Image Processing Integration Into Global Navigation Satellite System Reflectometry To Remotely Sense Freshwater Surface

Lan Tran *,1, Dr. Seebany Datta-Barua *, Dr. Roohollah Parvizi *

*Department of Mechanical, Material, and Aerospace Engineering, Illinois Institute of Technology, Chicago, IL 60616, USA

Abstract

Global Navigation Satellite System Reflectometry (GNSS-R) is a technique that detects signals reflected off the surface and analyzes the reflected signals to obtain surface characteristics. This technique was used to differentiate between surface ice and water condition of Lake Michigan in Chicago [1]. To confirm GNSS-R results validity, a separate reference is needed to compare with [2]. A sensor fusion of camera and a lidar was used to reconstruct the lake surface [2]. This reconstructed surface was used as a reference to compare with GNSS-R results [2]. Since the current camera frames rate being used to reconstruct the lake surface using the sensor fusion of camera and lidar is two frames per minute, this research explores the effect of increasing the camera frames rate on the reconstructed surface.

I. Introduction

GNSS-R technology was illustrated in Figure 1

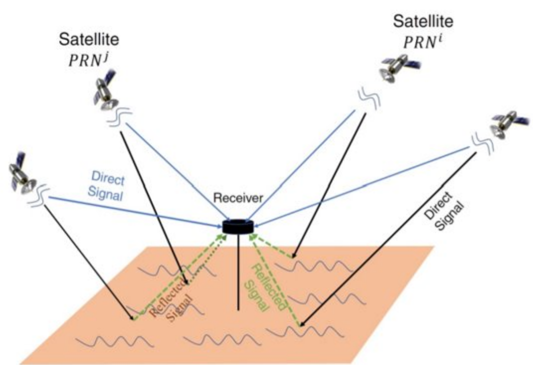

Figure 1: GNSS-R technology is used to analyze surface characteristics

A camera is a device that captures visual images. A lidar, an acronym for light detection and ranging, is a device used to measure distance of an object by emitting a laser beam.

Each pixel is identified by a set of coordinates in the camera coordinate system as shown in Figure 2

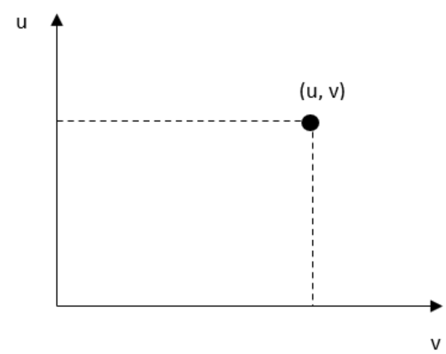

Figure 2: Camera pixel in camera coordinates system

Backward projection is performed using the distance obtained from the lidar and pixel coordinates from the camera image plane to reconstruct the lake surface as shown in Figure 3 [2]

