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## Anexos

# DHM and serious games: a case-study oil and gas laboratories

Santos, V<sup>a,\*</sup>, Zamberlan, M<sup>b</sup>, Streit, P<sup>b</sup>, Oliveira, J<sup>b</sup>, Guimarães, C<sup>b</sup>, Pastura, F<sup>b</sup> and Cid, G<sup>b</sup>

<sup>a</sup>*Pontifícia Universidade Católica do Rio de Janeiro - PUC-Rio. Rua Marquês de São Vicente, 225, Gávea, Rio de Janeiro, RJ - Brasil - 22451-900*

<sup>b</sup>*Instituto Nacional de Tecnologia, INT. Avenida Venezuela, 82, Rio de Janeiro, RJ. Brasil - 20081-312*

**Abstract.** The aim in this paper is to present a research on the application of serious games for the design of laboratories in the oil and gas industries. The focus is in human virtual representation acquired from 3D scanning, human interaction, workspace layout and equipment designed considering ergonomics standards. The laboratory studies were simulated in Unity3D platform, which allows the users to control the DHM<sup>1</sup> on the dynamic virtual scenario, in order to simulate work activities. This methodology can change the design process by improving the level of interaction between final users, managers and human factor teams. That helps to better visualize future work settings and improve the level of participation between all stakeholders..

**Keywords:** digital human model, simulation, virtual environment

## 1. Introduction

The research in serious games has been a focus issue for Government and corporate organizations, applied on training, simulation and education. There is a clear need for considering new frameworks, theories, methods and design strategies for making serious game applications and virtual world technologies more effective and useful as part of education, health and training. Virtual simulation has been used in Ergonomics for the design of control centers, transport design and product evaluation. (SANTOS, V., et al. 2009, SANTOS, V. et al. 2008, GUIMARÃES, C. P. et al. 2010).

This paper presents a project in which virtual reality and game engines are used to improve the workflow and interaction between teams in the design process of a series of oil and gas laboratories. This interactive environments provides the possibility of realistic scenario based drills among the use of DHM built from 3D anthropometric data and MOCAP, aiming to evaluate layout proposals,

training new personnel based on the simulation of activities performed by the workers themselves .

The project is based in the research center of one of the biggest oil company in the world. In the stages of the project were considered: (1) gathering of laboratories and personnel data among its diagnosis based on ergonomic analysis, which provides the multidisciplinary team with data and knowledge on the procedures, in order to build new work environment layouts, (2) 3D scanning of the workers in several postures aiming the design of workstations, proposals of new working conditions and the development of their DHM for the virtual interactive environment and (3) MOCAP of the same workers performing daily activities in order to have their DHM with life like movements in the environment.

## 2. Materials and methods

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\* Venétia Santos. E-mail: ergon@ergonprojetos.com.br.

The development of the simulators were segmented in a couple of stages: (1) building the 3D environment based on 2D CAD representation of the new proposal, (2) creation a furniture and workstations database with ergonomic recommendations and the application of both, Brazilian and International standards, (3) creation of an equipment database, which are based on real equipments located in the laboratories - dimensions, utilities, textures, etc., (4) development of the DHM with 3D scanning and MOCAP technologies and (5) implementation in the game engine with scripts and other setups.

Each 2D CAD proposal is transformed into 3D models (Figure 1), where later in Unity3D are applied interactive elements such as doors, drawers and windows, external scenarios, materials and textures, character controllers' built in options, and others, so that the environment is as realistic as possible. (Figure 2).



Fig. 1. 3D model based on 2D CAD floorplan

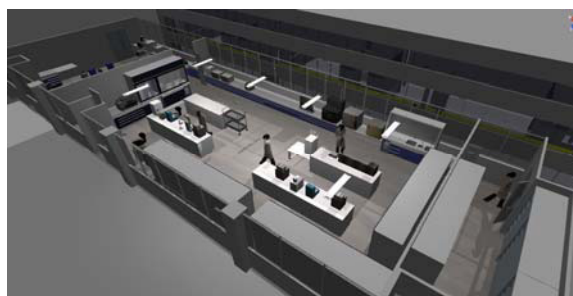


Fig. 2. 3D environment in Unity3D

Furniture and workstations present in the virtual laboratory are reproduced based on ergonomics recommendations and standards, modeled in

SketchUp software and implemented in a database among 3D equipment and other instruments (Figure 3). The 3D database allows direct exporting to the game platform in \*.FBX format. The software also allows the segmentation of interactive components in groups, which in Unity3D can be easily set up by its hierarchy characteristic. It also exports their textures in \*.JPEG, which are reproduced using their own pictures as textures (Figure 4), providing clearer understanding and faster recognition of each equipment by their respective users.

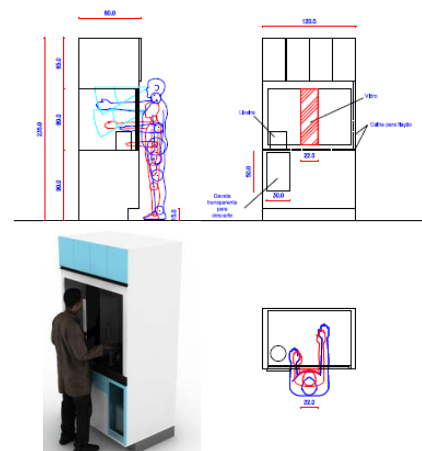


Fig. 3. Furniture recommendations



Fig. 4. Laboratory's equipment 3D database.

