MOVEMENT AND POSITION DETECTION PROCESSING DATA FROM AN ACCELEROMETER: MOTION SIMULATION OF AN AUV WITH A INERTIAL NAVIGATION SYSTEM BASED ON MYRIO

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Abstract
Inertial reference based on measurement and processing of acceleration data is needed for guidance and function controls of Autonomus Underwater Vehicle. This work proposes a method for acceleration data processing in order to implement 1D motion simulation of AUV.

I. INERTIAL NAVIGATION SYSTEM

Inertial navigation is a self-contained navigation technique in which measurements provided by accelerometers and gyroscopes are used to track the position and orientation of an object relative to a known starting point, orientation and velocity. Inertial measurement units (IMUs) typically contain three orthogonal rate-gyroscopes and three orthogonal accelerometers, measuring angular velocity and linear acceleration respectively. By processing signals from these devices it is possible to track the position and orientation of a device. Inertial navigation is used in a wide range of applications including the navigation of aircraft, spacecraft, submarines and ships. Recent advances in the construction of MEMS devices have made it possible to manufacture small and light inertial navigation systems.

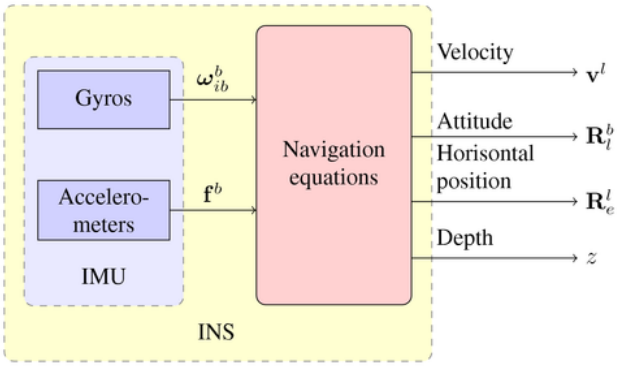

Figure1. A block diagram of an inertial navigation system (INS)

Accelerometer.
In low-cost, small-size inertial sensors the accelerometers commonly used are Micro-Electro-Mechanical System (MEMS) accelerometers. There are two main classes of MEMS accelerometer. The first class consists of mechanical accelerometers (i.e: devices which measure the displacement of a supported mass) manufactured using MEMS techniques. The second class consists of devices which measure the change in frequency of a vibrating element caused by a change of tension.
Inertial navigation system based on myRio is provided by the Analog Devices ADXL345, a small, thin, ultralow power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 g. The acceleration is usually in MEMS application measured in G unit.

Position detection from accelerometer.
The signal obtained from the accelerometer does require processing. In order to obtain position a double integration must be applied to the signal. By defining a(t) as the acceleration at time t, v(t) as the velocity at time t, x(t) as the position at time t, the acceleration can be expressed as the derivative:
The Fundamental Theorem of Calculus can be applied to write this relation in the form:

$$a(t)=\frac{dv}{dt} \quad (1)$$

The velocity is defined by the derivative:

$$\int_{T_1}^{T_2} a(t)dt=v(T_2) - v(T_1) \quad (2)$$

By the Fundamental Theorem of Calculus,

$$v(t)=\frac{dx}{dt} \quad (3)$$

where the last term is call displacement.

$$\int_{T_1}^{T_2} v(t)dt=x(T_2) - x(T_1) \quad (4)$$

II. AUTONOMUS UNMANNED VEHICLE

Autonomous Underwater Vehicles (AUVs) are simply computer-controlled systems operating undersea. They are considered autonomous because they have no physical connection to their operator, who may be on shore or aboard a ship. They are vehicles that, depending on their design, can drift, drive, or glide through the ocean without real-time control by human operators. Some AUVs communicate with operators periodically or continuously through satellite signals or underwater acoustic beacons to permit some level of control. During a mission, AUVs have assigned tasks that may involve traveling a certain path and collecting information about the areas traveled. They can be configured with different sensors and communication systems to provide real-time information back on land or to a ship over the horizon.

