3D Pipeline Mapping

EWI TECHNICAL BRIEF

Issue

The existing casing and pipeline mapping systems have progressed to the technological stage where they can relatively accurately determine the location of a buried pipeline in a right-of-way (ROW). In terms of X, Y, Z coordinates (where Z is the depth of the pipeline), the X and Y (latitude and longitude) can be attained through a multitude of techniques. Many of the techniques require the use of fly-overs, people walking/driving the ROW, and/or interpolation of know pipeline locations.

One of the shortcomings is the lack of directly transferable GPS data, specifically in terms of the depth of the pipe (or Z variable) into a geographic information system (GIS) system. Knowing the true location of the pipe would help make GIS systems more reliable and reduce the time required for repair and verification digs.

Background

The basic concept of EWI's proposed 3D mapping system is a hybridization of current pipeline mapping technologies, aeronautical locating technologies, and techniques used to monitor penguin swim speed and distances. All these techniques are independently being used in their respective industries but no effort has been made to combine the good aspects of each technology to make real-time observations of the exact location of a crawler. While the equipment will not directly translate from the penguins back to a pipeline pig or crawler, the concept remains the same.

Currently, many pigs and crawlers (or robots) use an inertial measurement unit (IMU) to determine location and motion. These typically use a combination of accelerometers and angular rate sensors (simple gyroscopes) to track how the 'craft' is moving. An IMU detects the current acceleration and rate of change in attitude (i.e. pitch, roll and yaw rates) and then sums them to find the total change from the initial position. An IMU stands in contrast to the GPS system, which uses external satellites to detect the current position. This allows them to function without continuous external reference.

These IMU's, while effective, do not paint the whole picture. EWI proposes augmentation of the IMU with both ring laser gyroscopes (RLG) and gyrocompasses. An RLG uses

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interference of laser light within a bulk optic ring to detect changes in orientation and spin. The benefit of RLG's is that they are stable elements that can be used as a reference point for the rest of the measurement system (each limited to one degree of freedom).

A gyrocompass is an electronic compass that electronically orients itself in the direction of the North Star. It uses the rotational axis of the earth as its reference and is thus not affected by magnetic fields or other steel structures (commonly used in ship and submarines).

By combining the four types of location technologies (penguin locator, IMU, RLG and gyrocompass) and a synchronizing data collection system, it is believed that a pig or crawler outfitted with this technology suite will be able to develop a 3 dimensional map of the pipeline. This 3 dimensional map can electronically be converted to GPS coordinates with elevation (relative to sea level). The GPS coordinates will be validated using the start and stop locations of the pig or crawler. The exported data can be uploaded directly into a GIS system. To our knowledge, coupling of these technologies has not previously been utilized for 3 dimensional mapping of a pipeline.

Benefits
The first order variable being addressed with this system is the true GPS mapping of North American pipelines. This will be useful for mitigating third party damage and reduce the time required for repair and verification digs. It is conceivable that this technology can ultimately be deployed on any ILI system, thus providing exact GPS (with elevation/depth) of indications. A secondary benefit of this system coupled to an ILI system is that the gyrocompass measures orientation relative to the pig and pipe. This extra piece of information will enable inspection and repair crews to know exactly where on the pipe the indications were detected (not only GPS coordinates, but also clock position around the diameter of the pipe).

Not insignificantly, this 3D pipeline mapping system would not require sounding or walking of the ROW. Additionally, it could provide the GPS and elevation data in a format directly importable into a GIS system. Both of these will help reduce the manpower requirements for mapping and entering of the GPS data.

If you have questions or would like to learn more about 3D pipeline mapping technologies, contact:

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New technologies for 3D pipeline mapping will help reduce the manpower requirements for mapping and entering of the GPS data.