DHM used in the simulation have been obtained starting from high resolution DHM (more than one million vertex) obtained by 3D scanning of employees using "Cyberware Whole Body Color 3D Scanner" and "Cyberware Head and Face Color 3D Scanner" (Figure 5).

To import the avatars into the virtual work environment in the Unity3D, their meshes must be seriously reduced. The high poly scan is imported into a 3D software to make a manual re-topology -



Fig. 5. Mesh hole filling in the high poly model and final low poly model

The result of such a process is a realistic virtual representation of the user (low poly and detailed mesh of the user) that respects with high fidelity the morphology of the person that was scanned.

To generate a planar texture which can be edited in graphic software, the process of retopology must consider the following step of marking the loops for UV mapping, so it can be opened properly (Figure 6).

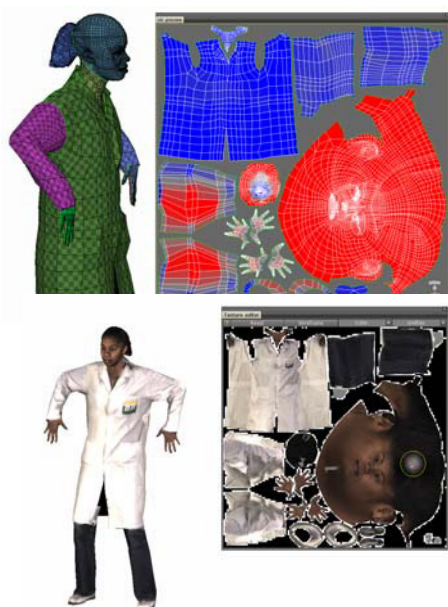


Fig. 6. Low poly model UV mapping and painting

To apply the texture in the low poly model, there are two approaches: (1) consists in the capturing photographs during the scanning process in order to have several pictures in different angles, which provides better resolution and (2) rendering the high poly model, which enables sectioning the model in order to have hidden surface images, such as armpits, inner legs, top and bottom views (Figure 7).

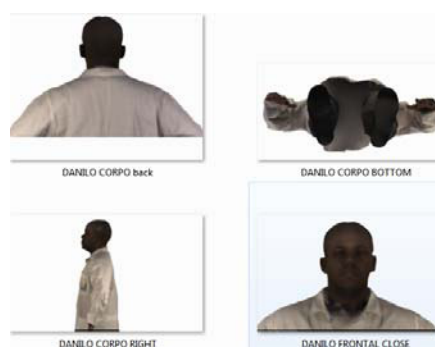


Fig. 7. DHM rendering to acquire texture images.

Most of the animations were acquired using "Moven" motion capture suite. The MOCAP sessions took place in the laboratory with personnel performing daily activities. The mocap files were exported to an animation format recognized by 3D Max (\*.bvh format), then were edited and imported into the digital human models (Figure 8). In this process, the low poly model (\*.obj format) is imported into 3D Max, where the biped structure is placed, correctly skinned to respond to each bone movement and exported to MotionBuilder.

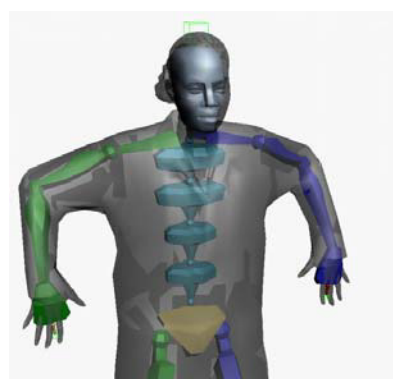


Fig. 8. Biped structure placed in the low poly model to be skinned.

Inside MotionBuilder, the biped structure is characterized to follow the bones naming conventions and the motion capture files are imported, animations are then divided into full animation and cycle animations, as walk and idle, animations that play on loop, avoiding that the animation loading takes too much time.

After all animations are correctly set to its character, the animation is plotted to the skeleton and the DHM is sent back to 3D Max where the empty skeleton animation will be updated for those sent by MotionBuilder. At this time the file is already set to be exported to Unity with its correct media and animation.

### 3. Results

One of the simulator's goal is to allow multiple users to interact with each other using their own avatars. It will provide the team the ability to train activities, learn more about how their colleagues proceed and train new personnel.

In the final steps of the development of the project, the network function is set among all the 3D models. This setup involves: (1) scripting the objects (most of them are in java script language - e.g. interactive doors, drawers, equipments, picking up and dropping objects), (2) scripting the scene - menus, cameras, interactive cameras, networking, illumination, layout, possibility to enable or disable a trail render in order to map users paths across the laboratory. (Figure 9).

All these components are brought to the users through a friendly GUI (Graphic User Interface), which makes the simulator as intuitive as possible, so the users can focus on the activities and not on how to work with the engine.



Fig. 9. Simulator's GUI.

### 4. Conclusion

Nowadays, industrial projects are developed with the use of 3D software engines instead of 2D tools, allowing the main focus to be human labor and not only the project itself. Allaying it to the study of social interactions at work helps to project better environments.

The use of virtual environments gives the possibility to discuss, change, create and deliver a better result as it is more graphic and visual for non architects and designers professionals, to understand and discuss the new layout of the work space where can be chosen a better design alternative, optimize the interfaces, integrate countless projects and a great number of professionals involved.

Transparency of the future project allows adjustments and error recovery throughout the design process. Projects become more robust, since the scenarios and future activities may be simulated and also the risks involved studied.

