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It is important to recognize the assistance of Universidad Militar Nueva Granada's Virtual Reality Centre along with the DaVinci and PIT research groups. It is also worth mentioning the collaboration of researchers from the Games Institute at the University of Waterloo, the University of Ontario Institute of Technology, York University, the Wilson Centre, the São Paulo University, the University of West Indies, the El Bosque University, and the research team of Universidad Militar Nueva Granada's project IMP ING 1776.

Finally, I would like to thank all the participants, whose interest and enthusiasm was the heart of this workshop.

Byron Perez M.Sc.

General Chair
2nd WORKSHOP ON ENGINEERING
IN MEDICAL APPLICATIONS
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ORAL PRESENTATIONS

Games User Research in Medical Applications

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***Abstract*—The Games User Research (GUR) field has thrived in the domain of commercial games, as conducting user research is now an integral part of game development cycle. However, the GUR field must advance toward demographics that will benefit from it but currently underrepresented in this field. Hence, this summary article (and its associated keynote presentation at the 2nd Workshop on Engineering in Medical Applications) aims to introduce and discuss contributions of GUR in the game-based medical applications (i.e. the application of games, simulation and virtual reality in medicine).**

Keywords—Games User Research; Medical Applications; Serious Games; Simulation; Usability, User Experience

I. INTRODUCTION

Games User Research (GUR) focuses on development of techniques and tools to measure and analyse user behaviour and experience to help game developers to enhance on usability and user experience (UX) of their titles [1]. Therefore, the application of GUR is often focused on evaluation and gaining insights from users (or players) to enhance game designs. This is often achieved by comparing developers' intended design decisions to how users experience them [2].

In recent years, there have been many changes in video games development, including new business models, widening player demographics and new controller interfaces. Video games are now more popular, pervasive, and ubiquitous than ever. They are also developed by a more diverse set of people than ever [3]. This means there are many opportunities to create game-based applications to enhance our daily lives. Medical applications are among major fields that offer exciting opportunities for game developers; and therefore, there are many game-based medical applications being developed.

Despite the immediate importance of user research in commercial games (as arguably higher quality is often an important factor contributing to the success or failure of commercial games), GUR is less mature throughout the industry and associated academics in other domains. Small and indie development teams (often as part of academic organizations or non-profit entities) that have an interest in game development often lack resources, knowledge, and experience to include GUR in the development process of their projects. They may also lack the necessary knowledge to communicate the results of user research to the various stakeholders involved in the development (e.g., programmers, designers, producers, or marketing), whom all benefit from GUR but may require different representation of the results. These issues often lead to lower quality games, which means these game-based projects often fail before they release [4].

Small productions studios are also known for having limited resources, which means that hard choices have to be made on what to focus. Giving the lack of GUR knowledge, this aspect of development is often ignored or delayed until making changes becomes too expensive. In essence, a lack of GUR impacts sales, increases fail rates, which often leads to a low persistence on the market and thus real impact. Hence, there is a substantial need to support and educate developers of these types of games that especially have purposes for good (e.g., medical applications, education and training).

The author has made significant contributions on GUR field in his previous works (e.g. [1], [2]. [5]). He sees strong value in the GUR field by addressing the underrepresented small independent developers, non-profit organizations, and academics that create games for medical application, health or behaviour change. The goal of his keynote presentation is to promote, and discuss the value of GUR for game-based medial applications and their developers. The presentation will discuss how developers can benefit from existing GUR strategies, tools, and techniques, or how these need to be modified, adapted, or re-thought to meet the developers' need.

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Serious Gaming: Fidelity and Multimodal Interactions

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Abstract— Real-time high-fidelity rendering of complex environments across all of the senses is currently beyond our computational reach. Taking advantage of multimodal effects, perceptual-based rendering can be employed to limit computational processing by adjusting the rendering parameters based on the perceptual system. Here, a brief overview of previous work that examined audio-visual interactions is provided followed a description of how this work can be extended to examine the effect of audio-touch (haptic) interaction to ultimately use sound to increase the perception of haptic fidelity in serious games that employ low-end haptic devices.

Keywords—serious games; multimodal interactions; fidelity.

I. Introduction

Despite the many benefits associated with serious games (e.g., engaging, interactive, fun, etc.) and their growing popularity, there are a number of issues related to their development that must be addressed before they become more widespread. One of the issues pertains to fidelity, that is, how realistic the virtual environment that the serious game is centered on must be in order to ensure effective learning, while another issue pertains to multimodal interactions (what effect do the cues from the various modalities considered have on each other). The perception of fidelity is influenced by multimodal interactions, and this can have significant implications for designers and developers of serious games given that with our current technology, we cannot faithfully recreate a real-world scenario with equal consideration to all of the senses. However, we can introduce perceptual-based rendering whereby the rendering parameters are adjusted based on the perceptual system to limit computational processing by leveraging multimodal interactions and effects.

We have recently begun investigating the issue of fidelity and multimodal interactions and their resulting role in serious games aimed and medical education to develop a greater understanding of fidelity, multimodal interactions, perceptual- based rendering, user-specific factors, and their effect on learning. The ultimate goal of this work is to develop more effective serious games. Through a series of user studies, our work to date has methodically examined the direct effect of sound on the perception of visual fidelity and its relationship to task performance. Although this series of experiments have shown a strong influence of sound on visual fidelity perception and task performance, results have also shown strong individual effects, whereby the influence of sound is dependent on various personal, individual factors [2]. Although our results cannot be generalized, they do indicate the importance and need for designers and developers of serious games to customize the user interface to the preferences of each user. This can, for example, involve allowing users to choose their own background music, sound effects, and graphic styles (e.g., toon-shaded graphics), where appropriate. Despite the progress made so far, greater work remains. More specifically, prior work (including our own), has focused primarily on the interaction of sound and visual cues while ignoring the sense of smell, taste, and more importantly, the sense of touch. Ignoring the sense of sense of smell and taste both of which are very difficult to simulate there has been limited progress made to date with respect to simulating the sense of touch particularly at the consumer level. The simulation of the sense of touch falls under the field of haptics which collectively refers to machine touch and human-machine touch interactions. It includes all aspects of information acquisition and object manipulation through touch by humans, machines, or a combination of the two within real, virtual, or teleoperated scenarios [1]. Although various high-end haptic devices are currently available, due to their cost, they are typically restricted to research laboratories. Recently, consumer-level haptics devices are available, but greater work remains to determine whether these low-end devices are suitable as an alternative to the higher end devices.

II. Current Focus

Building upon our prior work, we are investigating audio- haptic interactions within a serious gaming environment. Using a low-end haptic device (Novint Falcon), we are conducting experiments to determine whether sound can be used to enhance our perception of haptic fidelity and thus allow for the perception of haptic fidelity perception to be increased through he use of sound. We hypothesize that perceptual-based rendering, whereby the appropriate use of sound, will lead to an increase in haptic fidelity perception. This will allow consumer level haptic devices to be incorporated into applications where higher haptic fidelity is typically required (e.g., surgical technical skills training). Ultimately this will allow us to develop more cost-effective virtual simulations and serious games that focus on technical skills development.

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Probing Human Perception with Virtual Reality

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***Extended Abstract*—** Probing human perception traditionally relied on the development of physical devices to present controlled stimuli to observers. Although such devices can be very effective and are still used today, virtual reality has emerged as a useful tool in probing human perception. This talk reviews various approaches to exploring human perception of self-motion and self-orientation including ‘traditional’ devices such as large-scale physical simulations as well as virtual reality-based techniques. For over twenty years we have been building and using virtual reality installations to explore a range of aspects of the perception of self-motion and self-orientation. Although many of these devices are interesting from a technical point of view, the primary long-term impact of these installations has been advance our understanding of how humans integrate multiple perceptual cues in order to develop internal models of self and the environment.

Results from experiments relying on virtual reality hardware to probe these perceptual processes are described along with the technology used to generate the stimuli. As these devices were intended primarily to explore perceptual cue conflict and integration, the devices have typically been designed to enable the presentation of multiple cues in natural and unexpected ways. For example, the Virtual Reality Tricycle [1] was designed specifically to provide visual and non-visual cues to self-motion while IVY[6] was designed to simulate many of the properties of the Tumbling and Tumbled rooms (see [5]).

A fundamental assumption underlying human perception on earth is the constant direction of gravity. This constraint provides a constraint and input that is exploited in a range of different tasks from facial recognition to understanding which way is up [4]. This has important implications for virtual reality as it is typically quite difficult to simulate different gravity states using VR technology. But understanding the role of gravity is also a critical issue in a range of real world tasks.

Conducting experiments that explore the effect of gravity on human perception require mechanisms that manipulate the normal direction and magnitude of gravity. On earth the direction of gravity can be easily manipulated through motion platforms and similar devices. Manipulating the magnitude of gravity requires the use of microgravity flights (e.g., [2]) or human centrifugation. Adapting virtual reality hardware to such environments has its challenges, but microgravity flights and human centrifugation can only provide transient changes in the magnitude of gravity. Longer-duration changes in gravity requires taking experiments off earth, typically to the international space station (ISS). Experiments conducted on the ISS are restricted by the limited VR technology that has been available on board, although this is quickly changing as higher performance computing and state of the art HMD’s are to be deployed to the ISS shortly. The talk concludes with a snapshot of the current status of experiments that are in the planning stages for flight on the International Space Station in 2017-8 that will exploit the renewed VR technology be deployed to the ISS.

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A System Based on fECG to Detect Fetal Risk

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***Abstract*—The monitoring of fetal heart signals can be used to detect fetal distress and other affections. This kind of information can be extracted from the fetal electrocardiogram (fECG) signal morphology, a methodology that has been taking a great importance during the last decades. Nevertheless, the main problem associated with this technique is the difficulty in extracting the fetal electrocardiogram signal from the mother's abdomen, and the detection of relevant information. Another problem is the lack of expertise to read the information given by fetal electrocardiogram. The purpose of this paper is to show the work in progress to develop an alarm of fetal risk generated from the fetal electrocardiogram signals. To achieve this purpose we use a database, which contains the signals acquired from the mother's abdomen to extract the fetal signal using adaptive filters. Once we have the fetal electrocardiogram signal, we extract specific characteristics in order to identify different fetal difficulties associated with heart problems or the lack of oxygenation.**

***Index Terms*—Fetal distress, Fetal wellbeing, Alarm, Fetal electrocardiography, Intervals RR, QT, QRS, ST.**

I. Introduction

Nowadays, there are different ways to monitor pregnancy, one of the most commonly used is the Doppler Ultrasound, this test allows the monitoring of the fetal growth, amniotic fluid, blood flow, kidney operation, uterus size, the probability of Down syndrome, among other parameters. Other tests used during the pregnancy period are the blood tests and specialized and expensive tests which are used when the exams mentioned above show possible anomalies. The detection or monitoring of fetal heart rate (FHR) and the analysis of the fetal heart signal morphology are interesting techniques due to the benefits related to the low cost compared with the benefit of mother and fetus protection. Additionally, the great interest in this type of information is the great potential to detect different circumstances related to the fetus neurological system, fetal growth problems, the amount of oxygen, among others [1], [2], [3]. Nevertheless, the principal problem of this kind of test is the difficulty in extracting the fetal electrocardiogram signal from the mother's abdomen due to the small fetal signal amplitude and the spurious signals acquired. Another problem related to this test is the lack of precision from the medical staff in the signal interpretation [4], [5]. On the other hand, in a country like Colombia, there are several problems associated with the lack of control during the pregnancy period as the result of the poor performance of the Health System and socio-cultural factors [6]. The purpose of this work is to develop a portable system, which can be used to monitor high-risk pregnancies in order to expand the pregnancy monitoring coverage in Colombia, and the use of metrics in order to detect fetal distress.

The electronic fetal heart monitoring is usually applied during labor and delivery. Nevertheless, the monitoring can be realized before, when the woman has a high-risk pregnancy due to factors such as preeclampsia, gestational diabetes or fetal growth retard. The electronic fetal heart monitoring can be done in a non-invasive way or in an invasive way. The invasive method is done when the uterine membranes are broken attaching electrodes over the fetus scalp, which results in a high infection risk for mother and fetus. On the other hand, the non-invasive method can be done using auscultation (a Doppler system with an auditory signal), magnetocardiography, and the electrocardiography. The last method can be used after the 20th pregnancy week; it represents better security conditions for mother and baby at a low cost, and it leads a long monitoring period, where one can identify different intervals or waves of the cardiac cycle determined by the P, Q, R, S, T, U waves [7] (see Figure 1).

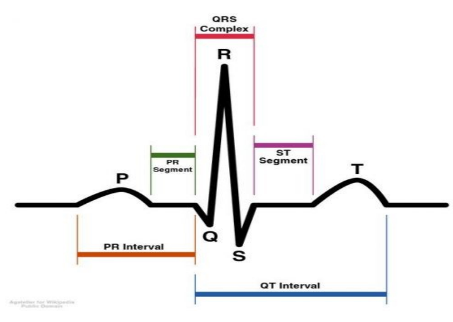


Fig. 1. ECG signal components [8]

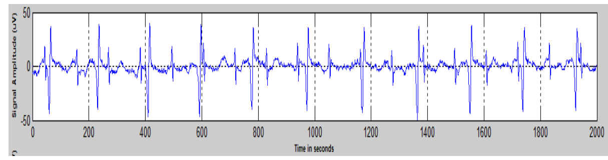
Detecting changes in heart rate of the fetus has played an important role in the exploration of pathologies or abnormal conditions in the fetus [9]. Some of the conditions related to fetal distress can be detected from the fetal heart rate analysis, some of them are: a) cerebral hypoxemia, which it is defined as an insufficiency of oxygen in the fetal brain, b) Neonatal hypoxic, which is the lack of oxygen in the brain of the fetus, usually by cardiopulmonary diseases and maternal placental insufficiency irrigation, c) Perinatal asphyxia as the result of transient myocardial ischemia with ventricular dilatation, distension of the atrioventricular ring, and the damage of the papillary muscles, d) Cerebral Anoxia, defined as the lack of oxygen and therefore the possible death of the fetus [10]. The alteration of the QRS, QT, ST segments among others can also reveals several pathologies or conditions in the fetus related to fetal distress, neurological problems or growth problems [11], [12], [13], [14].

This article is organized as follows: Section 2 briefly describes the fetal electrocardiogram signal extraction using a database, which contains signals acquired from the mothers abdomen, using adaptive filters to reach this goal. Section 3 describes the algorithms and the results to detect different complexes on the fECG signal. Finally, in Section 4 we conclude and we talk about the future work.

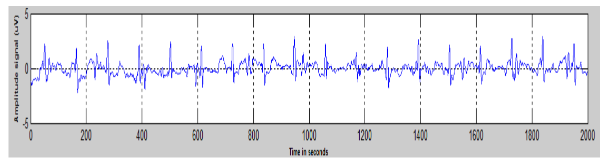
II. FECG SIGNAL PROCESSING

One of the main problems related to the acquisition of the fetal electrocardiogram (fECG) is the difficulty in extracting the signal without losing the signal morphology when the information is acquired in a non-invasive way. This is the result of the small fetal magnitude in reference to the mother electrocardiogram signal, which has a high component of the signal acquired from the mothers abdomen. Additional to the mothers electrocardiogram signal, other signals such as the mothers myoelectrical signal, and noise are present in the information acquired, therefore to extract the fECG requires several filtering techniques and signal treatment [12]. Some of the techniques developed are non-adaptive and adaptive filters [15], where you can find neural networks, fuzzy logic, independent component analysis (ICA) [10] and the combination of these [16], among others.

After the literature review on fECG signal processing and the test of several filters, it was found that the LMS filter is an effective alternative. The main benefits related to the LMS filter are the low computational complexity with a high performance because it only depends on the number of selected coefficients for the filter, and the adaptive variation of these coefficients according to the mean square error correction at the output of the system [17]. To test the filter performance, it was used the database "Cutaneous potential recording of a pregnant woman. This database consists of 2,500 points sampled at 500 Hz, using a reference of 8-channel electrodes acquisition distributed as follows: 1-5 abdominal surface electrodes on the mother and 6-8 surface electrodes on the chest of the mother. The first five channels are close to the fetus and therefore the fECG signals are visible and are combined with the mother signals. The other channels contain mainly the mother's electrocardiogram signal (mECG) and noise. The extraction of the estimated fECG signal was possible by combining two LMS filters. The first filter was developed to clean the mECG signal from the chest signal (see Figure 2(a)), the second filter was developed to extract the electrocardiogram signal from the mothers abdomen, which contains the mECG and the fECG. Finally, the first signal is extracted from the second signal to obtain the fECG (see Figure 2(b)).



(a) Estimated mECG signal



(b) Estimated fECG signal

Fig. 2. Estimated signals by the LMS filter

III. IDENTIFICATION OF PARAMETERS IN THE FECG SIGNAL

The electrocardiogram is the recording of the electrical activity of the heart. This activity is represented by a set of waves called P, Q, R, S, T [18]. Each of these waves represents a cycle made by the heart, where the P wave represents the depolarization of the atria, the QRS complex represents the depolarization of the ventricles, and the T wave is related to the repolarization of the ventricles [7]. For the correct interpretation of the fetal electrocardiographic signal and the detection of different anomalies or pathologies in the fetus, it is required the analysis of the electrocardiographic signal taking into account the following factors: a) Heart rate, b) The segment PR and c) Segment QT [19], [20]. In this paper we show the results of identifying the last segments, to test the algorithm it was used the database *"Cutaneous potential recording of a pregnant woman"* after the signal was treated with the LMS filters, explained in the last section. It was observed that the P wave height does not exceed the 5 uV. Also in the QRS complex, the R-wave does not exceed the 2,3 uV, and the S wave does not exceed the 0,1 uV. The QRS complex lasts less than 0,06 s and goes until 0,1 s. The segments were extracted according to the last signal characterization as shown in Figure 3.

