A Gait Analysis Software as a Service

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***Abstract*—This paper describes the first implementation version of a human gait analysis Software as a Service (SaaS). This approach has as advantage, the software availability at web. After the software is implanted at a web server, users can access him from a recent web browser with support to HTML5. The software objective is to minimize the code development efforts by gait analysis researchers, as well as to be a useful tool for health professionals interested in human gait analysis. The software allows import positionals data from a third party motion captures system, that uses surface markers and video cameras, to plot markers spatial progression, angles, angular velocities and angular accelerations. Furthermore, it is possible to see and to interact with a 3D animation from markers. The software source code is available as free software, often receive new features and a new community is being created to maintain him.**

***Index Terms*—Gait analysis, software as a service, SaaS.**

I. Introduction

WITH the software web advent now is possible to create services, put them at central web servers and use them from any part of world. Furthermore, modern web browsers have become a truly platform, allowing rich interfaces creation, including graphics presentation and 3D animations, without the necessity of plugins installations. These two technologies, web browsers and web servers, can be used to build what is known as Software as a Service (SaaS). The SaaS advantages for customers and software developers are [1]: customers do not need to install the application; data associated with the service is kept centralized, so it is more protected; data can be collectively accessed by a group of users; big datasets and data that is frequently updated, are kept centralized and remote access to them are offered; only a single copy of the server software runs in a controlled hardware and operating system environment, which avoids compatibility problems, in addition, new versions of the software can be tested with a small fraction of the real customers without disturbing most customers.

Although there was gait analysis advancements by the middle of century XX, clinic gait analysis became broadly available only with the modern computer advent [2]. Actually there are a lot of software packages for this finality [3], but until now at century XXI, no software provider committed to deliver a gait analysis SaaS, in other words, health professionals or gait analysis researchers who want use software, have to use software installed at specifics hardware and operating systems, they have to be responsible by data backup, if new features are incorporated to new software versions, the software must be installed again, if they want share data, they must copy and send them to the destiny and others security concerns must be addressed too. All these problems can be minimized or until eliminated with a SaaS.

To build a software it is necessary collect requisites, and a certain domain of the field must be addressed, at this case gait analysis. Thankfully, nowadays, the theme is quite documented [4], [5], [6], [7], [8], [9], [10], [11]. Moreover, there are health professionals at the development team with much experience in gait analysis. With all this in mind, this paper describes the first implementation version of a gait analysis SaaS [12]. This software version can import data from a third party motion capture system, at this case data collected from video cameras using surface markers, the software also can name markers, define angles, using data from the markers, and plot markers progression at space, angles, angular velocities and angular accelerations. Moreover, the software presents a 3D animation from data and allows user interact with the animation.

II. Materials and Methods

Two researches environments were used to undertake the project. One was the *Laboratrio de Performance Humana* (LPH) at *Faculdade Ceilandia* (FCE) / *Universidade de Brasilia* (UnB), and the other was the *Laboratorio de Informatica em Saude* (LIS) at *Faculdade Gama (FGA)* / UnB. At LPH data was collected and at LIS the software version was developed.

The next subsections presents the process for data acquisition, the development process and the software architecture general view.

A. Data Acquisition

The data are acquired by sixteen Qualisys Oqus MRI cameras, using the Qualisys Track Manager Software (QTM). The data are relative to surface markers along a patient body.

For this paper a healthy patient, male, with age between 20 and 30 years old was selected. Fig. 1 summarizes the data acquisition process. First markers positions are defined. For this paper only the left trochanter, left knee and left tibia positions were considered. So the surface markers must be fixed at defined positions on patient body. The next step is acquire data using the cameras and QTM software. In this step the patient executes a comfortable gait cycle in front cameras. Five gait samples were acquired. The last step is convert the acquired data to MATLAB format using the QTM software. It is necessary because this is the pattern of choice for the gait analysis software.

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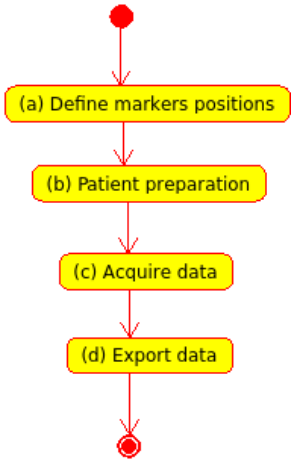

Fig. 1. Data acquisition process. (a) Positions of markers to be fixed in patient body are defined. (b) Markers are fixed at defined positions. (c) Patient executes some comfortable gait cycles in front of cameras. QTM software is used; (d) Data acquired are converted to MATLAB format using QTM software.

The process for data acquisition was approved by *Faculdade de Saude da UnB* ethics committee, process number N11911/12.

B. Development Process

A scrum [13], [14], [15] inspired process for development was implanted. The scrum is a agile method [16] that has as mainly characteristics to be iterative, incremental and change friendly. These characteristics are essentials to deal with software requirements volatility and hence with so common software changes.

The process flow is presented in Fig. 2. The process consists of iterations, called sprints. The sprints have a 2 weeks average duration. A product backlog is created and managed by the product owner. The product backlog is open to receive additions from all project stakeholders, at any time, but only the product owner can prioritize him, based in important values for final users. Each item at product backlog is a user story [17]. Before a new iteration begin, there are a two phases meeting between the development team members. In the first phase, the last increment is presented and impediments occurred in last iteration are uncovered. In the second phase the development team selects items from the product backlog. These items will be implemented in the sprint and are called the sprint backlog. Last, a increment consisting in a piece of working software is delivered.

