

A 3D Intelligent Campus to Support Distance Learning

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Abstract—The Intelligent Campus is an extension of control and monitor systems for interactive models. More than a simple 3D model, the Intelligent Campus is an interactive 3D model of a real campus that allows remote access of learning tools developed and available locally for present learning. It increases the set of learning tools and services provided by the institution and do not require re-development of tools. For access control, the Intelligent Campus implements an account mechanism that requires password for specific services and control access for distance learning classes that can occur in the campus. To manage the accesses were included levels of complexity in the virtual model that control the interactive details of an object presented to the user.

Index Terms—Interactive Center, Learning Tools, Virtual Reality.

I. INTRODUCTION

THE technology evolves in a fast way and increases users' expectations related to the computational applications. Students expect flexibility and mobility of the learning environments and more intuitive interaction with the university campus, employees desire an easier access to administrative tools and the society desires better information regarding the university localities, its activities and services. Aware of these necessities, the Intelligent Campus project intends to provide a three-dimensional virtual model of a real university to offer mobility associated to intrinsic services present in the academical context.

In this project, Virtual Reality (VR) is an instrument to the learning process and provides a three-dimensional environment where students can work with the information in a realistic way, what make them an active portion of this environment. This partnership between student and VR environment becomes very valuable in the learning process because it stimulates the students to search for information and

relates it to knowledge previously acquired.

Once the institution is a real and possesses a campus, there are departments, laboratories, classrooms, libraries and other structures whose main purpose is to promote an environment of research, education and extension. Among the limitations imposed by the university structure, there is the distance between buildings and the availability to its services, that can presents access restrictions depending on days and schedules. This way, the research related to the development of an Intelligent Campus would help make remotely available a set of services related to campus facilities.

In this work is presented a conception of a virtual model of a real campus with the details of the development or adaptation of local learning tools and local services for remote access through that virtual model.

II. RELATED PROJECTS

VIRTUAL Reality (VR) has being applied in several areas of sciences for different ends. According to Burdea and Coiffet [1] in 2003 were identified 805 projects involving Virtual Reality. The main areas of these projects are the entertainment, the arts and the education, from a total of 172 projects. Into the arts, the immersion and interactivity provided by VR can transform static art in dynamic art and make possible the exploration of the environment. So, besides VR improve the creation of art it also improves arts consumption, when, for example, through the Internet it makes possible to visit virtual museums [1].

In education, VR offers a significant support to the learning. Using VR systems students visualize abstract concepts, observe events from different points of view and scales (as example: atomic and giant scales), visit environments and interact with events at distance [2]. These types of activities are considered facilitators of the education; therefore they allow that students to get a better domain of the acquired knowledge.

The incentive to learning is also a concern to projects of virtual campus. For Paquette [2], a virtual learning center is where instructive events of learning and resources are created to provide a system for distance learning. In his project, the environment must help students to solve their problems by the availability of texts, e-mails and contribution of other students.

In this context, as well as VR in the arts intends to make dynamic the static models and VR in education intends to provide more interactive ways of learning, VR applications in

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Virtual Campuses intends use both approaches to provide more intuitive communication to user or to allow virtual visits to environments and stimulate the learning by the remote offer of educational tools.

Maher [3] defines virtual campus as a place where students can take classes and achieve meetings. In his idea of a virtual campus the present learning can be improved by the use of online content and interactive distance learning tools. He divides the project of a Virtual Campus in three levels: the level of implementation, the level of representation and the level of the interface. In the level of implementation, decisions are taken to select an implementation environment and to select the technology for the project development. In the representation level are identified components of the Virtual Campus that possess relation with real structures of the physical campus. In the interface level are defined and structured the interaction modes with the places, materials and other people in the virtual world.

For Drury [4], a Virtual Campus project focuses on the construction of a three-dimensional model of the physical structure of the campus based on 2D CAD models. This approach intends to keep the internal and external proportion of buildings and rooms.

Projects related to modeling for navigation/walk were initially used to provide training in flight simulators [5]. Later, they were designed to develop interactive mockups to support research, planning, study of properties and system monitor [4, 5, 6]. These mockups are the based on the Virtual World concept of networked worlds. Each of these worlds is similar to real places and the user can locate structures and navigate through them [3].

