The interaction is important in this context, because the communication between the user (health professional) and the Virtual Environment (VE) or VR system can offer necessary experiences and knowledge in the execution of a procedure, for example. The user manipulates VR equipments and the application simulates the procedure as it is executed in the real world, providing an effective training. As important as the implementation and the considerations about the real task is the evaluation of the application, in order to verify the adaptation of the system to the user’s need.

In the current project, a framework in development state was considered, denominated ViMeT (Virtual Medical Training), which uses free technology to generate VR applications with focus on medical area, initially to simulate biopsy exams. Frameworks can be interesting in the building of Virtual Environments (VEs) because they propitiate an increase of productivity in the software development.

The objective of this paper is to present the creation of an interaction module for medical training applications, with support to non-conventional and conventional devices for ViMeT framework. However, the principal part of this work is the evaluation of the applications by people of the medical area (students and doctors), with opinions and ideas to the improvement of the application, making them more realistic. The evaluation considered computational and human aspects.

Next sections present the related works, the ViMeT framework, the implementation of the interaction module to be embedded in this framework, the adopted devices, the evaluation’s planning, the view of professionals of the medical area, and the conclusions.

2. RELATED WORKS
There are several works involving the building and evaluation of VR applications in the medical area. As example, it can present
Virtual Haptic Back (VHB), developed in Ohio University, United States, it consists in a system to generate haptic simulations of the human body, aiming at students training in carrying out diagnoses of patients by palpation [5].

Another application is the development of the Simulator for Training of Chinese Acupuncture, which helps students in acquiring knowledge about this technique. The acupuncture is used in the prevention and treatment of some diseases and with through the application the user controls the frequency and depth of the needle according to information provided for a haptic device. In this work, mathematical equations were made to simulate the offered sensations by several parties of the human body, such as: skin, adipose tissue, muscle and bone, and characteristics of these parties, as viscosity, elasticity, deformation and toughness [6].

Interactive Training System in Gynecological Exam is an application to simulate the tactile and visual identification of diseases related to the cervix, offering different stages of diseases and pathologies. It was developed in Brazil, where professionals of the medical area determined parameters using their experiences in the execution of these procedures [9].

So, the knowledge of professionals of the medical area was essential in the building and evaluation of these applications, making them more realistic. 

3. THE VIME T FRAMEWORK

A framework can be defined as the abstract implementation and project, used in the development of applications in a previously defined problems domain, allowing the reuse of components [3]. This characteristic provides the use of implemented code, increasing the productivity in the building of systems.

ViMeT is an object-oriented framework in the VR area, in development stage, that aims at generating medical applications [11]. By now, ViMeT can provide the generation of applications for the training of biopsy exams. These exams are important to collect material from a region of the patient’s body by using a medical instrument, like a syringe, that will be analyzed in laboratory to discovery the presence of anomalies.

ViMeT is being implemented in Java and C++ programming languages, using API (Application Programming Interface) Java3D. It offers essential functionalities and characteristics to create applications in this medical procedures simulation area, such as: stereoscopy; modeling of three-dimensional objects to represent the medical instrument and the human organ; collision detection between virtual medical instrument and virtual human organ; deformation of the object that represents human organ at the moment of the collision and support to non-conventional devices, as dataglove and haptic equipment [11]. An example of application generated by ViMeT is shown in Figure 1. The application provides a VE composed by two virtual objects: one to represent a human organ and another to represent a medical instrument used to accomplish the biopsy exam. The user can choose characteristics of VE like size, position and location of objects, besides aspects of stereoscopy, deformation and collision functionalities.

The use of Java programming language aims at building low cost applications, because this language is free, having other advantages, as: portability, ready classes and methods. The API Java3D facilitates the creation of VEs. It is distributed freely and has several classes and methods to build this type of applications, allowing the collision detection, objects loading, and the use of devices. The C++ programming language was used for allowing the integration of non-conventional devices, whose drivers and libraries (supplied by manufacturers) are written in C/C++.

4. IMPLEMENTATION OF INTERACTION

This part of the project consisted in the implementation of an interaction module, since the collision detection, the deformation, the stereoscopy, the objects loading and the creation of VE were already ready. The interaction module has support to conventional devices (keyboard and common mouse) and non-conventional devices (haptic equipment and dataglove) offering several resources for interaction, according to desired degree of realism and financial availability. The non-conventional devices are projected to offer a greater degree of realism, however, they usually have higher costs when compared with the conventional ones.