These simulations may be used to evaluate technology, industrial safety and/or human performance. One may map process risks, ergonomic and architectural problems, escape routes, displacement of people in crisis situations, assembly and maintenance problems.

Therefore the conclusion is that virtual simulators of social interactions contribute towards: the activity of designers in the occupation of three-dimensional space; evaluation of possible alternatives; detailing the environment; validation of the future project by users, managers, and others; safety, health and environment evaluation; training of human resources.

As observed in this work, this simulation platform can be used by engineers in the design of future laboratories, thus minimizing the time required for similar projects and increasing the compliance of these environments to standards.

Even if character interaction cannot always be done in the virtual space, stakeholders can easily project their knowledge of the working situation in order to assess part of the new working space characteristics improving the participative dimension of the project.

Organizational decisions were taken around these tools; they help people to project themselves in their future working spaces and furthermore it was a great tool to improve the feeling of participation.

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- [4] C. Guimarães; F.C.H. Pastura; B. Pavard; N. Pallamin; G. Cid; V. Santos; M.C.P.L. Zamberlan, Ergonomics Design Tools Based on Human Work Activities, 3D Human Models and Social Interaction Simulation IHX Congress, Miami, 2010.

# DHM simulation in virtual environments: a case-study on control room design

Zamberlan, M<sup>a,\*</sup>, Santos, V<sup>b</sup>, Streit, P<sup>a</sup>, Oliveira, J<sup>a</sup>, Cury, R<sup>a</sup>, Negri, T<sup>a</sup>, Pastura, F<sup>a</sup>, Guimarães, C<sup>a</sup> and Cid, G<sup>a</sup>

<sup>a</sup> Instituto Nacional de Tecnologia, INT. Avenida Venezuela, 82, Rio de Janeiro, RJ. Brasil - 20081-312

<sup>b</sup> Pontifícia Universidade Católica do Rio de Janeiro - PUC-Rio. Rua Marquês de São Vicente, 225, Gávea, Rio de Janeiro, RJ - Brasil - 22451-900

**Abstract.** This paper will present the workflow developed for the application of serious games in the design of complex cooperative work settings. The project was based on ergonomic studies and development of a control room among participative design process. Our main concerns were the 3D human virtual representation acquired from 3D scanning, human interaction, workspace layout and equipment designed considering ergonomics standards. Using Unity3D platform to design the virtual environment, the virtual human model can be controlled by users on dynamic scenario in order to evaluate the new work settings and simulate work activities. The results obtained showed that this virtual technology can drastically change the design process by improving the level of interaction between final users and, managers and human factors team.

**Keywords:** digital human model, simulation, virtual environment, motion capture

## 1. Introduction

The research in serious games has been a focus issue for Government and corporate organizations, applied on training, simulation and education. There is a clear need for considering new frameworks, theories, methods and design strategies for making serious games applications and virtual world technologies more effective and useful as part of education, health and training. Virtual simulation has been used in Ergonomics for the design of control centers, transport design and product evaluation. (SANTOS, V., et al. 2009, SANTOS, V. et al. 2008, GUIMARÃES, C. P. et al. 2010).

The aim of this paper is to discuss the use of serious games applied in a control room design and how virtual reality and game engines may improve the workflow for the design of complex cooperative situations.

The project's context was to find a way to improve and accelerate participative design process for a new emergency control room. Due to a low level of availability and dispersion of stakeholders, it was decided to explore how serious games may improve

the participative design. From a human factors point of view, there are strong constraints because: (1) future users must not only "see" their future work-settings in a virtual space but also be able to project their future actions in order to anticipate the pros and cons of the new situation, (2) the workflow must be very dynamic in order to maintain a momentum for the participative process. The different versions of serious games must be synchronized with the organizational process. With modern game engines, this constraint may be easily satisfied; and (3) reusability of virtual material (both objects and movements) is also an important issue.

Another important aspect regarding this specific project is to reproduce cognitive features. In other words, one user should be able to visualize the others' intentions, processes and actions trajectories in order to make decisions, such as where someone is looking at, their reactions to adversities, "volume" of communication, dispersion and others.

In this context, one of the main concerns was the 3D human virtual representation. Other important issues studied were human interaction, workspace

\* Venétia Santos. E-mail: [ergon@ergonprojetos.com.br](mailto:ergon@ergonprojetos.com.br)

layout and equipment including their GUI (Graphic User Interface).

## 2. Materials and methods

The project's stages consisted in (1) gathering information of existing control rooms and of operational personnel in different shifts by a multidisciplinary team that evaluated ergonomics and architectural aspects, personnel data (interviews, filming and analyzing activities, motion capture, 3D human scanning), internal communication, displacement and quantification of work volume, in order to design alternatives, (2) developing these alternatives in walk-around 3D virtual scenarios, so their evaluation is more effective, (3) developing a simulator from the chosen alternative.

The development of the simulator were segmented in a couple of stages: (1) building the 3D environment based on 2D CAD representation of the chosen proposal, (2) implementing furniture and workstations from an existing database with ergonomic recommendations and the application of Brazilian and International standards, (3) development of equipment and instruments' 3D models, (4) development of the DHMs based on 3D scanning and motion capture technologies and (5) implementation in the game engine with scripts and other setups.

Each 2D CAD proposal (Figure 1) was transformed into 3D virtual models, where later in Unity3D were applied interactive elements such as doors and windows, external scenarios, materials and textures, so that the environment is as realistic as possible, providing the user a more lifelike experience (Figure 2).