To test the algorithm accuracy (ACC), the Eq. 1 is used, where TP refers to the existing and detected peaks, FN refers to the existing peaks that were not detected by the algorithm, and FP are peaks detected by the algorithm but not existing peaks [21]. This was performed for the QRS complex peaks, ST, R-R, and QT segments.

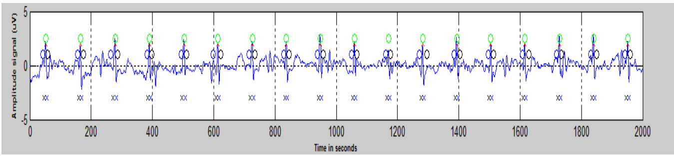


Fig. 3. Segments estimation

$$ACC = \frac{TP}{TP + FN + FP} \quad (1)$$

As a result, when we apply the Eq. 1 to test the complexes detection, we found the results shown in Table. I. Each ACC reaches values near to 1, which means that the false values FN and FP are close to 0, therefore the algorithm works properly for our purpose of identifying the complexes on the fECG signal.

TABLE I
ALGORITHM ACCURACY OF FECG COMPLEXES DETECTED.

Segment	ACC
QRS	0.980392
ST	0.980392
R-R	0.970874
QT	0.951538

IV. CONCLUSION AND FUTURE WORK

The use of medical systems to prevent, diagnose and treat pathologies or conditions, has been taken a great importance during the last years. In Colombia, a country with several problems in the Health Service, the possibility to use a medical equipment can help to access to remote populations and to prevent unnecessary deaths or reduce morbidity. This paper shows some of the advances and results in the process to develop an alarm of fetal risk. For this purpose, the first phase of the project is focused on the fetal electrocardiogram signal acquisition by the application of different filters to the signal acquired from the mothers abdomen and chest. A second task is an fECG parameterization in order to detect fetal distress. In the process, we obtained a powerful result employing the LMS filters, which have been tested with several databases, one of the databases was used in this paper to show the filters behavior. Currently, we are determining the metrics to detect fetal distress in order to parameterize the fetal electrocardiogram signal. In this work, we detected some electrocardiogram complexes; nevertheless, it is important to develop an algorithm that leads the parameters detection in any fECG signal. Furthermore, as a future work, we need to explore different alternatives for seeking greater accuracy and precision in the acquisition of the intervals (ST, QT, etc.), QRS complex and P waves. As well as the selection of metrics and fetal conditions that can be detected by means of the fECG signal, for example, the identification of arrhythmias [22], tachycardia [23] and bradycardia [24], among others.

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Designing a Serious Game for Ankle Rehabilitation with Runtime Calibration

Thales B. Pasqual, Glauco A. P. Caurin, Kleber O. Andrade and Adriano A. G. Siqueira

Abstract— **This work proposes an approach to adapt a game to ankle movement for a rehabilitation mechanism. Thus, a game was developed for ankle rehabilitation aiming a more intuitive game play. The movement underwent a transformation from elliptical motion, performed by the ankle, to game's rectangular workspace, reaching a better use of patient's movement.**

System calibration is performed runtime, which allows not only the game to adjust itself for each patient, but also to adjust for every new achievement in patient's movement.

Initial tests with a healthy subject showed that it is possible to adapt the game drive to the ankle movement through this mathematical transformation, better exploiting the player movement space and a smooth robot cooperation behavior, with movements more intuitive.

I. INTRODUCTION

One of the objectives of virtual games in rehabilitation is to make this process a better experience for the patient, since the number of hours involved in this process and activities repeatability may discourage the subject in rehab. The game provides an intellectual challenge, while the mechanism adds the physical challenge: the more immersed in the game the patient is, more motivated the patient will be.

This extended abstract proposes the creation of a game generation for ankle rehabilitation taking care about aesthetics and gameplay, about how patient feels the game, watching the ankle movement characteristic and, through a mathematical approach, adapt the game.

II. GAME DEVELOPMENT

A. Choosing the game

The game chosen is similar to the classic Pong, but, instead only two pads moving vertically, there are two other extra moving horizontally, then it receives the name DoublePong (figure 1). This enables the use of two degrees of freedom that AnkleBot [1] has, thus eversion and inversion movements control the pads moving horizontally (position x), and dorsiflexion and plantarflexion movements control the pads moving in along the vertical axis (position y). We call it the Movements Space (MS). The goal is to prevent the ball falling from the platform hitting it with the pads.

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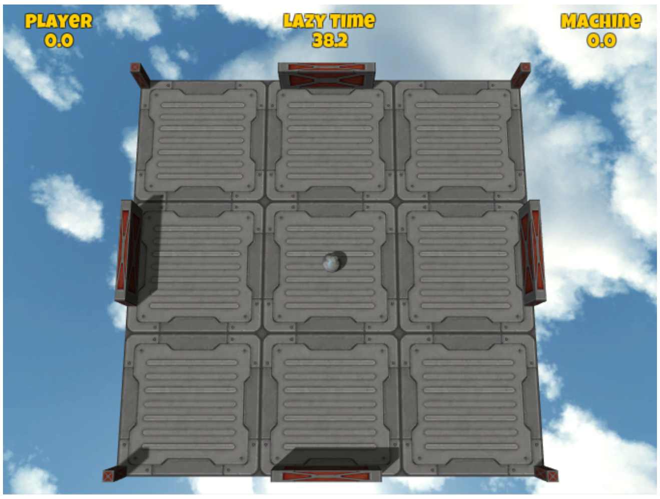

Fig. 1. DoublePong developed in Unity 3D.

B. User experience

To define how the user movement would result in the control of pads was acquired the ankle motion package of a person free from injury or movement incapability, seen in left side of figure 2.

The acquired data shows that the simplest geometric shape that fit ankle motion limits is an ellipse, eccentric relative to origin, but the game has a square workspace, which prevents using raw data without having ununseble movements or positions impossible to reach. To convert the motion of an elliptical movement space in a quadrangular space, we used the ellipse parametric equation (equations 1) and based on the extremes movement, the calibration of the elliptical space was made, defined for h_b, k_b, a_b e b_b.

$$_e\vec{P} = \begin{cases} _ex_b = h + a_b \cos\alpha \\ _ey_b = k + b_b \sin\alpha \end{cases} \tag{1}$$

The index e are related to elliptic space and b indicates that values are boundary, based on this, values inside this area will be contained in boundary of proportional ellipses, i.e. maintains relation as shown in equation 2 and concentric, with the same values of h and k, therefore these variables do not receive the index b.

$$\frac{a_i}{b_i} = \frac{a_b}{b_b} \tag{2}$$

Similarly we can define an equation for a $2r_b$-sized square parameterized as follows:

$$
{}_s\vec{P} = \begin{cases} {}_s x_b = \begin{cases} r_b & ,0 \le \beta < \frac{\pi}{4} \\ r_b \cot\beta & ,\frac{\pi}{4} \le \beta < \frac{3\pi}{4} \\ -r_b & ,\frac{3\pi}{4} \le \beta < \frac{5\pi}{4} \\ -r_b \cot\beta & ,\frac{5\pi}{4} \le \beta < \frac{7\pi}{4} \\ r_b & ,\frac{7\pi}{4} \le \beta < 2\pi \end{cases} \\ {}_s y_b = \begin{cases} r_b \tan\beta & ,0 \le \beta < \frac{\pi}{4} \\ r_b & ,\frac{\pi}{4} \le \beta < \frac{3\pi}{4} \\ -r_b \tan\beta & ,\frac{3\pi}{4} \le \beta < \frac{5\pi}{4} \\ -r_b & ,\frac{5\pi}{4} \le \beta < \frac{7\pi}{4} \\ r_b \tan\beta & ,\frac{7\pi}{4} \le \beta < 2\pi \end{cases} \end{cases} \tag{3}
$$

Indexes s are relative to square space. To describe r_1 on quadratic coordinated relative to r_b of square edge, we use the ratio between ellipses.

$$
\frac{a_1}{a_b} = \frac{b_1}{b_b} = \frac{r_1}{r_b} \tag{4}
$$

Both parameterized equations describing a complete form with their parametric variables ranging from 0 to 2π, so we can match the parametric variables $\alpha = \beta$. To find α value given any measured point $({}_e x_1, {}_e y_1)$, we isolate it in the equation 1 and replace a_1/b_1 according to the equation 2 in equation 3, we have all parameters to define coordinate on quadratic space $({}_s x_1, {}_s y1)$. Applying to measured points (left side of figure 2) we obtain the equivalent points in the quadratic space as shown in right side of figure 2.

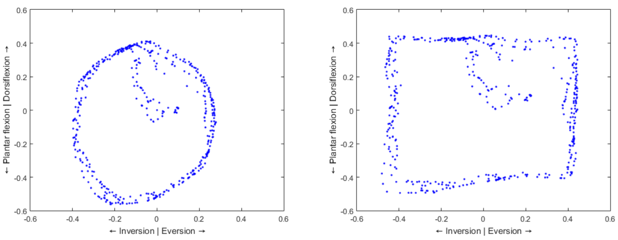

Fig. 2. Left: Ankle motion package measured; Right: Ankle motion package fitted on square space.

C. Calibration

Using the transformation showed is possible to have a better use of MS independent of amplitudes, including amplitudes each patient movement, since the game can be calibrated according to movement ends, as shown in set of equations 5.

$$
\begin{aligned} a_b &= (x_{max} - x_{min})/2 \\ b_b &= (y_{max} - y_{min})/2 \\ h &= (x_{max} + x_{min})/2 \\ k &= (y_{max} + y_{min})/2 \end{aligned} \tag{5}
$$

It is possible calibrate the movement space on the fly by checking for each new position if the there are a new maximum or minimum, and replacing it as follow:

$$
\begin{aligned} &if\ x_{max} < x_i,\ then\ x_{max} = x_i \\ &if\ x_{min} > x_i,\ then\ x_{min} = x_i \\ &if\ y_{max} < y_i,\ then\ y_{max} = y_i \\ &if\ y_{min} > y_i,\ then\ y_{min} = y_i \end{aligned} \tag{6}
$$

So the calibration is made automatically when patient reaches an amplitude greater than a previous one.

It is important to notice that patient has visual feedback of his/her ankle movement through pads position, then a previous calibration from patient's ROM is important before the first pad control, in order to give him/her a correct first impression over his control feeling. After that, every new small achievement over ROM will have a low impact on this control feeling but give a new challenge to the movement ends.

III. CONCLUSIONS

Tests with healthy users showed it is possible, through this mathematical approach, to adapt the game movement to ankle movement, better using player MS as well as softening the assistance, making it a more intuitive movement. The runtime space adjustment allows that, once the patient with movement limitations reaches a certain displacement, the game adjusts itself, making this new range the new MS limit, so the game stimulates exercise of the new gain.

Future works include: *i*) addition testing with patients with injury or movement limitations, this game also gives access to multi-player mode [2] and tele-rehabilitation [3], both cooperative as competitive (with therapist setting objectives); *ii*) providing a tool for training plans development for each patient and/or joint movements characterization such as amplitudes, force or passive stiffness; *iii)* applying the algorithm proposed by [4] to difficulty dynamically adjustment for each user to have a better game experience.

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Technology in Health Professions Education: Game changer or unnecessary investment

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***Abstract*—This paper presents a brief summary of the journey technology has had into health professions education. Technology has reshaped people behavior's in different fields. However, despite the vast influence that technology has had in other educational fields, health professions education literature on the topic is not conclusive and, at this point, is not clear yet what is the role that technology is playing when educating health professionals. This paper presents an analysis of "what has been done" as well as "what could be missing" for technology evidence to be conclusive in generating a positive impact in health professions education.**

***Keywords*—Technology, simulation, virtual reality simulation, educational theory.**

I. Introduction

Technology has revolutionized the world in the last decades. The invention of Web 2.0, iPhone, iPad, among others, have changed traditional behaviors by creating new avenues to perform tasks that back in the day would have seemed impossible. Education has not been the exception for this phenomena. Teaching and learning have been largely influenced by the inclusion of technology at different stages of the educational process. Particularly in Health Professions Education (HPE), technology has played an essential role in reshaping the way that medical students are trained to become proficient doctors.

Health professions education uses Randomize Control Trials (RCT) to measure the effectiveness of a given intervention (e.g., drugs, educational interventions), before implementing it in a real setting [1]. However, despite the myriad of non-conclusive results obtained as outcomes of technology implementation experiments in HPE [2]–[5], technology has been widely included already in the HPE curriculum [2]–[5]. This calls for further research to refine the implementation processes, to lead to more conclusive results.

Technology has enhanced the educational experiences in other contexts different than HPE [6]–[9]. The disparity of results among contexts raises the question, if technology has worked in other contexts, why there is no clear evidence of its effectiveness in HPE yet? In this paper, we suggest that the issue may come from the design/development stages. As a result, we offer an alternative framing to consider while developing new technology in HPE. We believe our approach could help future developers to tackle the current concerns/issues that prevent technology from reaching and the impact that it could have in HPE.

II. The Role of Theory in Technology Development

The simulation paradigm

Medical simulation is a resource that offers the medical trainees the opportunity to practice a skill before performing it on a real patient. However, although the benefit seems inherent, studies that have compared simulation with other traditional methods of medical training (e.g., Halstedian model) have shown largely inconclusive results to weather simulation leads to better skill acquisition and learning or not [3], [6], [10], [11]. Rojas et al., 2016 [12], for example, compared computer generated feedback (technology innovative) vs. Computer based video instructions (a traditional method of learning). The first group received computer generated feedback after every trial during suturing training, whereas the other group was allowed to watch the "how to perform the skill" video, after every trial. Results of this study showed that there was no significant difference at the retention level between the technology innovative approach, and the traditional method of learning.

The Virtual Reality simulation paradigm

The first field that implemented virtual reality (VR) simulators was the flight industry. For them, it was a cost effective solution to have a virtual reality simulator that could offer highly realistic environments for multiple scenarios rather than having to create a different simulator for each scenario. Virtual reality simulators offered versatility by providing multiple scenarios with rather a short burden compared to physical simulators. In HPE, virtual reality simulation emerged as an alternative to the non-realistic bench-top simulators that were used at the beginning of the simulation era [13]. Virtual reality also offered the opportunity of massive distribution and computer generated objective feedback, which in the HPE field could help overcome some of the simulation limitations due to faculty commitment constraints.

The highly realistic VR environments expected by HPE, demanded high computational resources, which is not always easy to obtain in a computer science world. Trying to find alternatives for this bottleneck, we decided to study multimodality, by analyzing the effect that different sounds would have on the visual-quality perception of a simulated medical environment. Our studies [14]–[17] showed that sound does influence visual quality perception of a virtual reality medical room. However, the degree of influence on visual quality perception was dependent on the type of task and how related the sound was to the task/environment presented.

Sidhu et al., 2013 [18], on the other hand, showed that fidelity/immersion probably did not play as big of a role as the one that education would have expected. In their experiment, they had two groups trying to complete a vascular anastomosis. The first group practiced with a human cadaver arm brachial artery. The second group practiced with a straw a needle and thread. Results of this experiment showed no significant difference at global ratings scores after the intervention, threatening the premise that a more realistic the environment would lead to better learning for the students. Norman et al., 2012 [19] conducted a review of studies that compared high fidelity simulation (HFS) with low fidelity simulation (LFS). The results of this analysis showed no significant different between the studies that have used either approach. The non-conclusive results of the comparison between HFS and LFS suggest further research to understand the educational mechanisms that connect highly realistic environments with better learning.

What next?

Despite the examples presented in this paper, we want to clarify that we are not advocating against technology in HPE. In fact, we advocate for the opposite. We believe that despite the lack of conclusive results out of the RCT experiments that have used new technologies in health professions training, further research is needed to define a set of best practices that could help to improve the implementation of new technologies into the field.

Our experience as simulator developers and medical education researchers have shown us that the technology design and development processes currently conducted in HPE are not flawless. This might explain the lack of positive evidence for technology implementation in HPE. In most cases, new technology is created only as a response to a "need". Health professionals approach technology developers with “We need a technological solution for X” and developers create a solution. This format works really well in an environment where the outcomes are linear such as engineering, or information technology. HPE, unfortunately, is not a linear system. Instead, HPE is considered a complex system due to the myriad of variables that play a role in achieving the expected outcome.

This is where we found the area of improvement. From our perspective, in HPE, technology development/implementation should be driven by the needs of the field, but also informed and guided by the educational theories that underpin the teaching/learning processes that would be elicited by the new technology. If the ultimate goal of the technology is to play a role in the medical education field, the design process needs to account and include the underpinning mechanisms that will enable learning. The identification of the educational theory(ies) and underpinning mechanisms that will support the new technology are as important as fulfilling the need/s of the field.

Medical education is intrinsically a multidisciplinary field. Hence, we propose that the technology development conversations should involve not only the content expert (i.e., doctors) and the person who is going to materialize the approach (i.e., technology developers), but also educational experts and medical educator-researchers. We believe that this newly proposed interdisciplinary structure will provide the support necessary to create technology that would finally make the difference when implemented for teaching/learning.

Further research is needed to be able to verify the real impact that an interdisciplinary team, like the one proposed in this paper, would have in technology development for medical education.