Recently, researches related to the design of intelligent buildings have been developed. Although the intelligent buildings concept is not well defined, it is based on control and monitor systems. The intelligence is related to the management of energy, safe automation of spaces, telecommunications and systems [7]. Concerns about the energy consumption are probably one of the key factors for these developments. Davidsson [8], presents in his work about intelligent constructions a system composed by a set of software agents to monitor and control constructions. This system uses lines of force for communication between agents and electric devices of the buildings, as well as sensors and actuators for light, heating and ventilation.

It is possible to observe that intelligent buildings approaches keep their focus on management through monitoring of environments to optimize the use of services, as the energy. The approach of virtual campus focuses on the availability of information through interactive models to improve user's access to educational tools. So, while one approach is related to administrative issues, the other is related to concerns about social access.

III. THE INTELLIGENT CAMPUS PROJECT

WE define Intelligent Campus (IC) as an extension of intelligent building and interactive mockups approaches. The IC integrates in a virtual representation of a real campus a set of administrative, academic and social services. Administrative services include the access and administration of electric and hydraulic nets, management of Internet and control of documents, among others. Academic services are related to the offer of educational tools. The social services include a set of general information to the society, as courses available at the campus, lectures, expositions and the virtual mockup of the campus.

The IC has several extensions that can involve since the simple construction of a service as control of documents until a restricted control of access to the possible users of the campus. In this in case, a specific subsystem for access control will allow the use of this system in the three contexts: administrative, academic and social.

Among several benefits of the development and availability of the IC, it can be highlighted:

- Offer of distance learning by the remote access of classes, lectures and educational tools;
- Offer of general information and services about the institution;
- Maintenance of the real aspects of localization and distribution of knowledge inside the university through the three-dimensional visualization and navigation in a campus mockup;
- Production of a 24-hour-active complex.

IV. SYSTEM ARCHITECTURE

DUE to the fact that the IC is an inclusion project, its structure should be simple and it should offer intuitive navigation. The navigation occurs through a virtual mockup that allows mobility and access to the services available. For remote access to the mockup and to its services, the interface of communication of the Intelligent Campus uses a client-server structure. This way, the user can access a homepage to connect him to an application that establishes a connection with the server through a protocol.

Because different users can access the Intelligent Campus, an access control is used to define user-levels and provide or not access to specific services [9]. In a similar way, levels of complexity are associated to the structures of the mockup. It makes possible to attribute in real-time interactive features to the structures and the user will see an entity only if he possess the corresponding access-level [9]. Through this control, the Intelligent Campus will configure the environment according to the user.

Basically, the Intelligent Campus is composed by: a virtual mockup situated in a Client subsystem; an interface of communication, responsible for the access to the services; and a layer of applications available for users, situated in the Server subsystem (Figure 1). The Client subsystem is responsible for the management and sending of requests for

the Server through the Internet. The Server subsystem is responsible by the translation, processing and reply of the requests [10].

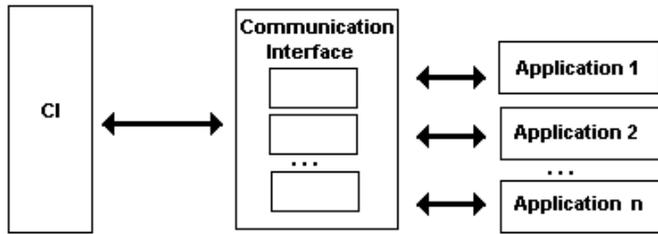


Fig. 1. General architecture of the Intelligent Campus.

V. MODELING

THE virtual environment of the IC is defined a simulation through a graphical representation of pre-defined aspects of the real world. In the modeling, each element of the real environment is considered an entity of the virtual environment. Each entity contains several attributes, but the more interesting are related to the visual qualities of the entity, as its shape, position and material, amongst others.

A. Attributes

For the visualization of environment entities some attributes must be considered in the rendering process. The choice of these attributes can influence the visual quality and a set of well-defined attributes can improve the realism of the final scene.