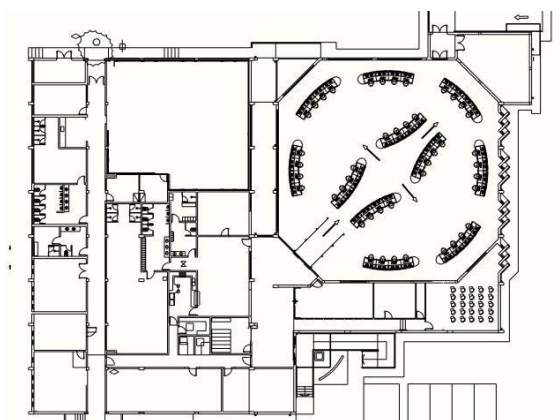


Fig. 1. 2D CAD floorplan



Fig. 2. 3D environment in Unity3D

Furniture and workstations present in the virtual laboratory are reproduced based on ergonomics recommendations and standards, modeled in SketchUp software and implemented in a database including 3D equipment and other instruments (Figure 3). The 3D database allows direct exporting to the game platform in \*.FBX format. The software allows the segmentation of interactive components in groups, which in Unity3D can be easily set up by its hierarchy characteristic. It also exports their textures in \*.JPEG, which are reproduced using their own pictures as textures (Figure 4), providing clearer understanding and faster recognition of each equipment by their respective users.

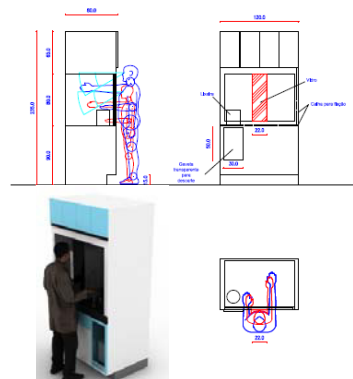


Fig. 3. Furniture recommendations



Fig. 4. Equipment 3D database.

DHM used in the simulation have been obtained starting from high resolution DHM (more than one million vertex) obtained by 3D scanning of employees using “Cyberware Whole Body Color 3D Scanner” and “Cyberware Head and Face Color 3D Scanner”.

To import the avatars into the virtual work environment in the Unity3D, their meshes must be seriously reduced. The high poly scan is imported into a 3D software to make a manual re-topology - doing this process manually allows us to control edge-flow of each model, therefore, keep expression details enhanced by subdividing the T-zone - eyes, nose and mouth. For the body, it's important to maintain articulations also with higher poly count to avoid deformations in the low poly mesh and keep the movements fluid.

To generate a planar texture which can be edited in graphic software, the process of retopology must consider the following step of marking the loops for UV mapping, so it can be opened properly (Figure 5).

To apply the texture in the low poly model, there are two approaches: (1) capturing photographs during the scanning process in order to have several pictures in different angles, which provides better resolution (Figure 6) and (2) rendering the high poly model, which enables sectioning the model in order to have hidden surface images, such as armpits, inner legs, top and bottom views.

The result of such a process is a realistic virtual representation of the user (low poly and detailed mesh of the user) that respects with high fidelity the morphology of the person that was scanned (Figure 7).

Most of the animation were acquired using “Moven” motion capture suite. The motion capture sessions took place in the laboratory with personnel

performing daily activities. The motion capture files were exported to an animation format recognized by 3D Max (\*.bvh format), then were edited and imported into the digital human models.

In this process, the low poly model (\*.obj format) is imported into 3D Max, where the biped structure is placed, correctly skinned to respond to each bone movement and exported to MotionBuilder.

Inside MotionBuilder, the biped structure is characterized to follow the bones naming conventions and the motion capture files are imported, animations are then divided into full animation and cycle animations, as walk and idle, animations that play on loop, avoiding that the animation loading takes too much time.

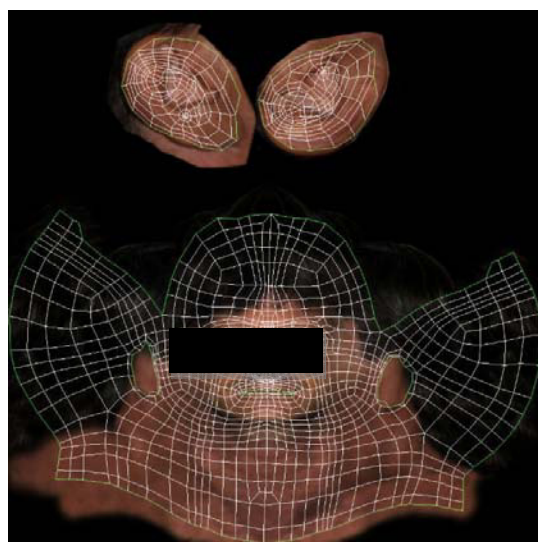


Fig. 5. Planar texture and UV map.



Fig. 6. Example of captured pictures during the scanning process.



Fig. 7. Retopology and painting process/result.

After all animations are correctly set to its character, the animation is plotted to the skeleton and the DHM is sent back to 3D Max where the empty skeleton animation will be updated for those sent by MotionBuilder. At this time the file is already set to be exported to Unity with its correct media and animation.

### 3. Results

One of the simulator's goal is to allow multiple users to interact with each other using their own avatars. It will provide the team the ability to train activities, learn more about how their colleagues proceed and train new personnel.

