Comparative Study Between Three LiDAR Registration Techniques

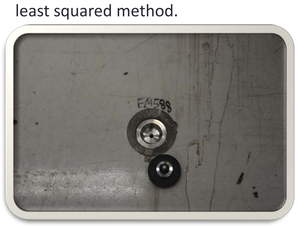
Created By: Matthew Lee MacDonald, Andy Fontana, and Tarik Ceric
Institution: Ferris State University, College of Engineering Technology, Survey Engineering

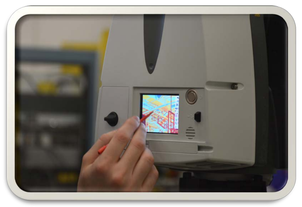
ABSTRACT

The use of Laser Detection and Ranging (LiDAR) systems has become increasingly popular over the last decade. The use of such systems requires the distinction of the following two categories: data collection and data processing. The processing side involves an action known as registration. LiDAR Registration is the process of obtaining a unified pointcloud through of a series of rigid coordinate transformations. This study compares three similar, but different, registration methods: Auto-registration, Manual Registration (using paper targets), and Visual Alignment. Each method was evaluated on two terms: its relative precision and accuracy compared to an established coordinate system. The data was collected in a single room at the Facility for Rare Isotope Beams (FRIB) on the Michigan State University Campus in Lansing Michigan with a Leica P40 static LiDAR unit. The data was then processed using all three of the mentioned methods.

BACKGROUND

- **Setting:** The data was collected at the Facility for Rare Isotope Beams on the Michigan State University Campus in Lansing Michigan, and the data was processed at Ferris State University.
- **Equipment Utilized:** Leica p40 Static Lidar scanner, Leica TDRA 6000, Leica Cyclone, and Microsoft Excel.
- **Control Network:** The accuracy of each registration method was evaluated with respect to the FRIB's internal high accuracy control network. The network was established using high precision metrology equipment and possesses an uncertainty of about 50 microns.
- **Multi-point Resection:** A multi-point resection was performed with the TDRA 6000 for the purpose of measuring the coordinates of a series targets within the room.
- **Targets Used:** Paper targets were placed strategically along the walls of the room. Each targets coordinates were determined using the TDRA 6000. The targets remained on the walls as the room was being scanned. The coordinate values were later used to transform the unified scans from each registration method to the FRIBS existing coordinates system.
- **Transformation:** The process of registration produces a unified pointcloud by identifying conjugate points within separate scans. After a list of conjugate points are developed, the individual scans are unified using a rigid affine coordinate transformation and a non-linear least squared method.





OBJECTIVES

- Obtain spatial data of a single room within the Facility for Rare Isotope Beams
- Evaluate the relative precision of three different LiDAR registration methods
- Evaluate the accuracy of three different LiDAR registration methods in regards to an established control network

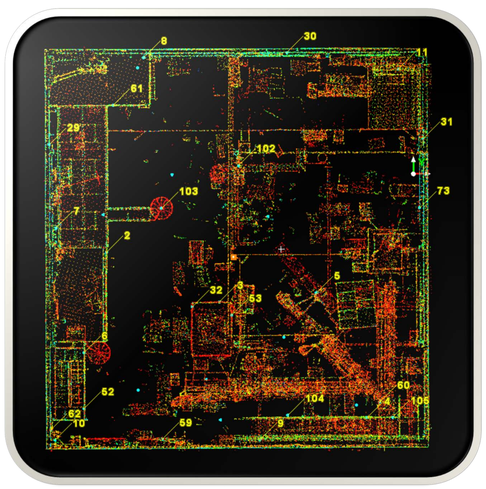
METHODS

- **Auto-Registration:** A method of registration that requires the user to upload each individual scan. The software automatically selects conjugate points and unifies each scan.
- **Manual Registration (Using Paper Targets):** A method of registration that requires the user to upload the each individual scan, and select conjugate paper target points in each scan. The software automatically selects conjugate points and unifies each scan.
- **Visual Alignment:** A method of registration that requires the user to upload the each individual scan, and visually align each scan. The software automatically selects conjugate points and unifies each scan.

RESULTS- ACCURACY & PRECISION

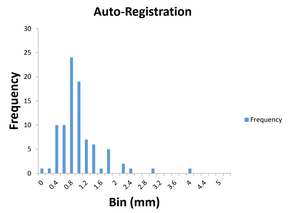
	Registration Methods (Standard Dev)		
Target ID	Auto-Reg	Man-Reg (target)	Visual ALG
1	0.585224	0.290615296	0.5537107
2	0.995954	0.867573664	0.779725
3	0.785911	1.034262872	0.6727598
4	0.873278	0.814378559	0.7485103
5	0.674362	0.831615897	0.9717487
6	0.989188	1.011191067	1.099825
7	0.616006	0.961062491	1.2111583
8	1.845899	1.585460063	1.9848927
9	0.525783	0.791477942	0.8779058
10	1.315563	1.137163876	1.4436259
29	0.540814	0.385594671	0.5726371
30	1.228187	0.713833489	1.0646625
31	0.980478	0.617325279	0.7853058
32	0.582157	0.399120909	0.837205
52	2.662791	1.923990478	2.5655736
53	1.013917	0.75596365	1.395479
59	0.877117	0.87213977	0.7520474
60	1.051868	1.617019712	1.0284538
62	1.571781	0.976289588	1.4756346
73	0.852683	0.774802627	0.6458546
Avg =	**1.028448**	**0.918044095**	**1.0733358**

