Towards an interactive medical system by augmented reality

Khawla BEN ABDERRAHIM
Unité de Recherche SETIT ISBS Sfax,
(ISBS), Sfax University
BP 1175, 3038 Sfax
Tunisie

Mohamed KALLEL
Unité de Recherche SETIT ISBS Sfax,
(ISBS), Sfax University
BP 1175, 3038 Sfax
Tunisie

M.S.BOUHLEL
Unité de Recherche SETIT ISBS Sfax,
(ISBS), Sfax University
BP 1175, 3038 Sfax
Tunisie

ABSTRACT

Augmented reality is a computer field that progresses rapidly. Its principle is to mix the real world and the virtual world. Many applications already use augmented reality, particularly the medical field. In another axis, Medical image allows doctors to make diagnosis of the patient. This diagnosis allows him to make the best decision without committing professional mistakes that can cause problems. Hence the idea of integrating augmented reality with medical image analysis to help the doctor to make the best decision.

In this paper, we give an overview of our bibliographic study about augmented reality: the definitions and some examples of new augmented reality systems applied in medicine. Thus, we describe basic elements to create an interactive system of augmented reality without markers.

Keywords

Medical image, augmented reality, system of augmented reality, interactive system, hand detection, tracking hand, virtual object.

1. INTRODUCTION

Augmented Reality (AR) allows enhancing our perception of the real world by including virtual elements. It makes possible to superpose a 3D model or 2D model at the real environment of the user and this in the real time. One of application domains of augmented reality is the medicine. An example of medical problems is errors that may commit the doctor during diagnostic of medical images. We aim to create a system of augmented reality which collaborates between doctors in order to help doctors to make the good decision. Firstly, we begin by defining the technique of augmented reality.

2. DEFINITIONS OF AUGMENTED REALITY

Unlike Virtual Reality, where the user is totally immersed in a virtual world; Augmented Reality aims to integrate, by superimposing, the virtual objects in the real environment of the user. In this sense, several definitions are allowed to characterize the augmented reality:

According to Philippe Fuchs [1]: "Augmented reality gathers all techniques allow combining the real world with a virtual world, especially using the integration of actual image (AI) with Virtual Entities (VE): synthesized images, virtual objects, texts, symbols, diagrams, graphs… ». Augmented Reality (AR) is defined by Mackay as a way to return "electronic information in the physical world" [2], [3].

AR is seen by Robinett [4] as a means to increase user meaning, transforming unnoticeable events to visible phenomena, audible phenomena and touchable phenomena. This is seen as a symbiosis between man and machine like never before.

There are many other definitions of augmented reality, but we can summarize that the AR vision aims, therefore, to improve our perception of the real world by adding objects that are not a priori be perceived by the human eye.Thus, augmented reality penetrates in most domains of our daily life. Medicine is one of these domains, which also uses augmented reality. In the next section, we quote some examples of new medical projects that are based on augmented reality.

3. EXAMPLES OF MEDICAL AUGMENTED REALITY SYSTEMS

3.1 Veinviewer

In this application, the computer detects, via infrared, the veins of patient, and performs a projection for the image on the hand to help the doctor. This system was realized by CHRISTIE society. The figure 1 below illustrates the operation of VeinViewer [4].

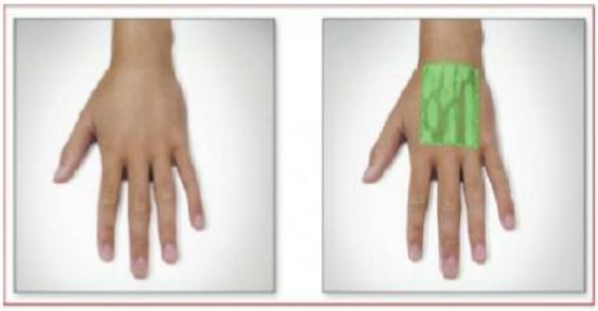

Fig 1: VeinViewer

3.2 CASPER

CASPER [5, 6, and 7] is a system which designed to help a surgeon to perform the puncture of a pathological liquid located close to the heart without making a heavy intervention: for this, the surgeon inserts a long needle puncture through skin and muscles until the outpouring that withdraw by suction with a syringe.. This is explained by the following figure.

