

Virtual Grocery Environment for Neurocognitive Assessments

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1. Virtual Grocery Environment Application

Determining precise levels of cognition abilities in patients with neurocognitive disorders, such as Alzheimer's Disease or traumatic brain injuries, is a crucial factor in creating effective treatment plans. This virtual grocery store environment has several components designed to allow for controlled testing in all areas of executive cognition. During testing, this environment will record every action made by the subject to calculate precise abilities, accounting for hesitation, repeated tasks, and other factors that may affect performance in a real-world situation.

2. Background

Neurocognitive disorders can yield a wide array of varying symptoms and can therefore be difficult to diagnose and treat. For example, a single type of physical injury might manifest itself through emotional problems in one person while another may experience changes in behavior. Although these two people suffer from similar physical damage, their lives are altered in very different ways.

Due to the complexity of these issues, current pen-and-paper testing procedures for people with neurocognitive disorders are often inadequate in classifying levels of cognitive abilities as they would apply to real-world situations. Additionally, physically going to places such as grocery stores and libraries to observe individuals with cognitive disorders is not the best solution due to safety concerns and interference from external stimuli.

Using immersive virtual reality, neuropsychologists are able to evaluate performance in common yet complex tasks and determine how a disease will affect daily life for an individual person.

2.1 Previous Work (see reference 1)

This virtual grocery environment is an updated version of a virtual environment previously designed and tested using NeuroVR. The original grocery store implemented several different tasks that tested for varying components of cognitive performance, such as memory, attention, and spatial reasoning. To do this, the subject was given a set of tasks similar to those that they might need to complete on a regular basis, such as picking up a prescription and purchasing groceries for a family gathering. The program recorded the time taken to complete the list of tasks and logged all movements within the environment.

3. Summer Work

Before I started working in the lab, the program was moved to an open-source graphics rendering engine, OGRE, to accommodate for the data collection and analysis limitations of the NeuroVR platform. Peng Liu, a graduate student working with Professor Interrante, did the majority of the work moving the program and rewriting the code to run in OGRE.

The previous model had groceries labeled in Italian, which made it difficult for patients to navigate the store. The goal for the summer was to create new groceries with larger and more familiar labels and to implement tasks using the new objects. I worked with another DREU participant, Haley Adams, on the project.

3.1 Reorganizing the Groceries

One of the limitations of the original grocery store model was the confusing nature of some of the grocery items. Several of the groceries were labeled in Italian and had unclear or blurred labels. Additionally, the complexity of several of the models caused lagging during tests, undermining the purpose of the immersive virtual reality environment. In order to maximize performance and create a more intuitive interface, we created a new set of groceries.

3.1.1 Method

Prior to making new objects, we developed two primary lists of groceries: necessary objects and filler items. The main purpose of the filler items was to make the shelves look more organized and realistic without adding too many polygons. To determine which items we needed, Haley and I met with Professor Interrante to discuss possible scenarios that would easily translate into grocery lists. We chose to focus on a barbeque theme, largely because it is relatively common and easy to customize. For this theme, we needed to create models for bread, meat, drinks, and plastic cutlery. The models were created using Google SketchUp and converted to a file type that was compatible with OGRE using both Autodesk Maya 2010 and Autodesk 3ds Max.



This model of Sara Lee® bread was created with Google SketchUp. Photographs of a real loaf were mapped onto a 6-face rectangular prism to add a realistic texture and keep the overall polygon count low.



In order to evaluate the areas of cognition that control decision-making and reasoning, we made multiples of some products like these baked beans. We planned to create a sort of “blue-light special” where the test subject would have a limited amount of time to pick up a product at a discounted price. If the sale price of the promotional product was cheaper than the alternative, then that would be the better option. For different sizes, the subject would need to calculate the total price to determine which option to choose.

We included objects like ketchup and relish for two main reasons: first, we wanted to make sure that the store was as organized and realistic as possible, and second, because we were not yet sure about how detailed the final grocery list would be. We figured that condiments would be among the items that people might forget if they are in a hurry or distracted. Because of that, these smaller items can help make the test more complex to create more specific results.



Objects that generally come in larger packages, such as these diapers, trash bags, and paper towels, make the shelves look full without increasing the overall polygon count and slowing down performance. The textures used for these particular models were found using Google Images and mapped onto the objects in SketchUp.

3.2.2 Limitations

OGRE has its own type of file formats for 3D models, with each object consisting of a PNG image, a “.mesh” file, and a “.material” file. The free version of Google SketchUp defaults to a “.skp” model type and has a limited number of export options. To convert these models to a file type that is compatible with OGRE using software that is freely available online or free for students, we used Autodesk 3ds Max to convert the “.skp” file to “.fbx”. OGRE has an export plug-in for Autodesk Maya, so we then imported the “.fbx” file into Maya and exported it to OGRE. This multi-step process ended up taking much longer than we had anticipated at the beginning of the summer. We later found that Google SketchUp 2013 has a “.fbx” converter and is available for a limited free trial period, so we were able to import items directly from SketchUp into Maya.