Basically, the attributes that compose an entity are: the geometric description, the appearance and the behavior. The geometric description is a representation of the shape or geometry of the entity and it is used to obtain entity visualization. The most used way of representation is through the union of polygons, as triangle meshes [11]. The degree of complexity of the geometric description is directly related to the visual quality and inversely related to the rendering performance. However, the visual quality can be obtained by the use of textures applied over the objects surface [12]. Its feature is related to the appearance that can also treats objects color.

The behavior is another interesting attribute in virtual environments, since the objects in these environments can be static or dynamic. Dynamic objects present a set of attributes that change according to events.

B. Hierarchy

Entities in a virtual environment are usually organized according to structural aspects in the real world and this organization reflects the relationship between entities.

One of the ways used to organize the entities of and environment is the hierarchic model. In this model the entities are arranged in structures of the type tree (Figure 2). This feature make easy to understand how isolated structures are used to compound the environment. This way of hierarchy

also allows deriving entities or part of them from other entities.

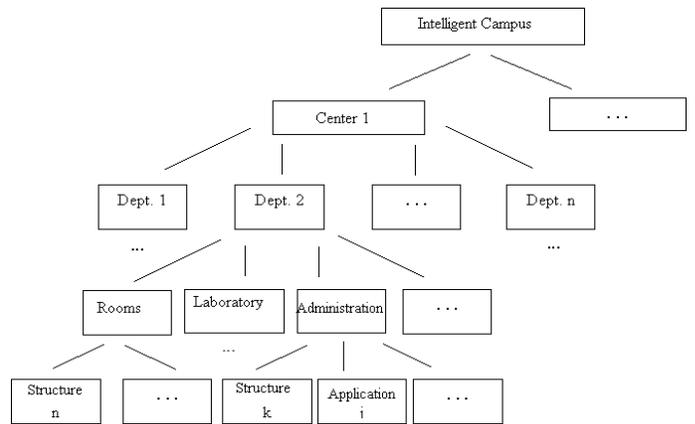


Fig. 2. Hierarchical model of the Campus.

As showed in Figure 2, the Intelligent Campus is described as a heterogeneous tree. The leaves of this tree can be links to applications or basic entities of visualization, as walls, chairs, etc.

VI. COMMUNICATION INTERFACE

THE IC intends to make available the access to applications already present in the university but not designed to access through the Internet. In this context, is only necessary to develop a communication interface between the CI and the local tool to deal with network access.

The communication interface (Figure 3) manages the interaction between the Client subsystem and the Server subsystem. It is responsible to control the access of services and to translate the request for the Server. For example, when the user interacts with the virtual mockup and request a service, the communication interface receives this access, registers it (in a distributed system, services can be requested simultaneously by several users) and translates the order for the Server. The Server executes that request and sends the answer back to the communication Interface to return the result to the correct Client.

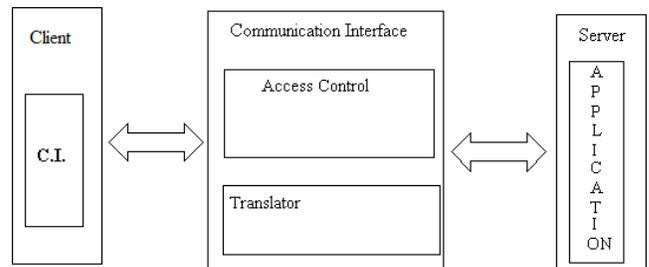


Fig. 3. Communication Interface of the Intelligent Campus.

VII. APPLICATIONS

THE IC allows the link to applications already available at the university and is flexible enough to allow the inclusion of any tool, no matters if the tool was or not developed for remote access (Figure 4). These tools can be gathered according to their subject and linked in the virtual model to the virtual entity that offer them. This feature preserves the relation between subjects and courses, departments or offices present in the institution.

The services offered by these tools or applications can be: access to professors' homepage, information of courses (associated to each department), control of materials in stock, control of processes, information about admission, supervision of electric and hydraulic nets, distance learning classes, educational tools and access to more detailed mockups of a selected entity.

