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3D Object Reconstruction *Through the use of Projective Geometry*

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Abstract

The world today is being captured by digital cameras that are incorporated into so many of our everyday devices. From cell phones and tablets, to glasses and watches, these digital cameras are quickly becoming our pair of “digital eyes.” The interpretation of these visual images by computers opens a pathway to the field of study called Computer Vision. The concept of Computer Vision was developed by utilizing computers to interpret digital images, combined with the focal length of the camera, to understand and reconstruct 3D objects and scenes from 2D planar images. The guiding concept of Computer Vision comes from the interpretation of Projective Geometry in images by using Simultaneous Location and Mapping algorithms, also known as SLAM. Programs such as AutoDesk 123D Catch and Adobe Photoshop take advantage of SLAM programming in order to reconstruct an object in 3D derived from 2D images or re-scaled or re-proportioned images based upon the usage of projective transformation. Computer Vision combines Science, Technology, Engineering and Mathematics into a study with practical applications in robotics, humanoid interactive recognition, bio-technology, video gaming and 3D mapping.

Research Objectives

Throughout this research, the objective is to define the concepts of Projective Geometry through the acquisition, analysis and application of digital camera images and angles. The theory of rigid body similarity transformation, affine transformation and projective transformation will be defined. Software will be used to reconstruct and 3D print the object.

Research Goals:

- Identify and apply the concepts of Projective Geometry through the use of digital cameras.
- Collect Digital Images by varying sources.
- Reconstruct a 3D object through the use of digital cameras.

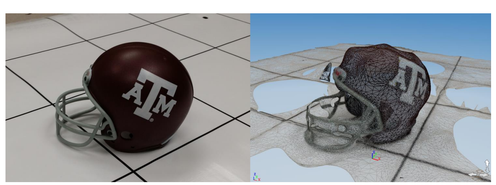

Figure 1. AutoDesk 123D Catch mesh of 2D image.

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Methodology

There are several methods that can be used in reconstructing an object in 3D from digital pictures. The method that this research follows is with the free software provided by AutoDesk, 123D Catch. To be successful, one must start with the knowledge and background of 3D modeling and projective geometry. Understanding of Similarity, Affine and Projective Transformation is vital.

Figure 2. Projective Geometry summary image.

Camera Calibration is another key aspect in SLAM programming and is utilized within the 123D Catch program. To calibrate a camera, the technique only requires the camera to observe a planar pattern shown at a few (at least two) different orientations.

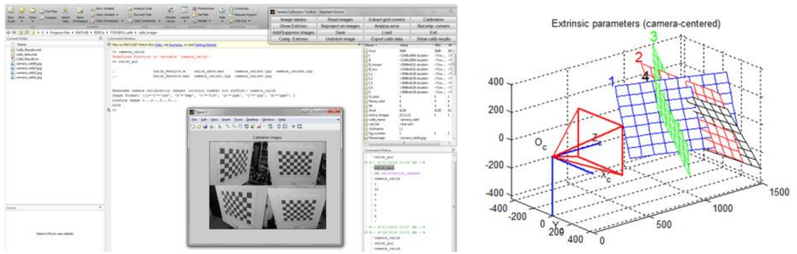

Figure 2. Camera Calibration with MatLab image.

Acquiring digital images of the presented object requires proper planning and procedure. A higher quality digital image will result in a better 3D capture, however images should not be altered from their original file after taking the images. Proper lighting is necessary. There should be no directional lighting that would result in shadowing and the level of light should be averaged so as not to offset the white balance. A series of a minimum of 20 sequential photographs should be taken in small increments around the subject. Following proper image acquisition, the files should be uploaded and processed by 123D Catch. During this process, the power of cloud computing and shared processing will allow 123D catch to render a 3D model derived from the series of photographs. From the camera calibration, to the knowledge of the focal length in parallel with projective transformation, the software can calculate a 3D model based upon the series of images. The model is rendered into the software for further editing. From there, the model can be refined, scaled and printed in 3D.

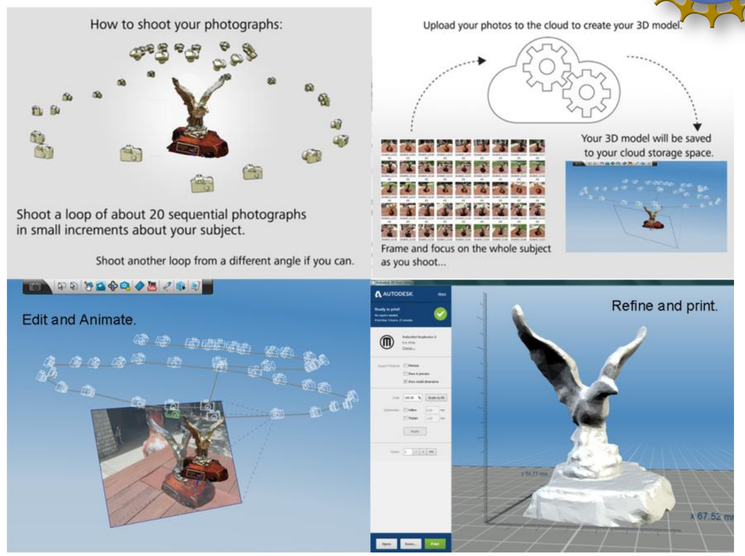

Figure 2. 123D Catch basics steps flow chart image.

Results and Conclusions

Computer Vision is a fascinating field of study that encompasses 40% of all Computer Science Research today. By utilizing and applying the theories of Computer Vision, SLAM Algorithms and Projective Geometry while having the ability to reconstruct and object in 3D, programs such as AutoDesk’s 123D Catch are making huge waves in the frontier of Computer Vision. Digital cameras, in combination with 3D printing, opens new pathways in research, analysis and even data acquisition. The utilization of this research can be applied into many real world applications, such as robotics and automation, location mapping, search and rescue, hazard detection and avoidance, 3D video gaming and gesture recognition.

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