3D User Interfaces and Augmented Reality
Professor Feiner

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Final Project Documentation

I. Introduction

"How is it Made?" is our Augmented Reality application that lets users visualize and learn life casting/mould-making done at the Making and Knowing laboratory. Our primary goal for this project is to take the user through the process and history of lifecasting of a leaf in an interactive and engaging manner.

II. Instructions and Interactions

Initially, the user must hold their phone above a flat surface, so that the application can detect a ground plane. A well-lit space works best, and the ARKit will soon show yellow particle effects detecting features as the application looks for a ground plane. When the ground plane is detected, a blue box will appear around its area. The user must then tap within the blue box. This sets up the entire scene and the user will initially see that the green leaf model appear at the point of touch in the center of the mobile device's screen.

From here, the user can move the mobile device around the space to view other models in the scene too.

If the user taps on the screen prior to detecting a ground plane, the models will show up in the incorrect positions (this is a constraint imposed by ARKit). If the user happens to tap on the screen prior to detecting a ground plane, he/she must close the app and re-open it.

A. Selection and Manipulation

A blue cursor that appears at the center of the screen allows 3D interactions on all models. The cursor follows the position of the camera, so user can move the mobile device to focus this cursor on top of any of the models in the scene. When nothing is selected, the cursor appears as a circle. When a model is selected, the cursor becomes a rectangle (See Figure 1). When a model has been selected by the cursor, it can be manipulated, either by scaling or rotation.

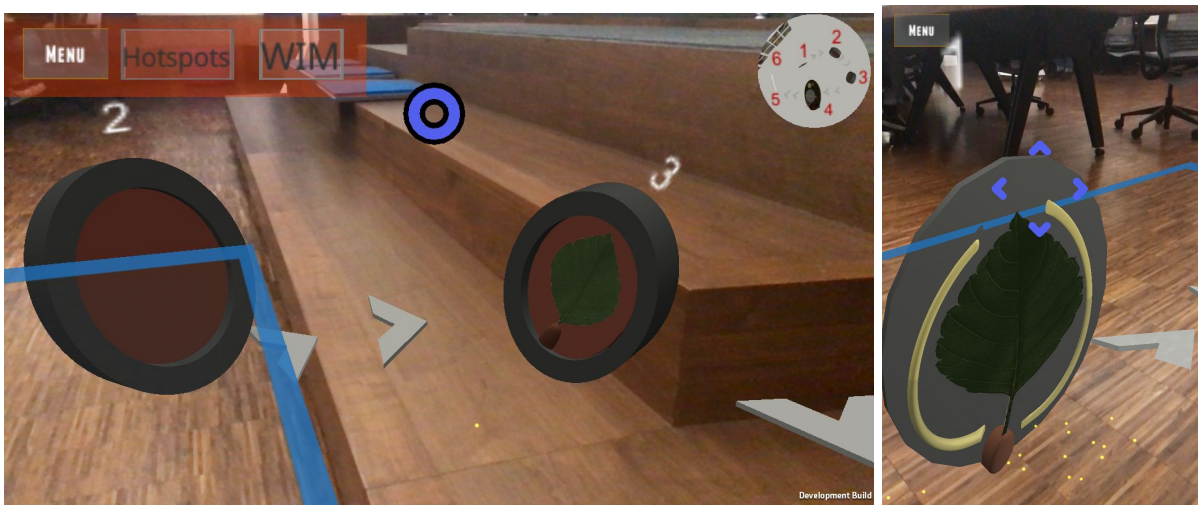

Figure 1: Circular cursor prior to model selection (Left). Square cursor upon model selection (Right).

To scale, the user can perform a two finger pinch zoom-in/zoom-out gesture on the screen. This allows the user to view each part of the scaled model in three-dimensional space with in great detail. To rotate

any model, the user can touch and drag one finger across the screen from right-to-left or left-to-right and the desired model will be rotated accordingly.

Initially when the models appear, they do not have any informational hotspots on them. A “Menu” button on the top-left corner of the screen brings up additional functionalities available in our application. On touching the “Menu” button, a panel showing two buttons “Hotspots” and “WIM” will appear alongside it. The “Hotspots” button shows and hides the hotspots on all of the models, and also makes the “Process/Historical” mode toggle visible.

The “WIM” (World-in-miniature) button opens and closes the WIM on the top right corner of the screen (See Figure 2).

