Development of an Intelligent Robotic Rein for Haptic Control and Interaction with Mobile Machines

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Abstract—**The rescue services face numerous challenges while entering and exploring dangerous environments in low or no visibility conditions and often without meaningful auditory and visual feedback. In such situations, firefighters may have to rely solely on their own immediate haptic feedback in order to make their way in and out of a burning building by running their hands along the wall as a mean of navigation. Consequently the development of technology and machinery (robots) to support exploration and aid navigation would provide a significant benefit to search and rescue operations; enhancing the capabilities of the fire and rescue personal and increasing their ability to exit safely. In our research, the design of a new intelligent haptic rein is proposed. The design is inspired by how guide dogs lead visually impaired people around obstacles. Due to complexity, the system design is separated into distinct prototype systems: sensors and monitoring, motion/feedback and the combined system with adaptive shared control.**

Keywords— Haptic Feedback, Haptic Rein, Navigation

I. Introduction

In the experiments conducted, a problem appeared when the robot made sharp movements; the human user had significant difficulty following the trajectory of the robot. In such cases, the system could be improved through pre-emptive indications to the user and a mutual adaption of both the robot and user's response (speed and turning rate) should be taken into consideration in order to maintain consistent fluid locomotion.

Following on from the previous research it has been proposed that an intelligent stiff rein system with the feedback of the environment and perceptual capabilities can enable and enhance navigation in complex environments. Additionally the use of haptic communication through force feedback guiding the user can be considered as a suitable approach to providing navigation information and is the least affected mode of communication in noisy environments [1].

II. Work Definition

The work focusses on investigating and building a prototype mobile robotic rein, which aims to emulate the natural and adaptable control relationship observed between a guide dog and a human user during navigation in new environments as Figure 1 shows. The research continues the work established in the REINS project [2].

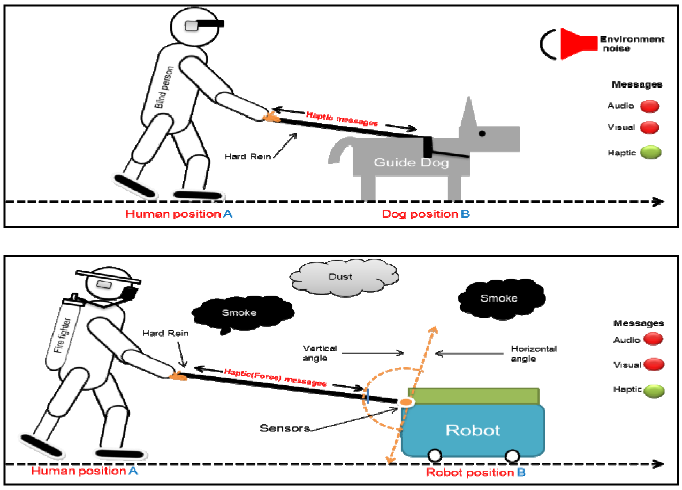

Fig. 1. Comparison between environments of a visually impaired and a firefighter

The proposed robotic rein will be designed and constructed to facilitate variable levels of haptic control and feedbacks allowing the user to either provide direct control over the proposed path of direction or the rein provide selective resistance/force. This will be achieved by using a high resolution stepper motor (position & torque control) in order to enforce the user response to the necessary change of route or direction determined by the mobile robot. In order to develop a prototype intelligent rein, detailed information about the relative positioning and compliance/resistance of the user to the robots responses must be known. This information is then be processed by the shared control system to provide adaptive control and force feedback. Figure 2 shows the stiff rein prototype with sensors and actuators (stepper motors) mounted on.

III. Prototype Design

The sensor design measures the vertical and horizontal rein angle by using digital encoders. The data collected by the sensors is analyzed, processed and subsequently interpreted into movement of the rein to actively guide the human in the desired trajectory. Proportional levels of the torque are applied to describe the intensity and the amount of movement (haptic feedback) that the user must respond to. Monitoring the rein torque (user compliance and resistance) and their relative position to the robot will then provide feedback into the control of the robot movement, adjusting the speed and rate of direction change accordingly. Both the sensor system and motor control is being implemented on a small embedded platform (National Instruments my RIO).

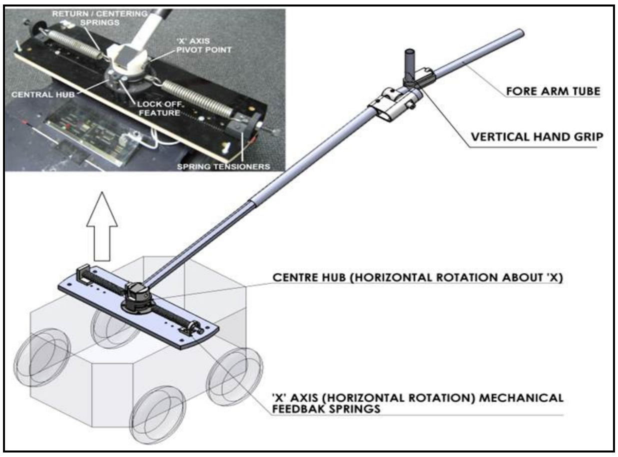

Fig. 2. Stiff rein prototype

IV. Current Work

The initial sensor system prototype has been completed and it provides detailed feedback on the human/rein interaction. Sensors have been mounted at all the flexing/moving joints and interfaced to a PC based logging system that will allow the capture of the rein kinematics during experiments. The work on the 2nd phase prototype, which aims to provide haptic force feedback, is nearly finished. Actuators are mounted and matched with the rein to give a specific movement as a haptic force feedback to user forearm with controlling the speed and angle. Figure 3 shows the structure of the prototype II. Test procedures are being developed to test the suitability of actuates to human sensing.

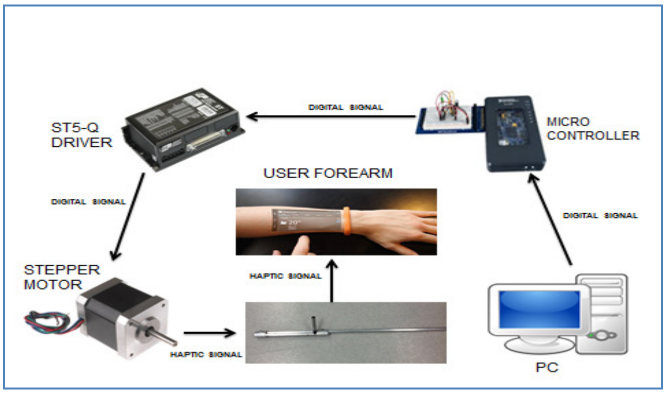

Fig. 3. Structure of prototype II

V. Conclusion

A first stage prototype system has been developed, which focuses on the deployment of suitable sensors to allow accurate and reliable measurement of the robot, rein and users relative positions. The data are required to enable for further stages of the intelligent robotic rein design. The stiff rein solves the issues of robot localization and orientation with respect to the user and provides a direct method of haptic feedback. The first prototype was tested and completed as the first part of the research. The majority of second prototype (motion /feedback system) has been finished and we are developing test procedures to insure the force haptic feedback is suitable for a human forearm. The overall system aims to mimic the complex shared control relationship observed between a guide dog and a human user.

Acknowledgements

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References

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[2] Ghosh, A., Alboul, L., Penders, J., Jones, P. and Reed, H., Following a Robot using a Haptic Interface without Visual Feedback, In: Seventh International Conference on Advances in Computer-Human Interactions, Barcelona, Spain (2014).

Section 3: Abstracts