In the final steps of the development of the project, the network function is set among all the 3D models. (Figure 8). This setup involves: (1) scripting the objects (most of them are in java language - e.g. interactive doors, drawers, equipments, picking up and dropping objects), (2) scripting the scene (menus, cameras, interactive cameras, networking, illumination, layout, possibility to enable or disable a trail renderer in order to map users paths across the laboratory). All these components are brought to the users through a friendly GUI (Graphic User Interface), which makes the simulator as intuitive as possible, so the users can focus on the activities and not on how to work with the engine.

### 4. Conclusion

Nowadays, industrial projects are developed with the use of 3D software engines instead of 2D tools, allowing the main focus to be human labor and not only the project itself. Allying it to the study of social interactions at work helps to project better environments.

The use of virtual environments gives the possibility to discuss, change, create and deliver a better result as it is more graphic and visual for non architects and designers professionals, to understand and discuss the new layout of the work space where can be chosen a better design alternative, optimize the interfaces, integrate countless projects and a great number of professionals involved.

Transparency of the future project allows adjustments and error recovery throughout the design process. Projects become more robust, since the scenarios and future activities may be simulated and also the risks involved studied.

These simulations may be used to evaluate technology, industrial safety and/or human performance. One may map process risks, ergonomic and architectural problems, escape routes, displacement of people in crisis situations, assembly and maintenance problems.

Therefore the conclusion is that virtual simulators of social interactions contribute towards: the activity of designers in the occupation of three-dimensional space; evaluation of possible alternatives; detailing the environment; validation of the future project by users, managers, and others; safety, health and environment evaluation; training of human resources.

Even if character interaction cannot always be done in the virtual space, stakeholders can easily project their knowledge of the working situation in order to assess part of the new working space characteristics improving the participative dimension of the project.

Organizational decisions were taken around these tools; they help people to project themselves in their future working spaces and furthermore it was a great tool to improve the feeling of participation.



Fig. 8. Control room simulator running.

## References

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# Social Interaction Simulators: Serious games for the design of complex socio-technical systems

V. SANTOS <sup>\*1</sup>, M. C. ZAMBERLAN<sup>2</sup>, B. PAVARD<sup>3</sup>, P. STREIT<sup>2</sup>, J. L. OLIVEIRA<sup>2</sup>, C. P. GUIMARÃES<sup>2</sup> and F. PASTURA<sup>2</sup>

<sup>1</sup> Pontifícia Universidade Católica do Rio de Janeiro, DEI - Rua Marques de São Vicente, 225, Rio de Janeiro.

<sup>2</sup> Instituto Nacional de Tecnologia - Av. Venezuela, 82 - Anexo IV, Térreo, Rio de Janeiro.

<sup>3</sup> GRIC IRIT Université Paul Sabatier

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## Abstract

The aim of this paper is to present our research on the use of serious games for the design of complex cooperative work-settings. Our main focus will be on the workflow we have developed and its impact on the final design of two work-settings: an emergency control room and a set of research laboratories in the oil and gas industry. On both cases, we were concerned with 3D human virtual representation, human interaction, workspace layout and equipment designed considering ergonomics standards. In this study we selected two different 3D platforms: one for oil and gas laboratory design developed in the Unity system and another for emergency control room design developed in the Blender system. In both cases, the digital human model can be controlled by users on the dynamic virtual scenario in order to simulate work activities. The results obtained showed that this virtual technology can drastically change the design process improving the level of interaction between final users, managers and human factor teams. Finally, this methodology helps to better visualize future work settings and improve the level of participation between all stakeholders.

*Keywords: Serious game, Simulation, Digital Human Model, Design of cooperative work settings.*

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## 1. Introduction

The research in serious games has been a focus issue not just for the entertainment industry but also for Government and corporate organizations that can be applied on training, simulation and education. There is a clear need for considering new frameworks, theories, methods and design strategies for making serious game applications and virtual world technologies more effective and useful as part of education, health and training.

Virtual simulation has been used in Ergonomics in the design of control centers, transport design and product evaluation (Santos, et al. 2009; Santos et al. 2008; Pallamin et al. 2010; Dugdale et al. 2005; Pavard 2005; Guimarães et al. 2010).

The aim of this paper is to relate two experiences on the use of serious games for the design of work-settings and to discuss how virtual reality and game engines may improve the workflow for the design of complex cooperative situations.

The first experience (Nascimento et al. 2010) is part of a major project concerning the design of a series of chemistry laboratories in a petrochemical research complex. Based on a multi-user virtual environment, the simulation concerns the interaction of people working in a laboratory in

order to study layout alternatives for the laboratories configuration.

The context of the second experience was to find a way to improve and accelerate the participative design process for a new emergency control room. Due to a low level of availability and dispersion of stakeholders we decided to explore how serious games may improve the participative design. From a human factor point of view, there are strong constraints because: a) future users must not only “see” their future work-settings in a virtual space but also be able to project their future actions in order to anticipate the pros and cons of the new situation. These ‘cognitive and social projection constraints’ refers to the paradox of the situatedness in any cooperative virtual space (Pavard et al., 1989). In other words, how can a cooperative virtual space be situated if people are usually not able to construct the meaning of their interactions due to the difficulty to use non verbal communication between virtual characters? b) the workflow must be very dynamic in order to maintain a momentum for the participative process. The different versions of the serious games must be synchronized with the organizational process. As we will see, with modern game engines, this constraint may be easily satisfied. c) reusability of

virtual material (both objects and movements) is also an important issue.

The two experiences that will be described emphasize the use of game engine platforms in a context of the design of real work-settings.

