Gait Analysis: Qualisys&GaitWatch data munich February 2014

Project 1:

Determination of terminal and initial contact in the gyro-data of the shank by comparing gyro-shank-data with soles and with Qualisys-recordings.

Reason: Most publications use gyro-recordings for the detection of TC and IC. We have a lot of data to determine these instances in dependence of velocity and other factors.

Comparison of gyro-shank-data with soles:

Soles-channels:

PD1;PD2;PD3; PD4;ADZ; PI1;PI2;PI3; PI4;AIZ;

PD4/PI4: heel

Tasks: synchronize soles/gyro-data, plot all soles data of individual steps, plot Gyro-curves, determine manually TC and IC, put all data in a table, evaluate table statistically. Question: are TC and IC different in different people? Are they depending on velocity? How to best describe TC and IC in terms of the gyro-curve only (Threshold??).

Comparison of gyro-shank-data with Qualisys:

Synchronize Gyro-Qualisis data, check backward/forward movement of foot, which is synchronous with gait belt as long as the foot is on the belt. Mark moments in which foot velocity and belt velocity begin to differ, these are probably moments of TC and IC.

Project 2:

Application of Kalman filter for gait data obtained from Gyros and accelerometers. Describe the Kalman filter applied here, describe the hardware, and describe the qualisys setup. Describe the results of the preliminary tests (box and others, this is probably ready already) and describe the results of the gait recordings of the treadmill. Assess precision of the data by setting qualisys recordings as gold standard. Analyse the errors (I think we should be able to define errors due to incorrect placement by comparing data from different people, in these cases the hardware is comparable, the placement should be different). This project would only describe leg segment pitch but not step length, because tis should be the issue in the next project.

Project 3:

Describe the use of inverse Kinematics for gait analysis. Compare step length obtained with the Kalman data with data from a) Qualysis and b) treadmill (we have the distance the subject was walking). Analyse the errors and see if pelvic movements which are not included in the Kalman data but in the Qualiysis data can help reduce the error. Come to a conclusion whether this approach is useful (because some people record gait with 2 sensors and get reasonable results).

Alberto’s mail 23.2.2014:

Dear Kai,

Yes, I agree with you, we should definetely try to write as many papers as we can from all the data we have so far.

Regarding the three papers you can count with my help for all of them.

- For the Gait Analysis using the Qualisys and the Gaitwatch, what would be the general goal of the paper? I think we can write a paper describing the Gaitwatch and then demonstrate its accuracy compared to the Qualisys system to estimate some inertial and gait parameters. So far I have compared the data for the legs and I am only missing the hip (my student Verónica is going to start working on this very soon). Do you have any more suggestions or another point of view for this publication? (I have specified this above)

- Determination of the terminal and initial contact in the gyro data of the shank by comparing gyro-shank data with soles and with qualisys. If I understood well we need to plot all shank gyro curves, synchronize them with the soles data and then determine TC manually (we could also try to do this automatically). What would be the general goal here? Determining the ability of the Gaitwatch to estimate IC and TC? (I have specified the goals above in project 1, and I have finished the program for synchronization soles data and gait watch data, it is in the attachment, maybe you will be able to use it, all comments are in English)

- Which is the third paper? (This would be project 3 as detailed above)

Regarding the APA project:

My studentes have synchronized the force plate and the Gaitwatch data for the experiments carried out by the two patients from which we have complete datasets. They are finishinig to integrate everything in just one script which does the following:  
1) Take the excel file with the protocol as the input.  
2) Read this file line by line and automatically load the source data from both the force plate and the GaitWatch for each patient. (you should check wherter these data really belong together by some plausibility measures as it is not completely unlikely that there is an error in the excel file)  
3) Calibrate the GaitWatch data and compute the orientation angles.

4) Apply the Force plate algorithms to determine the four force traces, and COP. (For me the path of the COP during the APA is the most important point. It should follow a certain pattern which is described in the preliminary paper which we are actually preparing for submission (see attachment). This pattern is unique and many reasearch has been done during recent years to study whether this pattern changes in PD. Therefore it might have some diagnostic value. And therefore my main question in this project was (and is), is this pattern somehow recognized in the data of the accelerometers (especially of the accelerometers of the trunk). That means, are the traces of the accelerometers unique before a step? (it must be clear that a step with the right and left foot are different!!)

5) Interpolate Force plate data to adjust the number of samples per second from 120 to 200 to match the sampling frequency of the GaitWatch.

Then, for each time the patient steps on the force plate:

6) Determine automatically which foot steps first on the force plate (sometimes the patient steps with the left foot and sometimes with the right foot).

7) Apply an intensity detection algorithm based on frequency analysis to distinguish the instants in which the patient is moving.