The inclusion of mouse and keyboard was made with classes, interface and methods provided by Java3D API. With the mouse, the user can manipulate the virtual object that represents the medical instrument in three axes. The user move the device in the x and z coordinates, and according to the pressed button (right, left or the third button), the application realizes movements of the virtual medical instrument, changing the rotation and translation in the coordinates x, y and z in the computer screen. Figure 2 presents the mouse’s movement with the pressed right button to realize the translation of the medical instrument.

The interaction through the keyboard is made by using specific keys, which are pressed or released by the user’s fingers, indicating the act to open and close the hand to hold and drop the organ during the exam. In this way, the keyboard is responsible for the movement of the virtual objects that represent the fingers of the user on VE.
The haptic device adopted was PHANTOM Omni, shown in Figure 4, and manufactured by SensAble Technologies. It has six degrees of liberty, allowing translation and rotation in the three axes (x, y and z), and it causes tactile sensation through a force feedback in the three axes [13]. Haptics is a term related to the science of the tactile, involving studies about the sensations proportionate by touch [5].

The haptic device allows to the user to manipulate the medical instrument, as the mouse, however, it captures more information, and promotes a force feedback, that must be calculated by application through mathematical equations. So, a greater computational processing it is necessary when compared with the use of common mouse.

The chosen dataglove for this project was DataGlove 5 Ultra, developed by 5DT (Fifth Dimension Technologies), shown in Figure 5. It has five sensors of optic fibers, which capture the flexion of the fingers within a values scale [1].

The dataglove, as the keyboard, transfers information to the application, according to the movements of the fingers of the user, changing the rotation of the virtual objects that represent the fingers. A virtual hand was included in the VE in order to provide a better visualization of the user’s movements. An application generated with the new object can be observed in the Figure 6, whose the objects are presented in wireframe.

A problem found during the implementation of the interaction module with non-conventional devices, was the diversity of programming languages (Java and C/C++), because the framework was being developed in Java and Java3D, and the non-conventional devices have drivers and libraries written in C/C++. Two solutions were proposals: the development of drivers and methods to work with these devices in Java programming language or the integration of both programming languages. The former approach involves some issues, such as: different types of input doors for connecting the equipments, programming in low level, dedicated time to study the equipments, development of drivers and libraries, and dedicated time for executing tests that could be used in the improvement of the application. The second one involves detailed research about integration techniques using different programming languages.

The latter approach was chosen, because the drivers and libraries of the manufacturers were already tested and available to use. To realize this step of the project, a native programming interface was used, denominated JNI (Java Native Interface), that enables the interoperation between Java programming language and other programming languages, as: Assembly, C and C++ [8]. JDK (Java Development Kit) provides libraries and tools to create link libraries, which are responsible for the integration of the programming languages.

Considering the availability of the four presented devices (mouse and the haptic equipment to manipulate the medical instrument; the keyboard and dataglove to manipulate the fingers of the virtual hand), the user can choose combinations of devices to realize the training: mouse and keyboard, mouse and dataglove, haptic device and dataglove, haptic device and keyboard.

The video display can also be considered as an important device in this system, because it presents VE, the objects and the reactions according to the user’s actions, facilitating the interaction. This way, when the haptic device is being used, it can say that the system provides tactile and visual feedbacks.

5. EVALUATION OF APPLICATIONS

With this prototype, it is possible to realize part of a biopsy procedure, consisting in the manipulation of the virtual medical instrument through the devices (mouse and haptic device) that must reach the virtual human organ. The application verifies the existence of a collision in real time and it realizes the deformation of the object that represents the human organ in the point where the collision occurred. The interaction with the haptic device is presented in Figure 7a and Figure 7b.
Another step of the training is the act to hold and release the virtual organ using the dataglove or the keyboard to move the fingers. Figure 8a and Figure 8b show the VE during a session.

An evaluation of the interaction between human and machine must consider aspects related to both parts (human being and computational system). The computational aspects involve the communication devices and software architecture, and the human aspects involve the human nature, with physical and psychological issues, that define the facility of the use of systems, and allow increasing the learning and motivation [2]. So, capabilities and limitations of the users must be considered.