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Children's Privacy Protection Engine for Smart Anthropomorphic Toys

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Abstract— *A toy is an item or product intended for learning or play, which can have various benefits to childhood development. Children's toys have become increasingly sophisticated over the years, with a growing shift from simple physical products to toys that engage the digital world. Toy makers are seizing this opportunity to develop products that combine the characteristics of traditional toys such as dolls and stuffed toys with computing software and hardware. A smart anthropomorphism toy is defined as a device consisting of a physical toy component in the humanoid form that connects to a computing system through networking and sensory technologies to enhance the functionality of a traditional toy. Many studies found out that anthropomorphic designs resulted in greater user engagement. Children trusted such designs serve a good purpose and felt less anxious about privacy. While there have been many efforts by governments and international organizations such as UNICEF to encourage the protection of children's data online, there is currently no standard privacy-preserving framework for mobile toy computing applications. Children's privacy is becoming a major concern for parents who wish to protect their children from potential harms related to the collection or misuse of their private data, particularly their location.*

I. INTRODUCTION

Toys have been a part of human existence for thousands of years, across every culture, being uncovered from as far back as ancient Egyptian times. A toy is an item or product intended for learning or play, which can have various benefits to childhood development. The modern toy industry is comprised of establishments primarily engaged in manufacturing dolls, toys and games. As such a substantial part of human development, toys have continued to maintain a presence in the daily lives of billions of individuals of all ages. While primitive toys included rocks and pinecones, they soon progressed into dolls, stuffed animals and trains. Traditionally, toys have been entirely autonomous and do not have any processing or networking capabilities to communicate with any other device. While a child user is engaged with a traditional toy, it will collect and store no personal data, and require no reason for concern for a child's privacy. With the introduction of electronic toys with embedded systems, electronic toys can have sensory capabilities, and the ability to collect and store inputted data based on the user's interactions. This data is limited and used only for the interaction, often discarded immediately. An electronic toy has limited or no networking capability. Thus, privacy concerns are limited to nonexistent in this context.

A smart toy is defined as a device consisting of a physical toy component that connects to one or more toy computing services to facilitate gameplay in the Cloud through networking and sensory technologies to enhance the functionality of a traditional toy [1]. A smart toy in this context can be effectively considered an Internet of Thing (IoT) with Artificial Intelligence (AI) which can provide Augmented Reality (AR) experiences to users. Examples of these are Mattel's Hello Barbie™ and Cognitoys' Dino. Smart toys are able to gather data on the context of the user (e.g., time of day, location, weather, etc.) and provide personalized services based on this context data. However, the user may not be comfortable with the level of data that is collected and inferred on them.

In general, there are three properties of a smart toy: (1) Pervasive – a smart toy may follow child through everyday activities; (2) Social – social aspects and multiplayer are becoming a mandatory aspect of interactive smart toys in a one-to-one, one-to-many and many-to-many relations [2]; and (3) Connected – Smart toys may connect and communicate with other toys and services through networks. For example, Cognitoys' Dino can listen and answer questions raised by children by voice because the Dino connected to the IBM Watson's knowledge called Elemental

Path's "friendgine," which is a kid-friendly database at the backend. Some research studies found out that children have emotional interactions with dolls and stuffed toys in anthropomorphic design [3]. Some children even prefer to take the toy to the dinner table or make a bed for it next to the child's own [4].

As a result, *Toy Computing* is a recently developing concept which transcends the traditional toy into a new area of computer research using services computing technologies [5]. In this context, a toy is a physical embodiment artifact that acts as a child user interface for toy computing services in Cloud. A smart toy can also capture child user's physical activity state (e.g., voice, walking, standing, running, etc.) and store personalized information (e.g., location, activity pattern, etc.) through camera, microphone, Global Positioning System (GPS), and various sensors such as facial recognition or sound detection. In 2015, a new invention called the "Google Toy," which is an Internet-connected teddy bear and bunny, like an anthropomorphic device with speech and face recognition functions that will have the ability to control smart home appliances and devices at home. However, this toy has caused many criticisms from the media as people express concern about privacy breaching and safety issues by Google.

More specifically, the toy makers are confronted with the challenge of better understanding the consumer needs, concerns and exploring the possibility of adopting such data-collected smart toys to rich information interface in this emerging market. For example, many toy designers have been researching the balance between the level of private information a toy collected from a child and the level of personalized features the toy provided to the child. Referring to the direction of the United States Federal Trade Commission Children's Online Privacy Protection Act (COPPA) and the European Union Data Protection Directive (EUDPD), this study adopts the definition of a child to be an individual under the age of 13 years old. In this study, the first assumption is that children do not understand the concept of privacy and the children do not know how to protect themselves online, especially in a social media and Cloud environment. The second assumption is that children may disclose private information to smart toys and not be aware of the possible consequences and liabilities. Some research studies found out that children have emotional interactions with dolls and stuffed toys in anthropomorphic design [3]. Some children even prefer to take the toy to the dinner table or make a bed for it next to the child's own [4]. For example, many studies found that anthropomorphic toys such as teddy bear or bunny serve a specific purpose, as children trusted such designs and felt at ease disclosing private information.

Breaches of privacy can result in physical safety of child user, e.g., child predators [6]. While the parents/legal guardians of a child strive to ensure their child's physical and online safety and privacy, there is no common approach for these parents/guardians to study the information flow between their child and the smart toys they interact with [7]. As smart toys are able to collect variety of data such as text, picture, video, sound, location, and sensing data, this makes the context far more complicated than many other smart devices in particular given that the subjects are mainly children in a physical and social environment. Parental control is a feature in a smart toy for the parents to restrict the content the children can provide to the toy. Though the toy industry has also issued regulations for toy safety, these regulations have no mention of privacy issues in this toy computing paradigm.

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Pomodoro: Autonomous Assistive Mobile Robot

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***Abstract*— Current technology has provided means for creating better assistive tools, among them assistive robotics has attracting academic attention due to cost reduction and flexibility of application. Yet, developing assistive robots is not an easy task because robotics is intrinsically multidisciplinary. This paper covers the ongoing research with the Pomodoro robot for child rehabilitation, and proposes an intelligent control architecture based on human-robot interaction for assistive applications. Furthermore, it presents a case study on assistive robots for special education.**

I. Introduction

Aiding people with disabilities is a challenging task. Current technology has provided means for enhancing existing solutions and for developing new assistive tools, such as robots for rehabilitation, autism therapy, and social inclusion. This growing interest in robotics is due to the popularization of electronics and software tools that ease the creation of robot controllers.

Even though robotics has become closer to medical applications, the cost and expertise required to use robots is still a barrier for researchers outside the field, such as surgeons, psychologists, physiotherapists and computer scientists [1]. Robots developed for a specific application are expensive and require skilled personnel, and these researchers have no access to them [2].

In the case of robots for social inclusive robots, two research fields play a major role on the final results of the robot: control architectures and Human-Robot Interaction (HRI). While HRI studies how a robot can interpret and convey human information through verbal and non-verbal languages, control architectures determine how the many robot modules, including those for HRI, will work together in an ordered and coherent course of action to achieve a given goal.

This paper presents the ongoing experiences using affordable mobile robots for the rehabilitation and social inclusion of children with severe motor impairments, and also proposes an intelligent control architecture for creating applications for this end.

II. Pomodoro Robot

The Pomodoro robot, presented in Fig. 1, is our current base for experiments involving control architectures, HRI and assistive robotics. Pomodoro is a 100 USD robot that is easy to replicate and provides high flexibility. It uses vivid colors to draw children's attention, and the body is designed with rounded shapes to not harm the user. The body structure uses flat acrylic parts that can be easily replicated.

(a) (b)

Fig. 1. Pomodoro robot (a) with costume (b).

The intelligent control architecture is composed of four main modules, as shown by Fig. 2. The *memory space* is the central module of the architecture, providing means of inter-process communication and data storage. The acquisition of sensor data, as well as the low-level control of actuators, is performed by the *hardware interfaces*. The *data processors* implements different services of data processing. The *controller* is the software that effectively controls the robot. The next sections will address the design and development of each module.

A. Memory space

The *memory space* has two objectives: to serve as a *communication mean* and to *store data*. It is inspired on the psychological concept of modal memory [3], which defines the human memory in three types: sensory, short-term and long-term. To compose the memory space, a whiteboard system [4] was implemented using the NoSQL (*not only structured query language*) database Redis.

B. Hardware interfaces

The *hardware interfaces* are the modules that capture and decode sensory data and that drive the actuators. Thus, the hardware interfaces "produce" decoded sensor data at the memory space with a short TTL, usually 1 s, and "consume" information about the set-points of its actuators.

C. Data processors

Data processors are responsible for reading and processing decoded sensory data to produce useful information to the

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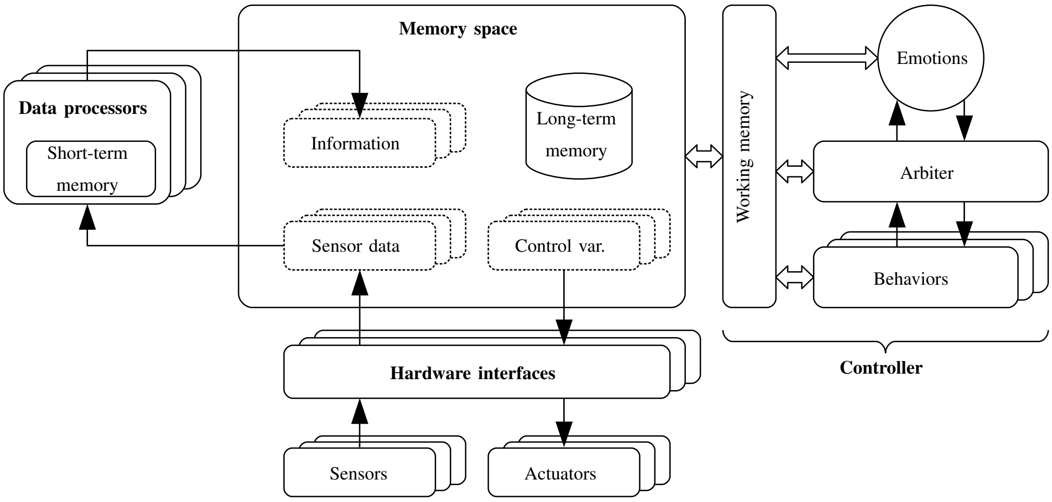

Fig. 2. Intelligent control architecture.

Fig. 3. Child playing with Pomodoro.

system. The definition of these modules is wide as they have the purpose of providing data-processing services to the controller, thereby reducing the complexity of the controller.

D. Controller

The controller is the module that effectively controls the mobile robot. In this architecture, it is composed of three layers, as shown by Fig. 2, namely: *emotion* based on the circumplex model [5], [6]; *arbiter*, which was implemented with a decision tree; and *behaviors*, that employed motor schema theory [7].

III. Pilot Study

The application was brought to the field to be evaluated by the target audience. The partnership with two institutions of Bauru, SP – Brazil, allowed this pilot study, which involved children with typical development (TD) and autistic spectrum disorder (ASD), as shown by Fig. 3. The experiments were conducted in institutions, i.e. in non-controlled environments. Although the environmental conditions (e.g. lighting, audible noise) were not adequate, the system operated as expected.

The use of pictograms instead of real faces was well received by technicians, who said that this type of image representation is more easily understood by children with ASD. On the other hand, the voice of the robot received a positive evaluation to be ”soft, firm and secure”, although its genre should be chosen according to the acceptability of the child. The lack of emotion of the synthesized voice was not perceived as a problem because, at least in the psycho-pedagogical development stage in which the application fits, the usage of a ”constant voice helps the child to associate the concept being exposed. Additionally, the ease of use of robot allowed the child to participate in the games with the help of a caregiver who does not have specific training in the area.

IV. Final Discussion

The application was well received by the therapists of both institutions visited during the pilot study. Certainly, there are adjustments to be made so that the system can be effectively applied in therapy, such as creating more cards and adding more movements to the robot during the activities. However, it became clear the correct adaptation of the application developed with the requirements. Future works will improve the system and add new activities.

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Do Brain-Computer Interfaces Have a Future in Learning Environments?

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***Abstract*—** The emergence of affordable off-the-shelf brain-computer interfaces (BCI) has facilitated the incorporation of electroencephalogram (EEG) information by the research community. With the intention of outlining benefits and limitations of consumer-grade BCIs, this talk will go over a number of experiments I have conducted with human participants over the past years, outlining the conscious and subconscious cognitive phenomena we have been able to identify and measure, including those we believe still pose a challenge given the inherent limitations of these devices. I will demo a healthcare simulation system we designed, developed, and used in a real classroom setting at the University of Ontario Institute of Technology, and will discuss possible scenarios where EEG feedback could make an impact in a simulation environment of this nature.

Modeling and Predictive Control of Human Gait based on the Dynamic Behavior

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***Abstract* - This paper presents a proposal for developing a lower limb orthosis based on the continuous dynamic behavior and events presented on the human locomotion, when the legs alternate between different functions, a computational model was developed to approach the different functioning models related to the biped anthropomorphic gait. It was addressed the Lagrange modeling by using the system of events modeling in addition to the non-holonomic dynamics of the system. One of the investigated factors is the gait bilateralism, so that it provides balance to the center of mass of the human body during locomotion. This paper combines the comparison of the use of the predictive control based on dynamical study and the decoupling of the dynamical model with auxiliary parallelograms for locating the center of mass of the mechanism with springs in order to achieve the balancing of each leg, a virtual model is implemented and its kinematic and dynamic motion analyzed through simulation of an exoskeleton aimed at lower limbs for training and rehabilitation of the human gait, in which it is already developed the dynamic model of anthropomorphic mechanism and predictive control architecture with robust control.**

Keywords—exoskeleton, locomotion, Kinematic and dynamic model, anthropomorphic gait, Predictive Controller

I. INTRODUCTION

The growing number of legged impaired in the world is a reality that as to be confronted. Available passive mechanic orthosis produce locomotion difficulties when walking our inclined terrain with obstacles, such as slopes and stairs [1].

The modeling of a system is a fundamental resource on the study, comprehension and simulation of its dynamic behavior. real systems are frequently rich in complexity, which hampers the task of reducing the dynamic behavior for a mathematic approach. By approaching robotics when, with the objective of optimizing the system, there is an attempt to emulate the biomechanical behavior present in the human locomotion, in which a trajectory assumed by the lower limbs is denominated gait, it presents discontinuities and mechanical impacts that make the modeling task laborious by means of the conventional mechanics formalism, and frequently limits the extension of the studies. This becomes critical when the interest is mimicking, i.e. the perfect assimilation of dynamic behavior on this system, intended objective when approaching the design of exoskeletons (mechatronics devices integrated with the human body), or parts of the body, intended to map and/or amplify its motor functions, and that interact in a physical and cognitive way with its user [2].

The development of a study platform for locomotion of human gait that permits the dynamic integration of the continuous behavior with the event dynamic, in order to develop a model that can be applied to a gait aiding exoskeleton.

The main objectives of this paper are the development of a physical model of the human locomotion system, taking the gait in the sagittal plane as a first step, and after to connect the control system previously developed for the human leg, integrated by the modeled system of the human gait.

This paper presents the study and simulation of an exoskeletics orthosis for reproducing human gait movement and integrating the patient further within today society. The organization of this paper is a follows. Section II describe Biomechanical approach and main objectives of this paper. Section III the direct and inverse kinematics model and gait movements. Section IV, proposes the study of the leg orthosis complete dynamical model with associate transfer function. Section V proposes the control architecture considering the dynamical modeling using serial, parallel and hybrid mechanism. Section VI presents the position controller implementation and simulation based on kinematics and dynamic model. Section VII presents a comparative study of the dynamic behavior of the corresponding coupled joins (hip, leg and foot) using a self-tuning PID controller, PID written in the form RST, and simple predictive controller (GPC), and robust predictive controllers: noise sensitive in the signal control (GPC-R1), and noise sensitive in the signal control and the disturbance in the system (GPC-R2), and finally in Section VIII is presented the final conclusions and future works suggests.

II. BIOMECHANICAL APPROACH

The orthosis are devices that improve the performance the body. Its purpose is to line up, to prevent or to correct deformities, of the mobile parts of the body. The therapeutic benefits are associated to minimize the limitation of movement, allow assisting movement, transference of force and protection of parts of the body [1]. The exoskeleton is a device that can be used for improving people biomechanics such, as walk, “run faster”, carry some equipment, among others.

A. Human Gait

The human gait is performed while being on the biped position. The gait cycle is initiated when the heel contacts the ground and is finished when the same heel touches the ground again; it is divided in two phases: the support and the rocking phase (Fig. 1).

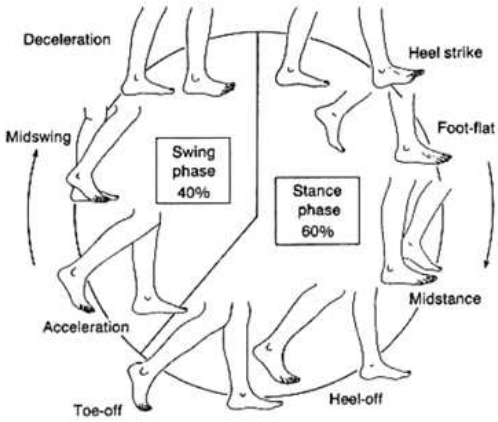


Figure 1: Events during the Human Gait Cycle.

B. Proposed Mechanism

The designed exoskeletic orthosis has to reproduce human gait as with much realism as possible. The joints are responsible for transmitting the angular motion between each member. The joint between the foot and the leg, is the ankle, between the leg and the thigh is the knee and finally, between the thigh and the pelvis is me hip [1]. Each one of these joints allows three basic rotations: flexion-extension, abduction-adduction and internal-external rotation.

The flexion-extension corresponds to the movement of the member executed in the sagittal plane. The abduction/adduction corresponds to the movement of the member executed in the frontal plane. Finally, the internal/external rotation corresponds to the movement executed in the direction of its proper axis.

