Analysis of Mathematical Models and Implementation of a Python-based 3D Attitude Estimation Software using 6 DOF Fiber Optic Gyro (FOG) Data in Tunneling Applications

Introduction

With appearance of FOGs as a completely isolated system, less volume and high sensitivity regarding other types of Gyroscopes make them more reliable and efficient. One of the inseparable parts of observations with Gyrocompasses are the errors. There are different types of methods to reduce these errors. VMT company is responsible for different tunnel projects around the world. Objective of this thesis is to implement an algorithm for the new gyrocompass in company. This algorithm has been developed to find the real north (Yaw) using the raw data that recorded by sensor. For VMT is important that at the same time offer cheaper prices and higher accuracy that's why the company need to test new gyrocompass with smaller size and cheaper price. The gyrocompass has been tested in laboratory and also in different projects (with implemented algorithm) to find the true direction of north.

Implementation

Gyrocompass for this work is *S LCI-100N* manufactured by Northrop Grumman LITEF GmbH, Germany. Frequency of output data is 200 Hz (200 packages of data per second sent from sensor to computer). Three filters including mean, moving average (different size of moving window) and butterworth have been designed to decrease the frequency to 1 Hz for handling the data, removing some errors and noises. The equations that have been used for finding the north are as following:

$$\omega_{ib,x}^{h} = \omega_{ib,x}^{b}\cos\theta + \omega_{ib,y}^{b}\sin\Phi\sin\theta + \omega_{ib,z}^{b}\cos\Phi\sin\theta$$
$$\omega_{ib,y}^{h} = \omega_{ib,y}^{b}\cos\Phi - \omega_{ib,z}^{b}\sin\Phi$$
$$\psi = arctan\,(-\omega_{ib,y}^{h}\,,\,\omega_{ib,x}^{h})$$

After calculation of azimuth, Gauss-Helmert model has been used for adjustment as follows,

Hochschule Karlsruhe – Technik und Wirtschaft
Faculty IMM • Geomatics (Master)
www.hs-karlsruhe.de
Author: Kianoosh Nazari
E-Mail Address: kianosh.nazari@gmail.com
First referee: Prof. Dr.-Ing. Reiner Jäger
Second referee: M.Sc. Andreas Hoscislawski
Supervisor VMT-GmbH: Dr. Sascha Schneid

$$\underset{(b,n)}{B}\ \underset{(n,1)}{v} + \underset{(b,u)}{A}\ \underset{(u,1)}{\hat{x}} + \underset{(b,1)}{W} = \underset{(b,1)}{0}$$

And finally the Python based GUI has been designed for the aboved mentioned process.

The box including Gyrocompass blue box to process the data

Conclusion

In this thesis, concentration was mainly on analysis of data that produced by gyrocompass, implementation and development of python based tool for the gyrocompass sensor to find the true azimuth (north) in tunneling application (for TBM machine). The following figure shows the best result from the algorithm that has been design for north detection. The average of error is -0.582 degree.
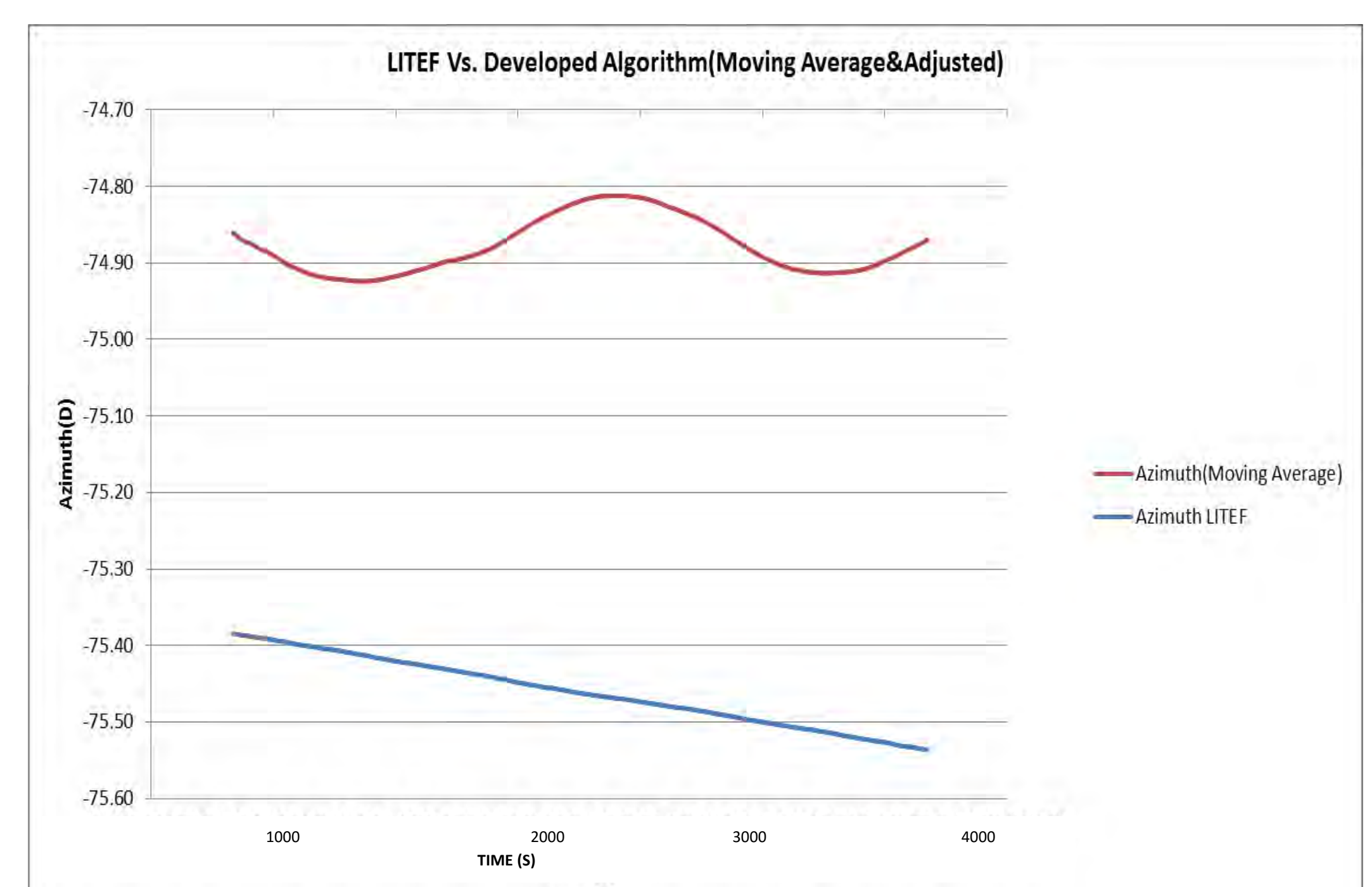
The best result of developed algorithm Vs. result from LITEF