

# On the use of a palm computer for design review interaction in a virtual room

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## Abstract

Increasingly often the use of photorealistic models for design review processes involves the setup of special rooms, fully dedicated to visualize digital models onto large display, the so called CADwall. In this scenario an effective interaction with virtual prototypes is a basic need, but it is almost always based on traditional input devices, such as mouse and keyboard. The design review process is usually led by a chief designer, but the use of traditional interaction tools requires an additional operator. This operator is guided by the chief designer through vocal inputs in a slow, misleading and inefficient way.

In this paper we propose a solution based on a handheld device and an inertial sensor node, with a graphic interface that allows a direct interaction with 3-D digital models inside virtual rooms with large displays.

## Keywords

CADwall; virtual room; interaction; handheld device; inertial sensor node; large display; design review

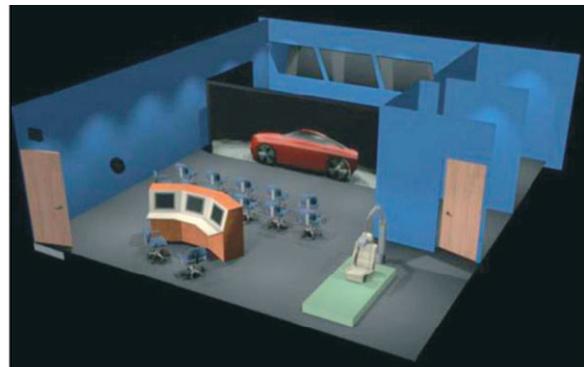
## 1. INTRODUCTION

3-D digital models are used in every step of the industrial design product development process. Digital models are used as virtual prototypes for anticipating and evaluating product features, as well as aesthetic appearance. For this reason, in the last few years, in the industrial context, several “virtual theatres” have been built for design review activities. These theatres are wide rooms equipped with projection-based large display, additional devices for stereoscopic visualization of digital models and several seats, so that many people can attend screening at the same time. Projectors are connected to one or more workstations, according to the requested rendering quality, equipped with software dedicated to photorealistic visualization of 3-D digital models. Usually, workstation controls are placed far away from the screen, behind audience seats.

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For this reason the work session needs an additional qualified technician to perform interaction tasks with the digital scene as the review activities leader may ask for, from his/her location near the display device. A visualization software is designed, usually, to be controlled by “traditional” input devices, namely mouse and keyboard, while advanced interaction devices, such as 3-D mice or data gloves used in virtual reality environments, are not yet commonly supported. The main reason is that mouse and keyboard represent the standard computer interface in every working area and users are already trained in their use.



**Figure 1. A typical virtual room configuration**

Moreover, the software is not used for virtual environments visualization, which requires high

immersion feeling and accurate manipulation devices. On the contrary it is used during design reviews in industrial environment, where these features are less important.

There is another fact that hinders the introduction of virtual environment interaction techniques: the design review activity itself. Design reviews involve a number of people who need to walk freely in front of the screen to interact with the digital model; at the same time, they need not to be isolated from the context and from other people because they have to exchange opinions and advices, being certain they are sharing the same vision of the scene. It is easy to observe that introducing a continuous tracking systems in this environment is very hard: tracking just one person would mean that everyone has to observe the scene from a point of view that moves according to someone else's displacement and position; on the other side, tracking every single person in the room would be possible only with individual display devices, such as HMD, that would isolate people involved in the design review. Mixed-reality techniques are neither very effective in this context, because they need cumbersome devices, such as see-through displays or "head-mounted" cameras, that would trouble the review activity or, at least, would move the attention from the real work focus. To these technical problems we must add that most of the chief designers are reticent in adopting systems too "technology-oriented" because they think these devices are exceptionally complex and difficult to use.

These considerations are true especially when the design review is focused on aesthetic evaluation of the product shape. A survey of the main Italian industrial design companies with a private virtual room, carried out at Politecnico of Milan, showed that design reviews can be very different depending on the product process step and that mainly two different types of design reviews can be observed. There is a first type of design review focused mainly on technical aspects, which main goal is to define product features: it involves, as general rule, only the project team so that all the users share almost the same know-how.

The second type of review is quite different; it resembles mostly to a product presentation and aims to present the product outside the project team. People attending the presentation can be members of the same company of the project team as well as external buyers, but this means, in any case, that users' skill and know-how are very different. These reviews are mainly focused on aesthetic and functional aspects of products and are led from chief designer, the person who coordinated every step of product design process. The survey showed also that, during this second type of review, the need of focusing on different model details involves a

continuous dialogue between the chief designer near the screen and the hidden operator far away from him; thus troubles the review activity and makes it less effective.

