3D Scanning Drone

Literature Review of Methods and Outline of Project Breakdown

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Definition of Requirements

- **Target Objects for 3D Modelling** – Objects similar to the size of humans (at least 1.5 – 3 meters).
- **Resolution** – Scanning resolution and level of detail has not been specified at this point in the project.
- **Scanning Range** – The drone should be able to scan the object from a distance of 2-5 meters
- **Drone Type** – Custom Pixhawk drone with ArduPilot firmware, high resolution gimbal camera and indoor positioning system
- **Operation** – Autonomous
- **3D Modelling Approach** – Photogrammetry

Overview of Photogrammetry

- Photogrammetry is a technique that involves taking multiple overlapping photographs of an object and processing them to create a detailed 3D model. The method calculates depth and dimensions by comparing multiple 2D images taken from different angles.
- Specialized photogrammetry software are used to process the images, identify common points between them to stitch the photos together into a 3D model. A dense point cloud, mesh, or textured 3D model can also be generated.

Overview of Photogrammetry

- Photogrammetry uses **Structure-from-Motion (SfM)** process to identify common points across images and create a sparse point cloud.
- The sparse point cloud is converted into a dense point clolud using **Multi-View Stereo (MVS)** techniques to create a mesh of the object.

Project Breakdown

- The project will involve 3 aspects:
  - Building a **Pixhawk-based ArduPilot drone** capable of Autonomous Navigation in indoor environments.
  - Integration of **high-resolution gimbal camera** for capturing high quality images for photogrammetric processing
  - Development of a **data capture system** to capture good quality images with sufficient overlap
  - Selecting a suitable, open-source **photogrammetry software** for 3D model reconstruction

Autonomous Navigation in Indoor Environments

- The drone should be able to circle around the object to scan it completely over 360 degrees.
- Since the scanning process should be very consistent and stable, drone flight should be autonomous and not manual (because it is nearly impossible to fly a drone in perfect circle around the object in manual mode).
- **Problem:** Pre-built autonomous navigation algorithms for drone rely on GPS data which cannot work in indoor environments.
- **Solution:** We must develop autonomous navigation algorithms using an indoor positioning system like **optical flow sensor (PX4 flow)** or with **Visual Inertial Odometry (Intel RealSense Tracking Camera).**

Integration of High-Resolution Gimbal Camera

- For 3D scanning of objects, we need a high-resolution camera that can capture a stream of images continuously with sufficient overlap.
- The resolution of the gimbal camera should be between **12 MP to 20 MP** or higher to capture enough details for the objects.
- The camera should have good low-light performance and a wide aperture as well as high dynamic range to capture details in both the bright and shadowy areas of the object..
- The camera system needs to be integrated onto a drone platform with a **gimbal** to provide stability during drone flight.

Development of Data Capture System

- For photogrammetry, we need to develop a data capture system to capture the high-resolution images of the object with **sufficient overlap (60-90%)** from different angles around the object.
- The object should be **stationary** at placed at a position with **good lighting** to ensure uniform image capture around all perspectives.
- There should be an SD card with **sufficient memory** to store the large number of images required for 3D scanning.
- The images should be stored in **JPEG format** for photogrammetric processing.

Utilization of Open-source Photogrammetry Softwares for Mesh Generation

- Some photogrammetry tools used for creating 3D models from drone-captured images include:
  - **Open Drone Map (ODM) Software** – It is one of the most widely used open-source solutions for drone photogrammetry and works well for close-range models
  - **Meshroom** – It provides a full photogrammetric pipeline, from feature detection to model texturing.
  - **COLMAP** – It provides a general-purpose Structure-from-Motion (SfM) and Multi-View Stereo (MVS) pipeline with high accuracy. It is ideal for detailed, small to medium-sized objects.
  - **CloudCompare** – It is more useful for cleaning and refining models after initial 3D reconstruction.