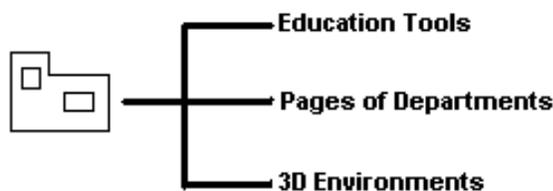


Fig. 4. Example of applications that can be linked to the IC.

VIII. THE INTERACTIVE CENTER

THE Interactive Center is the result of the IC approach applied to develop one administrative center of the Federal University of Paraíba (UFPB). The administrative center chosen to unit chosen was the Center of Exact and Nature Sciences (CCEN). Its development should provide the knowledge necessary for the construction of the complete mockup of the UFPB campus.

Two main areas compose the CCEN:

- Nature Sciences: conglomerates the Biology, Geosciences and Ecology;
- Exact Sciences: conglomerates the Statistics, Physics, Mathematics, Chemistry and Computer Sciences.

Each area of CCEN is subdivided in departments, composed by rooms, laboratories, libraries, secretaries and auditoriums, among other structures. Each department also offers services offered to its members: students, professors, employees or the general community. Examples of these services are: consult of course marks, registration for courses, control of materials (cleaning products, as example), control of processes and announces of apprenticeship opportunities. All these services can be identified in the academic, administrative and social set.

This development was totally based on free software to make it economically viable, allow the diffusion of the project and provide an easy and portable way of insertion for new tools. In this case, the programming of the virtual environment used to choose a model with layers of abstractions to preserve the application portability. For modeling 3D worlds, virtual

reality tools as X3D (Extensible 3D) and VRML (Virtual Reality Modeling Language) can be used. In general way, the tools used to develop the Interactive Center can be divided as:

- Packages for 3D drawing;
- Packages or languages for VR modeling;
- Programming languages to allow the development of interaction and access control.

For the development of the Intelligent Center were used the Linux operating system, the Blender for objects draw and modeling, VRML and X3D for the virtual world construction and the Java programming language to develop the interfaces between the mockups and the applications.

A. Blender

Blender is defined as an open package for three-dimensional modeling, animation, rendering and interactive creation, among other features. It is available in versions for Windows, Linux, Unix and other operating systems. Blender presents an interface that does not obstruct or block the vision of the user during the development. Its options for modeling include design of objects as polygon meshes, surfaces NURBS, Bezier and B-Spline curves. It also provides a tool to import and export some file formats, including the VRML format [13].

B. VRML

The Virtual Reality Modeling Language (VRML) is a language for modeling three-dimensional scenes. One of its main features is related to its support by the Internet browsers. This way, this language can be used to provide 3D environments over the Internet [12].

C. X3D

The Extensible 3D (X3D): is a new standard that defines a system with mechanisms for 3D contents over the Internet. It supports many file codifications and programming languages. Its goal is to provide interoperability for 3D data and flexibility for manipulation, communication and execution of interactive scenes [14]. Beyond modeling and link its code to programming application interfaces (API), this language also allows to modulate the environment and its services to restrict the access. The restrictions can be programmed in user profiles.

D. Java

Java is a free programming language, object-oriented, platform-independent, distributed, concurrent and dynamic. The Java Virtual Machine (JVM) offers the independence of platform and portability of Java. It interprets bytecodes of instructions to execute a program. Concurrent programming through the management of threads, net connection, client-server approach and other features are directly included in a standard API of the language [10].

IX. INTERACTIVE CENTER DEVELOPMENT

THE modeling of the Interactive Center was based on a hierarchical structure of the real center. For example, to modeling one of the corridors of the CCEN (Figure 5) was

built a heterogeneous tree where the corridor is the root. This root is linked to other trees, as rooms, laboratories, bathrooms and the secretary. The same method was used to the sub-trees to reach the basic entities as wall, door, floor, chair, window, beam, etc. These basic entities were shaped with the Blender tool.

