Master's Thesis Summary

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Title: *Improving the Quality of 3D Reconstruction for Indoor Scenes*

Context and problem. Indoor SfM+MVS reconstructions often contain holes, particularly on low-texture planar surfaces (walls, floors). These holes typically coincide with missing or unreliable depth estimates in the corresponding MVS depth maps. Increasing MVS density via parameter tuning can reduce accuracy. This thesis argues that missing/unreliable depth estimates in MVS depth maps are a key contributor to holes.

Goal. The goal of this thesis is to improve the completeness of indoor reconstructions (reduce holes) while preserving accuracy, without redesigning the entire reconstruction system.

Main idea. The central hypothesis is that improving reconstruction quality can be achieved by improving MVS depth maps. The thesis proposes to apply depth inpainting methods (originally developed for RGB-D depth completion) to fill missing regions in MVS depth maps.

Methodology.

- Benchmarked depth completion methods using the real-world RGB-D dataset SceneNN
  - GFMM
  - CBF
  - Sparse-to-Dense
  - ALC
  - Deep Depth Completion
- Integrated DeepDepth (as the best-performing approach) into *COLMAP* and *Agisoft PhotoScan* by post-processing MVS depth maps (and normal maps for COLMAP) between depth estimation and dense point cloud construction, keeping the pipelines almost intact.
- Evaluated original vs. modified pipelines on ScanNet using precision/recall (accuracy/completeness).

Results. Experiments show a statistically significant increase in completeness (recall) for both COLMAP and PhotoScan; for COLMAP, completeness improved without a decrease in precision. For PhotoScan, the recall gain came with reduced precision; incorporating geometric consistency filtering is a plausible next step (out of scope).

Key contributions.

- Introduced a depth-inpainting-based approach to improve indoor MVS reconstructions.
- Built a SceneNN-derived dataset of rendered reference depth maps and paired RGB images, and benchmarked depth inpainting methods on MVS-like sparse depth; selected *DeepDepth* as the best-performing approach.
- Integrated DeepDepth into two reconstruction tools — *COLMAP* and *Agisoft PhotoScan* — and evaluated baseline vs. modified pipelines on ScanNet using precision/recall-style reconstruction metrics.

Keywords: indoor 3D reconstruction; photogrammetry; structure-from-motion; multi-view stereo; depth maps; depth completion; depth inpainting; COLMAP; PhotoScan; SceneNN; ScanNet.