III. Direct and Inverse Kinematics Model

From experimental data from a biomechanical study of the human gait was adopted as the angular position reference signal, the curves obtained by the corresponding iterative model the angular variation of the knee joint angle, leg and foot of a person developing the speed 5 km/h [5]. From the obtained kinematic model were linear movement files relating to the corresponding trajectories of these three degrees of freedom (DOF), and they are used as position reference signal during the calculation of the inverse kinematic model of the system under study. For dynamic effects, the foot was considered as a concentrated mass. From the kinematic motion analysis, we obtain the complete model gait motion representation for the phases of support and balance, which will be used as a reference trajectory in the implementation of dynamic control proposed in this study (Fig 1).

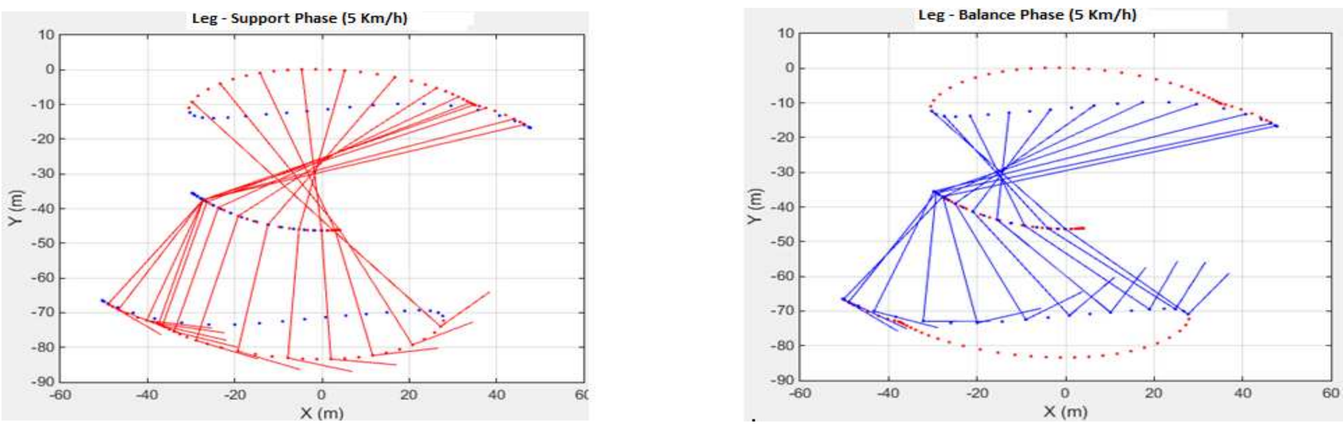


Figure 2: Full Motion Gate.

A. Kinematic Control Architecture

Fig. 3 shows the architecture implemented to obtain the angular reference position for each of the joints (3 DOF), corresponding to the knee, leg and foot movements.

The kinematic model allows the calculation of the current Cartesian position corresponding to each DOF (hip, leg and foot) from its geometric model and associated parameters.

The inverse kinematic model is realized from the inversion of the Jacobian matrix, and multiplying its terms by the increase of Cartesian position (Delt_X), allowed the calculation of the angular position increment, which when added to the current position of the joints (angular reference input) allowed the calculation of the new angular position to be used as reference signal to the controller.

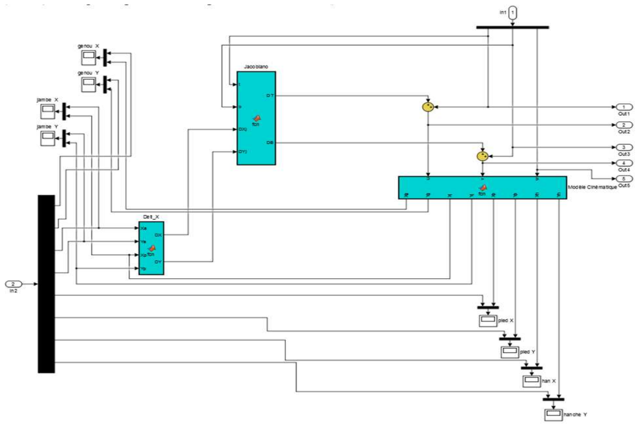


Figure 3: Kinematic Direct and Inverse Model.

IV. Dynamic Study

The dynamic study proposed in this paper was developed for the design of the drive and control system being studied three types of mechanisms to be put in the knee: serial, parallelogram and hybrid (parallelogram with efforts retaining springs). These mechanisms are arranged on the bars connecting the hip to the leg and the leg to the heel, thus not damaging the kinematics associated with joints (Fig. 4). Through this study, we note that the use of a parallel mechanism decoupling the complete dynamic model, thus simplifying the control architecture.

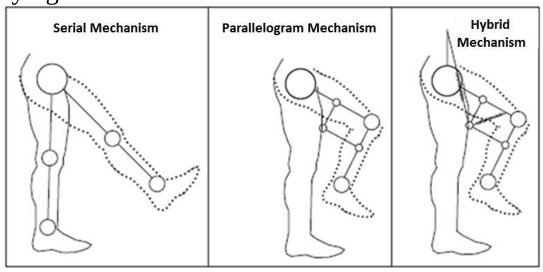


Figure 4: Serial Leg Model with parallelogram.

V. Control Architecture

The data for the dynamic model and implemented controller in Matlab-Simulink were parameterized, allowing the development of an open architecture control based on direct and inverse kinematic model, and complete dynamic model, as well as PID controller GPC (Generalized Predictive Controller). The gains of these controllers are previously obtained, thus achieving the complete simulation results of the study exoskeleton device [8]. Fig. 5 shows in the form of block diagram the full model control architecture implemented in this paper.

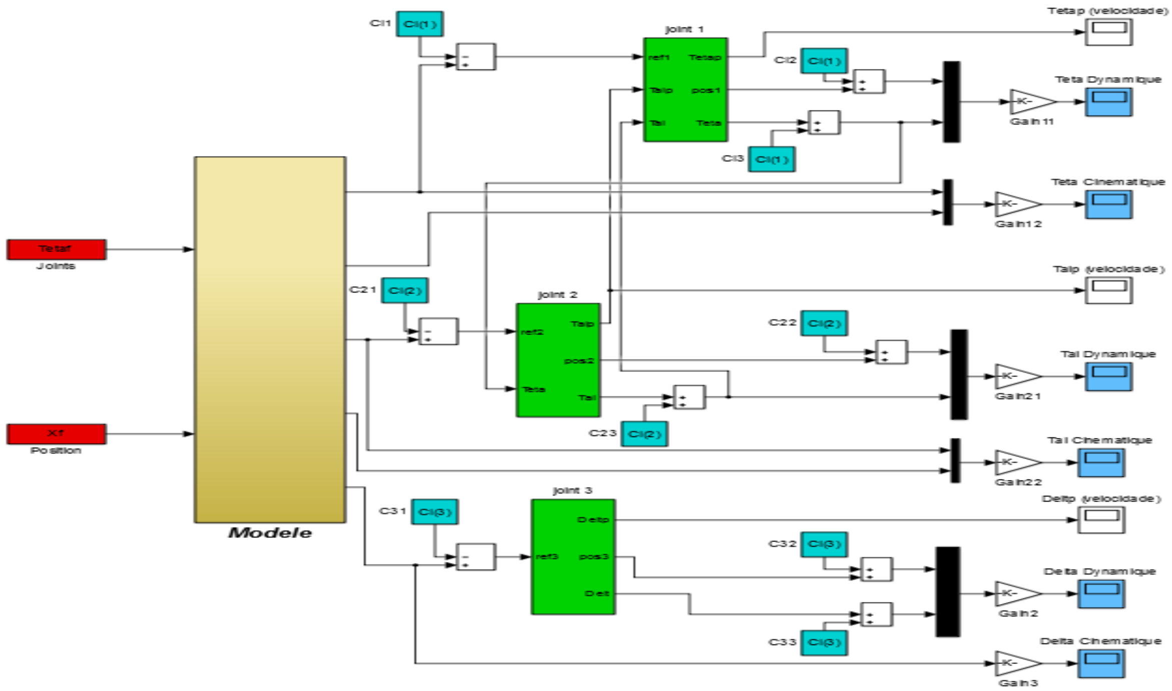


Figure 5: Dynamic Model and coupling joints.

For dynamic modeling and control system noted decoupling of the dynamic model when using a parallelogram mechanism and hybrid (with spring) with respect to the serial mechanism [4]. For the purpose of studying the influence of dynamic effects

It also used a reducer with a small transmission rate for the highest coupling joint (hip joint), thus enabling the driver to observe the effect on a dynamic system subject to perturbations due to the change of its load (70). As expected, a self-tuning PID controller presented for joints with strong coupling effect (hip) the occurrence of instabilities eliminated only with the significant increase in the gain of the charge reducing the mechanical transmission (> 200), directing thus a comparative study based controllers using GPC present as below.

A. *Position Controller Implementation*

The control architecture proposed for the system (3 DOF) was implemented with joint position controllers dynamically coupled (hip, leg and foot). For the dynamic model of the foot was regarded as a concentrated mass applied to the end of the leg. The parameters used were obtained from actual measurements of a mechanical design optimized for a mechanical structure [12].

Fig. 6 shows, joint control architecture used to simulate the previously described controllers, considering together dynamically decoupled.

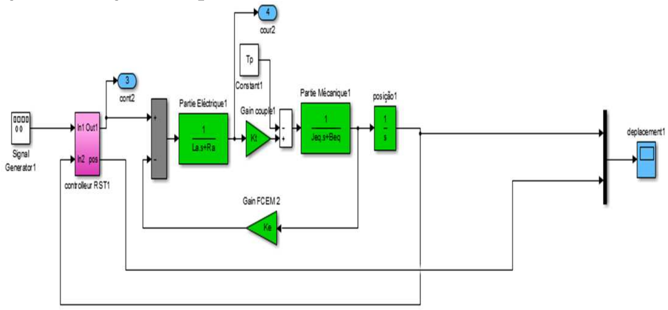


Figure 6: Joint Control Architecture.

B. *Comparative Study - Criteria*

A comparative study of the dynamic effect of the dynamic coupling of the hip-leg joints mechanism (2 DOF) was realized using serial, parallel, hybrid mechanism [4] where we can see the effect of dynamic decoupling the use of parallelogram mechanism and the addition of the inertial compensation effect (or mass) when adding a spring (hybrid mechanism).

The parallelogram mechanism provides decoupling of the dynamic equations of the model, that permits simplify the dynamic model, and decrease the mechanical transmission rate as well as the possibility to use of a simple position controller (PID). In this study was initially implemented a robust predictive controller for the case of a serial architecture, and use two criteria for comportment analysis:

- **Direct Sensitivity function:** direct influence of disturbance on the system output;
- **Complementary Sensitivity function**: influence of the measurement noise on the system output.

For convenient analysis of Robust Predictive Controller implemented the following adjustment parameters were used:

- **Delay Range:** more than one sample period;
- **Direct Sensitivity function:** modulo less than 6 dB;
- **Complementary Sensitivity function:** modulo less than 3 dB;
- **Noise power:** about 10 % of the control signal.

C. *Implementation of Control Based on Dynamic Model*

In this study, we initially used a self-tuning PID controller in its classical form, which showed the expected correction behavior, only in the case, when increased significantly to reducing the transmission ratio. At the same model was implemented a PID controller described as RST form. In this case, the joint corresponding to the hip, was presented very sensitive (due to the lower number of DOF) and for stabilization, he needs to increase the constant discrete time.

This study also implemented Robust GPC controller considering the existence of a possible noise in the control signal, and/or the existence of disturbance in the system, which can run in the case of dynamic coupling joints. The joints transfer functions (hip, leg and foot) are described below:

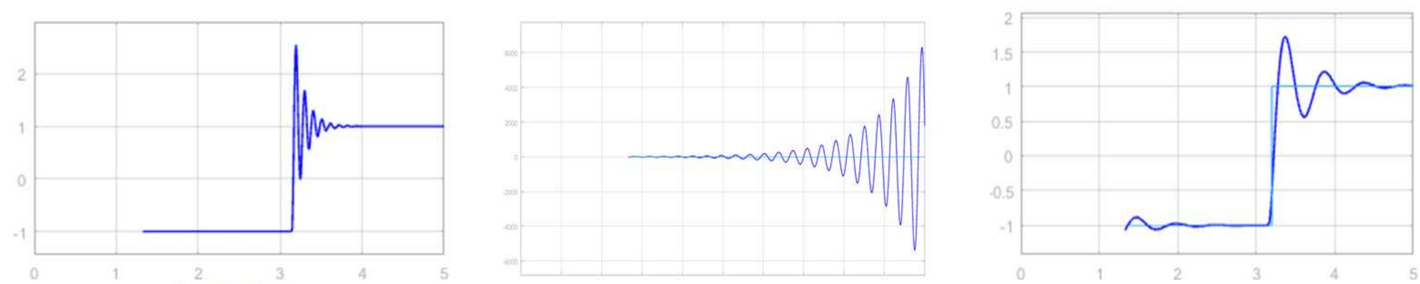
$$H_{Hip}(s) = \frac{1.37}{6{,}509e-7s^3+1{,}979e-4s^2+3{,}838e-2s} \quad (1)$$

$$H_{Leg}(s) = \frac{1.37}{1{,}091e-7s^3+3{,}367e-4s^2+3{,}731e-2s} \quad (2)$$

$$H_{Foot}(s) = \frac{1.37}{6{,}747e-8s^3+2{,}106e-4s^2+3{,}731e-2s} \quad (3)$$

D. *Controller Study Comparative uncoupled joints (3 DOF)*

Figs. 7, 8 et 9 presents a comparative study of the dynamic behavior of the corresponding uncoupled joins (hip, leg and foot) using a self-tuning PID controller, PID has written in the form RST, and robust predictive controller (GPC) with a noise sensitive in the signal control and the disturbance in the system.



a) Self-tuning PID

Figure 7: Comparative Study of Controller (Hip).

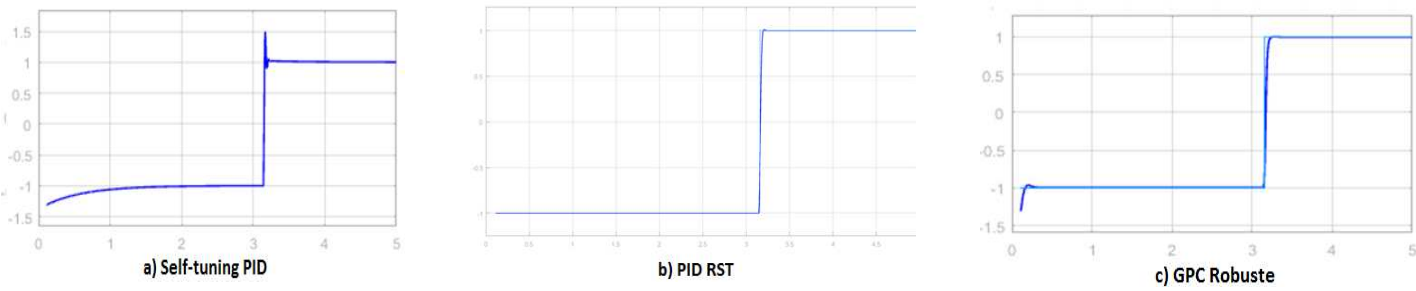


Figure 8: Comparative Study of Controller (Leg).

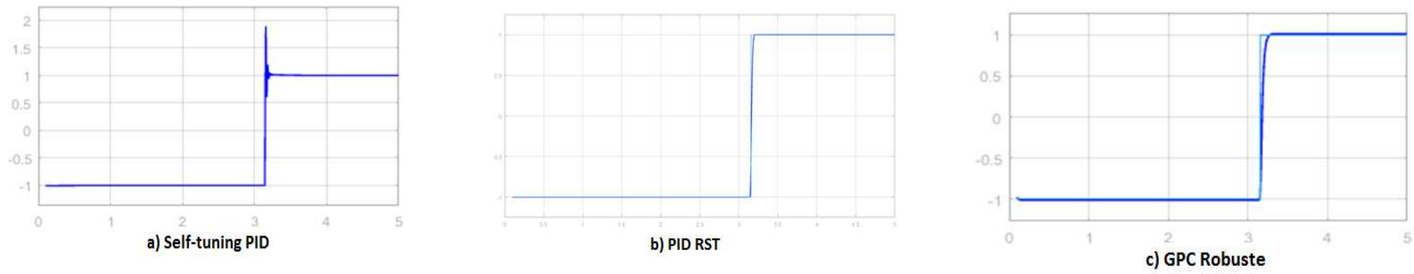


Figure 9: Comparative Study of Controller (Foot).

E. Controller Study Comparative coupled joints (3 DOF)

For comparative study of the dynamic behavior of the complete system (hip, leg and foot), was used the corresponding transfer functions for each DOF for the coupled dynamic model. The complete dynamic model SIMULINK block diagram is shown in Fig. 10.

