ABSTRACT

This thesis consists of six chapters. It discusses early warning of construction works to prevent potential damage to pipelines. Environmental sound is used to detect construction works. Several acoustic recognition technologies are tested for application and a new procedure is proposed.

Chapter 1 introduces the concept of context-aware recognition and the usefulness of environmental information for monitoring purposes. Damage prevention, rather than damage detection, is proposed for structural health monitoring. Some basic and important issues are reviewed and discussed. Then the objective of the dissertation is explained.

Chapter 2 presents overview on the pipeline failures and their causes. It was found that the third-party activities, mainly the construction works, were the main contributors to pipeline failures. Considering the potential danger of pipelines, it is proposed that an early warning system that will warn the potential hazard. Several attempts for developing such a system are reviewed.

Chapter 3 proposes a novel system for early warning of construction works to protect pipelines. Environmental sound is used to detect nearby construction. Among others, this thesis focuses on road cutters, the most representative equipment for construction works on the roads. The system can be easily realized by installing small sensors along the pipelines to “listen” for the potential damage threats. A time-frequency approach is proposed for efficient acoustic recognition. An incoming sound will be segmented into discrete short time frames with intervals. Each frame will be recognized individually and a final decision will be made based on results of several successive frames.

Chapter 4 proposes the cepstrum-based acoustic recognition. Different features, Mel Frequency Cepstral Coefficients (MFCC) and Linear Prediction Coding Cestrum (LPCC), are discussed, tested and compared. For the classifiers, both the Euclidean cepstral distance and one-class SVM are studied. Extensive real-site experiments are conducted and the resulting data are analyzed. Recognition success rate at different conditions are studied and compared. The results show that MFCC feature has the best performance. cepstral Euclidean distance is simple, effective and efficient, while one-class SVM can help to extend classification capabilities.

Chapter 5 proposes the PCA-based recognition method combined with the Mel residuals. Power spectra of a sound frame is initially transformed to Mel scale and then projected into a predefined road cutter subspace. After reconstructed back to original space, it is then classified according to the size of its Mel residual. The use of Mel residuals improved the performance of recognition significantly.

Chapter 6 concludes the thesis. The system uses environmental sounds for early warning of construction works to protect pipelines. The proposed time-frequency recognition approach, cepstrum-based or PCA-based individual frame recognition in frequency domain and stack-based decision making in time domain, make the construction detection very accurate but with less hardware requirement.

The early warning system proposed and related technologies discussed in this thesis will be very useful for real system implementation to prevent accidental damage and to ensure the safety of the underground pipelines.