

## Augmented Reality In-Situation Menu of 3D Models

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### Abstract

We present a design and implementation of an in-situation menu system for loading and visualizing 3D models in the physical world context. The menu system uses 3D objects as menu items, and is directly placed within the context of the augmented environment, to support visualizing and placing 3D models into the augmented world. The menu system employs a collection of techniques for the placement of 3D models in one of three relative coordinate systems: head, body, and world. The in-situ menu also serves as a 3D model selection/placement tool and a collaborative feature between an outdoor AR user and a desktop user. The insitu menu system extends the current Tinmith menu and modeling system.

### 1. Introduction

This paper presents an in-situation menu system that leverages the first person perspective nature of outdoor augmented reality (AR) systems. The menu system employs a collection of techniques tailored to different relative coordinate systems for the support of different tasks. The *head relative technique* allows the user to select a 3D model, visualize the model in context of the environment, and perform translation operations to place the object in the correct position. The *body relative technique* enables the user to quickly select and drop 3D models at the user's feet or at a relative offset from the user. The *world relative technique* allows the user to preview and place 3D models at a specified location.

Augmented reality systems provide an interactive medium through which the real-world environment is supplemented with virtual information. Tinmith is an outdoor mobile AR wearable computer system, in the form of a belt mounted computing system, video see through head-mounted display (HMD) helmet, and a pinch gloves input device [1]. Tinmith supports a

range of innovative 3D modeling techniques, including construction of 3D geometry using carving planes [2] and constructive solid geometry with boolean operators for creating complex 3D objects [3].

Pinch gloves are the main input devices for Tinmith, with fiducial markers placed on the thumbs for the control of two cursors. Tinmith hand cursors are detected if the user brings the markers into view of the video camera, located on top of the HMD helmet. The conductive pads on the fingers and palms of the pinch gloves are used for menu command execution. The command menu system is located on both left and right lower corners of the display with 10 options available at any time, each of which is mapped directly to the fingers on the corresponding pinch glove. By pressing the fingers against the thumb or pressing the thumb against the palm of the glove, the user can execute the command on the corresponding menu. This interface design allows the user to execute commands without moving their hands into or away from the camera [4].

Our research presents an innovative menu system for the visualization, comparison, selection, and placement of 3D objects in an outdoor, real world context. Instead of textual or iconic representation our menu system uses the 3D models themselves as menu items. The 3D models menu itself is placed within the context of the augmented reality environment, thus the name of the in-situation (in-situ) menu. The menu facilitates the placement of 3D models in either a world relative, body or head relative mode, to support the task at hand. The in-situ menu also serves as an interactive 3D model selection tool, with which outdoor AR user can choose to load various 3D models into the augmented world. There is a collaborative feature with our menu system between an outdoor AR user and an indoor desktop user.

This paper starts with an overview of related work on menu systems for AR and VR. The concept of in-situ menu is then presented, with the options of a world relative, body relative, and head relative menu.

Finally, a set future research directions on the concept and some concluding remarks are given.

## 2. Related work

Command execution has mainly been the main interest of research into menu system in AR. One of the most common approaches is based on the conventional pull-down menu in a desktop 2D environment. Blaskó & Feiner's work on a menu interface for wearable computing [5] implements a pull-down menu system using a touchpad as the input device. By gliding the finger along the horizontal lower edge or predefined vertical strips of a touchpad, the user can tap to select the required command in a hierarchical pull-down representation.

The Personal Interaction Panel in the Studierstube AR project [6,7] uses a pen-and-pad technique for executing object manipulation commands. The hand-held panel is augmented with various controlling widgets like sliders, buttons and even miniature versions of 3D objects, to support a range of system commands and object manipulation tasks.

The Bowman and Wingrave's TULIP menu system [8] exploits pinch glove to associate each menu item with a finger on the glove. Thus, by pinching the appropriate finger, the corresponding menu item is executed, in a similar fashion to the current menu system in Tinmith.