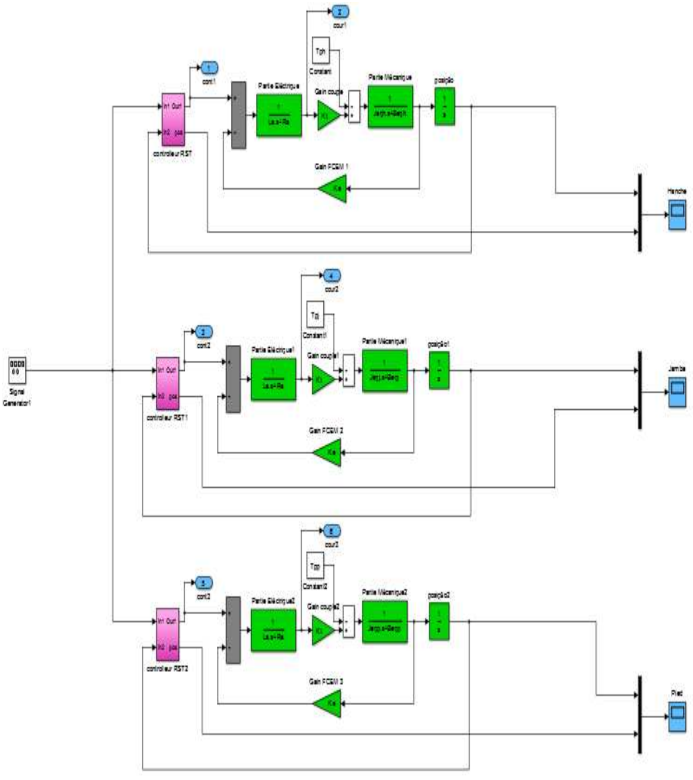


Figure 10: Proposal Architecture (3 DOF) using different controllers.

We present a comparative study of the dynamic behavior of these joins, using for each of the DOF a predictive controller described as RST form (GPC) and robust predictive controller: sensitive to noise in the control signal (GPC–R1), and robust noise-sensitive predictive in signal control and there is disturbance in the system (GPC-R2), submitted a step input. Fig. 11, 12 and 13 shows the main results obtained from the simulation (Dynamic Coupling of joints - 3 DOF).

VI. POSITION CONTROLLER IMPLEMENTATION

Fig. 14 shows the complete structure control using the dynamic model implemented. For comparative study of effects will be compared to the 3 DOF mechanism study using the control architecture proposed (Fig. 10) and the controllers GPC, GPC-R1 and GPC-R2.

For each joint (3 DDL) was implemented a position controller (GPC, GPC-R1 and GPC-R2), as shown in the Fig. 15 shows the block diagram corresponding to each degree of freedom associated (hip, leg and foot). These blocks contain sub blocks concerning the position of control architecture used in each degree of freedom (GPC controller in the RST form), and function block MATLAB, corresponding to the dynamic coupled model of the joint (motor and associate load).

The Fig. 16 shows the results of the simulation were performed by the comparative study between the reference position and calculating the inverse kinematic model and system response analysis in the study with dynamical coupling using structure Robust GPC controller with disturbance in output and noise (coupled dynamic model).

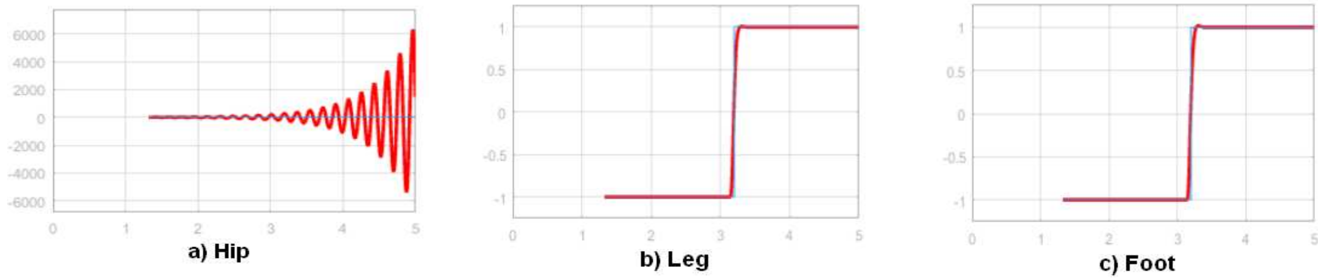


Figure 11: GPC RST Controller.

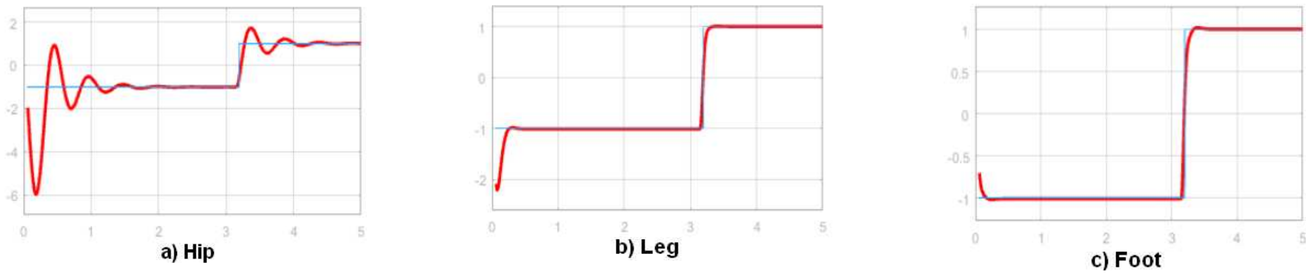


Figure 12: Robust GPC Controller (GPC-R1).

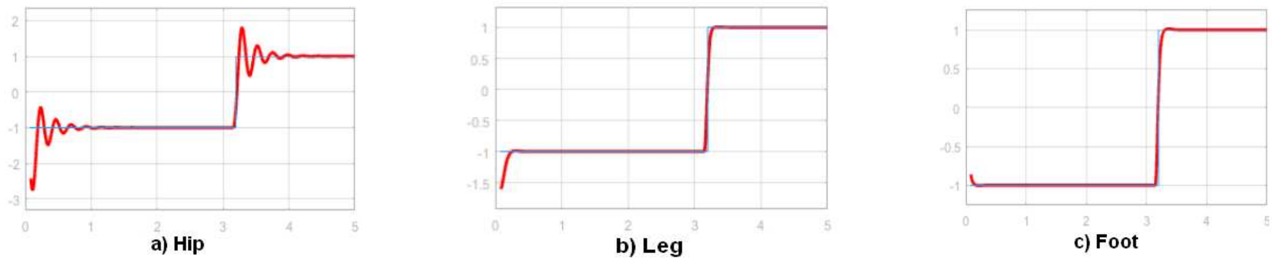


Figure 13: Robust GPC Controller(GPC-R2)

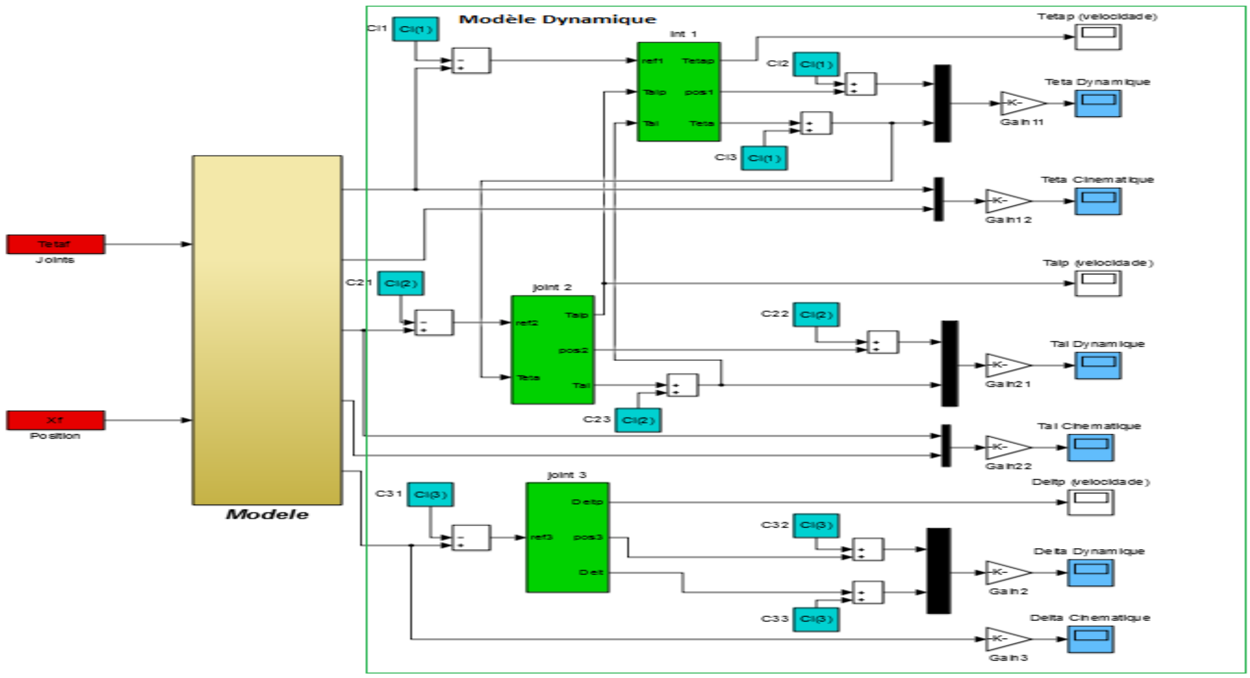


Figure 14: Proposed Control Architecture for 3 DOF.

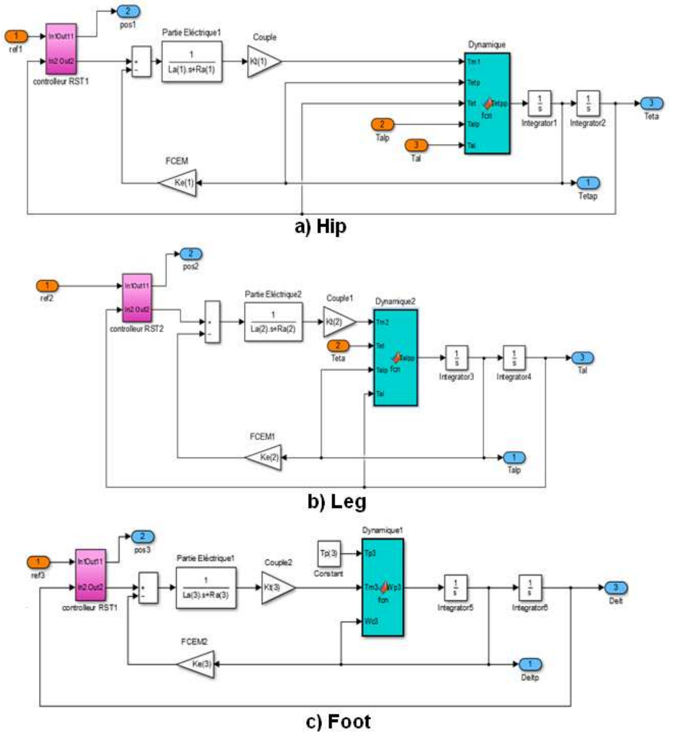


Figure 15: DC motor drive and joint dynamic controller.

VII. Main Results and Comments

A. Motor + equivalent dynamics (hybrid mechanism)

The regulator PID self-tuning PID presents the expected correction comportment, but it takes to stabilize with respect to a Robust GPC controller. The PID-RST controller does not stabilize with respect to PID controller with constant gain, while the GPC controller was more sensitive to disturbances compared to controllers.GPC-R1 and R2.

B. Motor + dynamical coupling joint (serial mechanism)

The use of a mechanical transmission is essential to compensate for dynamic effects due to coupling joints. For correction effects can make a comparative analysis with the different controller proposal in this study:

- **Self-tuning PID controller (classical form):** shows the expected correction of behavior when we increased the mechanical transmission (gear ratio), but it takes to stabilize in relation to a Robust GPC controller. The PID controller written in the RST form, in the case of joint corresponding to the hip is very sensitive (due to the lower number of DOF) and does not stabilize easily.
- **GPC (RST form) controller:** the same as the self-tuning PID controller is very sensitive to disturbance, especially if we look at the more coupled joint (hip), not stabilizing if not lift the mechanical transmission (gear ratio), also showing a considerable delay in relation to the reference input.
- **GPC Robust (R1) controller::** presents a less sensitive dynamic behavior disturbance in relation to the controller GPC-RST, especially if we look at the more coupled joint (hip), also presenting a significant delay in relation to the reference input, where it can be attenuated,if increase the mechanical transmission (gear ratio) of the joint (occurs a decrease of its inertial coupling).
- **GPC Robust (R2) controller:** presents a dynamic comportment even less sensitive to disturbance with respect to the controller GPC-R1, particularly for the more dynamical coupled joint (hip), also presenting a significant delay in relation to the reference input, In the same way for the regulator GPC–R1, it can be attenuated, if increase the mechanical transmission (gearratio) of the joint (occurs a decrease of its inertial coupling).

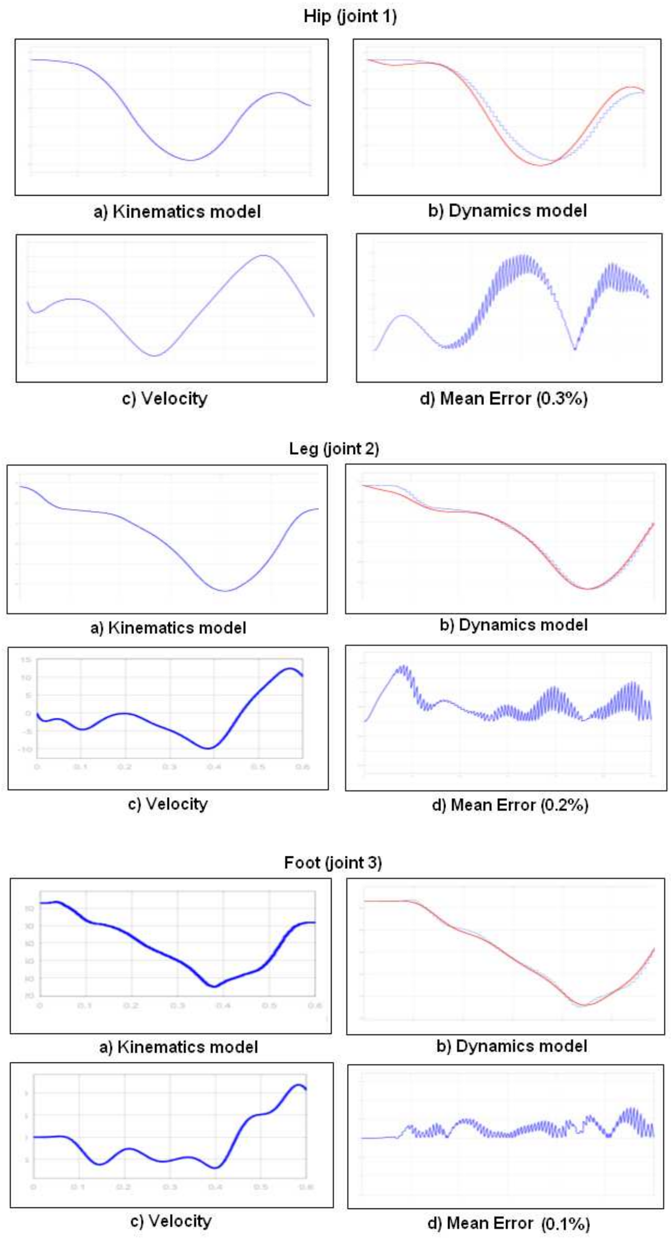


Figure 16: Kinematics and Dynamics Comportment.

VIII. FINAL CONCLUSIONS

From the development of this research work we can verify that solutions of problems of mobility of lower members using the hybrid method cause great impact the areas of Engineering of Rehabilitation. Orthosis exoskeletics of lower members was designed aiming at to the reproduction of the movements of the gait human being, with functions next to a natural member, for the implementation in patients with motor difficulty, having one of the weak legs.

The comparison of the use of the predictive control based on dynamical study and the decoupling of the dynamical model with auxiliary parallelograms for locating the center of mass of the mechanism with springs in order to achieve the balancing of each leg, a virtual model is implemented and its kinematic and dynamic motion analyzed through simulation of an exoskeleton aimed at lower limbs for training and rehabilitation of the human gait, in which it is already developed the dynamic model of anthropomorphic mechanism and predictive control architecture with robust control.

The controller GPC-R2 presents a convenient way for use in exoskeleton, with high join dynamic coupling, however it presents the possibility of a delay in relation to the reference input, and the same can be corrected in two forms:

- By eliminating the dynamic coupling between the joints, from a hybrid compensation mechanism (spring + parallelogram) that will dynamically decouple the system under study; and/or
- Increased mechanical transmission (gear ratio).

Finally, the main results of this work can be used to increase the number of degrees of freedom, to extend the study of balance of the gravity for the two legs.

ACKNOWLEDGMENT

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A Concurrent AI Engine for Realistic Non-Player Characters

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***Abstract*—While commercial game engines are multi-threaded, and have been for a while, all of them are still based on single-core architectures. and do not take advantage of multi-core systems. Open source and academic research projects exist that demonstrate the advantages of using a multi-core game engine. These projects are still very much in the early stages and primarily address problems focused on parallelizing the rendering loop. The work presented here is the design for a complete multi-core game engine that uses open source components and parallelize some key components in the game engine one of which is the AI engine. This design will enable game developers to create games that contain NPCs that possess fully articulated motivational, personality, emotion, sensing and decision models. The initial aim of the design of the concurrent AI engine will be to create games capable of running hundreds of such NPCs simultaneously.**

I. Introduction

Commercial game engines like Unreal, Unity, and CryEngine are based on a single-core design. The primary reason that these engines still do not take advantage of multi-core systems is because parallelizing such a large code-base is an extremely difficult and costly task. While there are performance benefits, the disruption it may cause to their customer base could be substantial. As a result, game engine designers focus on increasing the performance of their systems by making them multi-threaded and highly optimized for specific system architectures.