## 2. RELATED WORKS

Interest in finding new paradigms for virtual environments interaction has highly increased in the last few years. Specifically, two topics are catching researches' attention: multi-user interaction and multi-modal interaction.

Bierz [Bie07] offers an interesting overview of the current state of interaction technologies and metaphors for large displays.

Bourdot and Touraine [BT02] present a polyvalent display approach, which allows the system to determine the desired focus and the moving intention of the user for virtual navigations.

Kim and Fellner [KF04] as well as Corradini [Cor02] propose gesture recognition based systems, while Ciger et al. [CGVT03] suggest a combination of gesture and speech interaction.

A topic highly connected with multi user interaction is wireless communication systems applicability, see Green et al. [GSVS05], as well as handled or portable device use, see Kukimoto [Kuk05].

## 3. PROJECT GUIDELINES

The described project aims to build a device that can be used by chief designers for direct interaction with 3D models during design reviews in virtual rooms with large display.

The target user is represented by a chief designer, the project leader who guides the project team and coordinates all the product design stages. His knowledge of industrial product design processes is very good, but usually he is not trained in 3-D digital models creation and manipulation technologies.

The main goal is to allow the chief designer to interact with the virtual scene and to complete some basic tasks without the need of interacting with the operator.

For this reason, the device must have a very user-friendly interface, to allow every user to master it in a very short time and without special training. In addition, the device has to be small and lightweight, to be handled easily and not to disturb interaction with other people during review activity, and it must have a wireless connection so that the user can walk freely in the room.

The proposed system is composed by a pocket PC with a graphic interface that transmits information to the workstation and an accelerometer fixed to the pocket PC measures its position and sends it back to the virtual room workstation.

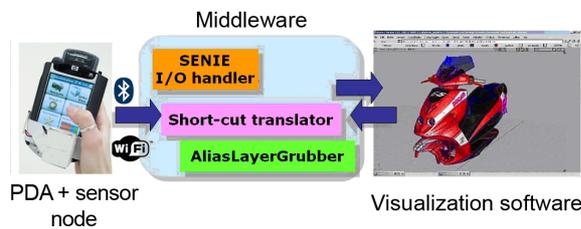
Project components have been developed at the same

time by Micrel Lab at DEIS Department at University of Bologna and at Virtual Prototyping Lab at Politecnico of Milan.

The DEIS research team designed the software for data transmission and exchange, and tested the connections between wireless devices and workstation, while Virtual Prototyping Lab team defined the general features of the system and developed the graphic user interface implemented onto the pocket PC.

#### 4. GENERAL SYSTEM DESCRIPTION

The general architecture (Figure 2) can be divided in three main components: (i) the input system, which is composed by the combination of a handheld device and a wireless accelerometer node and the software running on both, (ii) the middleware, (iii) the visualization software both for workstation and CADwall.



**Figure 2. System components**

The input system enables the use of graphical short cuts, displayed on the handheld device, namely a PDA, and of tilt based gestures to control the visualization environments. Data streams from wireless devices are received from the middleware, which acts as an intermediate software layer in charge of acquiring and converting data from the handheld device and accelerometer in controls for the visualization software.

The middleware handles the input device, transparently from the visualization software, by mapping input controls in mouse and keyboard controls. This solution is very effective, because it is platform independent and can be implemented on different systems by setting middleware preferences. Moreover, the user can ignore how the specific visualization software works: he/she just needs to select the task to perform on the digital scene.

#### 5. INPUT SYSTEM

##### Input Devices

Pocket PC has been chosen mainly because of its capability of exchanging information with the workstation, thanks to integrated data transmission protocols and high operating system compatibility. Moreover, it has a wide touch screen, it is a small device, lightweight, easy to use, available at a low

price and fairly popular, so that it may result a familiar device.

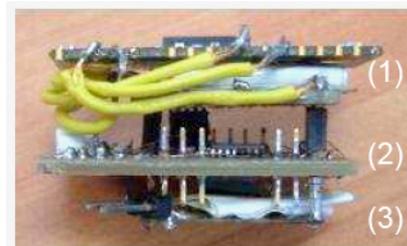
The model used in this project is the Hewlett-Packard *iPaq h5550* with Microsoft Windows CE 2003 SE, equipped with WiFi card, for connection to wireless LAN networks, and Bluetooth interface. It has a VGA resolution display, storage and processing resources. Moreover, the operative system supports *Microsoft.NET Compact Framework 2.0*, which supports the libraries we developed.