## 2. Materials and Methods

### 2.1 Experience 1: design of oil and gas research laboratories

The workflow that we have developed was based on the following steps:

2.1.1 Based on previous ergonomic and dimensional analysis, we have developed the layout design in which the interaction takes place (a chemical laboratory) and created a database of virtual 3D furniture and instruments presented in a typical laboratory.

2.1.2 Virtual character's data collection and interaction with the virtual environment - collected by means of 3D human scanning and motion files libraries for the animation of virtual characters .

2.1.3 Development of 3D virtual environment based on 2D CAD blueprints

2.1.4. Selection of interactions to be performed by the 3D DHM based on ergonomics work analysis.

2.1.5 Characters animation and implementation of interaction scripts using 3D game platform.

### 2.2 Experience 2: Design of an emergency control room

Our methodology and workflow were based on the following steps:

2.2.1. Discussion of space organizational concepts with a common shared tool: slide show (see Fig. 1);



Figure 1 Example of intermediary slide show working plan. Firemen and medics were able to set up several types of spatial organization.

2.2.2 Presentation of the 3D environment on a slide show (with addition of familiar objects and new communication artifacts, like large screens on the top of the room, new lighting system, etc. in the scene),

2.2.3 Design of an interactive animation with graphical programming game engine:

- Scan of workers
- Polygon reduction (we used weight painting and a poly-reducer algorithm written in Python).
- Character's mapping and rigging
- Basic and specific animation
- Game logic with the graphic game engine.

These steps allowed us to easily specify some interaction between user driven characters and autonomous characters. As an example, when approaching a co-worker, this one will gaze at you if he is not busy.

## 3. Results

### 3.1 Experience 1: Design of oil and gas research laboratories

The virtual Laboratory modeled is not the reproduction of an existing laboratory but is based on 2D cad blueprint of proposed layout (see fig. 2). This drawing represents a prototyped laboratory designed to respect all present security prescriptions and to insure good work quality for the users.

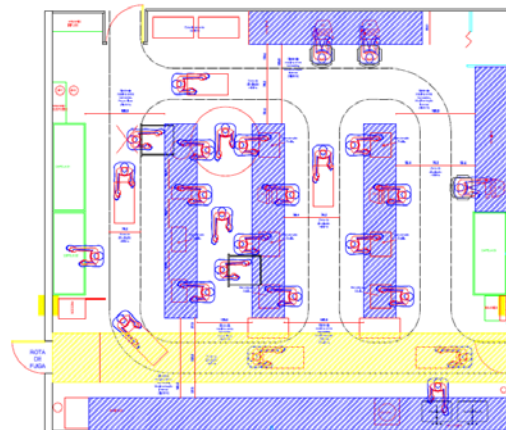


Figure 2: Architectural plan of the virtual laboratory

The furniture and work stations present in the virtual laboratory have been reproduced based on ergonomics recommendations, modeled in a 3D software and implemented in a database among 3D equipment and other instruments (see Fig.3) The 3D database allows direct exporting to the game platform in \*.FBX format, among their textures in \*.JPEG. Using their own pictures as textures provided clearer understanding and faster recognition of each equipment by their respective users (see Fig. 4)

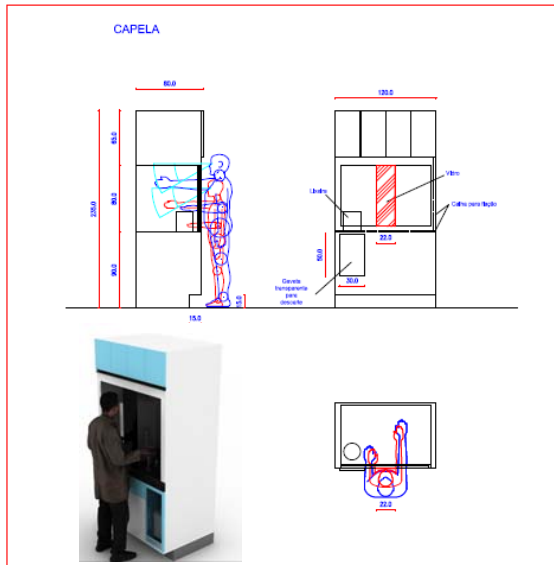


Figure 3: Ergonomically Recommended chemical fume hood

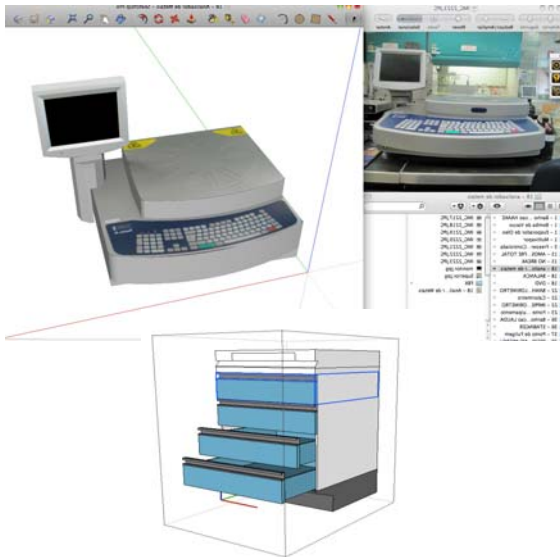


Figure 4: 3D equipment and furniture database

Characters used in the simulation have been obtained starting from high resolution DHM (more than one million vertex) obtained by 3D scanning of employees using “Cyberware Whole Body Color 3D Scanner” and “Cyberware Head and Face Color 3D Scanner”.