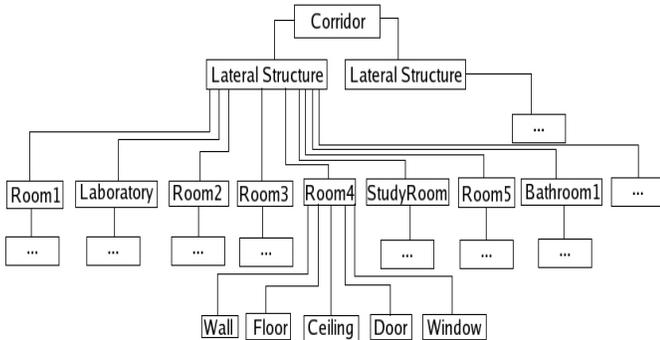


Fig. 5. General model of the hierarchy of a corridor of the CCEN.

The basic entities contain several attributes to describe their geometry, appearance and transformations. The geometric description of these entities of the CCEN is composed for the space definition of points and polygons. For the description of the appearance, the material or texture is specified and associated to the specific entity. The positioning, orientation and size of the entities in the graphical scene use geometric transformations as scale, rotation and translation.

In the tree of the scene, it is necessary to define the space position of basic entities and label them. After that, the basic entity can be instanced several times in the mockup.

The communication between the mockup and the applications was allowed by a Java applet is responsible. So, while browser offers a three-dimensional navigation environment, the applet offers a set of tools that make possible the manipulation of objects of this model through a Client-Server interface. Java also allows the use of libraries necessary to the application. As example, we can mention the JDOM for navigation in X3D structures with the rescue of specific objects [15].

The communication happens when an applet starts its execution in the Client machine. At this moment, user actions are captured and sent to Server to modify the visualized world or to show applications (Figure 6).

Simultaneous access of applications available from the Interactive Center is also controlled. Through multiple tasks (multithreading) support by Java is possible to manage multiple connections and simultaneous tasks. Another relevant question treated by the communication interface is the restriction of accesses. It depends on the user level (student, professor, employee or visitor) that requires the access. This level determines the scale of access to the applications. To manage these accesses were included levels of complexity to objects to restrict the presentation of dynamic features of the objects (links, as example).

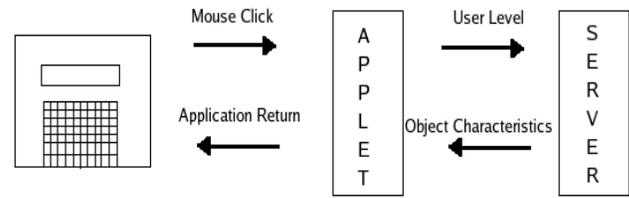


Fig. 6. Communication protocol of the Interactive Center.

The control of access and level of details make distance-learning classes available only for registered students, but can also offer selected lessons and presentations according to the user stage.

X. RESULTS

THE modeling of the Interactive Center already is concluded for three departments, vegetal structures (trees and bushes) and includes links to department homepages, laboratories and educational tools. The modeling could not be performed from CAD models due their complexity and elevated number of points to describe each structure. But the CAD models were used to identify proportions and localization of the structures in the 3D space.

So, the basic entities as wall, floor, ceiling, door and windows were defined, as well as several textures. The three first entities (wall, floor and ceiling) do not have variations. However, the door and window entities have several styles and were separated in more refined objects. The Figure 7 describes the hierarchic used to construction a room.

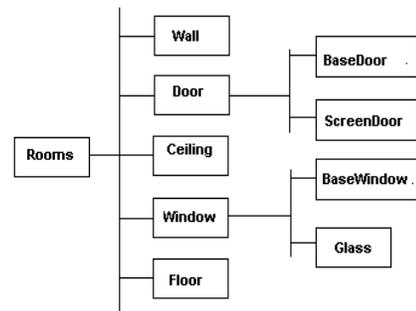


Fig. 7. Basic structures of a room from the Interactive Center.

Currently, the Interactive Center offers navigation through three departments (Figure 8), access to homepages, access to other 3D environments and access to a distance-learning tool to teach Statistics [16]. Figure 9 presents entities programmed to activate applications in the Interactive Center.