Proposed multi-core (or concurrent) game engines designs have existed for quite some time [1], [2], [3], [4], [5], [6], [7]. Additionally concurrent game engines that fully leverage multi-core systems have been attempted and have demonstrated performance gains [8], [9]. This is a growing area of research due to the complex nature of game engines. While demonstrating that the game/renderer can be parallelized is valuable, there are many other components that make up a game engine including a physics engine, a resource manager, scripting systems, and AI middleware. [10]. AI middleware like Kynapse [11] and Kythera [12] primarily focus on NPC navigation using path/navigation mesh generation, and NPC action-selection using behavior trees, finite state machines (FSMs) or selection trees. Missing from these AI engines are rich behavior modeling, autonomous action-selection and other realistic human behaviors like emotion and sensing. Although rich gaming experiences are achieved with current AI engines, the limits of using such systems in games is rapidly becoming clear with games like No Man's Sky [13] and Star Citizen [14], where rich extensive and immersive worlds provide many engaging objects and objectives, but can quickly become repetitive and meaningless because they lack truly rich and engaging NPCs [15] to complement these expansive worlds.

This problem is not limited to recreational games. Similar issues quickly arise in serious games as well. Serious games for healthcare education and training[16] and exergames for rehabilitation and social interaction [17] tend to focus on one-on-one experiences. That is, either the doctor is interacting with a patient through surgery or verbally, or the patient is using the game to improve some type of health outcome. Most serious games do not address the complex social issues inherent in treating and managing Chronic Non-Communicable Diseases (CNCDs) even if they are meant to be used to address problems associated with CNCDs like diabetes or hypertension. This is because the AI required to model the social relationships and influences a patient encounters is well beyond the capability of existing AI engines.

We propose in this paper a design for a concurrent AI engine that can be incorporated into a concurrent game engine architecture. This design will provide the basis for a game engine that can be used to create games with hundreds of autonomous NPCs that possess rich and believable human behaviors.

II. Overview of the Concurrent Game Engine

The design for the concurrent game engine is based on an architecture proposed by [2]. The main idea is that of a scheduler and task manager that is used to manage game systems. The design proposed by [2] relied on different managers, which we call controllers in our design. The controllers in our design can be separate multi-core engines and not simply a singleton object. For simplicity, our design focuses on four controllers: AI, Physics, Audio and Renderer. Three of these controllers will have concurrent capabilities: AI, Physics and Renderer and will eventually have a built-in OS abstraction layer so that they can run on different platforms. Figure 1 shows the architecture and the components that we will discuss below.

A. The Framework Scheduler

This component is responsible for submitting the appropriate controller for execution. It tracks time required for a controller to fulfill its request, time left in execution and which controllers are ready for execution on a core. This scheduler is in the framework and some of its capabilities can be controlled by the game developer. On a whole though, the Framework Scheduler is a support system that is invisible to the game developer and is initialized in the game loop as part of the system initialization phase.

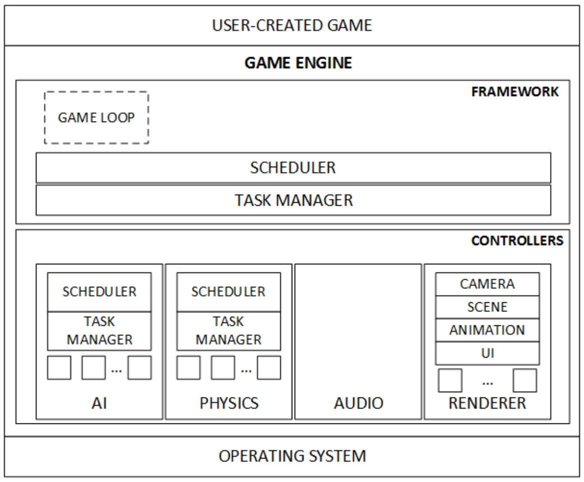

Fig. 1. Game Engine Architecture

B. *The Framework Task Manager*

The Framework Scheduler submits the controllers for execution using the Framework Task Manager. This component is responsible for running any subtasks required by the controller. The task manager balances processor loads and allocates any subtasks generated by the controllers to threads running on different cores.

C. *The Controllers*

Controllers are pluggable components that can run as single- or multi-core systems. The game engine itself is multi-core and can run the controllers concurrently using the Framework Task Manager. One key difference in our engine design is that the controllers themselves can be executed concurrently. The AI, Physics and Renderer controllers can execute their tasks in parallel beyond what is given to them by the Framework Task Manager. This additional level of concurrency makes it possible to scale to larger loads and handle the increased complexity that is part of running games with NPCs that possess richer human behavioral capabilities. The AI Controller in our design is itself a concurrent AI engine, which I will describe in the next section.

III. The Concurrent AI Engine

The AI controller, or concurrent AI engine, consists of three main components that interact with each other: Action Selection, Pathfinding and Navigation Mesh Generation.These are typical components of commercial AI middleware systems like Kynapse and Kythera. However, there are some key essential differences to how these components function, interact produce their output.

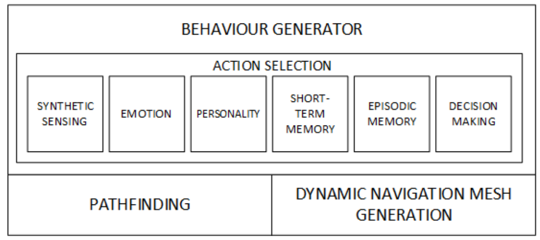

Fig. 2. The Behavior Generator Component of the AI Engine

A. *Component Execution*

Each component can operate on separate cores, sharing any information that is necessary to complete execution of their tasks through the Behaviour Generator, shown in Figure 2. Component execution is independent of the NPC for which an AI response is required. That is, the AI engine can fulfill requests for multiple NPCs simultaneously, and the output is collated by the Behaviour Generator to return to the Framework Task Manager. This is in contrast to other AI middleware where the AI behaviour is requested on a per NPC basis and all components being executed sequentially to generate the behaviour output.

B. *The Action Selection Component*

This component determines what action the NPC chooses to employ in response to particular stimuli it encounters in the game world. It has six subcomponents, each responsible for handling specific aspects of the NPC. Behaviour modeling in other AI middleware use trees or finite state machines as data structures. The data models used in this system are much more diverse - employing rich graphical structures to model emotion, personality and memory (both short and long-term). Additionally, the Action Selection Component, through the long-term memory subsystem is capable of learning behaviours that is transparent to the system and the designer. In fact, the game designer does not have to train the NPC to learn or remember aspects of the game world, the Action Selection component has that capability embedded and so learning itself becomes an emergent process.

C. *Pathfinding*

The AI engine has a separate pathfinding component that the NPCs use to move around in the game world. Even though the NPCs have richer senses than typical NPCs, it is more efficient to use established pathfinding and steering algorithms to move the NPC in the game world than have the NPC analyze its senses and then selecting each action it requires to make it move towards its destination. Of course given the features present in the Action Selection component it would be possible to create such a low-level pathfinding model; however, I will not focus on that aspect of pathfinding at this point in time.

Instead, I will integrate a new capability to the pathfinding and that is providing feedback to the NPC as it moves along its path to its desired destination. Current pathfinding systems treat NPCs as pawns. Even though the steering algorithms provide for realistic movement, an autonomous NPC is not possible using such methods because their movement is pre-determined by the designer. By integrating a feedback to the NPC as it moves along its path the NPC has the opportunity to "change its mind" about its destination and request a new destination. This would lead to more realistic behaviour that does not require scripting because situations like an NPC suddenly remembering it forgot to turn off a light, or pick up the laundry, can lead to unexpected and interesting behaviours and interactions.

D. Dynamic Navigation Mesh Generation

Another important feature of AI middleware is the ability to dynamically generate meshes (polygons) that can be used in pathfinding. The ability to do so on-the-fly for specific NPCs and at specific points as the game world changes is crucial to realistic gameplay. Mesh generation in the concurrent AI engine can be done either globally, for the game area being viewed by the player, or for NPCs and players at specific areas in the game that have changed. This flexibility is possible due to concurrency, since multiple meshes can be generated using multiple cores. Similar to the Pathfinding Component, Navigation Mesh Generation provides richer feedback to the NPC so that the NPC can do more than just simply adjust the path they are taking. NPCs for example could decide to turn back. Stop and look at the change, or even try to change the path back to what it was - depending on the NPC's "thoughts" based on what it senses.

IV. Conclusions and Future Work

I have presented the design for a concurrent AI engine that will be used within a fully concurrent game engine. The discussion has highlighted some key differences between existing AI middleware and the proposed concurrent AI engine. These differences will bring deeper realism to how NPCs behave in games and the engine will be capable of producing hundreds of NPCs that demonstrate rich behaviour because of its concurrent design.

The system will be implemented using existing open source systems such as Ogre for the rendering engine. Ogre has a multi-core version that uses two cores to perform rendering tasks. We will use that version in our system. We will transform a simple but feature complete physics engine into a concurrent version to include in the overall system to ensure any performance gains made will not be lost using sequential systems. Upon completion, the game engine will be tested using traditional steering/flocking scenarios as well as simple social interactions scenarios that are typical in serious games used for medical training.

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Home Telemonitoring for vital signs using IoT technology

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Abstract**—**Internet of things- IoT is a paradigm that represents the next step towards the digitization of society and economy, where objects and people are interconnected through communication networks in order to collect or transmit information about the objects of the environment in real time. The fields of application of IoT technology have significantly increased due to the benefits offered in terms of cost, time and accessibility to information. In the health field, IoT had contributed to improving living conditions of patients with chronic and non-communicable diseases. This facilities continuous follow-up of physiological statuses, reducing costs associated with medical attention and providing greater peace for the family members of the patient.

Although the devices IoT using used to monitor patients are powerful tools, these have problems with the use of resources such as bandwidth consumption, high energy consumption and low level of security of the information. For all the above reasons, the TIGUM group proposes a home telemonitoring system for vital signs based on IoT technology using MQTT protocol. The system is characterized for its ease of use and for an adequate response time for the exchange of data between "clients" and "broken". In addition, the system facilitates the analysis of data by a professional of the health from anywhere in the world thought of the internet. The results obtained for the researchers determine that IoT system could contribute to the improvement of healthcare services and the quality of life of patients with chronic and non-communicable diseases- NCDs, because the system sends in real time the medical parameters patient using a less bandwidth safely.

Keywords— *Internet of Things -IoT, Vital Signs,Home Telemonitoring, MQTT protocol.*

I. Introduction

The internet of things -IoT is a concept that has revolutionized the information and communication technologies. First, it became popular in 1999 at the Massachusetts Institute of Technology–MIT, in the projects that incorporated technologies of radio frequency identification–RFID and emerging technologies for wireless sensor networks [1]. But, only until 2009, the concept of the internet of things was officially implemented, a cause of massive growth in mobile devices in the market [2]. In 2011 did the number of interconnected devices on the planet exceed the number of people [4] and in 2015, the experts determined that there are 4.9 billion interconnected devices and is expected to reach 25 billion devices by 2019 [5].

Internet of Things Technologies has been characterized by their capacity to collect, process, analyze and store large or complex data in the cloud. It uses “smart tags” and emerging sensor applications, that they determine the status of the objects in the environment, with this technology user can manage different functions remotely [3]. The widespread deployment of smart objects in the market has caused great interest in the society over recent years, especially by the use of technology of Big Data and Cloud services for maximizing resources in different fields as transportation and logistics, healthcare, smart environment, personal and social. [6].

In the field of health, IoT has made possible the development of a huge number of applications to supply the necessities of the health system as limited resources, high costs and increase the chronic and non-communicable diseases- NCDs [7]. In 2014, The World Health Organization –WHO in her inform “Global status report on noncommunicable diseases 2014”determines that the NCDs produces 75% of deaths of people in low- and middle-income countries [8].The most common factors that lead to these types of deaths are the risk of exposure to harmful products, such as tobacco or unhealthy foods and the limited access to health services [9].Generally, the patients with NCDs have to wait several months for an follow-up appointment and they often suffer relapses of health.

Based on the public health problems and on the advantages of IoT technology, this document presents a system for monitoring and controlling vital signs, in real-time. It used the MQTT protocol for collect, process, analyze and store data in the cloud. The system allows to accessing from anywhere in the world. Also, the system guarantees protection and confidentiality to the patient's data during the transmission and storage process.

Specifically, in Section 2. We present the overall IoT vision in the health field, in Section 3. We describe the materials and methods employed in the system, in Section 4. We present the results obtained with the implementation of the system and the conclusions of the research suggestions given, in Section 5.

II. INTERNET OF THINGS IN HEALTHCARE

At the global level, the advantages of IoT technology have strengthened the development of a large number of health applications that they aim to improve the quality of the people's lives [10]. The most common applications used for tracking of objects and people, identification and authentication of people and automatic data collection and sensing.

- **Tracking of objects and people:** the function of tracking aimed at the identification of a person or object in motion [6].
- **Identification and authentication of people:** it includes patient identification to reduce incidents harmful such as, medication errors, procedural mistakes, and loss of time. Also, it enables to maintain the electronic medical record updated [6].
- **Automatic data collection and sensing:** Automatic data collection and transfer functions are mostly aimed at reducing form processing time, process automation, automated care, procedure auditing and medical inventory management. In the case of sensing, this function is centered on patients, and in particular on diagnosing patient conditions, providing real-time information on patient health indicators [6].

III. SYSTEM DESCRIPTION

Materials

The system for monitoring and controlling the vital sign in real-time has an architecture comprised of hardware and software. It facilitates to the acquisition, the transmission and the display of the date of patient's vital signs remotely.

The hardware integrates different sensors for measuring cardiac frequency, oxygen saturation, temperature and blood pressure, a single board computer (Rasberry pi3), a micro-controller un micro and e-Health Sensor Platform [11], all materials are presented in figure 1. In the case of the software, we used platforms and operating systems "open source" easy programming.

Fig 1. Materials and E-health sensor platform [13]

Method

The descriptive and experimental method used in this research has three phases: In the first phase, we will acquire the data of vital signs of 10 volunteers using the e-health sensors. In the second phase, the transmission process using MQTT protocol and Hub- IoT. Finally, in the last stage, the system controlled and showed the data, through an app mobile.

- **Phase 1: acquisition of vital signs**

The acquisition of vital signs is a process non-invasive, which uses special sensors located at patient's body, as shown in Figure 2. In in this research, we acquisition frequency heart with three electrodes connected to the e-Health platform. In the acquisition of temperature, we used a sensor located distal to the pinna, because of this location the temperatures are the most accurate. In the case of the pressure blood, we used a blood pressure monitor digital that records, stores and sends the data to the system, after a time certain.

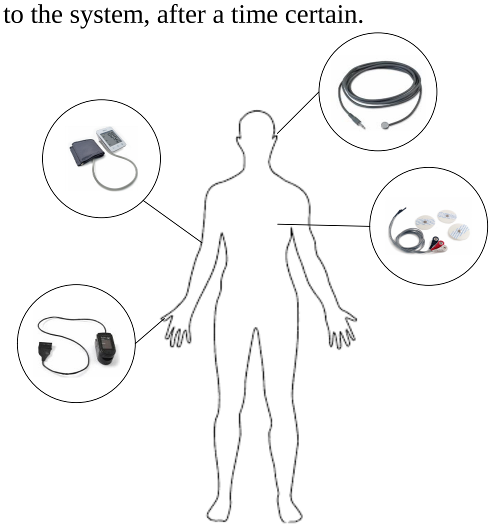

Fig. 2 Location of the measuring sensors.

- **Phase 2: Transmission and storage process**

The transmission process is performed through the Protocol message tail telemetry-MQTT, it allows exchange messages between small coatings with low-bandwidth. The MQTT protocol uses an architecture that it uses a node central or “broken”. It is responsible for managing the network and transmitting them messages to keep active the channel [12]. In this system the client sends packets periodically, waiting to receive a response from the broker. In the process storage is necessary to use a Hub-IoT, which establishes two-way communication, safe and reliable between the devices and the cloud. It is presented in figures 3. The transmission time on device IoT was obtained through of the mobile app and in the other technologies were measured with a stopwatch.

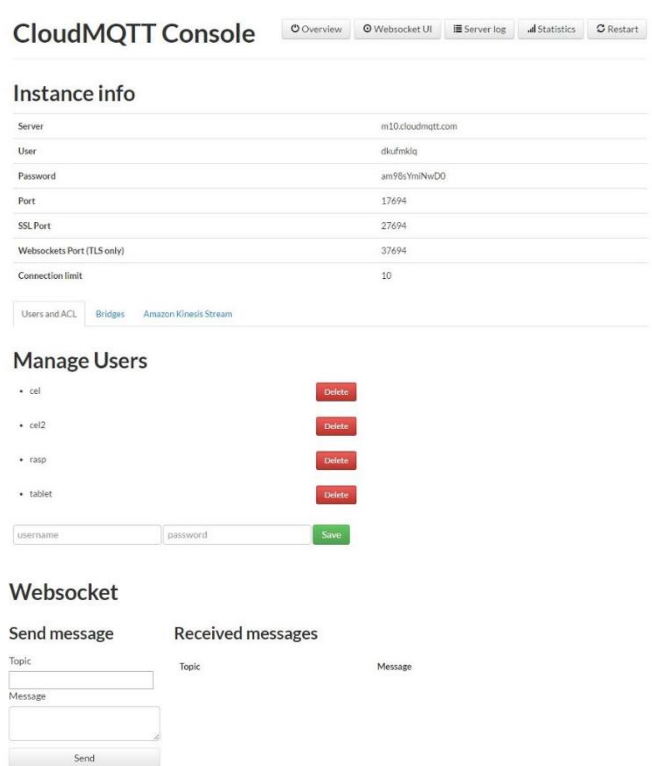

Fig 3. Hub-IoT

- **Phase 3: Display and control of data**

In the phase of display and control of data, we use the application MQTT Dashboard of the Google Play distribution platform. The mobile application was installed on a Smartphone and on a Tablet. The both two devices will communicate through of the "broken". They used topics to determine which subscribers should receive messages published. The topic is a UTF-8 string, which is used by the "broken" to filter messages for each connected client, and topics are treated as a hierarchy, using a slash (/) as a separator [13]. In the research, the tablet phone works as "subscribe", which receives the sent messages of subscribed customers and mobile phone as "publish", which sends the message to the broken, as presented in figures 4.