Circular menus are a compact visualization of menu items in a virtual environment. The HoloSketch VR 3D geometry creation and manipulation tool implements a 3D pie menu with concentric menu items that can be activated with a wand – the system's 3D input device [9]. Liang & Green [10] presents the JDCAD 3D modeling system that uses a spherical and ring menu for object selection. The idea is further evaluated and developed by Gerber and Bechmann [11,12] into a hierarchical spin menu as a context menu in a VR environment.

## 3. In-Situ Menu for 3D Models

Our menu system is innovative in the use of 3D models, either full-size or scaled-down versions, as menu items, and the menu itself is placed within the context of the AR environment. This insitu feature supports visualization and placement of 3D models into the augmented world. The previously mentioned AR/VR menu implementations have their own limitations. Some menu systems [5,6,7] use non-preferred input devices, i.e. touchpad and pen-and-pad

that occupy the user's hands. All of the abovementioned menu systems require the user to shift their attention off the current task to focus on using the menu. Most of the menu systems are exploited only for command executions.

Our menu system is activated via the pinch glove menu in Tinmith. This in-situ menu system is optimized for the task of placing virtual 3D objects in context of existing physical and virtual ones. This section will describe the overall concept of the menu system, and go on to explain each of the three techniques of the system: world relative, head relative, and body relative.

### 3.1. Overall menu concept

The in-situ menu is created in the form of a linear line of 3D models, whose object placement position is either world relative, body relative or head relative, based on a similar concept of augmented reality working plane [13]. Models are loaded from files stored in a specific folder on the wearable computing system. The contents of the folder can be dynamically updated by a desktop user, via a wireless connection. The user steps through different models by pressing the *Next* or *Previous* options in the pinch glove menu, which moves the line of models to either the left or the right, see Figure 1. The models from the in-situ menu are placed into the world by pressing *Create Model*. The user may choose to commit or delete all the placed models into the world by pressing *Ok* or *Cancel*.

Our in-situ menu system assists in visualizing 3D models in an outdoor AR environment. Instead of being part of the user interface, the in-situ menu is situated within the augmented world. Thus by loading the menu, the user is able to see 3D models with the context of surroundings. . The act of scrolling through the 3D model items provides the visualization of prospective virtual object placement. We decided to adopt a linear menu instead of the circular menu as with other systems, as this does not limit the number of models presented to the user. Figure 1 depicts a user using in-situ menu to consider placement of cars in front of a real world house, viewed from a distant point. The horizontal line of four different colored cars (grey, blue, red, and yellow), a street lamp, and a tree are items of the menu. Noticed how the menu blends naturally into the landscape, thus enhancing user's ability to visualize prospective models placement.

The in-situ menu system may be used as a collaborative tool between the AR mobile user and a

desktop user. Tinmith currently supports the construction of 3D objects on the spot. However compared to a desktop user, the mobile AR user does not have access to the same powerful 3D creating tools for complex objects. On the other hand, the desktop user is unable to visualize virtual models in real-world outdoor setting. Thus, collaboration between the desktop user, who creates complex virtual objects, and the outdoor AR user, who places the virtual object in the real world, outdoor settings, is greatly beneficial. This indoor/outdoor collaboration is similar to the God-like techniques [14]. Currently Tinmith only allows a set number of pre-defined models, and new models cannot be added while the system is running [1]. Because the directory containing model files is scanned each time the in-situ menu is loaded, the number and type of models can be dynamically changed by remotely updating the contents of the designated directory between executions of the in-situ menu, through a wireless connection. A desktop user creates complex 3D models and transfers the model files across to the mobile AR mobile user, who helps to visualize the virtual models in the real world environment. The application of this feature is useful in areas such as building construction, civil engineering and planning. The in-situ menu is used to choose which models to place into the augmented world. Based on the method of placement of models, the in-situ menu provides three options: world, body, or head relative.



**Figure 1. World relative in-situ menu for placing car models.**

### 3.2. World relative AR In-situ menu

The use of world relative AR in-situ menu contains three steps. First, the user specifies a location for

model placement and viewing. Second, the user will walk to a vantage point to allow them the proper context of the 3D model. Then, the user cycles through and views the different models before making a selection.