The sensor node used for extending pocket PC input is called *WiMoCa Sensing Node* and has been developed by Micrel Lab at DEIS Department, as a building block of a wireless sensor network, mainly used for gesture recognition and body movement tracking [FPBABR05].



**Figure 3. PDA with sensor node**

The WiMoCa node is extremely flexible, thanks to its modular architecture to ease fast replacement and update of each functional layer. The main layers of the node are the power supply layer, the microcontroller and sensor layer and the wireless transmission layer. This node has very small size and weight, it is wearable, it has low cost and very limited power consumption.



**Figure 4. WiMoCa Sensing Node structure: (1) Communication – Bluetooth transceiver; (2) MSC/Sensors – ATmega8 & Triaxial Accelerometer; (3) Power Supply**

The main hardware components are ATmega8 AVR RISC architecture, an 8 bit microcontroller with low-cost and low-power features. It has a tri-axial digital MEMS accelerometer, used in this work as inclinometer, thanks to its ability to capture the

gravity acceleration. The communication layer is based on a Bluetooth 2.0 transceiver that operates at 2.4 GHz and supports Serial Port Profile (SPP).

### Graphic Interface and Software

The graphic interface implemented onto the pocket PC has been designed specifically for this project by researchers at Politecnico di Milan.

The interface contains selected features that could be useful during design review activities. Features choice has been managed by the already mentioned survey of virtual rooms in industrial environment. Chief designers have suggested features of common use during design reviews, pointing out those tasks that create greater problems in obtaining the right interpretation by the operator at the workstation. These features include mainly digital camera controls for navigation tasks, visualization controls and selection commands; they have been collected in homogeneous groups, to give a better organization to the interface. Keys are designed so that they can be selected by touching the screen with fingers, not only with the PDA stylus, but this means that the display size does not permit to place all the keys in just one window. Considering both screen size and average finger size, the maximum number of keys that can be displayed at one time is of about six or eight. Thus, the interface presents to the user a main page with keys recalling submenu pages. Key position on different pages remains the same and it is planned to easily remembering where a specific key is on the display, speeding navigation inside the graphic interface. A “BACK” key on the bottom of every submenu page brings back the main window.

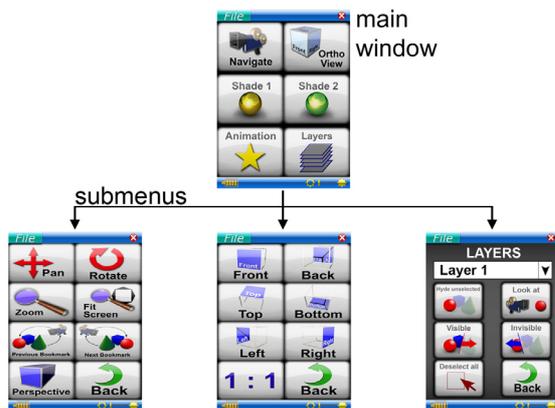


Figure 5. Submenus organization of graphic interface

Icons have been designed referring to a popular graphic symbolic system diffused in almost every software with graphic interface and their look is designed according to basic usability rules; features related to keys are immediately recognizable thanks to both graphic and written feedback. Colours used are bright, with high contrast between background

and icons, so that the keys can be seen and recognized even in the dark of the theatre and wearing shutter glasses for active stereoscopic vision, that absorb a high light percentage. Anyway, display brightness can be easily adjusted to fit lighting conditions and user’s need.

The sensor node is fastened to the pocket PC, to have the best lever length, and it is enabled by selection on the PDA interface. Accelerometer detects pocket PC pitch when it is rotated by user. Translations on horizontal plane have not been taken into account because they are strongly affected by scale factor due to the human component, which is not predictable and cannot be modified in an interactive way.

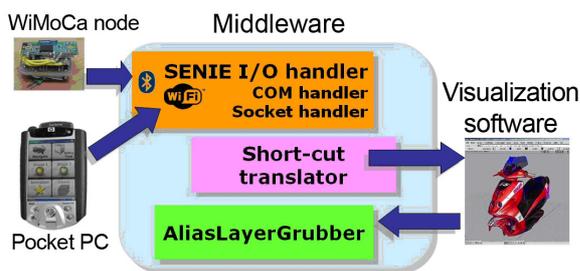
On the contrary, wrist rotation in left-right and up-down directions is a natural movement that can be performed without specific training, therefore the system has been designed taking advantage from these movements. Horizontal mouse pointer shifting has been connected to left-right wrist rotation, while vertical shifting has been connected to up-down wrist rotation. Thus, user can see the mouse pointer moving on the large screen according to a simple movement of his hand.