Fig 2: CASPER

3.3 The application of Tedesys

The applications intended for surgeons and invented by the Spanish Tedesys. It comes to using Kinect to access and manipulate remote medical images. The application presented at TechFest 2012 gives the surgeon a gestural interface to manipulate a 3D image calculated from medical imaging data. Surgeon can perform several tasks: zooming a zone, perform translations and rotations of the 3D model. Thus, many surgeons can work on the model and pointing the important point by an arrow as described in the following figure.

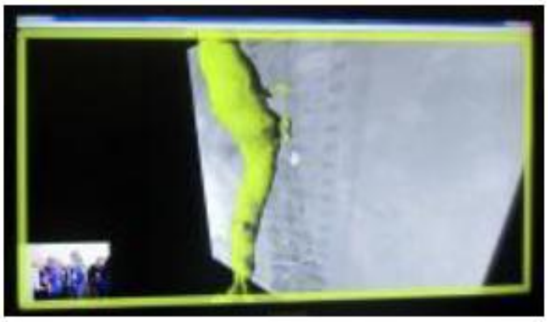

Fig 3: The application of Tedesys [8]

3.4 CAMDASS: Computer Medical Diagnosis and Surgery System

The European Space Agency (ESA) developed in 2012 an application which allows augmented reality to help astronauts to perform medical interventions: supposing that an astronaut was sick. So we must diagnose him, but there is not a doctor near him.

With the system Camdass, an astronaut, equipped with augmented reality eyeglasses, will be guided to use the scanner: it is sufficient to follow the path traced virtually on the patient. The prototype of application was tested at the University Hospital of Saint-Pierre in Brussels. The two following figures describe the Camdass system.

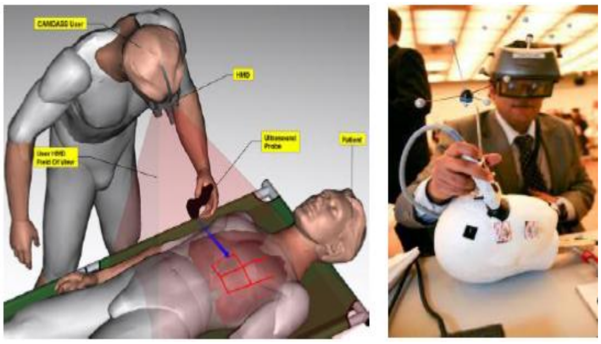

Fig 4, 5: Camdass

3.5 The application of Exakis

The French Exakis developed, using Kinect, an application to help physiotherapists in the diagnosis and the exercises performed by the patient. This application is unveiled during Techdays 2012. Kinect helps the physiotherapist to do its measures and also be able to guide the patient in rehabilitation exercises that must be carried out during its meetings. The application accurately measures gestures made and transmits the results of the patient's file. Figure 6 shows the application of Exakis [10].

Fig 6: the application of Exakis

After quote a few examples of medical augmented reality systems, we explain in the next section, the principle of augmentation in augmented reality system.

4. PRINCIPLE OF AUGMENTATION

In general, augmented reality systems, both fixed and mobile, are built on the basis of common hardware architecture:

- A camera filming the scene viewed by the user or a semi-transparent helmet worn by the user.
- A computer to generate the virtual entities.
- Input and output devices.

The augmented reality systems are designed to combine real and virtual objects in a scene. To do this, two methods are proposed:

4.1 Methods based markers

Consists to placing markers in real scene, which can calculate the 3D coordinates from three specific points recognized by the system. A marker is a simple pattern on a white background surrounded by a black frame. Figure 8 shows an example of the marker.