**Figure 2. World relative in-situ menu with cars and soldiers**

The first phase is commenced by the user activating the World relative object placement mode. The user then walks to a desired location in the physical world, and selects the *World Relative* command. Once the user completes the first phase, the world relative option will create a linear line of 3D models on the ground plane, starting from the user's current position, extending to the right of the user. Figure 2 shows a world relative menu with soldiers and cars, lining up in front of a real building. The user creates the menu while standing on the pavement. The figure depicts user's view sideways along the menu from a distant point. Having the menu placed relative to the ground, the user can walk around and view 3D models from various viewpoints in the physical world. Pressing *Next* or *Previous* moves the line of models to either the left or the right; thus the user can move the appropriate model into the required position in the world. Upon choosing the suitable model, the user employs the *Create Model* menu option to place 3D models in the augmented world. Placement of a model detaches them from the menu, but retains their position and orientation to the real world, as was depicted from the viewing menu. Once detached, models are no longer affected by the menu commands.

World relative option is optimal for tasks in which a high level of visualization at specified location is required. The user is able to examine models closely in details and from various viewpoints, thanks to the full-size construction of models and the convenient

distance they are located apart. Moreover, having a fixed position, this option also supports broad vision, in which user looks at the menu from a distant vantage point, and considers the models within a larger surroundings. Comparison with existing physical objects geo-reference near the specified location of the models could also be made.

World relative in-situ menu places models on the ground plane, in the exact location the user would like the chosen model to be placed; thus allowing the user to view models in their natural placement simply by loading the in-situ menu. The user only commits the placement of models by choosing to retain specific models; all the other ones will disappear upon menu deactivation. By placing models in a line, close to one another, this option of in-situ menu assists the user in comparing between 3D models.

### 3.3. Head relative AR In-situ menu

The second option for the in-situ menu is the head relative technique, which constructs a line of full-size models 10 metres in front of the user and bound to the ground. This line of objects is attached to the user's head orientation; thus the menu is always located in front of the user, wherever they are in the augmented world. The head relative in-situ menu allows the user to move the menu into the required position by turning their head and/or physically moving. These features help to represent 3D models naturally in the context of the environment, before committing their placement into the augmented world. Placement and alignment of the models from the menu into the world is performed using a head relative coordinate system, thus the name of this option.

Because the menu is attached to the user's head orientation, the user can only view the models from one perspective. This technique is not suitable for tasks that require visualization from a number of viewpoints before committing, which the world relative option is designed for. However, since the location of the menu is flexible, this menu option is recommended for tasks that involve the consideration and visualization of 3D models in various locations. The example in Figure 3 depicts a user trying to determine whether to place a tree or a street lamp in front of a house or next to a row of cars parked on the street.



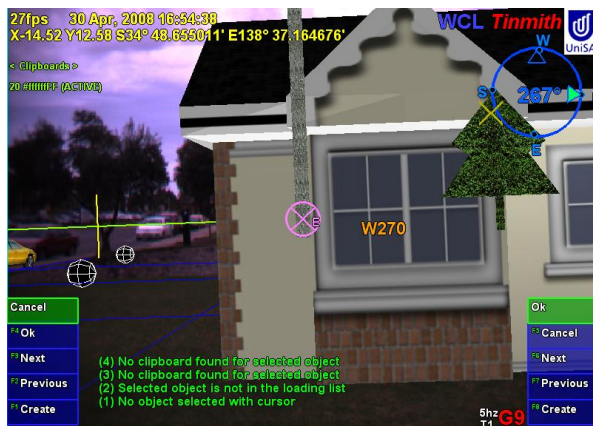
**Figure 3. Using head relative menu for placement of objects**

The in-situ menu is able to manage the viewing of a large number of 3D models. The position of the head relative menu is easily controlled by walking or turning the head. Browsing through the menu only involves the pressing the menu commands, Next or Previous, which can be performed effortlessly without requiring the thumb markers on the gloves to be in view of the head-mounted camera. The 3D models may be selected in one of two methods, with the cursor controlled by pinch gloves or with the head relative eye cursor. The pinch gloves allow the user to select any of the visible 3D models, but the eye cursor can only select the central 3D menu item. A benefit for the use of the eye cursor is the thumb markers of the pinch gloves do not have to be in the view of the HMD mounted camera. The whole process of loading the menu, browsing, and selecting models can be completed with the user's hands comfortably at their side. This approach is similar to that of the Look-at menu, which is considered an intuitive use of gestures in an augmented environment [15].

