Snake Robot In-Pipe Teleoperation System with Upper-Body Haptic Simulator

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ABSTRACT

The in-pipe inspection is one of the high frequent and challenging operations for facilities maintenance. Because the complex inner geometry and hazardous environments of pipeline systems are less accessible to humans, the in-pipe snake robots have been developed to facilitate the inspection of defects, corrosions, and the sampling of sludges. However, snake robot control is still nontrivial due to unique movements (such as helical motion) and environmental constraints like confined areas. The unique locomotion mechanisms of snake robots make it harder for the operator to perceive the remote environment and navigate the robot. This paper introduces an upper-body haptic simulator to support the snake robot controls with the haptic assistant. To prove the concept, a virtual model is built to simulate the in-pipe environments and the locomotion of a snake robot with a helical corkscrew motion. The proposed method collects signals relative direction of the gravity to the snake robot and convert the gravity direction information as vibrations of different magnitudes via an upper-body haptic suit with 40 vibrators. To demonstrate the potential of our simulator, a pilot study was performed, and the results showed that the operator could easily control the snake robot with the desired velocity in different shapes of the pipeline (straight pipes, T joints, and L joints) both horizontally and vertically.