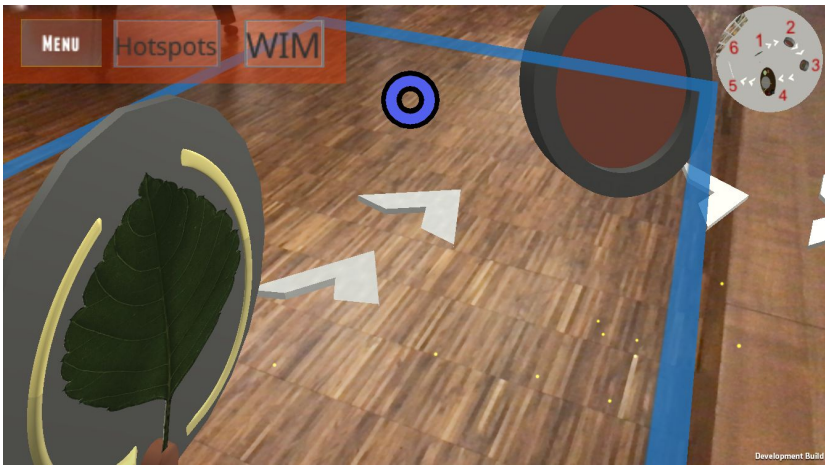

Figure 2: Top left- the Menu that allows the user to show/hide the Hotspots and WIM. Top Right- the WIM

When the user taps on a hotspot (using the touchscreen), red “hotspots” will appear on each model and informational text box will pop-up when the user taps any of the hotspots on the model. This will make Text Boxes containing a lot of information appear on the screen space where the user can read them comfortably along with the scrolling functionality.

Touching the “Hotspots” button will also bring up a Toggle on the bottom left side of the screen and this allows the user to select either “Process” or “Historical” mode and see textboxes with specific information on each models (See Figure 3). The text that appears will change depending upon which mode has been selected on the toggle. The “Historical mode” shows text from the original French manuscript that the Making and Knowing lab uses and the “Process mode” shows the text pertaining the steps of the process (given by the lab to us). The user can switch between the two modes at any time.

Figure 3: History/Process mode toggle on the bottom left corner of the screen. In the image on the right, there is a historical mode textbox open, corresponding to a selected hotspot. Top of right image: the “Menu” that allows you to show/hide hotspots and WIM.

B. Wayfinding and Travel

Our application makes use of 5 main waypoints (See Figure 4). The first three waypoints corresponds to a specific model used in the lifecasting process in incremental order. These waypoints are that of the model of an initial green leaf in the clay base with wax strips, a model showing the process

after plaster was poured onto it, and a model showing the other side of the leaf when the base is flipped state.

