ABSTRACT

Shuai, Li. M.S.C.E., Purdue University, December 2013. A GPR-GPS-GIS-Integrated, Information Rich and Error Aware System for Detecting, Locating and Characterizing Underground Utilities. Major Professor: Hubo Cai.

Underground utilities have proliferated throughout the years. The location and attribute information of many such utilities have not always been properly collected and managed. Such information is critical throughout all life cycle phases of civil infrastructure management. Lack of adequate knowledge on the location and attribute of the underground utilities will result in a number of disastrous consequences, such as property damages, project delay, cost overrun, environment pollution, injuries and deaths. In this thesis, a ground penetration radar (GPR), global positioning system (GPS), geographic information system (GIS) integrated system is created to detect, locate and characterize underground utilities. Three main knowledge gaps are identified and addressed in this thesis: 1) the interpretation of GPR and GPS raw data, 2) the registration of utility location data, and 3) the measurement and modeling of positional errors. The research contribution is achieved by closing the three technical gaps.

In this thesis, a novel very important point (VIP) algorithm is created to retrieve the location and radius of underground utilities. It overcomes the limitation of requiring a perpendicular-to-utility GPR scan in previous studies. In addition, rich information

including 3D location, radius and spatial orientations of the underground utilities can be retrieved. Several field experiments are carried out to validate this algorithm.

The measurement of locating errors of the system is through a number of simulated GPR scans. The locating errors are evaluated in different depth and soil conditions. Quantitative linkage between locating error magnitudes and buried depth and soil conditions is established. To account for the positional error of the underground utilities, a prototype of 3D probabilistic error band is created and implemented in GIS environment. This makes the system error-aware and also paves the way to a more intelligent error-aware GIS.

With all the hardware (i.e. GPR, GPS and GIS) and software (i.e. VIP algorithm and error model), the newly created system can detect, locate and characterize the underground utilities in an information-rich and error-ware manner.