AWI O GP VGF 'TGCNKV['U[UVGO 'YKVJ 'EJTQO C'MG[HQT SIMULATORS

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ABSTRACT

This paper presents a training solution for heavy equipment operator professionals which need to improve general operation skills, exercise or wish to experiment with different risk decision making scenarios. Commercial simulators usually have high cost, demand great large installation areas or displacement to specialized training facilities. This solution combines the advanced Augmented Reality techniques, Chroma Key and Head Mounted Displays (HMD) to provide acceptable, low cost and on site training environment.

The system installed in limited space when compared to the commercial simulators. Through video composition the application adds the user's own and real equipments/controls over the virtual training environment. This work, also presents results on a comparison between a color projection and a high contrast cloth for mask filtering. The overall result provides acceptable results for general training purposes.

Keywords: Augmented Reality, Chroma Key, Immersion

1. INTRODUCTION

In some situations, the expertise and the ability are indispensable factors to the execution of the work to be accomplished.

In all areas, the training process becomes important for forming qualified professionals'. In this context, the objective of training future professionals, lies in the real sensation of being in the environment. (Crane cabin, Airplane, etc)

The basic idea was developing a simulation system which reproduced with the maximum realism, considering spatial limitations and cost factors, the true situations faced by the professional in the future, however in an augmented virtual environment.

2. SISTEMS IN THE APPROACHED AREAS

With the objective of offering a good immersion, there are several works, such as, the work of Ronald T. Azuma, 1997, which presents techniques of Virtual Reality or Augmented Reality for visualization in real time.

However, in general we face limitation like the cost of equipments and the necessary space for the use of the whole apparatus. The first part of this work presents systems used in the visualization training field and respective equipments used.

2.1. Delta 3D

The Delta 3D is a Open Source program with characteristics of a Game Engine appropriate for a wide variety of usage including simulation, formation or other graphic applications.

This program was used by the Federal Aviation Administration (FAA); its objective was to improve operational procedures and better pilot performance when following Global Positioning Satellite (GPS) routes.

Figure 1: Delta 3D using Digital Cave in "U".

2.2. Virtualization Gate

The Virtualization Gate is an immersive environment similar to CAVE-based technology, but for use with the HMD (Head Mounted Display) and based on sophisticated Chroma key tracking system. The solution overcomes several limitations present in Occlusion based Augmented Reality applications. Allowing full body immersion and interaction with the virtual world by scanning the users' contours from several points of view and generating a 3D avatar with similar appearance. Having its shape captured in real time allowing its insertion in any Virtual Reality application.

This system uses multiple cameras, a 3D modeling tool and real time texture generation for avatar creation

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in low, but acceptable, resolution. However, the challenge of this system is the ability to render a finer quality model with a higher refresh rate, which could improve immersion.

Figure 2: Visualization of the model with low quality.

2.3. VAR-Trainer

The project VAR-Trainer was financed by the European Union, with the main objective to create and develop a simulation program for heavy machine operation. This training reduces accidents related to operator error.

Figure 3: VAR-Trainer.

2.4. ChrAVE

The ChrAVE, is a system for helicopter pilots' training, based on Chroma Key technology. The objective is to supply a realistic simulated environment where a pilot can improve abilities which are important for general mission success.

Since it uses real helicopter structure to function it can implemented in the pilots own work environment.

Figure 4: ChrAVE in the pilot's cabin with blue screen covering the windows

3. OBJECTIVES

The objective is to develop a training environment which can, through Augmented Reality and Chrome Key, allow the user to interact with virtual content without the need for avatars. The simulator blends virtual and real content, in this case, the user will see not only himself but other relevant equipment and controls.

3.1. Augmented Reality

The use of virtual reality for training applications has proved itself useful and been validated by several previous works, such as Ayman Wasfy, 2004 and Fuhua Lin, 2002. Although Augmented Reality has been around for about the same time as Virtual Reality, only recently has it emerged as practical a tool. Augmented Reality can extend the perception of space and the information about that space.