To import the avatars into the virtual work environment in the game engine, their meshes must be seriously reduced. We imported the high poly scan into a 3D software to make a manual re-topology - doing this process manually allows us to control edge-flow, therefore, to keep expression details enhanced by subdividing the T-zone - eyes, nose and mouth. For the body, it's important to maintain articulations also with higher poly count.

The result of such a process is a realistic virtual representation of the user (low poly and detailed

mesh of the user) that respects with high fidelity the morphology of the person that was scanned (See Fig. 5).

To generate a planar texture that can be edited in graphic software, the process of re-topology must consider the following step of marking the loops for UV mapping, so it can be “opened” properly. The pictures taken in the scanning process are used in the low poly mesh, so the avatars can keep their own realistic features (see Fig. 6).



Figure 5: Original “High Polygons” 3D model and the final low polygon mesh.

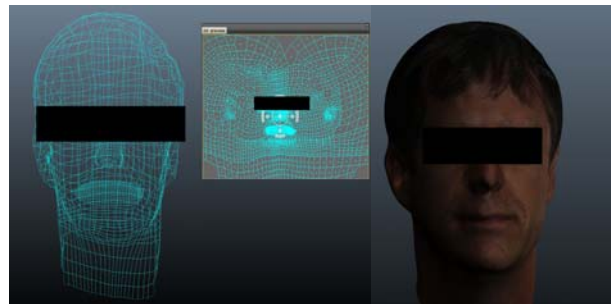


Figure 6: UV mapping (from 3D low poly mesh to 2D map) and texture painting.

Most of the animations concerning the virtual characters have been obtained using the “Moven” motion capture suite. The MOCAP sessions took place in the laboratories, with personnel performing daily activities. The motion capture files (in \*.bvh format) have then been edited and applied to the virtual characters.

To help visualize the displacement of the workers inside the laboratory, trail lines are rendered to represent the path inside the environment (see Fig. 7). The trail lines can also be rendered for the objects as well.



Figure 7: Top view of the laboratory with the trails lines and avatars.

In details, the project is based on a multi-user virtual environment where two users are controlling their own virtual character. They could control the displacement of the avatars in the virtual environment and perform some basic interactions (move objects, activate some machinery). The users were able, as well, to communicate in the virtual world via voice-chat (VOIP). To increase the level of realism and efficiency of the communication some basic gestures and facial expressions (pointing, basic lip-sync, etc) were implemented. By accurately reproducing the proposed work environment - furniture, users and activities performed, it was possible to see how these elements combined influenced the way the tasks were performed. To grant accuracy to the environment, the development was based on 2D CAD blueprint data, 3D scans of workers and linear measurements of equipment spaces. In order to easily identify the users, their 3D scans were implemented with their own MOCAP animations. It also allows users to observe their interaction among others and improve their communication artifacts (see Fig. 8).

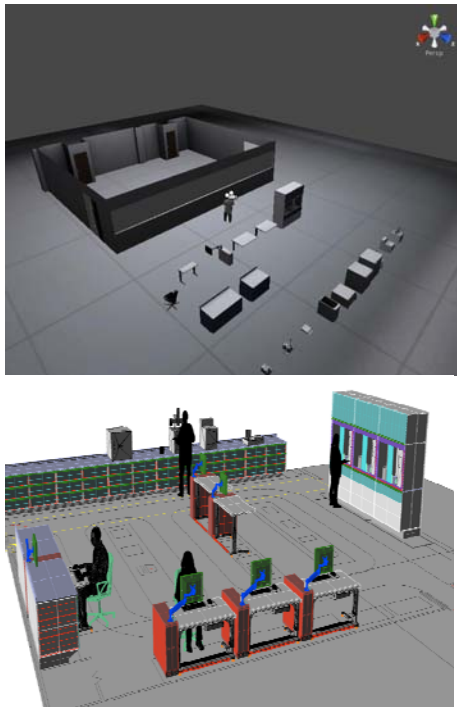


Figure 8: Game platform for development of laboratories with ergonomic standards.

### 3.2 Experience 2: Design of an emergency control room

In order to maintain a fast work flow, in which all stakeholders could interact, it was developed a 3D representation of the work space (see Fig. 9). This tool provided access to all in distance meetings with possibility to walk through the environment.



Figure 9: Example of a 3D representation of the working space through Blender.

To develop the characters, we started from high poly scanned characters and used a painting algorithm in order to interactively specify the polygon density (see Fig. 10).



Figure 10: Interactive polygon reduction allowing details on desired places (Wartman, 2008)

This approach allowed fast adjustment of the polygon density of the character depending on the area. We kept high density for faces and member articulations.

The workflow allowed the exportation of the avatar meshes and application of customized animations. The whole process was easily done in a matter of sending and receiving a few mails (see Fig. 11).

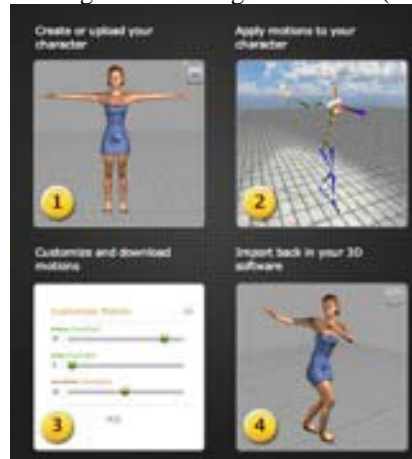


Figure 11: Mixamo workflow

This facility was used to implement basic animations for both autonomous and user driven characters (walking at different paces, discussing, etc.). Stakeholders were then able to process these animations through an easy interface like a keyboard (See Fig. 12).