Motion simulation of AUV with a INS based on myRIO
In this section an overview of developed labview software for the navigation data processing and the mono-dimentional AUV motion simulation has been presented. The navigation data acquisition system is based on the embedded hardware device NI myRio. The software development environment in this work is LabVIEW, that is a graphical programming language widely adopted in industry and academia as a standard for data acquisition and instrument control software. The aim of the software is to evaluate the position data obtained by

acquiring acceleration data from myRio and to plot these data on the x-axis in order to simulate the AUV movement in one dimension.

The software development consists of the following steps:
- acquisition of the x-axis acceleration data, through the Accelerometer block
- implementation of a noise reduction filter;
- implementation of the first integration section in order to calculate velocity value from acceleration value;
- implementation of the second integration section in order to calculate position value from velocity value;
- implementation of the graphical position data representation, through the Build XY Graph block.

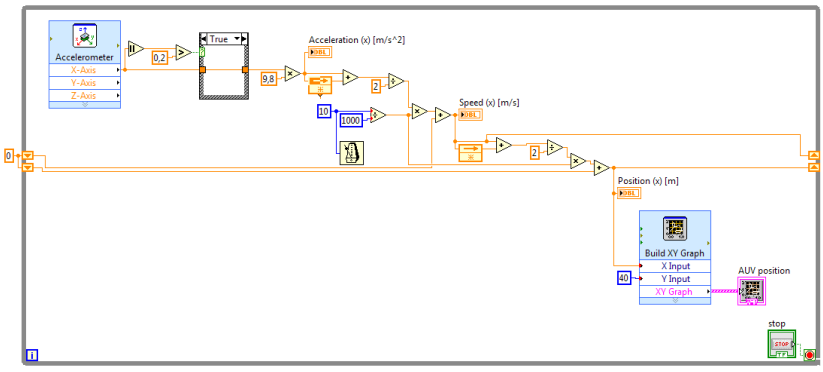

Figure 2. The LabVIEW block diagram

The integration process was done by averaging adjacent samples two by two and multiplying them by the sampling period.

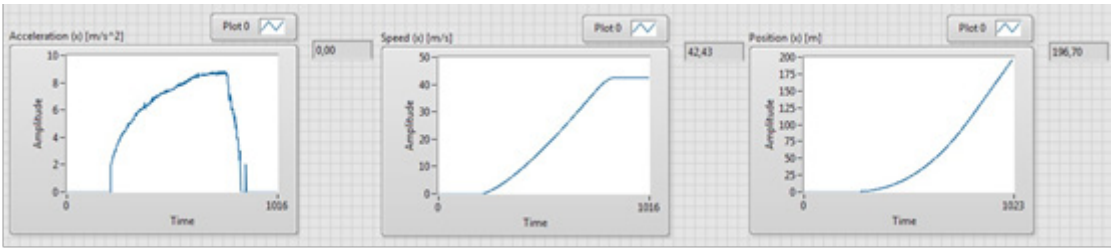

Figure 3. The LabVIEW front panel (one dimension navigation data)

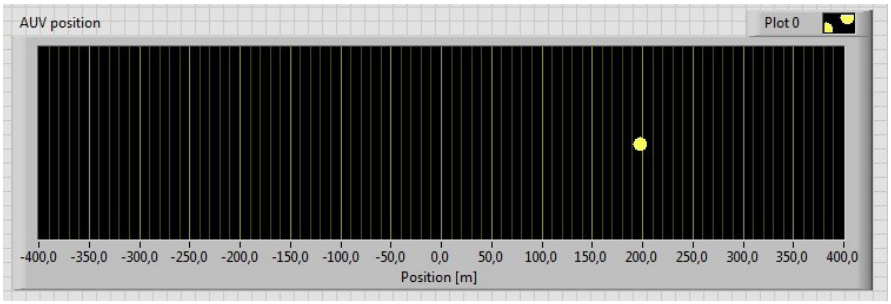

Figure 4. The LabVIEW front panel (mono-dimensional AUV motion simulation)

III. CONCLUSIONS

This paper presents a navigation data processing method. This method has been implemented on NI myRio as a simple solution in order to show the potentiality of the architecture in the navigation systems. Generally, important error sources such as accelerometer bias, are a very important problem. The developed LabVIEW software introduces a threshold represented by a case structure in order to reduce the acceleration noise, and the integration section and in the related position value. Starting from the position data, the AUV mono-dimensional motion simulation shows how it can be possible to implement graphic support to the navigation systems.

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