3D Anomaly Detection using Structure from Motion

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Introduction

We present a 3D change detection algorithm designed to flag volumetric changes in an environment. The algorithm we present utilizes a 3D scene reconstruction technique originally designed to support an autonomously navigated unmanned aerial system (UAS). The scene reconstruction system is able to provide positional self-awareness for navigation within a known area. It can also be used to construct a new model of unknown areas. By obtaining accurate dense representations of the scene, we are able to detect environmental changes irrespective of lighting, seasonal, and view point changes. This change detection algorithm processes on un-calibrated images captured from an EO sensor. No sensor specifications are required for a coarse scene reconstruction.

Structure from Motion Methodology

The nine step reconstruction process produces a Dense Point Cloud Representation (DPR) of a scene. Additional preprocessing steps can be added to enhance the input images and the resulting representation.

1. SURF Extraction
2. Feature Matching
3. Position Computation
4. Noise Suppression
5. Optical Flow Points
6. Disparity Map
7. Depth Map
8. Point Localization
9. Point Cloud Model

Visual Structure from Motion

Processing on un-calibrated imagery, Visual Structure from Motion (VSM) computes the precise camera location and orientation associated with each frame. These computed parameters are essential when processing nonlinear camera motion.

SURF Feature Extraction and Matching

The Speeded Up Robust Features method finds keypoints in the scene that are distinct and can be tracked across multiple frames, regardless of varying size, location, and perspective. In order to determine the distance of the feature to the camera plane, a tracking procedure is conducted on pairs of frames. Every feature in the current frame is matched with the most similar feature in the proceeding frames.

Disparity to Depth

The distance in pixels traveled by a feature point is referred to as a feature’s disparity. The Depth Map is computed using the inverse relationship between depth and disparity to transform each feature’s disparity into a depth value.

3D Anomaly Detection Methodology

Change detection is a challenging real-world real-application problem that research has not sufficiently tackled yet. Varying lighting conditions, camera sensor specifications, seasonal changes, and view point all cause the same object to appear different in videos captured at different times. We propose a novel approach to the issue. By subtracting 3D models, we eliminate the direct comparison of image intensities and features. We determine the differences between two 3D binary geometries.

3D Anomaly Detection

Using regression modeling we estimate the equation of the ground plane, thus suppressing the noise points along the ground while object such as cars, trees, buildings untouched.

Continuing Work

- Determine a proper model registration method to align the constant objects in the scene, such as buildings and trees.