Figure 12: Interactive exploration of the working space by future users of the working space.

## 4. Discussion

### 4.1 Experience 1: Design of oil and gas research laboratories

The application of 3D human scanners in simulators presupposes a different scanning than that performed in anthropometric studies (Robinette, 2002). With the approach of using 3D human models in work situation simulations, it is necessary to develop a methodology for compiling specific databases for simulation. People have to be scanned in different positions and there has to be provision for scanning the accessories used at work, such as personal protective equipment, canisters, flasks and even lab coats worn by operators.

According to our results, the identification of avatars by people facilitates their immersion into these systems.

The use of 3D DHM by workers who can identify themselves and test their proportion in relation to work spaces, leads to a different way of reasoning its design.

The application of a 3D data collection on the projects allows a better vision of the spacial occupation. The development of the simulator from the game engine tool involved an IT team (3 persons) in addition to the ergonomists, designers and architects who worked on the project.

The development of the platform for laboratory design lasted one year, and now, after the its conclusion, team members themselves can carry out new laboratory projects. The inclusion of new layouts (100 m<sup>2</sup> on average) takes two weeks (two people involved). Because of the ease in using the tool, the contractor wants its engineers to use the same developed platform in the next projects.

### 4.2 Experience 2: Design of an emergency control room

During this approach we were trying to maintain a fast work flow and a 3D interactive space fully

designed by human factor team (without specific knowledge in formal language) in order to reduce the design cycle. Our choice was going towards Blender because it has the same application tools necessary for a game design (from object editing to logic tools for the game engine). This level of integration was for us an argument for simplicity. The other advantage foreseen was an open source software with a very large community.

The 3D representations were used by stakeholders at different levels: they used walk through movies for the valorization of the project at the regional level; we clearly see the specific advantages of 2D versus 3D representations. The 2D space representation was used during meetings or through internet to propose alternative ideas. As far as we had the 3D furniture in our library, it was then a matter of minutes to implement the new working space (on our laptop during the meeting) and discuss it.

We have been positively impressed by the real-time performance of the system. We were able to run in real time scenes of 20.000 vertex, one human driven character and 4 autonomous avatar, interacting all together.

As Blender is an open software, people were able to run the simulation on their own and send feedback to the human factor team. What was the limitation or main constraint of this platform? First of all, even Blender being a very coherent 3D tool (we do not have to care about format change between application), it has to be learned. We found Blender very powerful if we handle shortcuts but it takes time to master them. Documentation has been easy to find and we never reached dead ends.

The game engine and its logic tools were easily used to handle simple character interactions but for more complex situations, it is necessary to use Python scripts (like the one used for polygon reduction). Presently it is possible to animate more than one human driven character in the same environment but we didn't try it within our time schedule.

## 5. Conclusion

Nowadays, Industrial Projects are developed with the use of 3D software engines instead of 2D tools, allowing the main focus to be human labor and not only the project itself. Allaying it to the study of social interactions at work helps to project better environments.

The use of virtual environments gives the possibility to discuss, change, create and deliver a better result as it is more graphic and visual for non architects and designers professionals, to understand and discuss the new layout of the work

space where can be chosen a better design alternative, optimize the interfaces, integrate countless projects and a great number of professionals involved.

Transparency of the future project allows adjustments and error recovery throughout the design process. Projects become more robust, since the scenarios and future activities may be simulated and also the risks involved studied.

These simulations may be used to evaluate technology, industrial safety and/or human performance. One may map process risks, ergonomic and architectural problems, escape routes, displacement of people in crisis situations, assembly and maintenance problems.

Therefore we conclude that virtual simulators of social interactions contribute towards: the activity of designers in the occupation of three-dimensional space; evaluation of possible alternatives; detailing the environment; validation of the future project by users, managers, and others; safety, health and environment evaluation; training of human resources.

As observed in our work, these simulation platforms can be used by engineers in the design of future laboratories, thus minimizing the time required for similar projects and increasing the compliance of these environments to standards. The platforms are tools which can be appropriated by other designers, building up the database of the company.

Surely these platforms will be used after the implementation of the project both for training sessions and for scheduling equipment maintenance and other services at the work locations as well as for the company's expansion.

Both approaches described in this paper were aiming at the same goal: improving the quality and the speed for the design of a workspace workflow using game engines. In both case, this experience was very positive and full of new possible improvements.

Both approaches have their pros and cons. The Unity approach took advantages of its very efficient game engine allowing more easily multi user serious games but at the price of a more complex organizational management due to the fact it implies different teams specialized in computer science, human factor, etc.

The Blender approach was looking for an approach with only one integrated tool and no programming competences so that the whole process can be easily managed by a human factor team. Our experience shows the pertinence of this solution but presently with the limitation with multi-user interaction. Nevertheless, interaction between active and passive users remains very possible.

Finally both approaches confirm the great potential of serious games for the design of working spaces. Even if character interaction cannot always be done

in the virtual space, stakeholders can easily project their knowledge of the working situation in order to assess part of the new working space characteristics improving the participative dimension of the project.

We can say that organizational decisions were taken around these tools; they help people to project themselves in their future working spaces and furthermore it was a great tool to improve the feeling of participation.

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