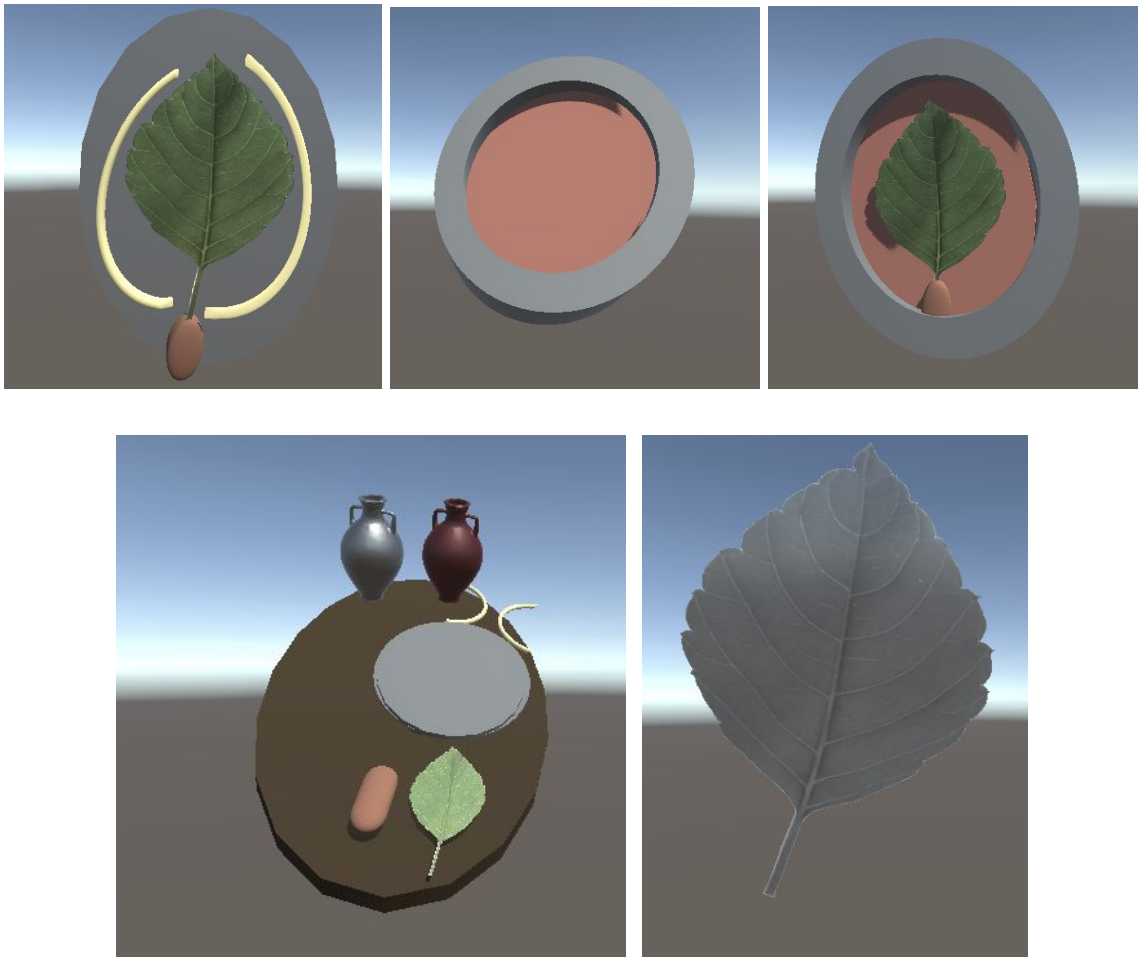

Figure 4: Five waypoints: Leaf in clay base, mold with plaster poured, Leaf in mold, animation of process, and final metal molded leaf

This is followed by the animation that takes the user through the full lifecasting process and then the final molded metal leaf. There are white arrows in worldspace places between each successive waypoint, so that the user can easily find the next waypoint. At any given view of the application, users will be able to see the progression between the waypoints so that they can effortlessly go through the entire process of life casting that we are showcasing.

All of these waypoints can be manipulated and interacted with in the manner described above. The user can play the animation (fourth waypoint) by touching the "Play Animation" button on the screen. A white panel with black captions will appear at the bottom of the screen to accompany the animation (See Figure 5).

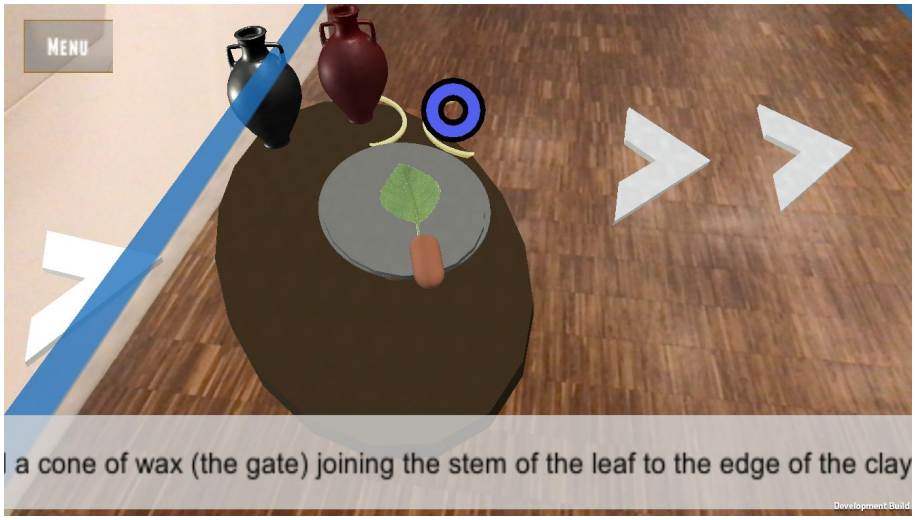

Figure 5: The animation after it has been played. The white panel with text at the bottom is the caption that accompanies the animation.

The World in Miniature (WIM) that appears in the top right corner of the screen provides additional help with navigation. In the WIM, the user's position in the space is indicated by a red dot that follows the camera. A blue cone protrudes from the red dot to indicate the user's line of view. For instance, if the user is looking at model 1, the blue cone will point towards the first model (labeled with a red numeral "1" in the WIM). If the user taps on the WIM, a larger WIM will appear below it for easier viewing. To close the larger WIM, simply tap on the original WIM again (See Figure 6).