The graphic interface is handled by a C# application running on the palmtop computer, responsible for capturing the event of touching a key and running the correspondent thread for dispatching the control request to the visualization software. Therefore, the application on the palmtop computer (i) captures events generated by the graphic interface; (ii) translate them into a code corresponding to a control command; (iii) access to the TCP/IP channel to send via socket the request to the middleware running on the visualization platform.

### 6. MIDDLEWARE AND VISUALIZATION SOFTWARE

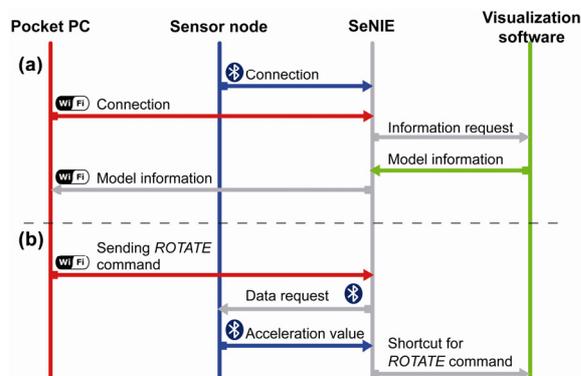
The middleware running on the workstation is mainly used for three aims. First, we exploited SENIE libraries to handle the I/O streaming of data both coming from the pocket PC and the inertial node. SENIE is a Java-based set of libraries and a visual environment to handle use of heterogeneous input/output platforms and devices and their use for various applications. It is also an environment to easily handle debugging and testing of new applications. In this work we exploited mainly SENIE I/O interfacing features, using the libraries specifically dedicated to handle the COM port and a socket communication. In the first case SENIE connects automatically to the Bluetooth device and extracts the payload from the data received, that are the accelerometer values. The socket connection is used to connect to the pocket PC, to extract controls coming from the graphic interface.

SENIE enables the implementation of new plug-ins to handle the interface with external application. For the visualization of the 3D models we used AliasStudio v.13.0.2 by Autodesk, state of the art software for industrial design. AliasStudio offers an advanced support for real-time rendering of 3D models, therefore enabling its use during presentation in virtual theaters. We chose AliasStudio for its wide use in companies with internal design reviews virtual room and for the support this tool gives to develop additional features to its work environment. Indeed, the license of AliasStudio includes the access to the programming API, that are the libraries that we used to implement our own application to interface the input devices with AliasStudio functionalities.



**Figure 6. Connection between system components**

Therefore, we designed and implemented two components: the short-cut translator and the *AliasLayerGrubber*. The first one is responsible of receiving the tilt derived from the accelerometer data and/or the controls coming from the pocket PC graphical interface and to translate them in short-cuts, that is combination of keys, understandable by the visualization software, as we will explain in the following paragraph. The *AliasLayerGrubber* is a plug-in that provides access to the 3D model layers. In particular, he reads a proprietary Alias file format (which extension is .WIRE) and translates information in an XML file. This plug-in, in practice, enables the selection of the different layers of the model by the pocket PC, providing access also to the features linked to each layers (e.g. it is this plug-in that enables the selection of the details of a model).



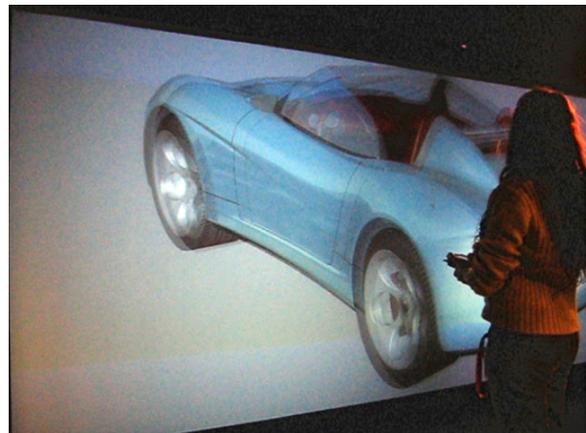
**Figure 7. Data stream during (a) the connection procedure and (b) a command activation**

We exploited, in particular, the powerful possibilities offered by the graphical interface of this tool. Because all the menu items can be mapped in keyboard short-cuts, by translating control commands coming from our input devices in short-cuts we provided access to all the features we displayed on the pocket PC.

Figure 6 shows the connection between the building blocks of the system. Figure 7 shows the direction of data flows among the pocket PC, the sensor node, the middleware (SENIE) and the visualization software.

