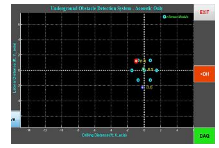
Integration of Acoustic and GPR Technologies for HDD Operations

Researchers and manufacturing representatives are investigating the potential for integrating acoustic-based and GPR technologies to detect obstacles during horizontal directional drilling (HDD) operations. The ultimate goal is to develop a system that can automatically and rapidly detect buried pipes/obstacles in front of and adjacent to the drill-head of HDD machines.



Project Description

A significant amount of gas distribution pipes are installed with horizontal directional drilling (HDD) machines due to the reduced pipe-installation costs associated with this construction method.

To avoid incidents during the installation process, it is important to locate other obstacles/pipes as they are approached by the drill-head. If these pipes are made of plastic, PVC, or other non-metallic materials, they can be difficult to locate during pre-construction surveys from above ground. Without an accurate obstacle-detection method, there is the potential for the drill-head to penetrate these obstacles during installation.

In completed OTD-sponsored projects, two technologies for detecting neighboring/approaching pipes during HDD operations were developed – one based on ground penetrating radar (GPR) and the other based on acoustic methods. GPR-based technology was successfully installed in the drill-head of an HDD tool to provide accurate pipe location in real time. However, the system has limited range for pipe-detection distance. Acoustic methods detected pipes as far as 25 feet in front and around the drill-head; however, the accuracy of detection is somewhat coarse.

The GPR-based technology was licensed to a major manufacture of HDD equipment for commercial application; however, the system has had limited success due to the limitation of detection range. In this project, researchers and staff from the HDD-equipment manufacturer are investigating the potential to integrate the acoustic and GPR technologies.

The acoustic technology is based on a unique method of listening to noise made by the drill-head and reflected by the approaching pipes/objects. The highly sensitive accelerometers on the ground “listen” to the reflected signals from objects/pipes and analyze the data to provide real-time information on the underground infrastructure.

The GPR technology is based on stepped-frequency continuous-wave modulation. A prototype drill-head radar was designed and built for a smaller class of HDD machines than are normally used. The drill-head was installed on a commercial HDD machine and tested in both laboratory and in semi-field settings. A unique technique to inject and receive reflected signals from pipes/objects near the drill-head improved the radar operation in the detection of pipes in many more types of soils than commercially available GPR sys-

tems operated at the ground level. Also, significant improvements were made in the software to provide information on the buried pipes near the drill-head in real time.

The overall project is structured to support four objectives: 1) update the acoustic system and test it in the semi-field environment (local area); 2) improve noise generators and evaluate with the acoustic system in the local area; 3) integrate acoustic and GPR systems; and 4) perform field trials.

Deliverable

The deliverable for this phase of the project will be a report outlining the next steps on integrating the two technologies for HDD operations.

Benefits

The integrated system would assist in accurately determining the location of pipes and other objects during HDD operations. This will reduce or eliminate hits to pipes (e.g., sewer and other pipes or cables) resulting in decreased future incidents, increased use of HDD equipment, reduced pipe-installation costs, and increased safety.

Technical Concept & Approach

The initial scope of this project is to consult with an HDD equipment manufacture to explore the potential of integrating acoustic technology into a product and defining a specific path for the integration of acoustic and GPR technologies.

The plan is for the integrated system to be designed with the acoustic technology providing an alert for objects in front of the drill-head, and the HDD operator then activating the GPR system as the drill-head approaches the object to obtain the accuracy.

Results

A semi-field test site (local area) was constructed that included various noise generators: three down-hole sources (axial motor, redial motor, and buried concrete blocks in the test area) and two devices (a device to impact ground surface to produce axial and transverse motion and a pneumatic piercing tool. The acoustic system was tested with all available seismic/noise sources and under differing attack angles. Data were collected and the locations of any data solutions for obstacle locations were logged.

Test results were described in detail in a separate report submitted to project sponsors, including the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration.

During data collection over a four-day test period, obstacle locations generated by the acoustic sensor were recorded in the storage device of the system along with the sensor and source locations. The data on various distances between sensors, drill-head positions, and pipe detection from the display were also recorded manually. A total of 800+ trial solutions were recorded and grouped into 11 different data sets depending on the source used. The results varied from a high of 70% for a concrete drilling source to 24% for the seismic actuator, with the average of 47% to detect pipes. The data analysis, with corrected drill-head position, resulted in 159 data sets that were validated to be meaningful data sets in evaluating the performance of the HDD acoustic system.

The corrected system performance from these 159 data sets was separated into two categories: static and dynamic. The static data represent the stationary field test with the noise source in operation (no drilling machine movement); whereas the dynamic data refer to when the drill-head is advancing (push/rotate) with the noise source in operation. Overall, for both stationary and moving drill-head processes, the acoustic pipe-detection system was able to achieve the average detection accuracy average pipe detection accuracy of ± 2.1 feet during the trials.

Status

The project plan includes additional tests with improved noise sources in the local test area.

For more information:

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