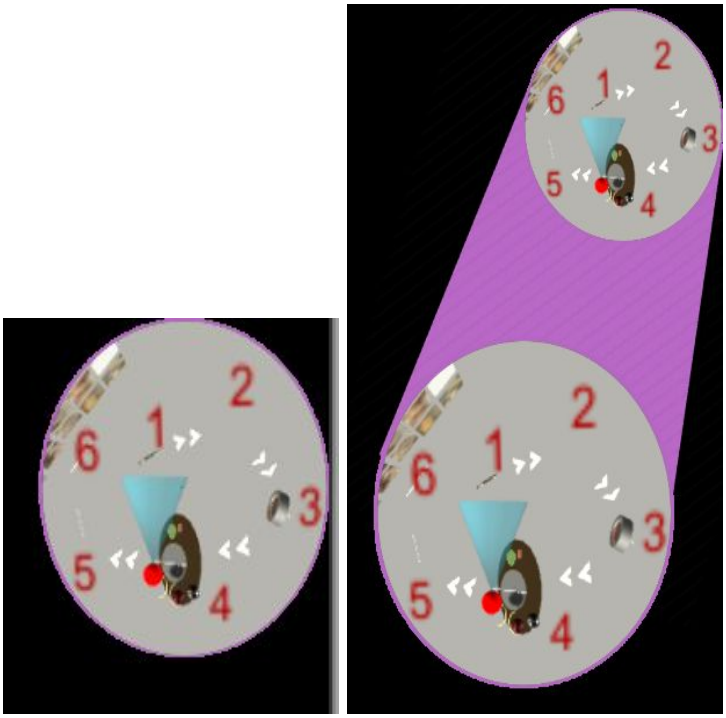

Figure 6: The World-In-Miniature

Additionally, there is a bonus “Reveal Gallery” button that we have incorporated right after the final metal leaf waypoint. On touching this button, an image gallery with images from the Making and Knowing lab will be shown in the three-dimensional space. Users can move around and see the images that correspond the the entire process that we have shown (See Figure 6).

Figure 7: The Image Gallery

III. Design Choices

We achieved AR functionality in our application by using ARKit. Our reasoning behind utilizing ARKit rather than Vuforia is that we wanted our application to have a convenient and intuitive user interface, and we thought that using Vuforia image targets would be cumbersome for users to interact with.

The following section details the different ways in which our application meets Jakob Nielsen's 10 heuristics for User Interface Design -

1. **Visibility of system status -**

Our application shows the user what is going on with the help of visual cues. The blue cursor shows which model is being currently selected and changes from a circle to a square to show the user whether or not selection is occuring.

When the user selects “Menu,” the panel fades in to indicate that the feedback and the appropriate functionality appears/disappears accordingly. The “WIM” (World-in-miniature) feature indicates the current position at which the user is viewing the models and manipulating the models and also shows an object being scaled or rotated. The models are numbered with red numerals on the WIM so that the user knows exactly where each model is in the space.

The white wayfinding arrows keep the user informed as to where to find the next waypoint.

The toggle for the hotspots indicates the current mode in which the texts on the hotspots appear (Process or Historical).

The models have also been numbered (a three-dimensional number floats above each of the models) so that the user knows exactly which step of the process they are currently looking at.

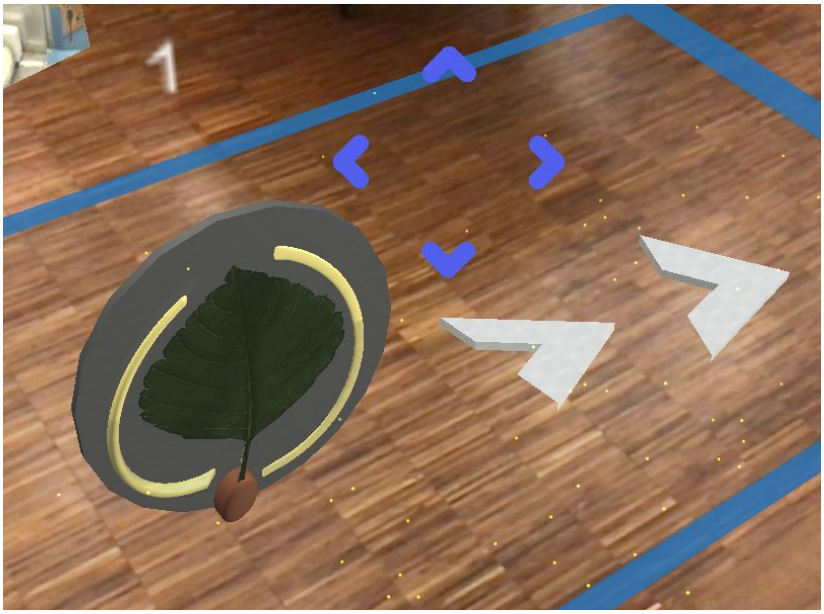

Figure 8: The square cursor indicates model selection. The wayfinding arrows indicate where to find the next model. Both contribute to good visibility of system status.