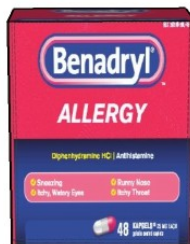
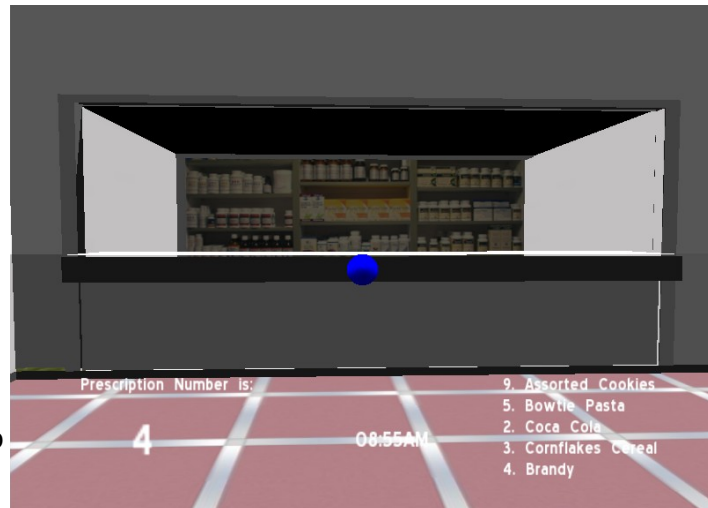
When we first started working on the project, Haley and I spent a lot of time editing the texture files for the existing models rather than creating new objects. We were not sure what the best method was or which option would be faster, so we figured that editing would prevent us from having to manually replace each item and would save time that way. After doing this for a couple weeks, we still had groceries with unfamiliar labels, even though the words were in English. At that point, we decided to make the majority of the objects ourselves with common grocery store brands so that they would be more easily recognizable, especially for people with limited vision. We lost some time this way, but the new groceries will make the environment easier to navigate. It will also help ensure that the results are accurate by making the store more similar to a real-world environment.

3.2 Updating the Model

After the new set of groceries was completed, we mapped out the different shelving sections to give the environment an intuitive layout. The previous model used a regular cash register as a makeshift pharmacy, so we replaced one of the grocery walls with a new built in window to replace the register.

3.2.1 Method

The pharmacy addition was made using Google SketchUp. We cut out part of the wall in the grocery store model and built a small room with a counter in front. An image of shelves with medicine-type bottles on it was mapped to the back wall to give the area more depth and make it look more like a real pharmacy. We initially planned to make a window gate that would close the pharmacy until 9:00 AM to add another challenge, but did not have time to add that to the model.



The shelf closest to the pharmacy was stocked with common over-the-counter medicines, similar to the way that a regular grocery store is laid out. These items were made the same way as the other groceries and make the pharmacy look more complete.

```
File Edit Format View Help
tns:matrix 1 0 0 0 1 0 0 0 1 -0.021 0 0 0 1
filename R00014.mesh
tns:matrix -4.37114e-008 -1 0 3.428 1 -4.37114e-008 0 -5.734
filename M00039_02.mesh
tns:matrix 1 0 0 1.335 0 1 0 5.923 0 0 1 0.921 0 0 0 1
filename P00001_08.mesh
tns:matrix -1 -8.74228e-008 0 0.716 8.74228e-008 -1 0 2.472
filename P00021_08.mesh
tns:matrix -1 -8.74228e-008 0 -4.295 8.74228e-008 -1 0 4.018
filename P00011_06.mesh
tns:matrix -4.37114e-008 1 0 15.221 -1 -4.37114e-008 0 9.473
filename P00017_02.mesh
tns:matrix -4.37114e-008 -1 0 0.392 1 -4.37114e-008 0 -5.804
filename M00039_02.mesh
tns:matrix -1 -8.74228e-008 0 -4.356 8.74228e-008 -1 0 2.418
filename P00027_02.mesh
tns:matrix -4.37114e-008 -1 0 17.111 1 -4.37114e-008 0 9.421
filename P00018_04.mesh
tns:matrix -1 -8.74228e-008 0 -4.323 8.74228e-008 -1 0 1.005
filename P00011_02.mesh
tns:matrix 1 0 0 -3.724 0 1 0 0.554 0 0 1 0.421 0 0 0 1
filename P00027_02.mesh
tns:matrix -4.37114e-008 1 0 6.477 -1 -4.37114e-008 0 2.924
filename P00023_08.mesh
tns:matrix -4.37114e-008 -1 0 4.476 1 -4.37114e-008 0 -10 0
filename F00002.mesh
```

```
File Edit Format View Help
tns:matrix 1 0 0 0 1 0 0 0 1 -0.021 0 0 0 1
filename R00014.mesh
tns:matrix -1 0 0 -4.500 0 -1 0 5.975 0 0 1 1.921 0 0 0 1
filename price_3_99.mesh
//Front 1 L L
tns:matrix -1 0 0 -4.275 0 -1 0 5.975 0 0 1 1.921 0 0 0 1
filename extra_pampers.mesh
tns:matrix -1 0 0 -4.275 0 -1 0 5.150 0 0 1 1.921 0 0 0 1
filename extra_pampers.mesh
tns:matrix -1 0 0 -4.275 0 -1 0 4.250 0 0 1 1.921 0 0 0 1
filename extra_pampers.mesh
tns:matrix -1 0 0 -4.275 0 -1 0 3.350 0 0 1 1.921 0 0 0 1
filename extra_pampers.mesh
tns:matrix -1 0 0 -4.220 0 -1 0 6.422 0 0 1 1.421 0 0 0 1
filename extra_forks.mesh
tns:matrix -1 0 0 -4.220 0 -1 0 6.131 0 0 1 1.421 0 0 0 1
filename extra_forks.mesh
tns:matrix -1 0 0 -4.220 0 -1 0 5.800 0 0 1 1.421 0 0 0 1
filename extra_spoons.mesh
tns:matrix -1 0 0 -4.220 0 -1 0 5.333 0 0 1 1.421 0 0 0 1
filename extra_spoons.mesh
tns:matrix -1 0 0 -4.220 0 -1 0 4.750 0 0 1 1.421 0 0 0 1
filename extra_napkins.mesh
tns:matrix -1 0 0 -4.239 0 -1 0 4.300 0 0 1 1.421 0 0 0 1
```