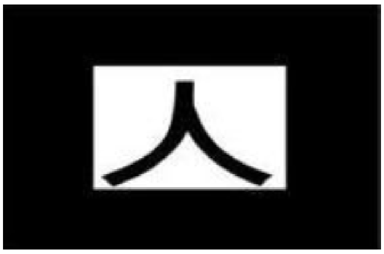

Fig 7: Example of a marker provided by ARToolkit

Augmentation process based markers consists of a sequence of operations on each image of the video stream on the one hand to detect the presence of a marker. Although this technology is the most widely used and best known for augmented reality applications it has some limitations:

- This technology intended for indoor AR applications because it requires a prepared environment, so a priori knowledge of the environment in which the user will change.
- Another limitation of methods based on markers is to be restricted in their visibility zone. Indeed, a marker may become undetectable when the camera moves away
- The main drawback of this technology is the not homogeneity and the change of the main characteristics of the real scene.

Fig 8: Examples of limits of technology based markers

Note in Figure 8 that the characteristics of the real part of the scene, human hand, are almost completely destroyed by the markers. In addition it is clear that the presence of markers makes the scene inhomogeneous. To solve these problems, methods to augmentation without markers are proposed.

4.2 Methods of augmentation without markers

To the augmentation in the augmented reality system based on a real component of the scene without introducing a marker, we use a component of the real scene (hand, face ...). The system must, therefore, identify this component first, and then do the tracking to achieve the augmentation.

Our goal is to create an augmented reality system that works to collaborates between doctors to help them to make the good decision based on one component of the real scene that is the hand's doctor. In the next section we detail the steps of creating an augmented reality system without marker on the base of the hand.

5. STAGES OF CREATION OF AN AUGMENTED REALITY SYSTEM

Augmentation process, in this system without marker, consists first, to identify and isolate the doctor's hand, tracking it and the augmentation by virtual objects.

The architecture's system is shown in the following figure.

Fig 9: The architecture's of augmented reality system without markers on base of hand

We explain in the following section, the process of detection of the hand, the monitoring and the augmentation process in the real scene.

5.1 Hand detection

This first step is intended to isolate the hand in the video.

Many detection techniques exist. In this paper we present an approach that is based on the successive use of tw techniques: the techniques of detecting the skin to remove the sections do not have the color of the skin, and that of the neural network to determine the areas which correspond to a hand. The main steps are as follows:

- Detecting zones of skin color from an input image:

There are several color can be applied to detection of the skin depends on the variability of the color space representation adopted for the chrominance pixels. The most used are: space RGB, RGB standard and YCbCr. Several studies have shown that the distribution of the skin color is restricted to a small area of the chrominance plane. So we can use this property to detect the pixels colored by color. We choose the YCbCr space for the equations of transformation of RGB space to YCrCb space are:

$$Y = 0.299R + 0.587G + 0.114B$$

$$Cb = 0.500R - 0.419G - 0.081B$$

$$Cr = -0.169R - 0.332G + 0.500B$$

The distribution of human skin color is shown in the following figure:

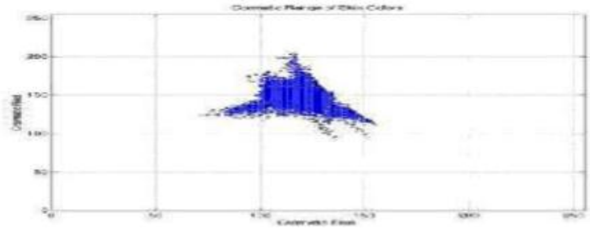

Fig 10: The distribution of Cr and Cb components of human skin color in the Y CrCb space. (From [11])

The process of detecting skin color is given by the following scheme:

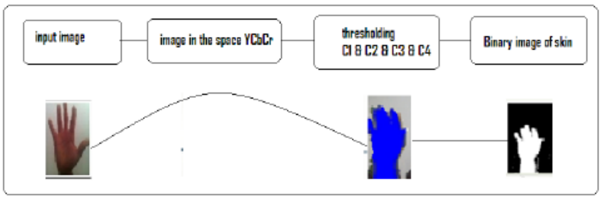

Fig 11: Illustration of the detection of skin color

Using the result of detection of the skin, we proceed with the extraction of the regions may contain a human hand.

