**Data Manual**

I. Introduction

1. Brief Description of the Data:

The point cloud data being used comes from three different sources. Since no single source of data contains all the situations found in the real world by combining multiple publicly available datasets we aim to provide a more representative evaluation of how registration algorithms perform. While some of the data contains additional data fields, for the purposes of this study we are only concerned in the x, y, z coordinates for each point in the cloud.

1. Dataset Sources:

SUN3D: This dataset comes from Princeton’s Geometric Registration Benchmark.

Xiao, J., Owens, A. and Torralba, A. (2013) ‘SUN3D: A database of big spaces reconstructed using SFM and object labels’, *2013 IEEE International Conference on Computer Vision* [Preprint]. doi:10.1109/iccv.2013.458.

ETH: This dataset comes from ETH Zurich's Autonomous Systems Lab (ASL).

Pomerleau, F. *et al.* (2012) ‘Challenging data sets for Point Cloud Registration Algorithms’, *The International Journal of Robotics Research*, 31(14), pp. 1705–1711. doi:10.1177/0278364912458814.

Cross-source: This dataset comes from the Cross Source Registration Benchmark (CSRB).

Huang, X., Mei, G., Zhang, J., & Abbas, R. (2021). A comprehensive survey on point cloud registration. *ArXiv*. /abs/2103.02690

II. Location

Each dataset can be downloaded from source using the download\_data.py script. Which will save source data to the /data directory.

Full information and downloads for each dataset can be found from source at the links below:

1. SUN3D: <https://3dmatch.cs.princeton.edu/>
2. ETH:<https://projects.asl.ethz.ch/datasets/doku.php?id=laserregistration:laserregistration>
3. Cross-source Dataset: <https://multimediauts.org/3D_data_for_registration/>

III. Description of Each Data Source

1. SUN3D

Description:

This source consists of 7 sets of scene fragments, where each fragment is a 3D point cloud integrated from 50 depth frames using Truncated Signed Distance Function (TSDF) volumetric fusion.

Data format:

This dataset is intended to serve as a benchmark to assess the effectiveness of registration algorithms in determining if point clouds can be aligned. The source data consists of point clouds in .ply files with the naming convention cloud\_bin\_{index}.ply. The gt.log file contains the ground truth for each of the point cloud pairs that can be aligned. This log file is parsed during processing to extract potential pairs and the ground truth transformation. An excerpt from a log file is given below:

4 6 57

0.931813 -0.151833 0.329652 1.2445

-0.0433474 0.855229 0.516434 -0.78035

-0.36034 -0.49551 0.790332 0.711526

0 -0 -0 1

7 10 57

-0.0657651 -0.0242835 0.99754 1.44585

-0.983248 0.171894 -0.0606383 3.72015

-0.169998 -0.984816 -0.0351812 3.10725

0 0 0 1

Dataset Summary:

|  |  |  |
| --- | --- | --- |
| Data Set Name | Number of Point Clouds | Number of Pairs  (min. 50% Overlap) |
| Sun3d-home\_at-home\_at\_scan1\_2013\_jan\_1 | 60 | 104 |
| Sun3d\_home\_md-home\_md\_scan9\_2012\_sep\_30 | 60 | 157 |
| Sun3d-hotel\_uc-scan3 | 55 | 172 |
| Sun3d-hotel\_umd-maryland\_hotel1 | 57 | 77 |
| Sun3d-hotel\_umd-maryland\_hotel3 | 37 | 33 |
| Sun3d-mit\_76\_studyroom-76-1studyroom2 | 66 | 178 |
| Sun3d-mit\_lab\_hj-lab\_hj\_tea\_nov\_2\_2012\_scan1\_erika | 38 | 59 |

1. ETH

Description:

This source consists of LiDAR scans taken across 8 different scenes. A summary of the datasets and the environment is given in the table below.

A screenshot of a computer

Description automatically generated with low confidence

The ground truth is obtained using high-precision GPS/IMU data, the full details of which can be found at: <https://projects.asl.ethz.ch/datasets/doku.php?id=hardware:tiltinglaser#platform_description>

Data format:

The source data consists of point clouds in .csv files with the naming convention PointCloud{index}.csv. The data downloaded is already in the global (aligned) coordinate frame, so there is no ground truth file.

Dataset Summary:

|  |  |  |
| --- | --- | --- |
| Data Set Name | Number of Point Clouds | Number of Pairs  (min. 50% Overlap) |
| Apartment | 45 | 499 |
| Gazebo-Summer | 32 | 404 |
| Gazebo-Winter | 31 | 314 |
| Hauptgebaude | 35 | 498 |
| Mountain Plain | 31 | 424 |
| Stairs | 31 | 215 |
| Wood-Autumn | 32 | 377 |
| Wood-Summer | 37 | 553 |

1. Cross-Source-Dataset

Description:

This source consists of 202 mixed source point cloud pairs from an indoor office environment, where the point clouds to be aligned are captured using different modality. The point cloud pairs can be broken down into two types:

* Kinect and Lidar (19 scenes)
* Kinect and SfM (2 scenes)

The ground truth is obtained by manual alignment, cross referenced by multiple people.

Data format:

The source data consists of point clouds in .ply files with the naming convention Kinect.ply/lidar.ply/sfm.ply, where each pair is being stored in its own subdirectory. The ground truth is in a T\_gt.txt file, which can also be found in the point cloud pair directory.

Dataset Summary:

|  |  |  |  |
| --- | --- | --- | --- |
| Data Set Name | Number of Point Clouds | Number of Pairs  (min. 50% Overlap) | Average Points per cloud |
| CSRB | 404 | 182 | 327034 |

IV. Preprocessing

Due to the different format of the source data, the steps required to preprocess each dataset differ. The result of preprocessing is that for each dataset we obtain a text file containing all the possible experiments for the dataset in a standard format, so later we can run registration experiments on them in the same manner.

For each dataset I will outline the individual processing procedure, but they all follow the main objectives which are:

* Finding point cloud pairs (if necessary)
* Calculating the percentage overlap of point cloud pairs
* Filtering out point cloud pairs that do not overlap sufficiently
* Saving experiment pairs to a text file: the experiment id, filenames of the point clouds for direct access, the percentage they overlap, the number of points in both point clouds (so it does not need to be recalculated later), and the ground truth transformation (if it exists).

SUN3D:

1. The gt.log file is parsed to extract the index of point cloud pairs that go together.
2. The point clouds are read in, transformed to be on the same coordinate system and the overlap calculated.
3. Pairs are filtered by overlap and filenames saved to a text file, with ground truth.

ETH:

1. All point clouds are read in and an overlap matrix is calculated.
2. Pairs are filtered by overlap and filenames saved to a text file.

Cross-Source:

1. Directory is walked through and point cloud pairs and ground truth are read.
2. Point clouds are transformed to be on the same coordinate system and the overlap is calculated.
3. Pairs are filtered by overlap and file path saved to a text file, with ground truth.

V. Data Usage

After these preprocessing steps, the data can then be loaded into the registration evaluation program, where the program reads in the experiment point cloud pairs text file and obtains the; experiment id, file path, overlap, total points and ground truth (if present). The evaluation program will then use the ground truth to obtain both point clouds on the same coordinate system. The program then generates a random transformation (given input parameters for magnitude of translation and rotation) and applies it to the target point cloud, it is this random transformation that we are then trying to estimate.

Note:

For the purposes of this study and given the fact that we are retraining models. Only a subset of this input data will be experimented on the rest is used in training the model. Full details on this selection and experiment methodology are in the report.