C. Software Architecture General View

The Fig. 3 shows the software architecture layered high level view. The layer web applications is responsible by application user interactions, see Section II-C1. The layer REST web API is responsible by business logic, see Section II-C2. The document base layer is responsible by data application persistence, see Section II-C3.

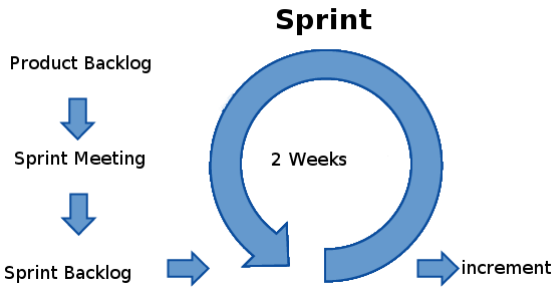

Fig. 2. Development process overview. Every two weeks a new increment, working software, is delivered. Adapted from [14].

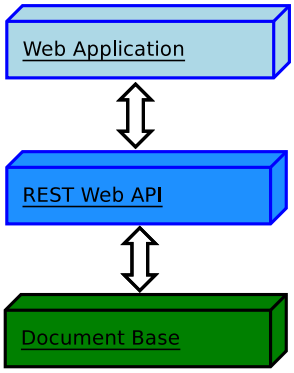

Fig. 3. Software architecture layered high level view.

1) Web Application Layer: These layer was designed to run in web browsers with HTML5 support. It was developed using Javascript, CSS and HTML languages. Moreover, the web development framework AngularJS [18], [19], was adopted. A AngularJS adoption advantage is the directive creation possibility. Directives are developed components which can be embedded in a HTML template. Also, it was chosen to use the Angular-Material directive library. This library is based in the Material Design specification from Google, which describes about graphical design patterns and user interaction, it is based in the material metaphor [20]. The Angular-Material use, facilitates to build a user experience acceptable by health professionals.

To run graphical 3D animations, the ThreeJS library was chosen [21]. This is a high level library which takes advantage from WebGL implementation in modern web browsers. The WebGL specification [22] uses the computer Graphical Processor Unit (GPU) natively, allowing to build applications which needs good performance to generate animations and graphics.

Fig. 4 shows the interaction between main components in web application layer. Note that this is only a logic representation. When a user interacts with the application using a web browser, they dispatches events detected by the AngularJS framework. The interaction can be a button click event, a mouse over event, a drag event or other. So the framework selects a controller component to process the event. Controllers components are components developed to the application, they are responsible to coordinate data access to

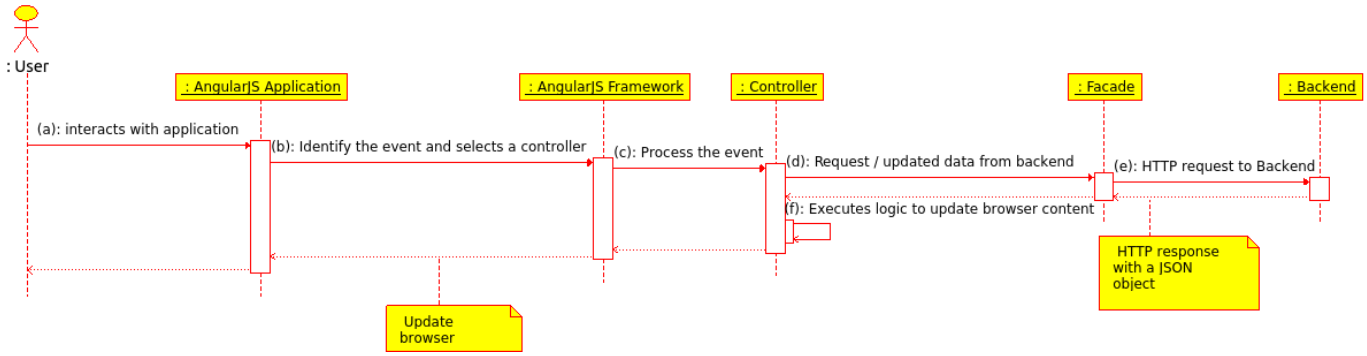

Fig. 4. Main web components interactions. All these components, except the component backend, run inside the web browses. The component backend correspond to the infrastructure and components of REST web API layer. (a) A user interacts with the application, maybe click a button on screen; (b) The AngularJS framework detects the event, selects a controller component and dispatch the evento for him; (c) The selected controller process the event; (d) If it is necessary to execute some action, how request more data, the controller requests to a facade component to requests the backend; (e) The selected facade component prepares and send a HTTP request to the backend, which sends a JSON object as response; (f) The controller updates the model, variables used by the framework to show data at screen, and signals to the AngularJS framework to update the screen.

the model and to update the view. AngularJS applications uses a famous designe pattern called Model-View-Controller [23]. In practice, this means that controllers update the application state, so the AngularJS framework can update the screen to users. If new data or busines logic execution are necessary the controller request to a facade component, to comunicate with the backend. Facade is a design pattern which hides complex logic necessary to perform some action [23], in this case is the comunication over HTTP protocol to the backend. After the backend receives the request, it process him and send a HTTP response with a JSON object inside. JavaScript Object Notation (JSON) are a specification to represent and exchange data.

2) REST Web API:

3) Document Base layer:

III. Conclusion

The conclusion goes here.

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