This process is summarized by the following steps: separating the regions and calculate the position and the air in each region: the determination of the position is to determine the coordinates (X, Y) of the upper left corner relative to the input image.

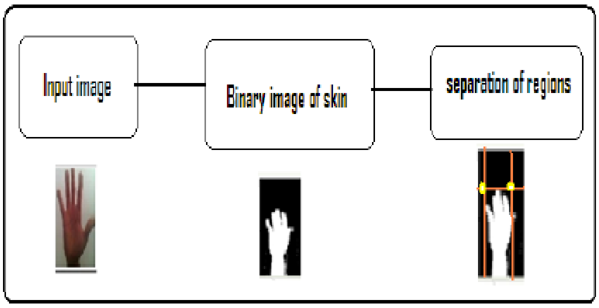

Fig 12: Illustration of the process of separating the regions of skin color

- Detection of the hand by the neural network: The training images are of two types: either the image corresponds to a hand or not. It is, therefore, to use a neural network to classify the training images into two classes: class hand and class not hand. primitives of the model.

Figure 13 below shows an example of a training base:

Fig 13: Examples of mages learning

The detection process by hand neural network is shown in figure 14.

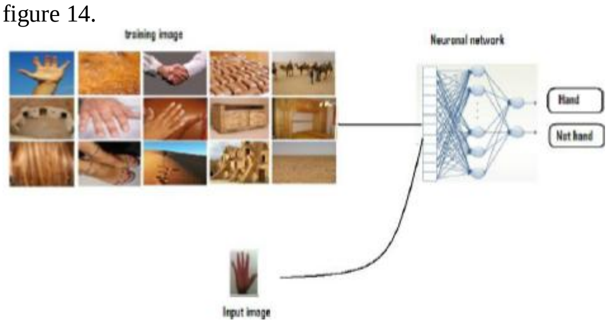

Fig 14: Detection of hand by neural network

After detecting the hand we must tracking it.

To the augmentation in the augmented reality system based on a real component of the scene without introducing a marker, we use a component of the real scene (hand, face ...). The system must, therefore, identify this component first, and then do the tracking to achieve the augmentation.

Our goal is to create an augmented reality system that works to collaborates between doctors to help them to make the good decision based on one component of the real scene is the hand's doctor. In the next section we detail the steps of creating an augmented reality system without marker on the base of the hand.

5.2 Tracking of the hand

All applications of computer vision require calibration of the camera. After calibrate the camera, we have to track the hand.

To do this, several tracking methods are presented:

a) Use of textured facets model: A time warp system based on the texture of the 3-D object was proposed by Gagalowitcz [34]. This system requires knowledge of the complete model of the object in the form of facets. To calculate the intrinsic and extrinsic parameters of the camera, it is necessary to make 3D-2D matching of points defined by the operator in the first image.

b) Methods using contours: detectors segments [12] are used in most algorithms based on the contours of the image. Once these contours determined, they will be matched with primitives of the model.

c) Approaches using a database of reference images: Instead of using a 3D model of the scene, Stricker [11] uses a database of reference images of the environment. This method begins with a comparison between the user's views of the current image of the video sequence and all the reference images. For each comparison, a correlation coefficient is calculated. The reference image which has the highest score will be used to evaluate the 2D transformation between it and the current image of the video. The virtual object can then be inserted using the 2D transformation calculated above. The success of this method depends on the choice of the method of comparison between images.

d) Tracking by neural networks of reference: The reference tracking method using neural networks is a method based pixels. It consists of two stages: a learning stage offline to make a relationship between the deformation pattern and its movement in the image, a second step for the online exploitation of this relationship to monitor the pattern selected.

