A Novel Stereo Vision 3D Scanning System for Microscopic Samples

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3D scanning of microscopic objects currently relies on expensive laser scanning microscopes, that can be inefficient or unusable in scenarios requiring multi-angle views or the analysis of samples such as welding lines and irregularly shaped objects. This project develops an affordable stereo vision solution that embeds a stereo camera into an optical microscopic effector, generating disparity maps from microscopic views, enabling a non-destructive 3D reconstruction from multiple angles. Several hardware iterations were developed. The initial system used rigid aluminum frame (350 × 500 × 600 mm) integrated with 3D-printed rotary guide rails and 3D-printed NEMA-17 cycloidal actuators. Scans are collected via stereo camera integrated into individual microscope lenses, which rotate around the microscopic sample. Subsequent hardware iterations were approximately half the size and introduced modularity through custom motorized optical effectors, enabling integration with an industrial robotic arm. The stereoscopic images are processed using semi-global matching to generate a disparity map, then converted into a point cloud through triangulation. Image processing and additional transforms are computed on NVIDIA Jetson Nano SBC, which via parallel GPIO connection, interfaces with a Teensy 4.1 to control the actuators. Software, developed using the Robot Operating System (ROS), publishes data channels to RViz — a GUI for monitoring camera images, disparity maps, point clouds, and system state. The acquired data are processed into a 3D model, enabling detailed cross-sectional visualization and analysis of internal structures without destructive sampling. This 3D scanner can be applied e.g. to the analysis of micro-particle structures, biological samples, or material defects.

Awards Won:

First Award of $6,000

Herschbach SIYSS Award