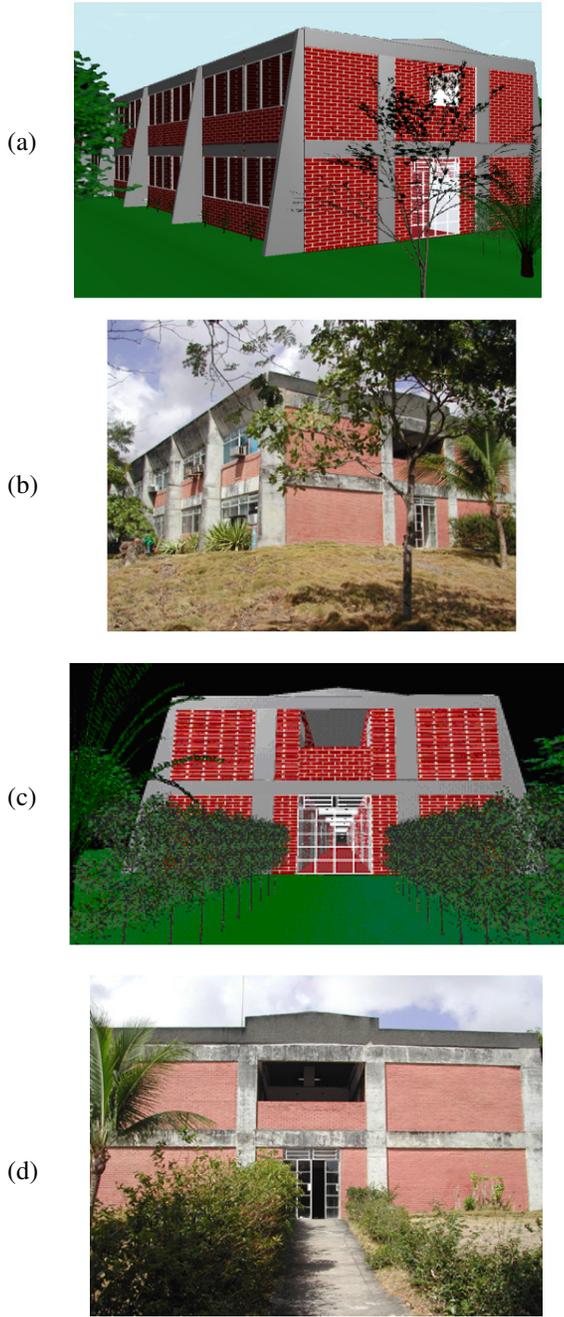


Fig. 8. Views of a building from CCEN. The images present the virtual (a,c) and the real (b,d) building.

The access to webPages occurs due to the use three nodes in the mockup: the call to start an action, the homepage address and the connection between the two previous nodes. The access to other virtual worlds occurs by the use of a anchor node. This node is responsible by the association of one geometrical entity to a new virtual world referenced through this entity. The access to education tools occurs by an applet to connect and provide remote access to the application.

Besides the entities modeled for the construction of the

virtual model, the area also contains vegetation as trees and brushes. To represents it are used textures applied over entities. These transparencies are images with transparent background, as observed in Figure 10. One interesting property attached in the vegetal entities is their direction calibrated by the user point of view, what preserves the idea of tridimensionality of the virtual world.