8) From these instants, determine the instants in which the patient is stepping on the force plate and not stepping down and turning around. The patient stands some time on the force plate (1-5s). Ten, the step occurs. So the instance at which the step occurs is important since the APAs are time locked (backwards) to this instance (see our preliminary paper).

9) From the instants in which the patient is stepping on the force plate, apply a peak detection algorithm on the shank acceleration gathered on the Z axis to determine initial contact. (They are also going check the gyro signal).

10) Using the force traces from the force plate, determine the length of the period in which the patient is standing on the force plate.

11) Store all the GaitWatch signals (raw signals, calibrated signals, orientation angles) for this specific period of time.

Finally, at the end of the execution, we have a cell for each signal of interest divided in as many chunks as times the patient stepped on the force plate. For example, patient ES39 walked 11 times on the force plate, so we would have a .mat file containing:

 - AP\_COP\_ts (1x11 cell)

 - ML\_COP\_ts (1x11 cell)

 - a\_shanks (1x11 cell)

... and so on.

I am attaching a matlab figure in which you can see the output of the synchronization signal for patient ES39. (That looks great! It seems that you were able to get a good synchronization even without having all these devices there.)

It is very important to try the algorithm in more signals to check if it works for all signals. How many patients did you gather data from in the end? (Up to now we have about 12 patients and we are planning for about 20 patients an 20 controls)

At this moment, we do not really know what to do now that both systems are synchronized. Initially I remember that we wanted to check whether the GaitWatch system can replace the Forceplate. (That woud be my idea. If we can describe the accelerometer- (or mayby gyro-) traces during the APA epoch together with the force plate signals, that would be the main issue in my eyes. As you know physics and kinematics much better than I, you may describe some kind of model, how the force plate signal and the accelerometer traces belong together, this would be new.)

But what aspects do we need to focus on in order to sustain that claim (that one system can replace the other)?

\* My other student, Rob, is going to implement a new kalman filter (the one that I told you about which uses two sensors to estimate the angle of the knee) for his bachelor thesis that he is staring on the third week of march. He, then, would have three months to complete it. It would be good to include the results of the new filter in the first paper (the one comparing the accuracy of the GaitWatch vs. the Qualisys). OK, greadt!!

So, summarizing:

- Paper 1: GW vs. QS (treadmill subjects):

  \* Already done: Compute orientation angles of the legs using QS data. Compute all orientation angles with GW. (I have some algorithms for that and I would continue to do this as soon as I finished with soles data and description of TC and IC)

  \* To be done: Compute orientation angle of the hip using QS data (Verónica), implement new Kalman filter for the legs (Rob).

- Paper 2: TC using gyro data, soles and QS.

  \* To be done: Determine TC manually (or automatically if possible) for sole, GW, and QS data.( I am actually working on this, see attachment)

- Paper 3: As I said before, I can not distinguish in the document you sent me which is the third idea. (Because I sent you by accident a preliminary issue of my ideas, now they should be complete, see first page)

- Paper 4: APA (force plate subjects):

  \* Already done: Gather data from subjects. Synchronize FP and GW automatically, extract interesting signals for each step-in-step-out period and store them.

  \* To be done: Structure data from remaining patients, update Excel file with the protocol and send it to Granada. Determine next steps to be carried out in order to be able to affirm that one system can substitute the other.

So, this is it for now! I already submitted the application for the 5000euro mini project and by May I would know if I get it or not (it would be really good to have this money so I can travel twice or three times to Munich before the end of the year).

I also think that it would be good to have a Skype conference to discuss all these issues, it is surely going to be faster and more effective than the email.

I want to send more Force plate and GaitWatch data APA data during next days, but probably not before weekend.

Have a great day!

Best,

Alberto.

On Mon, Feb 23, 2015 at 9:50 AM, Bötzel, Kai Prof. Dr.med. <[Kai.Boetzel@med.uni-muenchen.de](https://webmail.med.uni-muenchen.de/owa/kboetzel@helios.med.uni-muenchen.de/redir.aspx?C=MTG_HPxzYEmr4NJcTqK69N41kK9AI9JIN3ETC7Bc5bQHEsjHbP6iDF7KDGvo_WIqfW8yz-eb8co.&URL=mailto%3aKai.Boetzel%40med.uni-muenchen.de)> wrote:

Dear Alberto,

I hope you are well. I just returned from holidays and we had one week of wonderful skiing in the swiss alps!

Concenring the present project I will send new data within the next days. I need to arrange the platform- and GaitWatch data so that they belong together and that is not so simple but I am working on it.

Concerning the recordings of last February we definitely should go in direction of publications because we have excellent data. To make this easier I have made a proposal for three publications (see attachment) and I am busy working on the first project and will come up with some results in the near future. So I wanted your opinion to my proposal (see attachment). I would take care of the structure of these papers but probably I would need support from you and your colleagues. About authorship we certainly will come to an agreement.

Best wishes, Kai