Measuring Glacier Thickness in the Yukon with a Portable USB Digitizer

Unnamed Glacier in the Donjek Range,Kluane National Park, YK
Image credit:Laurent Mingo

By Laurent Mingo, P.Eng.
Project Leader & Systems Development
Blue System Integration Ltd.

The Goal

Building a cost effective, portable data acquisition system to characterize glaciers thickness.

The Challenge

Validating a hardware device capable of acquiring radar signals at 100MS/s, that must be portable, and that requires low-power. Integrating the device with an existing radar equipment to measure radar echograms and deriving ice thickness.

The Solution

Using the the National Instruments USB-5133 bus-powered digitizer, together with a small size laptop computer running NI LabVIEW.

Introduction

Characterization of the natural environment is a fundamental step towards its understanding. Faced with today's environmental challenges, it is critical to further our knowledge of natural processes such as water cycle, and greenhouse effect. Glaciers dynamics and their responses to climate are yet another of these processes that requires research to be carried out. One of the many steps that scientists at Simon Fraser University in Vancouver, BC, Canada, must take to model glacier dynamics, is to come up with a reliable three-dimensional representation of the glaciers they study. 3D representations, are typically produced from a combination of high precision GPS surveying and glacier bed radar surveys. This application note focuses on a portable system developed to measure ice thickness over an entire glacier to produce the data necessary to build its a 3-D representation.

Hardware

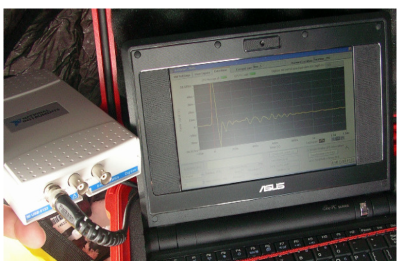
A typical ice thickness measurement system consists of a radar device with a transmitter and a receiver. At a given location, the radar emission antenna generates a recurring pulse. This pulse travels through the ice and a fraction of its energy is reflected back, traveling upward through the ice again. When reaching the ice surface the signal is captured by a receiving antenna terminated with a BNC connector.

NI USB-5133
Photo Credit: National Instruments

This is where the lightweight (250 g) NI USB-5133 digitizer becomes useful for capturing the antenna signal. For this specific application, triggering is based on the radar signal itself as one of the many triggering options the device offers. The large 4MB internal buffer can be used to store returned waves with the longest required travel times, as would be found on the thickest ice sheets, but also to acquire multiple returned waves for further processing. This is assuming sufficient power is produced by the radar system for the EM wave to travel through the ice and back to the antenna with sufficient power that it can be detected by the digitizer. For the current purpose, being capable of measuring a few 100 meters of ice was our target.

On the computer side, priority was given to a cost-effective device, reasonably rugged, and lightweight. A small size Asus *eeePC* laptop was found to be ideally suited to meet our requirements. This device sports a solid-state hard drive, hence no moving part, three USB ports, and it weights about 950g.

To associate each radar echogram with the location where the measurement was performed, a portable, waterproof GPS instrument was used. The model we chose is USB-based and comes with its virtual serial communication port driver.



NI USB-5133Digitizer and small laptop EEE PC
Photo Credit: Gwenn Flowers

Software

The data acquisition software IceRadar was developed with NI-LabVIEW. Building a powerful digitizer application was simplified by taking full advantage of the native NI-SCOPE drivers, providing an intuitive programming interface to the digitizer hardware. To improve the signal-to-noise ratio, the application offers the option to perform *returned waves stacking* which consists of averaging radar signals on-the-fly. To implement *stacking*, a multi-trigger scheme is used, capturing full 100MS/s sampled echograms in sequence, according to the 512 hz radar pulse frequency. Additionally, automated echogram capture, with or without stacking, can be selected to acquire the signal at a predefined time interval. The GPS unit was integrated into the system using LabVIEW's standard serial device drivers. Parsing of the GPS's NMEA messages was also implemented in software.

Special attention was conferred to data management. Each location where a measurement is taken is associated with radar data, GPS data, a location name, and a time stamp. In addition, meta data is collected to indicate some of the data quality. For instance, GPS coordinates are saved with both a *fix quality factor*, and the *number of satellites* used for producing the coordinates, indicating the level of confidence on the position. A simple file saving scheme would become cumbersome and difficult to manage due to the incongruous nature of the data set. To address this in IceRadar, we used a hierarchical data format to store the information. The file format being self-describing, it allows an application to interpret the structure and contents of a file without any outside information. In IceRadar, data are first grouped into a top level object, called *lines,* that represent a given path on the glacier where point measurements were taken. Each point measurement within a *line* is attached to a subgroup called a *location* and it contains all the related data: the radar data set as an array, the GPS data set as a cluster. Meta data are saved as a data set's *attributes*. All these objects are consolidated into the hierarchical file system, and can be accessed by the analysis routines of IceRadar, as well as by any compatible third-party API.

These simple analysis routines allow researchers to scan through hundreds of radar data echograms, keeping track of where each one of them was acquired. Ice thickness calculation can be performed post-acquisition using a set of cursors. This new data is consolidated into the hierarchical file scheme. The entire data set can maintained within a single file, and is hierarchically organized for fast access to key information.

Radar Transmitter and carrying box mounted on skis.
Photo Credit: Laurent Mingo

Conclusion

By using a NI-USB 5133 digitizer and NI LabVIEW we were able to create an ice thickness acquisition and analysis system at a fraction of the cost of comparable commercial products used for ice thickness. The same approach could also be used for ground penetrating radar measurements (GPRS). Our system is portable and can be used on foot or skis. Planned improvements for next field season are expected to boost the analysis capabilities of the system, and to improve its portability even further.

For more information, contact Laurent Mingo. laurent.m@bluesystem.ca
www.bluesystem.ca/environmental.htm

Team:
Architecture, digitizer acquisition, serial com. GPS driver integration, data model, field testing: L. Mingo, BSI.;
GPS serial driver: O. Lessard Fontaine, BSI

Acknowledgement: We are thankful to Whistler Blackcomb resort for letting us access the mountain for field testing.