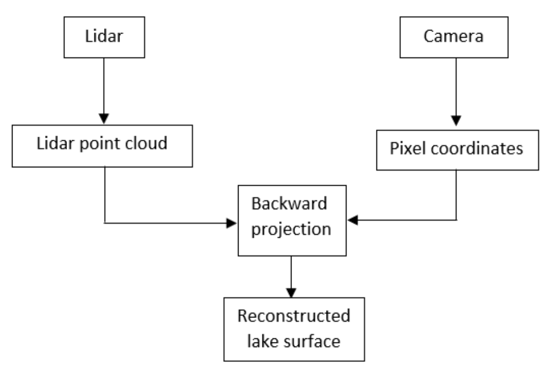

Figure 3: Backward projection is performed to reconstruct the lake surface

Backward projection is illustrated in Figure 4

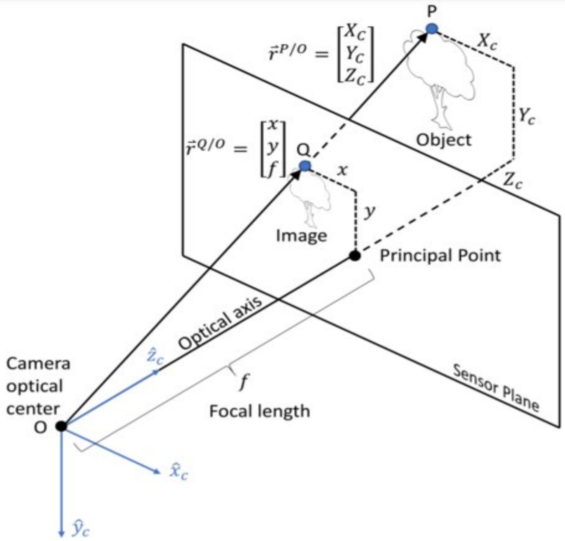

Figure 4: Backward projection technique

The current camera frames rate being used is two frames per minute, and this research aims to increase the camera frames rate to capture more data about the lake surface.

I. Method

The camera frames rate is determined to be fifteen frames per second using a MATLAB function, and the lidar frames rate being used is ten frames per second. The raw data collected from the camera and the lidar is then processed. During data processing, a certain number of lidar and camera frames were skipped, so the current camera frames rates is reduced to two frames per minute.

The lidar sampling rate was also obtained because data processing is done on camera and lidar data, so their sampling rates are related.

The proposed sampling rate is one second as shown in Figure 5

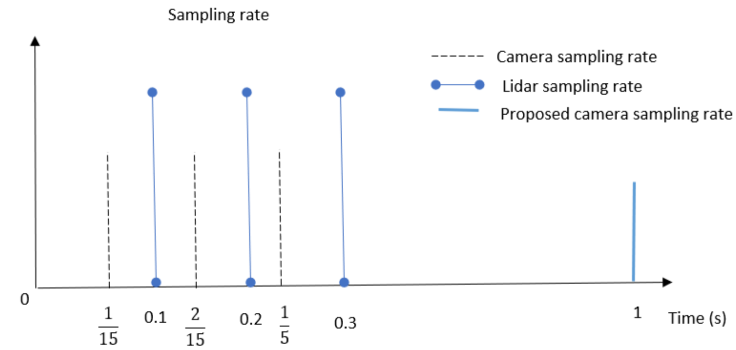

Figure 5: Proposed camera sampling rate

II. Results

The lidar point cloud was overlaid into camera images generated with the current camera frames rate as shown in Figure 6 [2]

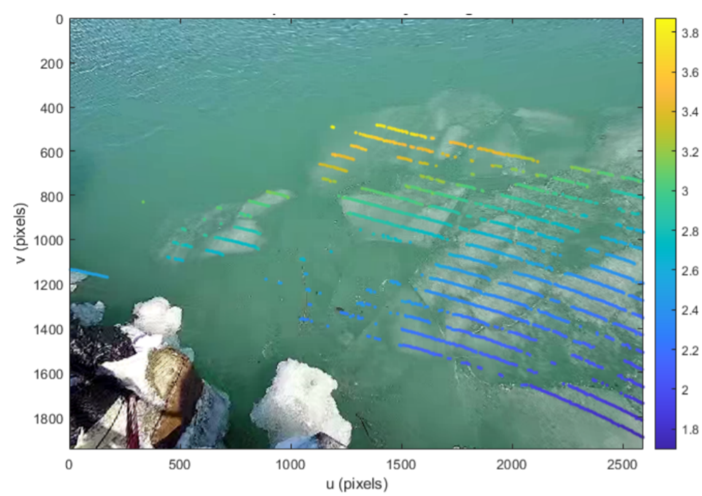

Figure 6: Lidar points cloud overlaid into camera image plane. Image credit: Sharukh Khan [2]

A similar plot of lidar points cloud and camera image will be generated to explore the effect of increasing camera frames rate.

III. Discussion

Surface conditions and its rate of changing are better understood if more camera frames are available. Therefore, the surface reflectivity can be computed with more accuracy.

IV. Acknowledgement

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V. References

[1] Parvizi, Roohollah. "A Novel Remote Sensing System Using Reflected GNSS Signals." *PHD thesis* . Chicago, August 2020.

[2] Khan, Sharukh. "3D Reconstruction Of Lake Surface Using Camera And Lidar Sensor Fusion." *Master thesis* . Chicago, August 2020