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Joint Senior Project Proposal

Projector Mapping for 3D Objects and Photometric Calibration

General Idea:

The IMP (Intelligent Mobile Projector) is an experiment in novel forms of mixed-reality and human robot interaction by combining recent advances in mobile robot and projector-camera systems research. [1]

In my project, I will investigate the problem associated with alignment of projected images on different surfaces. The basic problem arises when an image is projected on a flat screen. Since the projector is not necessarily aligned with the screen, the projected image might be distorted (for example, it might show a trapezoid instead of a rectangle). Some projectors offer keystone correction, which is an option to adjust the image to eliminate the distortions. However, such correction typically requires the user to manually adjust the keystone parameters, so it has to be repeated every time the projector changes position, and is not a reliable solution for non-stationary projectors.

Previous Work on the Topic:

I was inspired by a novelty solution to this problem that guarantees a correct alignment (within some error margins) without requiring the user to manually adjust the projected image [2]. This approach uses an additional camera placed at a fixed position with respect to the projector. This way the camera and projector will create a fixed system, which allows us to accurately detect the distortion of the projected image and negate it by pre-warping the image sent to the projector. To do that, we need to find homography matrices that map points between the projector, the camera, and the real world plane (in this case: the screen). The homography matrices are specific to each camera-projector system, so it is important that the camera and projector remain at the same relative positions at all times. The fixed projector-camera system with automatic keystone correction makes it possible to update the correction in real time, and therefore, this solution can be used on mobile projectors.

Professor O'Hara's BSRI project explored the IMP in the context of creating expansive mixed-reality interfaces [3]. The research also included a laser pointer tracker that was implemented utilizing the same homography matrices to map laser points on the screen to the virtual points on the projector/computer screen.

The Focus of My Project:

Building on previous research, I would like to address two topics/problems. First, I would like to explore move on from projecting on flat surfaces to projecting on 3D objects. This direction of research has potential applications in performance arts, where images projected on dancers or objects can enrich the entertainment value of performance. Typically, the standard approach used a camera to determine coordinates of the points on the projected surface. Projecting on a 3D object, however, will require the knowledge of exact position of the object, which might not be a flat surface. For this purpose, we will use the Microsoft Kinect, which utilizes an infrared projector and camera to acquire specific coordinates of the object.

My second focus will be on photometric calibration. While geometric calibration deals with rectifying the distortions created by misalignment of projected image and the screen, photometric calibration attempts to solve the problem of projecting on colorful surfaces. The idea is to detect the colors, and possibly also positions of the color patches that appear on the real-world plane, and adjust the colors of the projected image accordingly so that the projected image has correct colors. For this approach, I plan to work on the estimation problem of the geometric calibration and develop a well-tested photometric calibration technique.

References:

- [1] Drablab page about imp projects: <http://drablab.org/imp-projects.shtml>
- [2] Rahul Sukthankar, *Smarter Presentations: Exploiting Homography in Camera-Projector Systems*, Proceedings of International Conference on Computer Vision, 2001.
- [3] Keith O'Hara, *The Intelligent Mobile Projector (IMP)*, AAAI-2012 AI and Robotics Multimedia Fair — Robot Demonstration, 2012.
- [4] Anis Zaman, Curtis Carmony, Keith J. O'Hara, *The Intelligent Mobile Projector (IMP)*, AAAI 2010 Robotics Exhibition – Student Research Challenge, 2010.
- [5] Drablab wiki page about the IMP: http://wiki.drablab.org/index.php?title=The_IMP (requires login)