One of the most important qualities of the Augmented Reality is its tangible properties in user interaction. AR makes it possible to mix real and virtual elements in one user interactive environment. The real world, in this case, can be the foundation for a virtual simulation and training exercise. Virtual objects can visually interact with virtual ones through object occlusion techniques, so virtual objects can pass behind real objects. Current limitations lie self user visibility, since occlusion of the users body cannot be done the same way as solid, non organic objects.
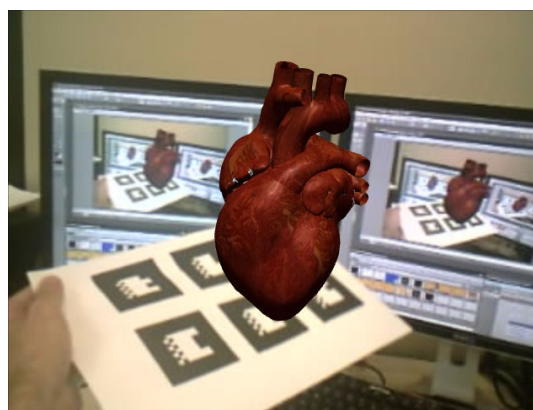

Figure 5: Model for study.

3.2. Chroma Key

Chroma Key is a technique commonly used in the film and television industry. It can be used to superimpose two video feeds, by filtering out specific colors that stand out. Usually this can done play placing people or objects in front of a luminous green, blue or red screen and later using these contrasting colors as a mask for image composing.
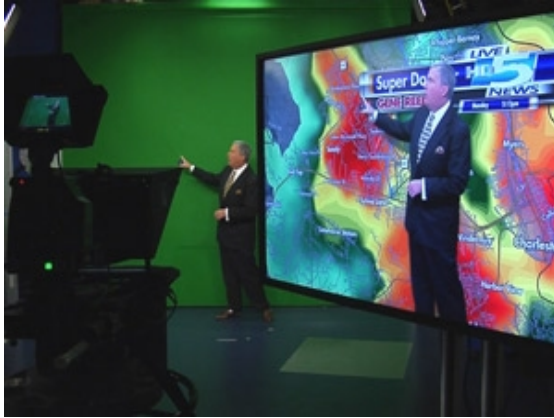

Figure 6: Chroma Key – Image Composition.

4.   DEVELOPMENT OF THE SYSTEM

After an overview on Augmented Reality and Chroma Key applications, it was determined that and integration of these technologies would be possible by altering AR the rendering pipeline to include overlay of a masked video layer. The combined use of AR visualization system with Chroma Key filtering for self and instrument visibility improves immersion qualities on the crane training application case.

This application was developed and tested in the LAMCE/GRVA (Laboratory of Computational Methods in Engineering / Applied Virtual Reality Group) CAVE. This work also discusses the integration of real instruments and controls with a virtual environment by Chroma key AR training application. Below follows a summary of software and hardware used throughout the system.

4.1. Director

Adobe Systems Program, allowing to the user to develop multimedia applications, it has support for vectorial graphs and interactive three-dimensional objects with the use of Shockwave 3D.

4.2. DART

Group of tools developed to provide support for development of Augmented Reality applications. It was built an extension for Macromedia Director Environment, integrating tools like OpenAL (for sound 3D), VRPN (real team streaming dates) and ARToolkit (optical tracking).

4.3. 3D Max

A complete 3D graphic application that has sophisticated modeling tools and an extensive list of plugins, used for game design, architectural visualization, special effects , TV studio and industries in the development and study of new products.

4.4. VFX3D

It is a helmet with head phones (stereo) and an articulated visor containing two optic screens. Used for mono or stereo vision.

4.5. Intersense I-1200 Vistracker

The I-1200 has a 6-DOF (degrees of freedom) and high precision, with vision-inertial system for the movable control and autonomous control in simulation and training.

4.6. Creative Live! Cam Notebook Pro

This Webcam allows to generate pictures with 1.3 Megapixels, it possesses an adjustment of 180° and remote control.

5.   THE SYSTEM PROCESS

For this system, the process is divided in three stages:

- First Stage: The image capture from a Webcam, with the use of libraries, such as, DirectShow for Windows (Videoimput Lib).
- Second Stage: It consists in converting the primary colors of the image from RGB (Red, Green, Blue) to the HSL format (Hue, Saturation, Lightness) representing the points in a model of colors RGB. This provides better tone control for frame color filtering.
- Third Stage: This stage performs the extraction of the images alpha channel and the assigning values based on comparison with the reference color pre-selected.

