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15-400 Project Proposal

Project Title: Integrated Virtual/Physical Environments
Project Web Page: http://www.andrew.cmu.edu/user/jfashimp/research_project.html
Project Description:

Though virtual reality provides a platform for many new types of work, education, and entertainment, it has the side effect of cutting users off from their surroundings. For some games and activities, this is exactly what one would want: to be transported entirely. But there are plenty of problems associated with wearing this kind of digital blindfold. First of all, it can be hazardous, letting users collide with or trip over unseen obstacles. Secondly, it can be socially isolating to not see or be able to interact with others in one's space. It alienates those outside of the headset, and leaves the user always unsure of who is with them. Next semester, I will be working independently under the advisement of Professor Jessica Hodgins to develop a virtual reality system that solves some of these problems, transforming one's space rather than replacing it entirely.

A specific objective of the project will be the preservation of select physical items in the virtual space. For example, I might want to sit on my couch while playing a game, and still be able to see the couch and the side table while the rest of the room is replaced with a virtual environment. Another related objective is making people and animals visible within the headset. So, if I am watching a virtual movie, I can see if someone I know walks into the room, even if they aren't wearing a headset or any technology themselves. This keeps me from accidentally colliding with them, and allows me to speak with them as I normally would. Ideally, which items are visible would be able to be modified programmatically by VR developers, so a virtual game could just replace one wall of a room, or everything but the large furniture, or everything but other people, depending on what is needed.

Plan:

The most obvious challenge with this project will be differentiating between what should remain visible and what should be replaced. I hope to use existing computer vision and/or image segmentation models to analyze images from cameras on the headset. Then, I need to make sure that each visible item/person has the appropriate depth, blocking things behind it and being blocked by things in front of it. Some existing technologies used for merging green-screen videos with virtual environments appears to handle this quite well, and I will research how they do this. Ideally, lighting on the real-life objects would also be modified so that they take shadows from surrounding virtual objects, but this is a stretch goal. An important consideration

throughout all of this will be performance, since any reduction in frame rate can lead to serious VR sickness for the user.

No matter how much I am able to technically implement, I plan to run user tests with whatever I have to answer several questions, including how much of reality people want to be able to see in different situations, and how important certain factors (like resolution, matched lighting, etc) are to their experience. I also plan to test my VR system in a variety of environments other than my primary work space, to make sure the technology is versatile. Once I have done this, I will make the software available to other researchers/developers and write an academic paper on my findings.

Project Goals:

75% - Physical objects and people are able to be seen in virtual reality, possibly low quality or "ghostlike." I will also have user study results.

100% - Physical objects and people are able to be seen in virtual reality, with some means of programmatically adjusting how much reality is visible. These should clip virtual objects appropriately, but might not have correctly adjusted lighting. I will also have user study results.

125% - Physical objects and people able to be seen in virtual reality, with appropriate clipping, lighting, and physics (virtual objects collide with physical objects). In addition to adjusting the degree to which reality is visible, individual objects can be selectively shown and hidden. I will also have user study results.

Milestones:

End of 15-300: Be caught up on related research, make more specific plan, have all required hardware/software (if not in possession of it yet, know exactly where it's coming from), update other milestones if needed.

February 1st: Implement simple AR application for Vive Pro, to practice using its AR capabilities, and try differentiating furniture/people from the background using CV.

February 15th: Build basic VR scene that incorporates real-world elements. Prepare and submit IRB proposal for user study.

March 1st: Continue building VR scenes that incorporate real-world elements. Make these scenes increasingly more complex if possible.

March 22nd: Add programmatic control over degree of realism. Begin recruitment for user study, and begin planning playtests.

April 5th: Construct demo experience for user study that incorporates everything that was able to be implemented. Finalize playtest procedure/questions for user study.

April 19th: Conduct user study, test software in other environments.

May 3rd: Wrap up user study, perform data analysis (will work on paper during the summer), create polished Unity package or GitHub repo for finished software.

Literature Search:

I still have a lot of literature to review for this project, including what type of CV/image segmentation would be best, what methods exist for merging real-life and virtual images, and what previous studies involving AR indicate about user preferences for hybrid virtual-physical spaces.

Resources Needed:

I will need to get access to a virtual reality headset, and I believe the best one for this project will be the HTC Vive Pro, because its dual cameras on the front give it AR capabilities. I will also need a place to work, and a computer on which to run the project, but both of these can be shared. I will be using Unity with Steam VR, which I already have, and likely some other softwares (like for CV) that I haven't identified yet.