When the subject is the computer (hardware and software), it is necessary that it executes a processing generating a determined number of frames per second, and scenes of quality to keep the immersion of the user and an adequate level of realism [7]. Other issues can be mentioned when the evaluation of a VR system is being built, such as: computers network and distributed systems, collaboration in VR systems, number of users, application type, among others.

A relevant term in this context is the usability, which consists in the use facility and utility of a system, including the user’s satisfaction, learning capability, velocity and accuracy in the execution of a determined task on VE [4]. So, the evaluation of this project considered computational aspects, as system performance (answer time, frames number per second), because the interaction must happen in real time and with precision, requirements of medical applications [10], and human aspects (use facility, comfort with the devices, understanding of the task, task’s execution time).

In this evaluation in particular, two questionnaires were used. The first one was applied before tests, with questions about the level of knowledge about VR (applications, non-conventional equipments, concepts) and experience in the execution of biopsy exams. The second one was applied after sessions of testing, with questions about the understanding of the task made in the VE, level of comfort and satisfaction with each device and each possible combination of devices, composition and behavior of the virtual objects during the interaction.

Both questionnaires had a common question about the use of simulators in medical trainings, aiming at verifying the professional’s opinion when the subject is the use of computers in the health area.

6. RESULTS AND DISCUSSIONS

In relation to the computational evaluation, the applications built with the ViMeT framework presented satisfactory performance, reaching a time that doesn’t affect the interaction, and a satisfactory frames per second (fps) rate (61 fps for mouse, 59 fps for keyboard, from 57 to 61 for dataglove and from 59 to 61 fps for haptic device). It also occurred with the use of non-conventional devices, that require a higher processing and need another software layer to the programming languages integration.

A first prototype was submitted to the evaluation of professionals of the medical area, one professor and eleven students of Medicine of University located at Marília (São Paulo State, Brazil). They tested several applications generated by ViMeT, using all the cited devices, in two evaluation sessions: the first executed only by the professor and the second one including the students.

In a preliminary evaluation, executed by the professor, some questions have arisen, such as: the necessity of a spatial correlation between physical devices and the virtual objects; modifications in the visualization, presented in wireframe mode (without texture, as shown in Figure 6), and the inclusion of different visualization angles of the scene to facilitate the perception of the environment.

Another suggestion was to work without combination of devices in this prototype, using the devices separately, because according to a professor, the virtual hand, fixed on VE, interfered in the visualization. In this case, a position detector could be used to solve the problem, verifying the hand’s movements of the participant of the simulation.

The availability of a more complete object, including parts of abdomen for an application to simulate the breast exam was also required. The figures 9 and 10 show the environment before and after professional’s opinion.

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medical instrument, using the haptic equipment and a common mouse, until the volunteer can reach the virtual human organ and the system detects a collision. Another task consisted in moving the virtual fingers through the keyboard by using specific keys and dataglove, devices used by the user’s hand.

Some volunteers declared they had difficulties during the tests in the execution of the task, in the visualization of VE (concept of depth), adaptation with devices, most of the mouse and haptic equipment.

Moreover, the volunteers presented ideas to allow a correct force feedback could consider the angle of the medical instrument during the penetration, the different layers of the skin, presence of the several tissues, and the point to be drilled.

7. CONCLUSIONS

The interaction module was implemented to provides support to conventional devices (common mouse and keyboard) and non-conventional devices (dataglove and haptic equipment), and after that, incorporated to ViMeT. The generated applications were evaluated by health professionals and a computer professional (volunteers for testing) through training simulations with each device. In this step of the project, questionnaires were used to collect information.

The evaluation under the view of the professionals of the area is important to build and improvement the applications, implementing systems with high degree of realism, because these professionals know the procedures widely and they can provide useful experiences for other people (students of the area, for example), through the simulation of procedures by the computer.

The volunteers had difficulties with all the devices of the module of this prototype, mostly with the mouse and haptic equipment, probably, because of the type of task to be made using these devices, which consisted in manipulating the medical instrument. In terms of the dataglove and keyboard, the task was rotating objects that represented the virtual hand fingers, flexing the real hand fingers with the dataglove or pressing and releasing specific keys of the keyboard.

The criticisms, suggestions and ideas of the volunteers were very important to define ways in the improvement of the ViMeT and the building of other frameworks of this nature or medical applications. The volunteers believe in VR systems to help in the medical training, using in several procedures.

8. REFERENCES