After detailing monitoring methods, we explain in the next section, how to insert virtual objects into the real scene.

5.3 Inserting virtual objects

- The first step is to determine the center of gravity of the region that contains a hand humaine.il is give by:

Cgr (C1 = L / 2, C2 = H / 2)

With: Cgr: center of gravity of the region that contains the hand

L: is the width of this region

H: is the height of the region

- The second is intended to become embedded the synthetic object in the scene on the component of hand.

Suppose that the coordinates of the object in the real scene are Obj3D (Xobj3D, Yobj3D, 0). So just augment the real scene with the following parameters:

• Xobj3D = C1
• Yobj3D = C2
• Zobj3D=0

- The third step is to determine the process of moving the virtual object according to the trajectory of the hand.

After detecting the hand, making a good tracking of the hand, we can integrate the virtual object with in this way. Finally, we obtain an augmented scene.

In the next section, we will compare the medical applications of augmented reality, already mentioned in the third part of this paper.

6. COMPARISON OF PREVIOUS APPLICATIONS AND PRESNTATION OF THE CONTRIBUTION OF OUR WORK

About VeinViewer: This is a system that offers the possibility of projecting a virtual map of the vasculature of a patient.

Each person has a unique "map", although Luminetx uses new technologies to develop applications for the VeinViewer, but until now we cannot use VeinViewer out of the doctor's office. Hope to have the green light in hands at home, at office or at airport…

We note the same problem to the system CASPER.

That is why, new applications provide the solution: holding the application of Tedesys, which is intended surgeons who can consult and manipulate medical images remotely. Thus, the application of Exakis that helps and guides the patient in rehabilitation exercises and accurately measures gestures measurements and transmits it to the patient's file. It is in real time and remotely.

In this context fits our work: we seek to create an interactive system that works across multiple doctors and help them to make diagnostics. So to give help to his colleague, a doctor simply access to our system that it offers the possibility to analyze the medical image on any background, and not necessarily touch tables, thus, it allows multiple application of medical image analysis, such as: zooming image or a part of the image, signal the anomaly in the image, segmentation of the image, add virtual comments,...

Therefore, we can have multiple diagnoses on the same real image, and remotely.

The architecture of our future system is as follows.

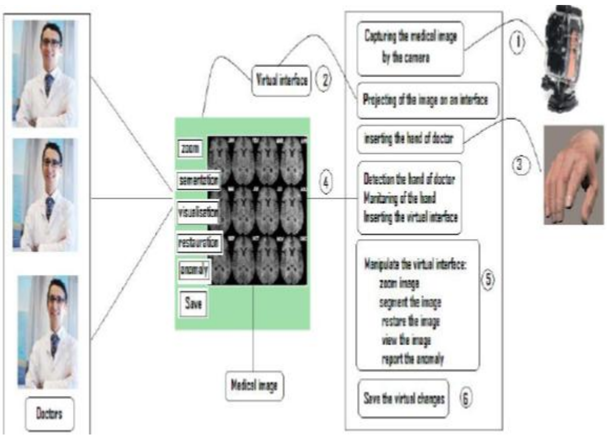

Fig 15: Architecture of our system

7. CONCLUSION

In this paper, we have presented first, the basics of augmented reality: definitions and examples of its applications in the medical field. Thus, we presented the principle and problems increase real scene with virtual objects. Then, we explain the principle of increase in augmented reality without marker: the basis for a component of the same scene (by hand): it suffices to detect the hand, and then follow integrate virtual objects in the actual scene. Finally, we compare the applications of augmented reality applied in the medical domain, to present the principle of our future system, and we describe the architecture of this system.

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