Using Unmanned Aerial Systems to Detect Pavement Elevation Change

Felicia Formisano

Abstract: Research studies have been conducted over the past few years by Engineering Departments at the University of New Hampshire to improve pavement performance on road and highways. Frost heaves lead to excessive pavement roughness that impact the safety of aircraft and vehicle operations. This roughness has created a need for research and development of automated sensing and decision systems to support aircraft and vehicle movements during spring/ summer thaw durations of rural locations in cold-climate regions. LiDAR is a promising tool used for reliable and accurate frost heave measurements on roadways. In this work, artificial frost heaves were simulated to test the ability of UAS sensors to detect and accurately reconstruct subtle changes in elevation and irregularities on pavement surfaces. This data was analyzed to determine its limits in detecting road roughness. Upon analysis, it was determined that LiDAR is a powerful tool which can detect even slight elevation changes.

Introduction/Background

- Several research studies have been conducted at the University of New Hampshire to improve pavement performance.
- Road roughness impacts the quality and efficacy of roads.
- This roughness created a need for automated sensing and decision systems to support road movement during thawing.
- This work focused on using UAS sensors to detect and accurately reconstruct changes and irregularities in pavement surfaces.

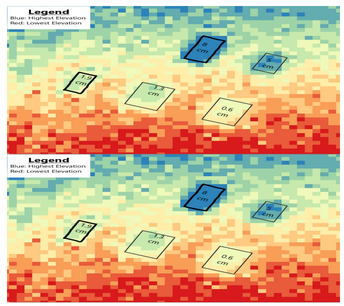
Methods

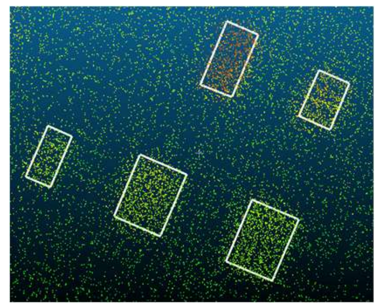
Data Collection:

- Artificial frost heaves were constructed using plywood.
- The most recent flight included five simulated heaves with heights of 0.6, 1.3, 1.9, 5, and 8 centimeters.
- The simulated heaves were set up in the GOSS parking lot, perpendicular to the UAS-Lidar flight lines. UAS-LiDAR observations and optical photogrammetry data were collected for each heave.

Data Retrieval:

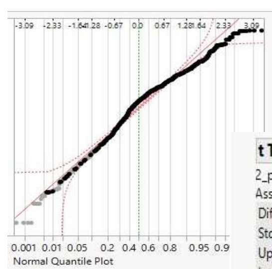
- Point Cloud, QGIS, Excel, and JMP were used to extract and analyze the LiDAR and Photogrammetry data gathered from the flight.
- The primary analysis of the collected data show that the LiDAR system and Photogrammetry can detect even small changes in elevations.
- Some statistical methods have been applied to the measured data to determine if the estimated values are significantly different or not.

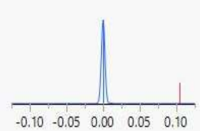




Data Analysis:

- T-Tests were run to determine if there was statistical significance between the plywood and asphalt layers.
- Normality tests were run to ensure the collected data are within a normal distribution.
- The results show that the obtained data follow a normal distribution, and there is a significant difference between the means of plywood layers heights.
- To determine the accuracy of LiDAR and Photogrammetry, the average heights of the plywood layers were compared to their actual height on the ground.





t Test

2_p-2_g

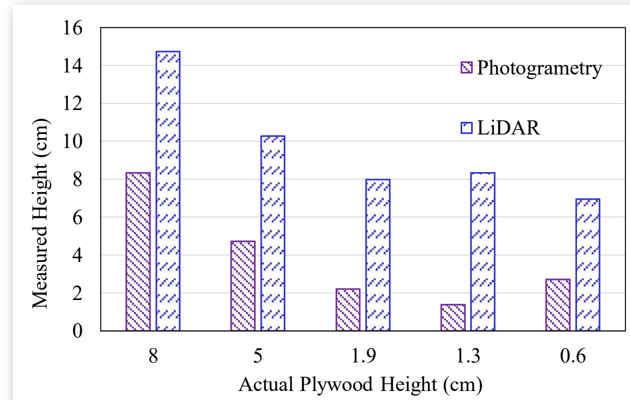
Assuming unequal variances

Difference	0.104332	t Ratio	44.00213
Std Err Dif	0.002371	DF	1093.121
Upper CL Dif	0.108985	Prob > |t|	<.0001*
Lower CL Dif	0.099680	Prob > t	<.0001*
Confidence	0.95	Prob < t	1.0000

Statistical Analysis Results for the 2-inch Plywood for Lidar

Results

- LiDAR and Photogrammetry are powerful tools which can detect even slight elevation changes.
- The Photogrammetry proved to be more accurate than the LiDAR according to the collected data.
- The LiDAR accuracy could be skewed by the reflective nature of the plywood.



Conclusion/Summary

- Comparing the LiDAR with the Photogrammetry data has revealed that, for this specific flight, the Photogrammetry was more accurate than the LiDAR at detecting changes in elevation.
- The team has discussed that this may be due to the reflective nature of the plywood. This reflection could skew the data.
- The next step for the research team is to conduct more LiDAR and Photogrammetry flights.
  - The team may conduct the flights at different times of day to reduce sun reflection.
  - They could also try to spray paint or place tarps on the plywood to avoid reflection.

Acknowledgements – This research was supported through the National Science Foundation's Research Experience for Teachers in Engineering grant (ENG-1757371).
A special thank you to Farah Zaremotkhases, Adam Hunsaker, Dr. Eshan Dave, and Dr. Jo Sias.
Thank you to Steve Hale for giving me this opportunity.