Fig 4. Publish message

IV. Experimental results

Vital signs reflect essential body functions of human body and establish the physiological state of fundamental organs, such as: the brain, the heart and the lungs. The limits of vital signs are: i. Temperature: 97.8°F to 99.1°F (36.5°C to 37.3°C)/average 98.6°F (37°C), ii. Heart frequency 80 to 140 beats per minute iii. Blood pressure 90/60 mm/Hg to 120/80 mm/Hg, iv percentage of saturation of oxygen, between 95% and a 100% The Normal vital signs change with age, sex, weight, physical capacity, and overall health [14].

The system developed in this research was tested with a sample of 10 voluntaries. Table I presents the characteristics of the sample.

Table I. Characteristics of the sample.

Characteristics of the sample.			
Gender	***Age***	***Wight***	***physical capacity***
5 women 5 Male	18 to 30 years	between 40 and 85 kilos	10% high 50% medium 40% low

Table II presents the results obtained in the phase 1.it determined that vital sign ranges of the volunteer are found among normal limits of adult.

The transmission and storage process, the IoT technology provides a greater efficiency in the transmission of data in comparison with the ZigBee system. The average transmission time for each one of the vital signs is presented in Table III.

Table II. Record vital sign data

Record vital sign data				
N°	***Heart rate (bpm)***	***%SPO2***	***body temperature (C°)***	***blood pressure (mmHg KPa)***
1	88	79	36.02	S: 108 D: 66
2	92	93	36.09	S: 106 D: 61
3	89	94	35.98	S: 109 D: 66
4	73	94	35.95	S: 107 D: 77
5	67	95	35.91	S: 130 D: 82
6	80	93	36.02	S: 132 D: 75
7	72	96	35.98	S: 138 D: 81
8	71	94	36.31	S: 119 D: 89
9	72	94	35,10	S: 109 D: 75
10	66	97	35.66	S: 129 D:86

*S: Systole, D: Diastolic.

CONCLUSION

IoT technology has provided efficient solutions for the management of public health by reducing cost, increasing the accessibility of medical information, ensuring the safety of the patient's information and optimizing time in medical appointments, through connections between different entities, such as patients, medical staff, and technologies platforms.

The results obtained in research highlight the benefits of using the Internet of things technology for monitoring and control of vital signs, such a faster response time in comparison with other technology with ZigBee and Bluetooth. Furthermore, the MQT protocol provides on the transport level can be ensured that the communication is encrypted and the identity is authenticated.

Table III. Average response time in the transmission process

Average Response Time by technology				
	Vital sign			
technology	*Heart rate*	*SPO2*	*Body temperature*	*Blood pressure*
IoT	26.3 sec	25.8 sec	24.9 sec	60 sec
ZigBee	256.0 sec	-	240.8 sec	234.4 sec
Bluetooth	76.1 sec	-	75.8 sec	73.05 sec

Initially, the tests of this study were made with healthy people because the resolution number 8430 of 1993 of the Ministry of health Colombian determines the use of the mechanism of “Informed consent" the research on patients with chronic and non-communicable diseases- NCDs and this mechanism in the moment of the research not be had.

The advantage of IoT is the efficient management of a large volume of data using Cloud Computing and the application of artificial intelligence techniques to characterize and create predictive standards, which allow for the system report in real time to health professionals unexpected changes in vital signs that they put patient health at risk. Another advantage of IoT is to provide a more “personalized” system based on the information supplied by users of the devices.

ACKNOWLEDGMENT

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Off-the-Shelf Room-Scale and Mobile Virtual Reality for Medical Training

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Abstract— Virtual reality is currently gaining a lot of attention as a result of the interest in offering more immersive and interactive affordable experiences in the entertainment industry, more specifically in filming and videogames. Early virtual reality equipment was bulky and expensive limiting its use to few companies and institutions that could afford them to conduct research, and innovation. Virtual Reality research on medical training has seen the development of numerous simulators integrating physical and virtual features. However, there are limitations in term of availability for practices, costs, maintenance, readiness and infrastructure. In this work we discuss current off-the-shelf virtual reality hardware and software that help address some of the limitations previously described.

Keywords—serious games; medical training; virtual reality.

I. Introduction

Medical training offers a wide range of challenges due to the various skills required amongst different procedures. Virtual Reality (VR) provides means to recreate through visualizations or simulations, multiple training scenarios otherwise impossible in the education environment. However, visual feedback has its own limitations due to how the interactions take place. VR environments coupled with mouse, keyboard and touch-based interfaces are more focused on cognitive tasks, while using the VR component to enhance, engage and catch the trainee's attention. When coupled with haptic interfaces, the VR environments can focus on cognitive, dexterous and spatial skills, providing a more real experience.

Traditionally, VR components (e.g., headsets, CAVE-like immersion, user interfaces, motion tracking, sound, and haptics), have been characterized for their size and infrastructure requirements to provide the best interactions. Current advances in hardware and software have provided tools that are resulting in affordable off-the-shelf VR devices that are bridging the gap between high-end VR and low-medium-end VR, opening the path for research on the effects and opportunities that such technological shift presents.

II. Current Focus

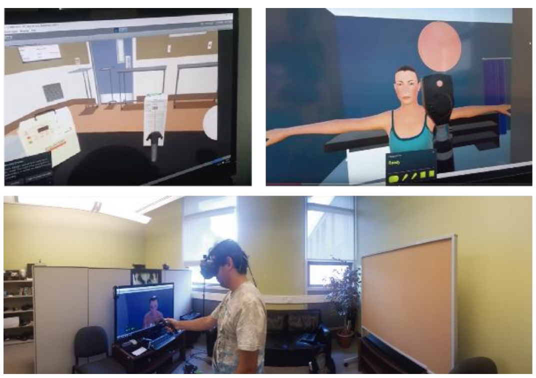
Building upon our prior work, we are investigating the effects of using VR with different levels of immersion, from 2D, to 3D, and, Stereoscopic 3D, using mobile phones and gaming VR headsets [1][2]. Currently, affordable VR viewers range from $15 USD[1] (requiring the user to hold them in front of their eyes while interacting with the virtual content through the inertial sensors, ray casting triggers, and one NFC button), to $50€[2] and up, with strapping, buttons, lens adjustment, and an enclosure to provide better immersion[3]. In terms of medical training, smartphone's VR headsets may be suitable for stereoscopic 3D content, but user interactions require external devices (i.e., wireless controllers) that may compromise portability, and more importantly may not represent realistically the interactions during a medical procedure.

The next category in off-the-shelf VR headsets is comprised of computer-based devices that offer additional features, such as motion tracking (ranges

[1] Google Cardboard, viewers, https://vr.google.com/cardboard/get-cardboard/
[2] Durovis Dive, https://www.durovis.com/dive.html
[3] Samsung Gear VR, http://www.samsung.com/global/galaxy/gear-vr/

and degrees of freedom depending on the device), controllers (wireless gamepad or independent controllers for both), and audio (built-in or available stereo jack). The two most common computer-based VR headsets are the Oculus[4] and the HTC Vive[5]. We focus on the Vive, since it allows room-scale interactions where the user can move around, gathering information from the head and the two hands (current version of the Oculus only tracks the headset depth).

Currently, we are exploring the use of computer-based VR headsets in a cardiac auscultation scenario [3], an eye examination scenario [4], and an epidural operating room scenario as presented in Fig. 1. We have finished the alpha developing process and we are moving towards experimentation to study and analyze the results on medical students. We expect to obtain a greater understanding of the effects of VR and its potential in medical training.



. **Fig. 1.** Vive setup with the cardiac auscultation, eye examination and OR scenarios

ACKNOWLEDGEMENTS

The financial support of the *Natural Sciences and Engineering Research Council of Canada* (NSERC), *Social Sciences and Humanities Research Council of Canada* (SSHRC) is gratefully acknowledged. Medical support from Fuad Moussa, Adam Dubrowski, Norman Jaimes, and Fahad Alam is gratefully acknowledged.

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Rational Game Design

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***Abstract*—This presentation covers a brief overview of a popular design approach used in the games industry known as Rational Game Design (RGD). The purpose of the presentation is to provide initial insight into RGD concepts such as objectives, atomic design, flow, accessibility and variety. These concepts pave the foundational knowledge required to utilize design activities like variety and skills versus inputs matrices. The activities will be performed in the second half of the workshop. The activities are effective for visualizing design and brainstorming interesting gameplay sequences.**

Keywords—rational game design; game mechanics;

I. Introduction

Rational Game Design (RGD) is a design approach that was conceived by Lionel Raynaud (Ubisoft worldwide content director) and Eric Couzian (Ubisoft game design conception director), and led by Olivier Palmieri (level design director on Rayman Origins). The approach was used when developing Rayman Origins and is focused on developing deep game mechanics which are well explored and well exploited. Key aspects of RGD are to eliminate unnecessary information, make things inherently readable, introduce mechanics in an orderly and easily digestible fashion and, preserve learning and difficulty curves.

II. Agenda

The presentation breakdown is as follows:

- Rational Game Design
  - Objectives
  - Atomic Design
  - Flow
  - Accessibility
  - Variety
- Exercises
  - Pillars
  - Skills vs. Inputs Matrix
  - Variety Matrix

III. Objectives

Objectives are important to be clearly defined and to provide the player with a sense of purpose in the world they are traversing. The presentation will cover several objective statements to define what the purpose of the player is, in the interactive experience.

IV. Atomic Design

Atomic design is also known as low level game design wherein the designer examines the small influential factors and finds clear ways to harness their power in the pursuit of creating a learnable, balanced, fun and exciting experience.

Game mechanics in the context of atomic design are a challenge based on a specific input and skill. The presentation describes a variety of physical, social and mental skills that designers often associate with mechanics for games. The presentation continues to describe the purpose of game inputs in correlation with mechanics to provide the foundational knowledge to introduce the skills versus inputs matrix.

The skills versus inputs matrix is a tool to compare the desired mechanic with the correlated input to define specific complexities. See Figure 1 for an example of the matrix.

Figure 1 – Skills vs. Inputs Matrix

V. Flow, Acessibility and Variety

The concepts of flow, accessibility and variety will be briefly covered in the interest of staying under time. The concept of flow state is covered in many other design methods as well as accessibility. The variety matrix will be shown as a tool to generate various gameplay situations.

DEMOS

VR Hand Tracking in Occupational Health Care

DEMO

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***Abstract*—Continuous, uncontrolled and misuse of various forms of information and communications technologies (such as physical or virtual keyboards), increase the risk of developing some form of musculoskeletal disorders. Amongst the many types of injury, those related to hand are the most common and painful affecting the daily interactions of person with its environment. This demo presents a virtual reality prototype based on hand motion capture for occupational health exercises that complements current forms of exercising.**

Keywords— Active pause, musculoskeletal, virtual reality

I. INTRODUCTION

Currently, misuse or excessive use of the information and communications technologies (ICTs) [1], has resulted in users engaging in repetitive or forceful movements with static postures sustained for longs periods of time, such as keyboard typing. These has resulted in musculoskeletal disorders leading to occupational health problems [2]. Musculoskeletal disorders can lead to work disability, decreased quality of life, limited movement, physiotherapy [3] Strategies to minimize the risk of developing musculoskeletal disorders include guides in various media with lower rates of engagement [4][5][6], and more recently the use of motion capture technology and games [7].

II. RESULTS

The VR game records flexion, extension, abduction, adduction and apprehension hand-based movements that were mapped in each of the interacting characters of the games. Due to the sensor's characteristics, the ranges of motion were limited using the average movement of a regular person. The final game was presented to a group of fifteen people to get feedback on the game. The participants were asked to complete the game reaching the goal. Preliminary results indicate that users found the game useful, the interactive design used allowed the development of a solution that has the potential to attract the attention of a wide range of users to perform hand occupational health exercises. Participants also believed that the hardware was affordable and suitable for other applications. The games are presented in Figure 1 to Figure 3.

ACKNOWLEDGMENT

The authors acknowledge the support of Mil. Nueva Granada's Virtual Reality Center.

Fig. 1. Game 1 ingame screen shot.

Fig. 2. Game 2 ingame screen shot.

Fig. 3. Game 3 ingame screen shot.

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External Automatic Defibrillator App

DEMO

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***Abstract*—Cardio-vascular diseases are the main cause of death worldwide according to the World Health Organization. Heart attacks can happen at any moment and are characterized by acute chest pain and difficulty to breath. First responders witnessing such scenario must respond with cardio-respiratory resuscitation (CPR) or using external defibrillators while emergency services arrive. However, unfamiliarity with cardiac arrest first aid help may limit bystanders prompt engagement in helping someone in cardiac distress. To help the general public engage in such activities, we have developed a mobile serious game to convey the basics of CPR and defibrillator use.**

Keywords—CPR; DEA; Serious Game

I. INTRODUCTION

Cardio-vascular diseases are amongst the main causes of death worldwide according to the World Health Organization [1]. Promptly response to a cardiac arrest situation may make the difference between life and death. Currently, external automatic defibrillators (AED) can be found in multiple locations with high concentration of people to provide first responders with a tool to help someone in cardiac distress. AEDs are easy and safe to use as they provide clear operational instructions and conduct an analysis to ensure the electric charge can be applied to person in distress [2]. However, there is a lack of confidence in bystanders without previous training with AEDs that may prevent them to use it in an emergency situation.

To boost bystanders ‘confidence, training courses can be found along with printed and multimedia guides explaining the steps of CPR and how to use AEDs. Training curses use manikins and dummy AEDs to provide hands-on practice and help built confidence. However, training equipment presents limitations due to affordability, maintenance and proper care [3]. A complementary solution is found in digital media, where animations, videos, websites, and virtual reality can provide engaging contents to understand the process. Recently, serious games have gained attention and have been acknowledged as suitable learning tools in cognitive and tasks practices given their inherent positive effects during the learning process [4].

Our aim with this demo is present a serious game approach to provide the general public with a practicing tool for CPR and EAD with random scenarios and outcomes depending on the decision making accomplished during the game.

II. RESULTS

Serious game with touch-based interactions and movement-based CPR to increase realism and engagement during the cardiac arrest situation [5]. Fig. 1 presents a screen capture of the serious game patient ready for defibrillation, and the CPR compressions by touch and hand movements.

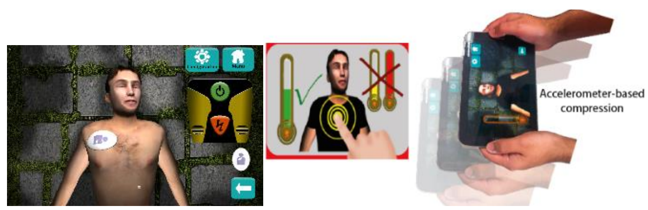

Fig. 1. Virtual patient being prepared for defibrilation and CPR compressions.

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We thank the support of Mil. Nueva Granada University on grant INO1641, its Virtual Reality Center and Medical Simulation Laboratory.

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Convulsive Treatment App

DEMO

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***Abstract*—The use of manikin simulation has provided a sandbox for medical hands-on practice in safe, controlled and pedagogic environments where students can engage in cases otherwise impossible in real life. Although the realism and functionalities are not completely replicated, manikins are currently the preferred tool for cognitive and skill development training. However, manikin requirements involve high expenses in terms of acquisition costs, infrastructure, maintenance and training, which can result in their limited use. Similarly, computer-based simulation suffers similar challenges, and most recently an integration between the two is providing tools where tablets and smartphones are becoming part of the training. The current growth on virtual reality is resulting in several research and developments on virtual patients. Our work focuses on a virtual patient for training convulsive treatment, a common scenario found in emergency rooms that require agile treatment involving diagnosis and drug administration to avoid health complications and risks.**

Keywords—Convulsive Treatment; Virtual reality; Virtual Patient;

I. INTRODUCTION

Medical simulation has positioned as an important training tool and has become the standard to gain experience in many medical fields. Through the evolution in medical simulation, the use of simulation has proven relevant in help students train cognitive, tasks and decision making in numerous scenarios [1]. Although physical and virtual simulators present limitations regarding access, features, feedback, multimodality, and fidelity, they can complement each other to overcome some drawbacks and respond to current trends [2].

Our demo focuses on convulsive treatment, a scenario where manikins lack the visual realism (due to their level of fidelity that doesn't allow to reproduce spasms, convulsive face expressions and other symptoms), and depending on the model, the features to administer medication to the patient. Our demo presents a serious game mobile app that allows a medical student to treat a patient suffering a convulsion. First it will examine, then diagnose, and finally, supply medicaments. The app presents random scenarios and depending on the decision making during the case, the patient can be saved or it can die.

II. RESULTS

Our solution presents the user with the option to examine the patient through inspection of the face, eyes, vital signs check and review of clinic chart to decide the best treatment. The purpose of our app is to serve as a complementary tool to medical training [3]. Fig. 1 presents the main view of the app and the vital signs windows. Fig. 2 presents the drug administration dosage.