With the generated image in RGBA format, it is passed to Director which receives the data and saves it to a specific variable to store the image. Allowing the user to access and manipulate this image in a friendly environment through scripts (Lingo, JavaScript). The Shockwave 3D, is the 3D format based on the Director. This format is based on a complete system called Stenograph that enables you to change, manipulate and control nearly all aspects of visual and functional environment or a 3D object.

The Director 3D engine is efficient in layer composition and can easily blend two-dimensional and three-dimensional elements. In this case, the system enables Stenograph add graphics designed respectively in front and behind the 3D content, known as:

- Overlays – texture overlay, shown in front of all models on the list of a camera being used.
- Backdrops – Image appears behind the 3D content that will be processed in the projection of the camera.

The simulator developed in this work uses a Chroma Key video filtering to produce a masked overlay layer for the 3D, but the overall system is based on three composed layers which are listed below:

- The last layer drawn (Backdrop), is the actual video or captures image without transparency Webcam (camera image unchanged).
- The core layer or the second layer has a three-dimensional environment, in which case the environment of the port and the crane used for training.
- In the first layer (overlay) or top layer, receives the manipulated video with alpha channel.

The top overlay layer distinguishes this work from conventional Augmented Reality, by allowing the user to see the equipment, himself and the virtual environments.

For correct virtual orientation and display precise head tracking is required. Orientation tracking for this application was produced by the use of a high response and precision sensor called Viz-Tracker or IS-1200 (Intersense). This sensor is a small and box shaped which is fixed on the HMD.

Sensor access inside Director is available through an extension compiled using Intersense SDK, this extension binds the "isense.dll" with the Director Script interface (Lingo). Through a few simple access methods it is possible to monitor sensor state, calibrate and convert between Euler and Quaternion angle representation. Quaternion orientation was preferred over Euler due to unresolved gimbal lock problems apparently presented in Euler transforms available in Director.

5.1. Development

Taking into account the large number of cameras on the market, including the ability to control their settings.
The wide variety of software and libraries that would perform such a task. The first step in the implementation of this technique is to correctly capture a video feed. To accomplish this task the videoInput library was used.

This system uses a video feed which is spitted in two separate processing pipelines. The first is an unaltered version of the video and the second is the masked overlay video. The first step was the creation of a virtual camera system which retrieves video from a real camera and converts the color system to HSV for later control. This system creates the first virtual camera which will be accessed by videoInput extension.
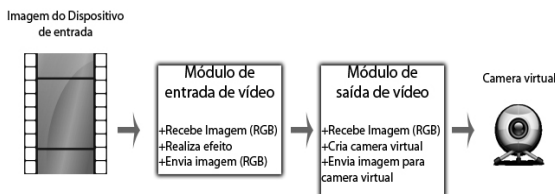

Figure 7: Real Camera to Virtual Camera

Once the video is properly converted from RGB to HSV, a simple algorithm can filter the selected Chroma color and adjacent lightness values. Below follows a step-by-step description of the filtering and masking process:

1. Capture the current RGB frame of the video and then store the video on an image created by video module.
2. In RGB color space, each pixel is converted to the HSV color space (hue, saturation and value - hue, saturation and value). The possibility of a better description of the relationship between colors. That is, this conversion is an alternative to the perceptual non-uniformity of colors from RGB space.
3. As for the HSV color space, the pixels are compared with the color chosen by the user and then with his color components in RGB color space, or alpha component (RGBA being) are changed when you have the same color or a color that is the desired tolerance range.
4. Applications of linear blur filter in order to smooth the edges that the effect of Chroma Key can affect.
5. The picture that has changed color is sent to the output module, which appears as a virtual camera.

The Director multimedia platform was chosen for its capacity to easily manage masked layers inside its 3D engine. Through its extension it was possible to import in real time the unaltered and masked video into planar textures to be used in simple overlay and backdrop composing.
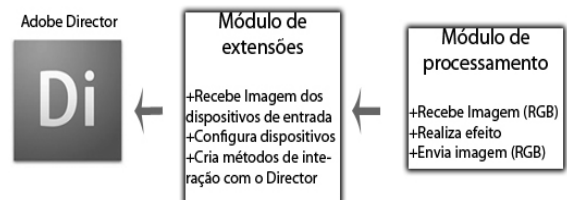

Figure 8: Image filtering and sending to Director.