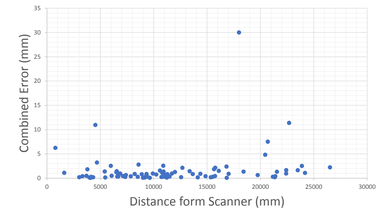
	Registration Methods (Combined Error)		
Target ID	Auto-Reg	Man-Reg (target)	Visual ALG
1	0.649614	1.386028499	0.5895329
2	0.766374	0.912241196	0.5509056
3	1.000724	1.176238921	0.425542
4	2.561401	2.580134299	1.2588241
5	1.045744	0.99138842	0.6389828
6	1.994306	2.137524503	1.0108951
7	1.902808	2.295399094	0.8838196
8	1.601096	1.670625332	0.7623392
9	1.281434	1.295091116	0.5974186
10	2.005962	2.426120154	0.8951771
29	2.766126	2.864190985	1.3684477
30	1.127039	1.328462645	0.610847
31	2.137844	2.05569526	1.1650343
32	2.027863	2.185445721	0.9842769
52	3.227019	3.593345516	1.67731
53	1.73714	2.024277402	0.9280102
59	1.798059	1.973697292	1.0923136
60	3.648588	4.085366079	1.9021267
62	2.129995	2.03557977	1.0338283
73	0.63402	0.345543051	0.238168
RMSE =	**1.974996**	**2.154041434**	**1.0136752**

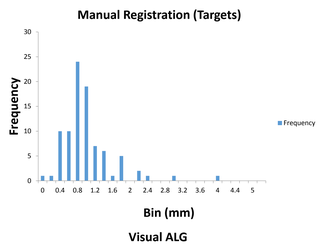


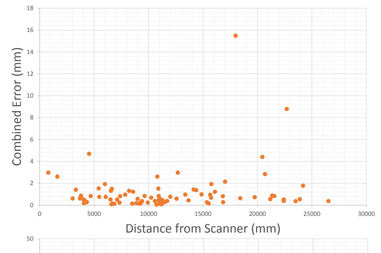
Frib Control			
Target ID	X	Y	Z
1	298.444477	534.558689	50.597268
2	298.450597	534.565655	52.048883
3	306.060663	531.203366	52.098353
4	315.942845	523.349022	54.395195
5	312.584476	531.795347	51.503166
6	296.904158	527.819607	54.823369
7	295.043586	536.224701	55.505929
8	300.996142	547.672909	55.361103
9	308.734618	521.895631	52.348583
10	294.944203	521.930377	52.042387
29	294.61549	541.83742	51.632295
30	310.633316	547.981253	51.967329
31	319.827264	542.155532	51.921926
32	304.210801	530.867769	51.9086
52	296.896889	524.038264	53.055594
53	306.857854	530.312964	53.710161
59	302.156731	521.953886	51.470741
60	316.831248	524.403395	51.328212
62	294.630075	522.585033	51.557562
73	319.563614	537.495664	52.131453

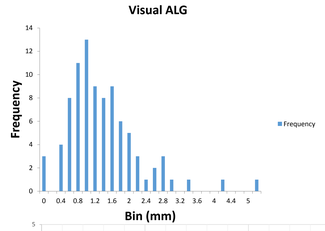
RESULTS – RELATIVE PRECISION

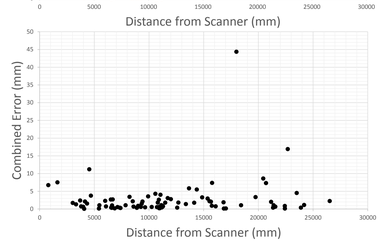


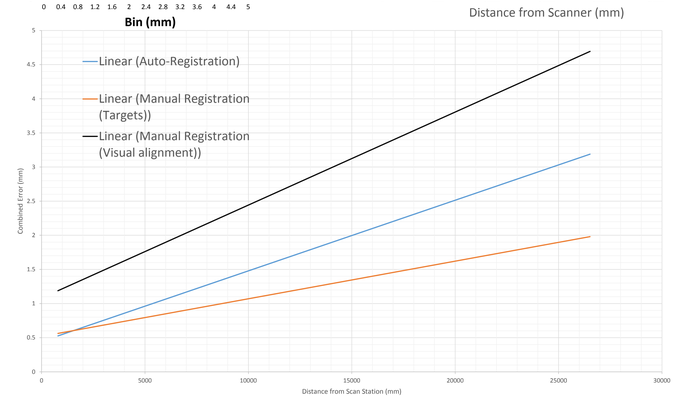












CONCLUSIONS

- Through data analysis the following was concluded
  - In terms of relative precision, manual registration using paper targets was found to be the most precise method yielding an average Standard deviation of 0.92 mm.
  - In terms of accuracy, the visual ALG method was found to be the most accurate method yielding an RMSE value of 1.01 mm.

ACKNOWLEDGMENTS

- We would like to thank the following people for their contributions to this project: Peter Manwiller, Richard Sauve, Sagar Deshpande, Emily O' Dea, Chad Studer, Doug Schueneman, Carl Shangraw, Gabor Barsai, and Evan Choi.