Image-based, geometric sensing in unstructured environments Subterranean Robotics

Motivation

Laser-based sensors are considered the gold standard for modeling outdoor environments. While generally highly accurate, these systems are costly, provide sparse data, and require actuation of planar devices.

Vision-based methods generate geometric models capable of high resolution. Camera-projector (Structured light) and camera-camera (Stereo vision) methods can be used to generate 3D meshes. Exhaustive testing of image-based sensors has not been conducted in unstructured environments.

Structured Light (Camera-projector)

•Striped patterns are projected on the scene •Pixels decoded to find disparities between physical and projected locations

• Triangulation is used to produce dense depth maps



Gray Code



Stereo Vision (Camera-camera)

•Camera pair is used to match areas within the scene. •Template matching finds the same structure in each image. •Triangulation maps points to 3D data



Disparity found using normalized cross-correlation γ = correlation f = image t = template







often limited by a small field of view.

lighting solutions.



Accuracy Analysis: Cubic fiducial (length = 304.8 mm) at a distance of 1525 mm

ANT Sec. 1



Scene



Structured Light



Setup	Samples	Error (mm)	Error (%)
SL (x)	10	18.4	1.20%
SL (y)	10	-23.0	-1.51%
SV (x)	7	-15.6	-1.03%
SV (y)	5	-25.5	-1.67%

Stereo Vision

Future work

•Quantize differences between features for each sensor type

•Enhance noise removal

•Examine wide field of view projector lenses and high dynamic resolution images

•Explore real-time structured light and infrared patterns