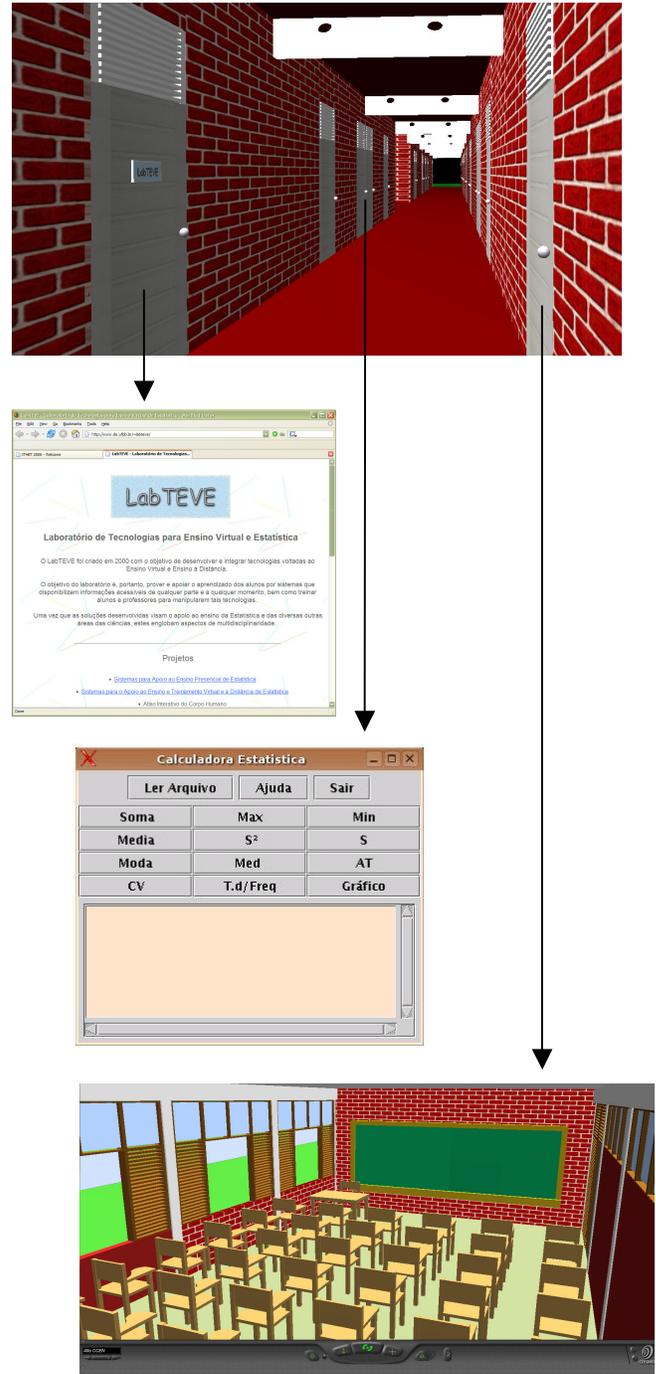


Fig. 9. Example of applications available through navigation in the Interactive Center: (a) laboratory homepage, (b) educational tool Statistics Calculator and (c) 3D virtual environments.



Fig. 10. Image with the texture of one tree with transparent background.

Figure 11 presents a interior view of the Intelligent Center. The Interactive Center can be accessed from a browser with a VRML/X3D plug-in installed.

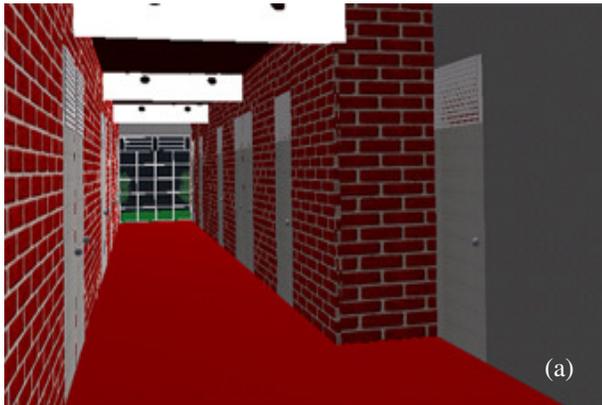


Fig. 11. View of the internal building of a department from CCEN. Image (a) was extracted from the virtual model and (b) image shows the real view.

XI. CONCLUSION

This work presented the Intelligent Campus, a VR environment that integrates in a virtual mockup services available in a university campus. As advantages of this system can be mentioned the remote access to a variety of services and educational tools, the representation of real structures in a 3D model that favors localization of services and preserves the administrative organization of the university, and the availability of an active complex opened 24 hours a day. For that, was implemented a control access for users and an interface to allow the use of previous educational application not designed for remote access besides. The Intelligent Campus also provides an easy way to insert/link other elements.

As first results was presented the implementation of the Interactive Center. At this moment the Interactive Center allows the user to explore its physical structures and have access to applications associated to its different entities as webpages, three-dimensional environments and educational. The experience obtained with this implementation should be used as basis for the complete implementation of the Intelligent Campus.

It is intended with this project, to provide a complete methodology for the modeling of intelligent buildings to expand its use for other applications.

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