The two figures at the bottom of page 5 show the way that objects are added to the virtual environment. Each object has a corresponding 4 x 4 matrix of coordinates that places it somewhere in the grocery store. The window on the left is a sample of the unedited version with the original items listed in no particular order. The list shown on the right side shows part of the final edited version. When the program renders, each item in the list is pulled from a separate folder and added to the environment based on the listed coordinates. We created a system to categorize and label all of the groceries so that they can be easily identified in the file.

3.2.2 Limitations

The program used in the previous version of the virtual grocery store had a drag-and-drop interface for adding objects to the model. Because OGRE has no graphical user interface, manipulating the coordinate matrices is the only way to move objects. The original groceries were named using non-descriptive letter and number combinations, such as "P00021_88.mesh" because they could be manipulated visually. We had to spend some time adding test objects to help us understand how the coordinate axes were oriented in the environment. Since we knew that we would not have time to finish the project before the end of the summer, we spent additional time making sure that we fully implemented an organization system for the text file so that the next students can easily add or remove items.

When making the pharmacy addition, it was easy to import the grocery store model into SketchUp to edit, but it ended up being much more difficult to import the updated model back into OGRE. Somewhere along the string of conversions, the sizing changed and some of the textures were reversed. It took some trial and error to figure out how to alter the settings to fit the new model back into the parameters set in OGRE.

3.3 Implementing Tasks

At the beginning of the project, Haley and I met with Professor Interrante to discuss potential tasks. Each scenario had to be able to test for task analysis, strategy generation and regulation, prospective working memory, interference and dual task management, response inhibition, and both time-based and event-based prospective memory. Based on these requirements, we concluded that a barbeque scenario would work well. The test subject would need to make several decisions about main dishes, sides, drinks, silverware, and dessert, while also keeping track of his or her prescription. The "blue-light" promotion would help test for strategy generation, response inhibition, and dual task management, and the prescription task covers both time-based and event-based prospective memory. Task analysis and prospective working memory will be tested by analyzing shopping efficiency and accuracy. Within each category in the list (main dishes, sides, etc.), there are additional opportunities to examine performance and fine-tune the test results.

4. Future Work

One of the most important projects that we ran out of time for is the addition of price tags. The tags need to be large enough that people with limited vision will be able to easily read them, but they cannot be so large that the environment loses its realistic quality. Additionally, because OGRE lacks a graphical user interface, it will be difficult to add shelf

tags for every item, especially if the store is reorganized again. Adding ~400 shelf tags would be time-consuming, and there is a possibility that it might slow down the program to load that many separate texture files. Another option would be to edit each of the groceries to have their own tags included in the mesh files, but this would also be incredibly time-consuming, as each object would need to be converted and formatted again. However, this second option would allow for simple editing in the future, and the store could be customized for several different scenarios.

Professor Interrante talked about updating the interface to make it more realistic, such as putting the grocery list on a cellphone screen instead of having it constantly displayed on the main screen. We also talked about adding a coupon board to the front of the store to add another dimension to strategy generation, so this would be a great thing to consider. With the groceries organized now, hopefully students who work on this project in the future will be able to work more on the functional code to implement the different ideas that we came up with.

Acknowledgments

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References

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