GAITBASE: APPLICATION FOR EVALUATION AND PROCESSING OF MOVEMENT DATA FROM VICON VIDEO CAMERA SYSTEM.

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Annotation

Gaitbase is a specialized application for processing and presentation of the clinical gait records. Application is designed to work with records provided by VICON system with peripheries (tensiometric, EMG, spirometer etc.). Application presents movement data in clear kinematic and kinetic graphs and allows to compare the gait with measured normative group. Calculated parameters which describe gait cycle and its deviation from the normal gait are free to export for additional evaluation. Data is processed on the server and is available via web interface. One part of the application is a database of patients and their examinations which can be easily modified under different roles. Application is developed at Faculty of Biomedical Engineering at Czech Technical University in Prague in cooperation with Departement of Paediatric Surgery, Medical University of Graz. Application is currently deployed and tested for purposes of clinical evaluation and research of gait of children with cerebral palsy.

Keywords

Data processing, VICON, gait, web interface

1. Introduction

Diagnosis of patient with a gait pathology consists mostly of a medical doctor evaluation based on his/hers knowledge and experience. Doctor evaluation is descriptive without specialized equipment and often is not sufficient to objectively describe all aspects of the gait. Removing these defects and improving of quality in diagnosis is achieved via new specialized laboratories of gait – gaitlabs [1] [2].

Gaitlabs are well equipped with different accessories such as accelerometers [3], tensionmeters [4][5], walkways [6], EMG, video camera systems [7] etc.

The best equipped gaitlabs are currently using mostly video camera systems for patient's 3D motion capturing. Number of video cameras varies, mostly is between six and ten. Except of video cameras, there are tensionmeters in the workplace which are necessary to calculate the gait kinetics. Kinetic is very important for more precise model of motion and better gait evaluation. Less common tools comprise of EMG, spirometer and other devices depending on laboratory focus. All systems are mutually synchronized what enables real time measurement and evaluation. Provided software for processing data and calculation of gait parameter is robust and provides all necessary information about the motion. Unfortunately, time complexity of subsequent data processing does not allow for regular usage. This deficiency is removed by our system Gaitbase which processes gait data, evaluates it and presents it to the doctors.

Gait measurement in laboratories proceeds mostly as follows. Firstly, patient is examined by orthopaedist who covers basic diagnosis, enter patient data to the hospital register and orders the patient to the gaitlab. The ordering is not necessary for the same day. The gait examination is done by physiotherapist and operator of the video camera system (the technician).

The physiotherapist does the basic measurement and patient examination. Physiotherapist's work result is patient record and his/hers classification by different scales (GMFCS, FMS 5) with focus on patient specifics or the group where the patient is in.

The technician operates video cameras and other devices in the gaitlab. Firstly, the reflective markers are attached to the patient. Space position of these markers is read by the video camera system. The patient can in a case of need use orthosis or assistive device. The patient moves during the recording only in the demarcated space in the way he/she goes through a tensionmeter. The patient must not know about the tensionmeter otherwise the results could be influenced. Typical number of trials is fourteen to twenty where several invalid trials are rejected. The result is measured kinetics, kinematics and video of the gait. The optional output is for example EMG.

The results from the technician and the physiotherapist are subsequently handled over to the clinic where they support healthcare of the patient. Currently, these results are mostly in the paper form and thereof the gait video is not usable outside the gaitlab. Doctors' interest is not only in clinical experience but also in research of bigger patient groups and consequent result publication.

2. GaitBase Application

The GaitBase application was created as a reaction to medical doctors' and technicians' demands in hospitals. The biggest influence was from the Medical University of Graz where the most intensive cooperation evolved.

The core of the GaitBase runs on a server where user can access via web interface. This allows work not only in the gaitlab but also on tablets or other mobile devices without the need of installing additional software. The work from home is an option in a case of approved security measures. Nevertheless, it is assumed the application will be used mostly at the clinic and gaitlab. The doctor enters patient data at the clinic and subsequently displays results from the laboratory measurement or the video of the gait from the angle he/she needs. Gaitlab servers for data measurement and processing.

Another advantage of the system is the possibility for multiple users to work simultaneously. No similar systems can provide this option. One user can examine the patient, the second one writes the data and the third user evaluates the gait video. User access is based on the roles in the system which are added and managed by the system administrator. One role allows for example physiotherapist the access to read data but not to write or modify any information about measurements. The application allows import of the data from two patients concurrently.

2.1. Application Structure

The basic unit where are all the information bound is the patient. The patient has the basic entries such as weight, height, sex and other. The patient comes for visits in separate days. There are several sessions during one visit. Sessions differ by the used orthosis, EMG or oxygen measurement and so on. Each session has several trials. One trial is one walk of the patient in front of the video cameras. One gait cycle is chosen from one trial. This correlates with standard Vicon Nexus selection.

