**Draft Outline**

1. Intro, why relevant and novel
   1. Using computer graphics to render scenes for SFM reconstruction accuracy assessment it beneficial because…
2. Background (put research in context)
   1. Previous work has done similar things, but not exactly. Cite dirsig, etc.
3. Describe Computer Graphics to render a scene
   1. Describe basic computer graphics pipeline. How it works, different renderers, different methods, etc.
4. Methodology to Validate a Photogrammetric accuracy of Computer rendered imagery
   1. Need to validate imagery to ensure that any resultant error in an uncertainty analysis is due to SFM algorithm, not the rendering.
      1. Validate Photogrammetric accuracy (fx,fy,cx,cy)
         1. This also validates object and camera placement in the scene (Translation, Rotation Conventions)
      2. Validate Texture resolution and “sharpness” (confirm Point Spread Function = unit impulse)
5. Description of workflow/methodology developed using Blender
   1. Why was Blender chosen? Any downsides?
   2. What is the workflow for using Blender
      1. Xml file schema keeps things simple, intuitive
6. Proof of Concept Demonstration
   1. Perform a simple rendering scenario with objects and “realistic” scene with moving sunlight
      1. Render a scene
      2. Process in Photoscan
      3. Analyze pointcloud error in Cloud Compare
      4. Analyze Orthophoto error in Matlab
7. Conclusion/Future Work/ Implications of Methodology
   1. Spell out some example future work experiments that are possible in blender, but would be cost prohibitive and difficult in real world.

**Intro really very rough draft…**

Structure from Motion (SfM) and MultiView Stereo (MVS) algorithms are increasingly being used to generate pointcloud data for various surveying applications, however the accuracy and sources of error in the resultant pointcloud across various use cases are difficult to realize without thorough experimentation. The acquisition of imagery and rigorous ground control data at field sites is a time consuming and sometimes expensive endeavor. These experiments are also almost always unable to be perfectly replicated due to the numerous uncontrollable independent variables, such as solar radiation and angle, cloud cover, wind, objects in the scene moving, exterior orientation of cameras, and camera dark noise to name a few. The large number of independent variables creates a scenario where robust, repeatable experiments are cost prohibitive and the results can be site specific. Here, we present a workflow to render computer generated imagery using a virtual environment which is capable of mimicking all of the independent variables that would be experiences in a real world data acquisition scenario. The resultant modular workflow utilizes the open source software Blender for the generation of photogrammetrically accurate imagery suitable for SfM processing, with tight control on camera interior orientation, exterior orientation, texture of objects in the scene, placement of objects in the scene, and Ground Control Point (GCP) accuracy. The challenges and steps required to validate the photogrammetric accuracy of computer generated imagery are discussed, and an example experiment assessing accuracy of an SFM derived pointcloud from imagery rendered using a computer graphics workflow is presented.

The photogrammetric accuracy of the rendering methodology must first be validated in order to ensure that the interior and exterior orientation are set correctly. An assessment is performed by rendering a scene consisting of photo identifiable targets at known coordinates using a simulated camera with user defined interior and exterior orientations. The coordinates of the photo identifiable targets as calculated using Harris feature detection are compared with the expected coordinates of these targets based on the photogrammetric projection equation.

Before rendering more realistic scenes, it is advantageous to start with idealized scenes consisting of regular geometric shapes and patterns. If photogrammetric techniques and the known interior and exterior orientation parameters of the modeled camera can be used to measure coordinates of points in the imagery that agree closely with their known coordinates, this provides confirmation that the methods work in the simplest test cases. It is then possible to move onto more challenging test cases by introducing lens and motion blur, noise, vignetting, and more realistic objects, since degraded accuracy in the photogrammetrically-derived coordinates will then be attributable to these factors, rather than to underlying issues with the methods. To this end, the following section describes tests conducted using a simple scene consisting of a 1000 m^3 cube with a 10x10 checkerboard on each wall.