Fig.1. Patient view and vital signs

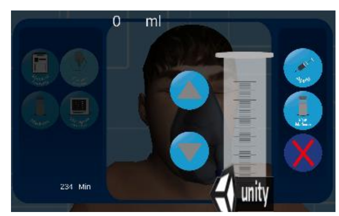

Fig.2. Drug administration and dosage

ACKNOWLEDGMENT

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Human Eye Pathologies with Haptics

DEMO

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***Abstract*—New multimedia apps are providing more immersive and interactive scenarios that provide suitable tools to complement medical teaching. Virtual reality allows users to explore 3D computer environments while getting information about its contents. Multimodality plays an important role in medical training as visual, audio and haptics can help better convey information regarding a medical procedure. The goal of this project is to develop an eye anatomy tool that allows students to interact through haptics with eye pathologies in order to provide a touch feedback on the physical changes undergoing on a diseased eye that videos, images, photos or 3D animation can't convey.**

Keywords—Multimedia, Eye, Pathologies, Haptic, Anatomy

I. INTRODUCTION

Since the first surgery simulator created by Satava in 1991[1], Virtual Reality (VR) and haptics have impacted medical training. Eye examination and surgery has also been a topic of study, currently there are various simulation systems such as Eyesi [3] to simulate cataract surgery, and Simquest to practice open incision surgery [4]. Eye anatomy learning present challenges due to its physiology, given that it is a volumetric body that it is studied in two dimension through pictures, illustrations, 3D models, and the ophthalmoscope. However, the mediums provide flat images that do not allow its proper exploration and visualization of 3D physiological features [5].

In this demo we explored how haptics can provide a sense of how the changes through various conditions. We used haptics and deformable models to achieve such effect, and the haptic feedback was tuned based on an expert feedback.

II. RESULTS

The system was developed using three different eye conditions, a healthy eye, an eye with cataracts, and an eye with glaucoma as presented in Fig. 1 [5]. The healthy eye model and haptics interactions were configured using rigid body simulation between the eye layers (i.e., the fibrous tunic, the vascular tunic and the nervous tunic). For the eye with cataracts and glaucoma, we used a soft body simulation where the mesh collision transformed the 3D objects. We used Chai3D for the development as it provided and appropriate simulation between the eye parts. To test the haptic feedback, we used the Novint Falcon[6] and the Phantom Omni[7] devices and conducted a demo with medical students to gather their views regarding the use of haptics to study the eye anatomy.

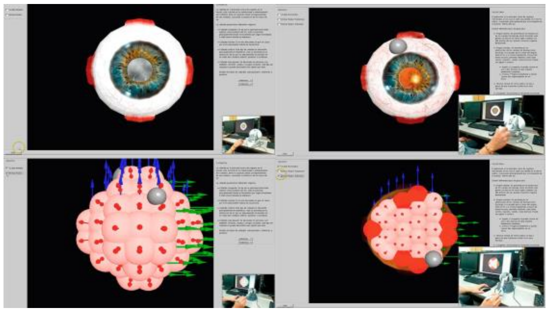

Fig. 1. Cataract and glaucoma 3D haptics model and results applied to the ear auricle**.**

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Stereoscopic 3D Augmented Reality Exploration of the Eye

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***Abstract*—Eye examination is medical procedure conducted to diagnose diabetic retinopathy, retinal detachment, and macular degeneration amongst many others. To master the examination, the medical trainee requires extensive practice to properly interpret the images seen through the ophthalmoscope. Currently, training is conducted with live or simulated practices using manikins, supported with images, pictures, animations, mock-ups and virtual models of the eye. However, eye examination uses bi-dimensional images based on pictures that do not account for the eye's physiology. In our demo, we present a stereoscopic 3D approach to render the eye using augmented reality to provide trainees with an stereo vision of the eye. The ultimate purpose is to allow trainees to better observe physical changes within eye.**

Keywords—Augmented reality, eye examination, virtual reality;

I. INTRODUCTION

Eye examination is an important medical skill that can allow detecting health risks by looking at the fundus of the eye [1]. Current training tools use pictures, illustrations, mock-ups, multimedia, cadaver and manikin simulators to provide practicing scenarios to the medical student. However, all the training is conducted on bi-dimensional images which increases the difficulty of interpreting the physical changes that occur in the on certain health conditions. To overcome the limitation of bi-dimensional visual feedback, we aim to take advantage augmented reality (AR) as a tool that enhances the real world with computer generate information [2]. To visualize the 3D eye, we use a 3D marker to obtain a suitable amount of tracking points for the smartphone's camera to track. We used Vuforia[8] in conjunction to Unity3D[9]. the stereoscopic rendering was implemented as a tool to provide immersion and depth perception while navigating the eye.

II. RESULTS

Similar to real examination, our AR app requires the student to hold an ophthalmoscope and approach in a 45º angle until the fundus becomes clearly visible. Once visible the eye can be observed in stereoscopic 3D. Interactions were programmed in two manners, one using a Bluetooth videogame controller and another using a five degrees of freedom haptic device [3][4]. The use of haptic device required a computer to host the device, to accomplish this, a server was configured to synchronize the AR camera with the movements of the haptic stylus representing the ophthalmoscope. Fig. 1 presents the 3D AR eye and the 3D marker. Fig. 2 presents the haptic device[10] navigation and the stereoscopic 3D visualization obtained from the screen.

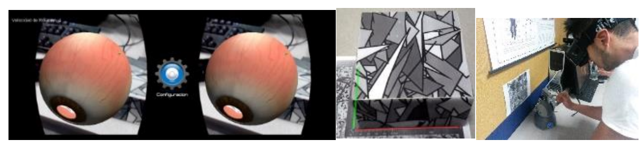

Fig. 1. 3D AR eye, 3D marker, and Haptic device navigation

ACKNOWLEDGMENT

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Lower Member Exergame Using KinectV1

DEMO

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***Abstract*—Healthcare has become one of the main focuses in modern lifestyle in developed countries, fighting against obesity and degenerative diseases are getting harder with the fast paced rhythm of people's daily activities. Currently, there has been an increased interest in games for health using numerous devices (e.g., wearables, smartphones, video game input devices), that can provide information about the user's performance. This trend is impacting how exercise is practiced at various levels (e.g., fitness, leisure, physiotherapy), and it is providing new opportunities to monitor and follow up the exercising process. In this demo, we present a lower-limb exergame using Microsoft's KinectV1 to show how a simple activity can provide engagement and data tracking for further assessments on the exercising session.**

Keywords—3DUI, Exergame, Therapy.

I. INTRODUCTION

Engaging and immersive technologies such as Virtual Reality (VR) have taken an important role in healthcare and physiotherapy by providing engaging, motivating and compelling experiences that allow the healthcare provider to gather data to better assess the patient's progress and fine tune the physical activities accordingly [1].

VR application in medical healthcare have been mainly focused on specific conditions such as patients with stroke [2], but as the technology has evolved, the spectrum of applications has expanded to offer complementary treatment to various conditions (e.g., phobias, pain reduction, exercise, physiotherapy). There are many challenges surrounding the proper execution and follow-up of an exercising session; when the exercise is supervised, the supervision is subjective limited to observation and patient feedback; when the exercise is unsupervised and performed under the patient's responsibility there are more possibilities that the exercise routine won't be follow up because of pain, lack of understanding of the exercises, lack of motivation, lack of time, and lack of interest amongst others [2].

Our approach uses the Kinect[11], a videogame user interface that was very popular given its non-invasive motion capture futures. The goal of the demo is to take advantage of the Kinect to let the user engage into lower-limb exercises that are recorded to provide quantifiable information to the health care provider. Similar videogames in this area offered only interactions without any tracking focusing only on the entertainment and fun side of the interactions.

II. RESULTS

The game was designed as football soccer game where the objective is scoring a certain number of goals in each level. The game uses the flexion and extension lower-limb movements to calculate the direction and velocity of the ball upon collision. The user gets visual and audio feedback resembling a soccer field scenario. A lower-limb plot shows the ranges of movement so the user can adjust to the limits to better practice the movements. A screen capture of the game is presented in Fig. 1 [3].

Fig.1. Penalty lower-limb scenario

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Rotator Cuff and Elbow Exergames

DEMO

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***Abstract*—Upper-limb care is relevant to avoid suffering from musculoskeletal disorders caused by work activities or sedentarism. Proper exercising accounts for minimizing such risks, but are challenging due to the inherent characteristics of physical activity, it can be found repetitive and monotonous, that in conjunction with unclear tasks, pain or perception of lack of time, can result in ineffective exercising sessions. In this demo we present a rotator cuff and elbow exergames to address the monotonous aspect of exercising while tracking data for further healthcare assessment on behalf of a specialist.**

Keywords—Exergame; Elbow; Rotator Cuff; Motion Capture

I. INTRODUCTION

Upper-limb musculoskeletal disorders are rising among the global population caused by occupational work habits, such as stress, repetitive movements, excessive forces, sedentary and sports practices [1]. Exergames can provide tools that allow the user to perform physical activities within a controlled environment where rewards, feedback and clear goals can result in engagement to achieve the exercising goals [2].

In this demo, we present an upper limb exergame focused on the shoulder and the elbow active pauses, where rotation, flexion and extension movements are important to keep the rotator cuff in good health.

II. RESULTS

Two exergames for shoulder and elbow were developed to help a user engage into upper-limb exercising. Each exergame depicts a scenario inspired in real life activities that requires the rotator cuff's rotation and the elbow's flexion and extension. The games measure the ranges of motion and save the data for further analysis and assessment. The game mechanics use checkpoints and time-based tasks to encourage the user to reach the goal. For the development we used Unity3D[12] and Microsoft's KinectV1 SDK[13], that in conjunction with the exercises analyzed with medical experts, provided the ground for the development. Fig. 1 presents a screen capture of both games [3].

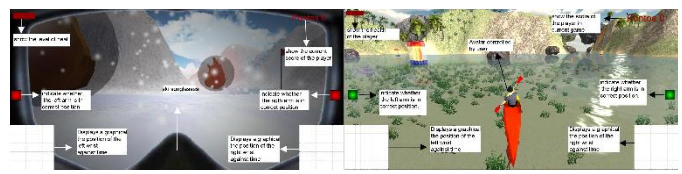

Fig.1. Skiing elbow exergame and kayaking rotator cuff exergame

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The authors wish to thank the Mil. University Nueva Granada for their support on project ING-1545. Also thanks to the Virtual Reality Center along with Dr. Bibiana Moncayo and Dr. Claudia Robayo.

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Jugular Neonate Central Venous Access Haptics-Based Training Tool

DEMO

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***Abstract*—Medical simulators are currently being used as training tools to help trainees to develop and fine tune medical skills amongst various procedures. Simulator features vary depending on the complexity of the task, for the central venous access, most solutions focus on adult training so when the physician faces a neonatal scenario, a transfer of knowledge occurs to adapt the training to the challenges of the newborn's anatomy. This procedure is the principal focus of this demo due to its relevance for administering medication and nutrients directly into the circulatory system. In this demo, we present the developed prototype of virtual simulator of jugular central venous access based on a haptic virtual reality system with hand motion capture, to interact with a virtual newborn.**

Keywords—Central Venous Access; Haptics; Head Mounted Display; Neonate; Simulator; Tracking; Virtual Reality

I. INTRODUCTION

The use of simulation to support training and skill development in medical scenarios providing safe, controlled and monitored experiences. Several types of simulators can be found on both research and commercial solutions targeting an ample range of medical procedures [1].

The central venous access (CVA) is an invasive medical procedure that demands great knowledge and skills during its execution to keep out of risk the patient [2]. Available CVA simulators in the market are focus on adult training, but few are focus on newborns with limited procedures only offering the umbilical venous access, and not providing support for the jugular, femoral or subclavian venous access, which depending on the case may suite better the patient's needs [3]. The unavailability of neonatal CVA simulators requires that physicians adapt their knowledge and skills from the adult process to the newborn [2]. Provided the scarce solution on neonatal CVA, we focus our demo on the jugular access by providing a training scenario to familiarize with the required elements and the execution of the needle insertion with haptics.

II. RESULTS

In the VR application [4], we recreated an operation room with Unity 3D[14] using 3D models for representing the required surgical tools. The virtual system has three modules, a practice module, where the user can manipulate all the tools with his/her hands using the Leap Motion[15] tracking system, an evaluation module, presented in Fig.1, where the user performs the CVA procedure, carrying out the patient asepsis, the needle insertion with the Phantom Omni[16] haptics device, and the catheter placement, and finally an information module.

Fig.1. Evaluation Module

ACKNOWLEDGMENT

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Design and Implementation of an Improved Methodology for Characterizing Anthropometric Profile Using Kinect Sensor

DEMO

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***Abstract*—In everyday life human being uses accessories that maintain a relationship with their characteristics and physical dimensions, such as chairs, places and workplaces. From this it is identified that population's comfort and well-being can be influenced by the degree to which such accessories engage people. For the development of these tools, it is important to have anthropometric profiles established by statistical analysis of previously acquired measurements. Anthropometry is known as the science that studies the human body dimensions; including linear dimensions, weight, volume and types of movement, involving the use of body reference marks, carefully defined, the specific positioning of subjects for data collection, use of appropriate instruments and their respective statistical treatment.**

Being this project a continuation of "Development of an application of anthropometric measurement based on Kinect", aims to modify the methodology through the implementation of an update of variables in use (measures), with which is adjust the characterization of the anthropometric profile of a precise and convergent shape to its applicability in the ergonomic design of workplaces, taking into account the differentiation between genres and the use of Kinect sensor as a way for measuring, structuring and virtualize anthropometric profile.

***Keywords*—Anthropometric profile, Kinect, Virtualization, anthropometry, ergonomic design.**

I. INTRODUCTION

Anthropometry is known as the science that studies the human body dimensions, these measurements are acquire using special devices and techniques whose results are analyzed through statistics. Anthropometry plays an important role within the industrial design process in areas such as clothing, ergonomics, and biomechanics, where statistical data about body medians allow optimizing product design [1]. During the last decade the field of anthropometry has witnessed a remarkable change due to the introduction of 3D scanning technology to measure the body shape rather than using traditional tools such as calipers and measuring tapes to generate 1D measurement such as distances and circumferences [2]. The device selected for the development of this research was Kinect sensor, that incorporates several advanced sensing hardware. Most notably, it contains a depth sensor, a color camera, and a four-microphone array that provide full-body 3D motion capture, facial recognition, and voice recognition capabilities [3].

II. RESULTS

It was developed a virtual reality application of anthropometric data acquisition that works in conjunction with a Kinect sensor whose primary focus is rapid and inexpensive making of anthropometric bases that can be used in the field of ergonomic workplaces design. Such application has the following structure:

A. Subject recognition and virtualization: Using the Kinetc's RGB camera and depth sensor for parameterization and acquisition of anthropometric measurements (height, wingspan, vertical reach, shoulder height, elbows height, width of shoulders, functional scope, iliac crest height, knee height, length and distance between elbows forearm).

B. Data structuring: Data collected are processed in plain-text files that enable subsequent statistical analysis in Excel.

C. Results: After statistical analysis an anthropometric table is generated, that contains measures of central tendency (mean, mode and median), measures of position (percentiles 5 and 95) and a measure of dispersion (standard deviation), to simplify the percentage of people to be considered for the design of ergonomic workplaces. Additionally, there is the calculation of Body Mass Index (BMI).

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RetailVR (Characterization of Anthropometric and Ergonomic profile in a Retail operation through Kinect Sensor)

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Abstract— ***The constant over time and especially the population growth has made emerging markets, have to make major changes to facilitate their adaption to globalization markets in the retail sector. For this reason the technology comes into play as an appropriate means for the emergence of this type of retail markets; considering the user as an important part of the process of continuous improvement, both on the trade done as well as the use of technological tools that allow user convenience against ergonomic positions that should have when being in front of rack with products associated with your preferences and also improving the acquisition of products for Latin American market anthropometric measures. In this paper, a software is developed with the Kinect Sensor technology as a low-cost tool for identifying anthropometric measurements of user to build profile in their own retail operations.***

Keywords—Retail; Anthropometry; Kinect; Technology; Ergonomics.

I. INTRODUCTION

The constant use of new technological tools has made certain emerging markets go afloat with certain types of operational or metric improvements for different transactions wither in the supply chain retail, store format, the Brand product assortment in rack [1]. Especially this last is of high relevance for this project because both the pump rack in the store and for the user, it is difficult at times access to product that are on sale. In the absence of rack and stands fit the anthropometric an ergonomic measures of the Latin America Population, there is always the problem of access to the products displayed on shelves.

II. RESULTS

This software is developed to characterize the anthropometric measures and ergonomic evaluation to the customers in retail operations sector. The proposed system is composed of three subsystems differentiated in their functions but connected through the data communication. i) Recognition ii) Storage iii) Validation. These data make a direct link from the customer positions obtained by the device Kinect©, the storage through tables created in Microsoft Excel and converting them in the result. Finally, the Interaction with the software is given by a graphical interface that connects the button actions and taking information by Kinect device.

Through the device Kinect © user recognition is developed by the RGB camera to identify the work space in which it is located, as well as get a clear picture of the user by means of image capture. In addition, the Depth camera which provides the position and distance from the user by the sensor [2]. Different measurements are obtained from the user positioning in front of the sensor, considering its image depth and superimposing the different parts of the body (inferred) are virtualized and assigned a joint to each body part (hypothesized joint), so though Euclidean distance formula [3] remote customer anthropometric measurements are obtained, as presented in Fig. 1.

Fig. 1. Anthropometrics measurement capture.

The data storage is achieved through interaction with Microsoft Excel, which allows us to form tables with data obtained in the process of capturing information from the sensor. Each time the "Data" button is pressed, we take real-time measurements of each user.

The results window shows the comparison between the data obtained and currently used data to characterize the size of the current rack. In addition, it gives us the possibility to check the last user that was measured with the device to compare different measures and people who have been evaluated. Finally using data tables and images obtained to define a characteristic profile of our population type.

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