2.2. Patient Overview

The basic screen of the application is the patient overview (see Fig. 1).

The screen shows us the list of the patients, their count and the detail of the chosen patient. The detail consists of the basic entries such as residence, phone number, and email. Values are chosen from the list therefore a user cannot chose any other sex than men/women. The format of an email and phone

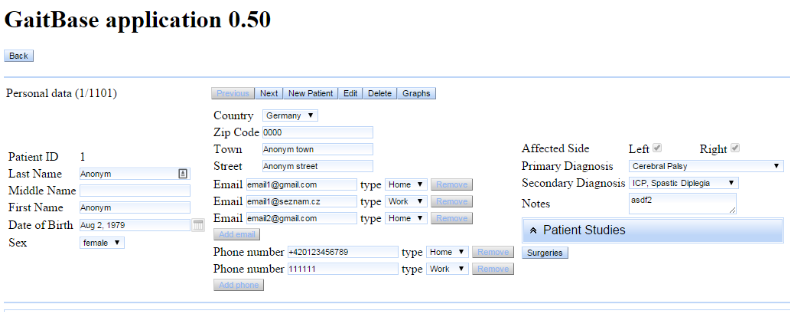

Figure 1 - Patient overview screen with all the basic information and the diagnosis

is also checked. The items in the list are configurable and can be easily filled by database scripts. Each patient has the affected side split to left and right. Very important field is diagnosis which has two parts – primary diagnosis and secondary diagnosis. The secondary diagnosis specifies the primary one. An example for diagnosis combinations is primary diagnosis "Acquired Foot Deformity" with the secondary diagnoses "Pes Adductus", "Pes Cavovarus" and others. The lists of values are used to avoid the spelling problems what makes better data consistency.

2.3. Session Overview

In the bottom part of the basic screen (see Fig. 2) is the information about visits and sessions. The information is very similar to the patient one with small differences such as list of patient classifications on several scales and available notes. Notes should be viewed as complementary information, all substantial data should be chosen in lists to avoid mistakes.

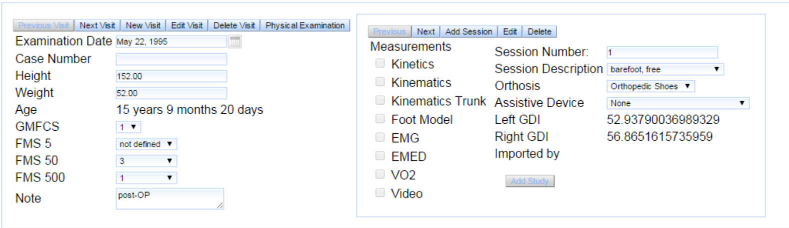

Figure 2 - Patient visit and one session. Gait indices are shown as part of the session

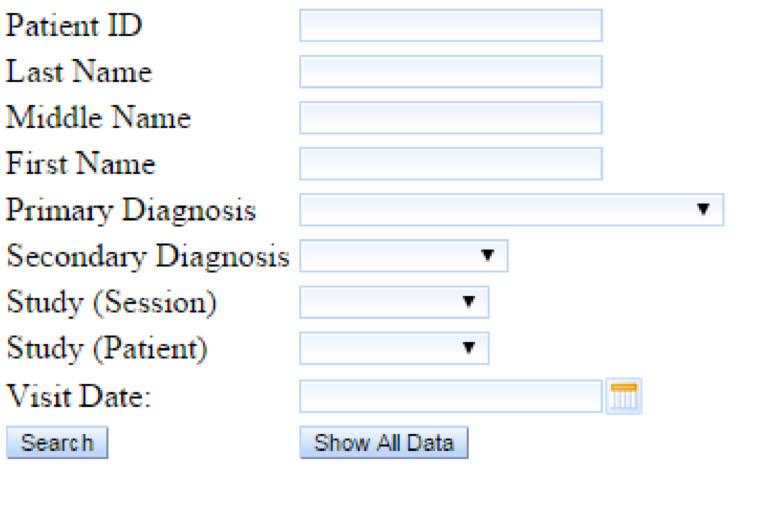

Figure 3 - Patient filtering by various criterions

2.4. Filtering

In the right part of the basic screen is a patient filter (see Fig. 3). The filter allows a user to search for patients by various criterions. The name of the patient is searched as case insensitive and also as substring. Filtering can be done by the primary and secondary diagnosis – the medical doctor can easily found all the patients who are affected by the cerebral palsy.