5.2. AR Solution

Director provides more than one solution to work with Augmented Reality. AR is mostly based on tracking systems, which can be based on video processing or sensor data. As mentioned before, positioning sensors where used, for their stability and precision, none the less, experiments where made with fiducial markers and are commented below. Communication between sensor and Director is achieved by using the Intersense Xtra. The challenge is to integrate position information into virtual environment considering scale and coordinate system alignment.

6. RESULTS
6.1. Test-1

In the first tests, the fiducial marker did not produce good results. The tracking process presented a constant inaccuracy in marker recognition, this produced a leg in virtual camera positioning. It was also observed errors

in tracking, even when the marker was clearly visible and visual detection thresholds where within acceptable tolerances.

6.2. Test-2

The first Chroma Key test the CAVE environment with the HMD. The experiment placed the within a crane cabin while he the user was sitting on the real control chair. Through the HMD the user could see himself and the real controls composed over a virtual dock. The video user image was captured by a simple webcam and tracking was done a position/orientation sensor. The camera captured user images over a green contracting background. The green background was generated by projection green light over the CAVE walls.

This experiment produces the equivalent result of using several projectors to generate the virtual dock immersive environment. The main problem was green reflected light leaking into on the user image and producing distorted colors on the final composition. This was due to the reflection of green light projected on to the walls. Unfortunately this hard to correct without distorting general image color, loosing contrast and altering image lightness.

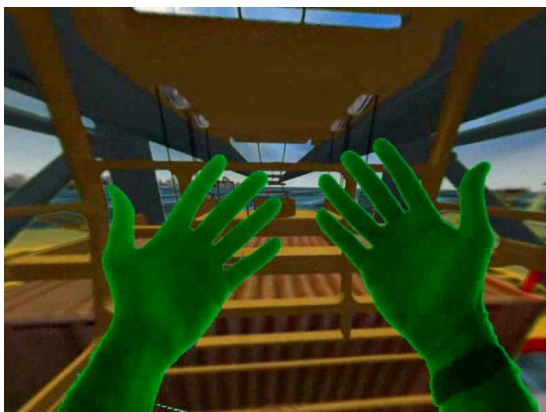Figure 9: Environment with the effect of light green.

Figure 10: Own vision of the observer in the simulation.

6.3. Test-3

For the second Chroma Key test, the same CAVE configuration was maintained, but with the addition of two spots lights directed to the equipment (mobile base) and the user, to try to counteracting the green light

effect. Some improvement can be observed by comparing Figure 10 with Figure 11.

Figure 11: New result in the observer's vision.

6.4. Test-4

This experiment used the same cave environment as tests 2 and 3, but without background color generated by light projection. The background color, in this case, was generated by a special green colored cloth like material, which has high contrast properties.

Figure 12: Environment to simulation with Chroma Key cloth background.

Figure 13: Testing Lighting.

In this test, the results were satisfactory as can be seen in Figure 14. The results were more consistent with the proposed objective, because the equipment and the

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user are no longer influenced by the reflected light green.

Figure 14: Vision of the observer without the influence of green light.

6.5. Final Considerations

The system proved to be a functional tool, reaching all the initially established goals. Enabling the extraction of real world elements through Chroma Key technique and allows the viewing and use of real equipment for training in various types of simulators. The virtual environment then extends real world elements and allows simulation of endless training scenarios.

With the insertion of the wearer and the equipment in the foreground, we see that there was a consistent position relative to the observer with the virtual objects and real objects, allowing a more realistic interaction than a conventional process of Augmented Reality. It is worth observing that the implementation of the Chroma Key technique was achieved entirely by software and using a low cost video capture system.

With the addition of Chroma Key Techniques and Augmented Reality, this system demonstrates the feasibility of using a simulator in small areas at a reasonable cost. Allowing adaptation to a simulated environment offering an immersive feel and consistent in order to meet the needs.

6.6. Future Implementations

Future research is still required in relation to low cost video capture devices with better color correction and exposure control. These improved device qualities would help in augmenting color fidelity and filtering by computer software.

It also intends to implement the system allowing the visualization and extraction of depth map in stereo mode, which will allow the placement of virtual objects relative to the observer without the need for markers. This would greatly improve the overall user depth perception. Using two cameras to catch the real elements, with a slight viewpoint shift, providing conditions for the placement of observers in the virtual space allowing a virtual object is manipulated.

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