2. **Match between system and the real world -**

Our process and historical modes have text that are interpretable in users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Our menus and the buttons also use phrases that are intuitive to its functionality - for example “Play Animation” and “Reveal Gallery” perform actions that are self-explanatory. Moreover, the arrangement of the models in the application itself follows an order of natural progression in the life casting process and the information appears in a logical order on each model too.

3. **User control and freedom -**

Users can move around the three-dimensional space freely after the plane has been detected and models initialized. If users click on the hotspots but mistake, the text pop-up on the screen and there is a clearly marked red cross on the top left corner of the text box allowing the user to close the box at any point and they can reopen it whenever they want to later.

The scaling and rotation allow the user to go back to a state that they were previously in before. The application also puts a limit on the scaling so as to not scale the models to an extent where one model obstructs the space and view of the others next to it.

4. **Consistency and standards -**

Models in the application denote a natural and consistent progression in the process for easy understanding of the entire process. The hotspot colors and text boxes appear in the same manner throughout the space in the application and the manner in which each model is manipulated remains the same as well.

5. **Error prevention -**

The application is curated in a manner in which the user cannot get lost in space. The wayfinding arrows between each model indicates the order and the path in which the user can navigate through the system. The “WIM” is also a way in which the user is prevented from moving away from the models in the AR space.

The clearly marked red “x” button on the hotspot text boxes prevent the user from opening and viewing multiple hotspot textboxes at a time. We also incorporated the text box on the screen space to reduce the difficulty in viewing the text on top of the model itself.

When the app is initially opened, a warning/guidance message is displayed on screen to help users understand that if they tap before a ground plane is detected, the models will be placed in an undesirable manner.

6. **Recognition rather than recall -**

We used simple and well-known interaction techniques so that users do not have to learn any new interaction method to perform the actions in our application. For example, the two finger pinch technique to scale resembles the conventional zoom-in/zoom-out feature that touch-input devices uses. The rotation technique using the drag and swipe motion is also very straightforward and easy to implement. The buttons and naming convention of all the steps are easy to read and recognize and the animation follows a pace at which users can read the caption and learn the entire life casting process.

7. **Flexibility and efficiency of use -**

Our use of accelerators are minimal as the functionality is simple and easy to follow for any novice user as well as an advanced user of augmented reality applications. The “WIM” (World-In-Miniature) feature has an accelerator that gives it the capability of scaling by tapping on it. This is something a novice user may not be aware of, but would accelerate wayfinding for a more experienced user.

Users can also close a currently open textbox by pressing another hotspot, which will close the open textbox and open the desired hotspot’s textbox instead. This will accelerate the experience of a familiar user if they do not want to close the textbox and then open another one each time.

If users do not want to go through each of the models, they can directly go to the animation and see all the models come alive and easily understand the process that is being illustrated.

8. **Aesthetic and minimalist design -**

We have incorporated a neat and clean design throughout the application with only the necessary and relevant information being shown to a user. This is true in terms of the models themselves, which are present without the hotspots obstructing their clear view when they initially appear.

The menu buttons, adjoining panel, WIM view and animation texts are all aligned to the sides of the screen so as to not obstruct the view of the models or complicate the UI design. The menu itself can be minimized by tapping the "menu" button a second time, further clearing the space.

The user can maximize the WIM by tapping on it, but the user has the ability to close the maximized WIM so as to avoid taking up additional screen space.

The buttons and UI elements follow a sprite that allow for a simple design across all the components in the application - also enforcing ergonomically consistent design.

9. **Help users recognize, diagnose, and recover from errors -**

The application works best when the user has detected a ground plane and then taps the screen to initialise the models. A warning or guidance message is displayed on screen to help users understand that if they tap before, the models will be placed in an undesirable manner.

10. Help and documentation -

We have provided a clear and detailed video along with narration to show the working application and the best way to interact with all the models. This written description clarifies any other information that a user may want to know regarding the application and the design choices made while building it.