An important information about the patient is the list of underwent surgeries and participation in various studies. List of surgeries includes basic information as the region of the surgery, type of the surgery (soft tissues or bony) and type of the procedure. The user choses procedures from the list. A study is connected to session, i.e. to one measured unit. This connection allows us to have one patient in multiple studies. There is also the possibility to have multiple session in one day and each session in in the different study. The system evaluates the standard gait parameters and one more – gait deviation index (GDI)[8], which describes the deviation from the normal gait. The GDI parameter is not currently available freely in any other application. Another parameters are planned to be calculated – gait profile score (GPS)[9] and movement analysis profile (MAP). These indices are used mostly in studies and as comparison for patient development. They have also use in the clinical experience.

The system records the name of the user who imported the data from given

Figure 4 - Screen of kinematics with the standard graphs and help markers

patient. This name is shown in the session part of the screen.

Graphical output from the measured and imported data is shown in the Figure 4. One session is shown in this case. The result are graphs of average kinematics from individual trials. Blue color is used to show the left lower limb, red color is used to show the right lower limb. Shown are standard graphs which are used at the most clinics. Each graph has the ability to zoom in to see specific details. Individual graphs can be enlarged to entire screen for better read. Graphs of kinetics are shown in a very similar way. No other graphs are implemented so far but it is possible to create new ones if there is an interest. There are shown special events in the graphs of kinetics and kinematics in GaitBase. These events are shown as dotted lines. Events include first contact of foot with the ground (initial contact) also known as the heel strike. Next is the event of foot off the ground (toe off). Combination of two lower limbs makes 6 events for each graph. These events split the gait cycle into segments or phases. Doctor immediately sees the double support phase or the swing phase.

2.5. Data Import

Probably the most import part of the application is the data import. Basic information about patients is entered manually (see chapter 2.2) but there are

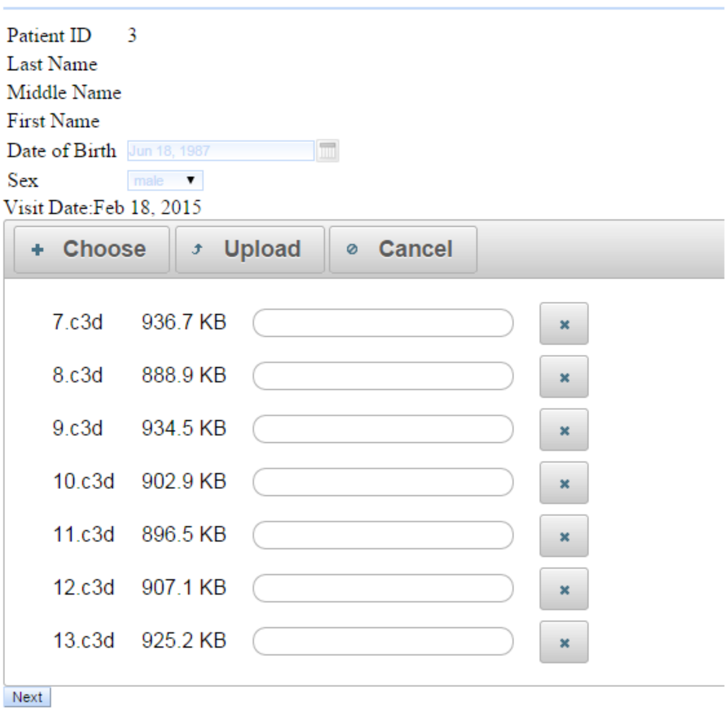

Figure 5 - Data import from the patiens C3D files

some data imported automatically. There are data from video cameras which includes video and analog data. Import of this kind of data is very simple in GaitBase. Application support directly the native format of files from Vicon, so called C3D files [10]. Data has no need to convert, all what is needed is to mark the beginning and end of a gait cycle. Example of chosen import data and patient is shown in the figure (see Fig. 5).

The user can search for patient by the filter. Next, the user choses day of the visit and input files. GaitBase allows user to select multiple files for the processing together. Very popular drag & drop is also supported. Data import from one patient is therefore only one processing what makes it very fast and easy. When the patient and data are selected, two pairs of screens follow. Each pair is for one side of the body. The user imports kinematics and kinetics for each side (see Fig. 6)

Similar to basic screen, the user sees 12 standard graphs. The difference is in the projection of individual trial instead of their average. Everyone knows the situation when some trial went wrong. That is the reason why GaitBase sup-