## 7. USABILITY TEST

A first test of the system is now in progress at Virtual Prototyping Lab of Politecnico di Milano. The test is performed with a usability form filled in by groups of users after using the device in a design review simulation. Users have been parted in three different groups, according to their 3-D models skills, to have different feedback steps for a better understanding of the interface usability. A first group of users is composed by virtual room technicians, skilled in 3-D digital models creation, experienced in virtual scene interaction and with advanced product design process experience. A second group is made up of users with minor skills in product design process but experienced in 3-D models creation and interaction. The third group, on the contrary, is composed by target users that are highly skilled in industrial product processes but do not have experience in virtual scene interaction.

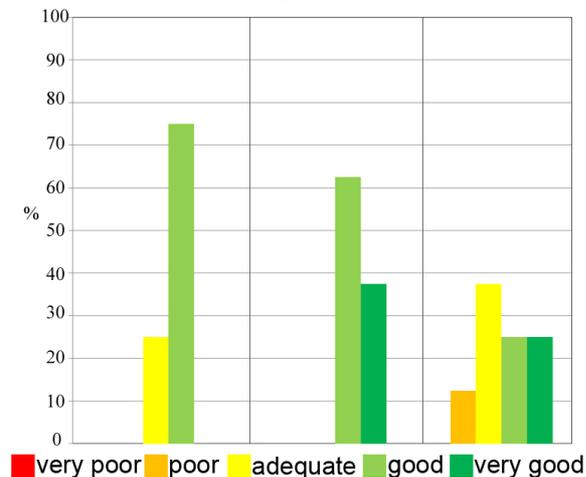


**Figure 8. Test in the INDACO virtual room at Politecnico di Milano**

The form aims to understand completeness of features implemented and usability of both the single feature and the whole interface. It is divided in two sections: the first part is focused on the graphic interface evaluation and includes questions about feature usability and interface look, while the second part is focused on usability of camera control commands.

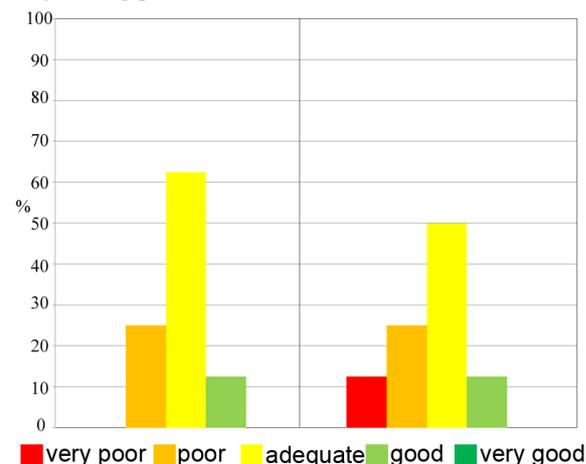
Preliminary tests have been carried out with virtual room technicians, corresponding with the first group of users already described. The test provided a first hint about device usability, and it was performed in an advanced device development stage.

The interface implemented on the pocket PC gained a generally high appraisal both for completeness of features and usability (Figure 9).



**Figure 9. Some diagrams from usability test about: (i) interface look; ii) features identification; iii) interface usability**

With regards to navigation tasks, on the contrary (Figure 10), users report some difficulties on using the device, mainly due to high feedback speed of sensor node, which causes the perception of having scarce control of the digital scene. To this, it must be added that appraisal is very different for every single function. Rotating tasks are generally considered easier to understand and perform than other navigation tasks, while zoom and pan commands involve a less natural movement and are harder to accomplish. By the way, the feedback speed is an easy tuning parameter.



**Figure 10. Some diagrams from usability test about: (i) navigation tasks; ii) self-training time**

## 8. CONSIDERATIONS AND FUTURE WORKS

The system designed and implemented is made by state of art technology building blocks. The novelty can be identified in the integration of the building blocks in an effective and working prototype where a great attention has been focused on providing an *ad hoc* solution for the particular needs of the target scenario. In this direction most of the effort has been dedicated to study an effective graphical interface, easy to learn and of immediate use, in covering exhaustively the features used in typical presentations, and in providing mobility and involving interaction method by the use of a mobile device and tilt-based gestures.

During industrial virtual room survey, managers demonstrated high interest in having a direct input device for design reviews. Moreover, a first set of usability test shows that appraisal for the device interaction approach is very high, therefore we decided to improve the device and go on with a second development step.

Problems raised by users during device tests suggest to differentiate the sensor node set-up for navigation tasks, to have the best response for every command. Anyway, users' opinion suggests that the main focus for device improvement is to slow down sensor node feedback speed, to grant higher control of the digital scene.

Once set the second prototype, a new testing step will be performed, involving also the others two groups of less skilled users.

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