The head relative in-situ menu may be used as an interactive 3D models selection tool. The models loaded in the menu should belong to the same category or represent similar choices of 3D objects. The user activates the in-situ menu, browses, and compares different models to choose the appropriate models to be retained. The chosen model is translated to move from the menu into the augmented world. Before this feature is implemented, Timmith only supports placement a predefined set of models from the menu, with various drawbacks: only textual representation is supported, and the user cannot see the models in the context of the environment before committing the placement.

### 3.4. Body relative AR In-situ menu

The body relative menu allows the user to drop 3D models quickly from the selection of options, at or a relative offset to the current position of the user (employing a coordinate system that is relative to the body). The body relative in-situ menu creates miniature versions of all models and places them on a linear line in an AR working plane floating at eye height in front of the user. The menu itself is presented as head relative 3D objects. So as the user moves their head, the menu is always visible. The user browses through the list with the menu options of Next and Previous, which moves the line of models to the left or right of the user. If the user is interested in a particular model, the Create command allows the user to construct a full-size model at or a relative offset to the current position of the user by using the cursor to select from the floating line of models. The orientation of the model is aligned with the direction the user is facing. The menu options of Ok or Cancel let the user either commit into the augmented world or delete all the previously created models in the same execution.



**Figure 4. Using body relative menu for landscape populating.**

As previously mentioned, the models in this menu are scaled down versions, thus decreasing the level of visualization. Nevertheless, being the most unobtrusive technique of our menu system makes body relative menu suitable for use as a palette of 3D models to perform the task of populating the augmented landscape. Miniature models are used for the menu and the distance between models is smaller, thus allowing more models to be in view. Instead of dropping models straight from the menu, the Create

Model command creates a full-size version of the model selected with the right-hand cursor at or a relative offset to current position of the user. This technique allows the user to visualize from the perspective of the models. With the aid of the GPS positional information, the user is able to use the body relative in-situ menu to precisely place models in the augmented world. Figure 4 depicts a user populating the surroundings of a virtual house with virtual objects such as a tree or a street lamp.

### 3.5. Menu comparison

Table 1 summarizes and compares the three types of in-situ menus on various properties. Each type supports different tasks in an AR environment.

**Table 1. Comparison of menu attributes**

Properties	World relative	Head relative	Body relative
Pre-view model size	Full size	Full size	Miniature
Menu Attachment	World – Fixed location	Head – Flexible location	Head – Flexible location
Model pre-view height	Ground	Ground	Eye height
Final model orientation	At time of commit	At time of commit	At time of presentation
Final model placement	At initially specified point	At menu specified point	At or offset of user's position

Our concept of in-situ menu can be further developed to work more effectively in an outdoor AR environment. A directory browser for 3D models would be a desirable feature for the user to browse through different directories, containing various types of 3D models, used for a more diverse set of tasks. Currently, in-situ menu only supports the position shifting of the line of models. We wish to investigate further manipulation techniques performed on the models while they are still part of the menu, such as rotation or scaling. Better methods of comparing different models require additional investigation.

## 4. Conclusion

The in-situ menu represents a versatile concept that serves the following purposes in an AR environment:

selection, comparison, visualization, and manipulation of 3D graphical objects. 3D models are placed within the context of the physical and virtual environments; allowing the in-situ menu to greatly aid the visualization and placement of 3D models. The collection of techniques for the in-situ menu serves three purposes of visualization and placement of models. Firstly, when the final placement of the 3D object is known in the physical world, world relative technique is suitable. This technique facilitates a choice between models and viewing from different vantage points. Secondly, tasks that require adjustments to the position of the model and an interactive placement of the model before a commitment are supported by the head relative technique. Finally, the body relative technique supports the rapid placement of 3D models relative the current user's position and orientation. The in-situ menu may also be used as an interactive panel for 3D object selection tasks, whose contents can be updated dynamically. This feature supports collaborative activities between an AR outdoor user and an indoor desktop user.

## 5. References

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