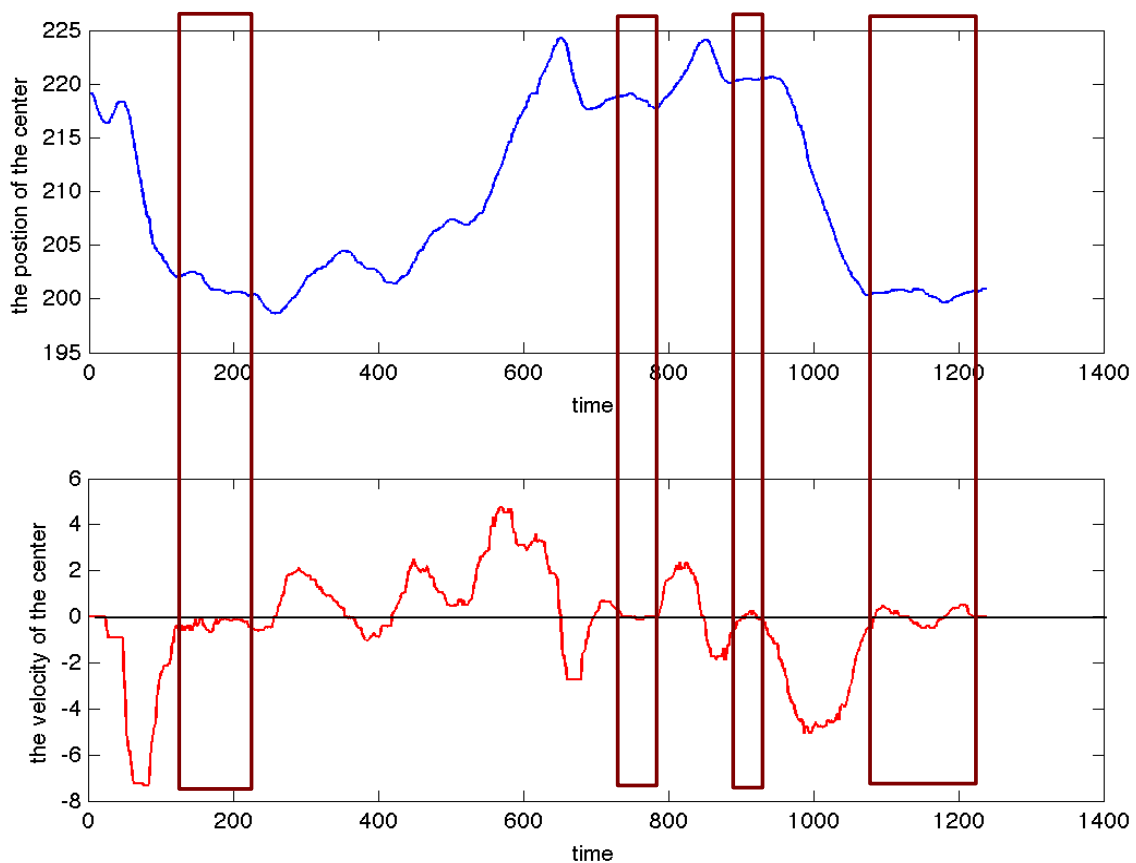
The freezing goes withing the floating quality.

2.2.1 discontinuity of the movement . (temporal descriptor)

distinguish the moment where the speed is zero

cf G.Volpe impulsion feature (non continuity is achieved when the pauses are frequent and the movement' phases are short)

- The discontinuity in the movement are the dish values in the position and the dish null values in the velocity of the center of mass.



Summary of the qualities and the descriptors to develop and how to distinguish the different part of the workshop regarding these measures :

	Center of mass velocity	Auto correlation of the bounding box	continuity	Maximum Verticality	Maximum diagonal	Maximum Shoulder angle	Shifting of weight	Maximum Extension
Growing	slow	No	Yes but sustain !	Yes	Yes	Yes	No	Yes
Ramification Exploring	slow	No	Yes but sustain !	No	Yes	Yes	No	Yes
Shoulder breathing	slow	No	Yes but sustain !	No	No	Yes	No	No
Gentle rebounding	Fast	Yes	Yes	No	No	Yes	No	No
Breaking action / Strenuous rebounding	Fast	No	Yes	No	No	Yes	No	No
Open boundaries / Transfer of balance	Slow	No	Yes	No	Yes	Yes	Yes	Yes
Articulated rhythm	Slow	No	No	No	Yes	Yes	Yes	Yes
Thick air / Floating	slow	No	Yes	No	No	No	No	No
Freeze	slow	No	No	No	No	No	No	No

We can distinguish :

the expanding from the breathing through the shifting of weight.

the jumping part is very specific because of the fast velocity it is characterized with.

the reducing part from the breathing and the expanding through the absence of extension.