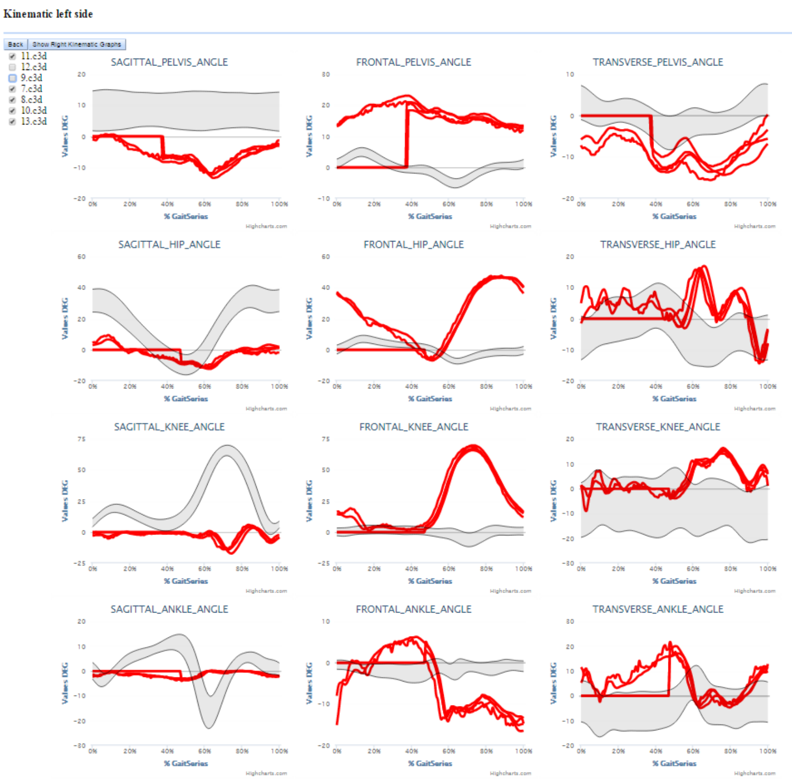

Figure 6 - Kinematic graphs during import with option of file pick-up

ports selective import – only chosen trials will be imported. All trials are shown together therefore easy identification of stick-outs. The graphs are re-rendered after the click on the trial name so the user sees the result without this trial. Each of the imports (left and right kinematics/kinetics) can include different trials. When it is necessary, we can achieve big utilization rate. The import itself is a matter of five screens and final confirmation. The data is ready to user from the moment of confirmation.

Less used part of the application is a physiological examination which is as of now copy of the paper examination in the gaitlab in Graz. It contains roughly two hundred fields. Fields are split to right and left side with significant color distinction. Naturally, broad usage of the lists is at place what minimizes misspells and accuracy of the data. None of the information here is mandatory due to significant laboriousness of the physiological examination. The next chapter presents the future improvements which are planned for GaitBase.

3. Future Development

The application is still in the alfa version. We are currently working on implementation of new functions and its testing.

Among the new functions is the data export for excel in csv format. The user choses the type of the export data, list of patients and the application gets the data ready and exports it. Another future functionality is integration of EMG measurements and acceptance of Oxford Foot model. Also whole body model will be supported in the future. Gillette gait index is planned to be calculated too [11].

GaitBase runs currently also in tablets and smart phones but with limited functionality. Our interest is to fine-tune the application to better support tablets which are now very useful tools in hospitals and clinics. The last but not the least part of the future is thorough testing of the application at clinics and gaitlabs. GaitBase is currently tested at Departement of Paediatric Surgery, Medical University of Graz.

4. Discussion

Even though we are convinced about the usefulness of the GaitBase application, we are aware of some possible problems bound by its running.

The primary problem is a security and maintenance of the application. The application is technically secured very well – save internet connection, strong data encryption and restrictive access to the application. The biggest problem is in the concept of a web service itself. Each web application runs on a server. Mostly, it is best when there is only one server and the server is at the operator's side. This setting allows immediate bug fixing without any technical background from the clinic or hospital. Also the updates can be delivered very fast according to doctor's demand. All technical aspects are hidden in the server. The problem is ethics and legislation. These problems originate from the fact that the data are sent to foreign server which is outside of the hospital and personnel do not have the data under control. The solution is to run server itself in hospital or in the gaitlab. All the data stay in a physical ownership of the hospital and developers will not have access to the data. This approach is tested also in Graz. Disadvantage of this approach is a necessity of technical personnel and slower access to updates and fixes for bugs. It is assumed this model will be the most used one, unless legislative questions are answered.

5. Conclusion

New application for data processing and imaging is developed as a product of cooperation of Faculty of Biomedical Engineering at Czech Technical University in Prague with Departement of Paediatric Surgery, Medical University of Graz. The application processes records from the VICON system and additional devices. The application access is possible via web interface. Multiple user access is also supported. The system shows data in standard kinematic and kinetic graphs. A part of the application is a patient database together with their examinations. Patients' data can be exported in the csv format. The application is currently deployed in a test mode for evaluation and research of gait of children with cerebral palsy.

Acknowledgement

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