Department of Mechanical and Industrial Engineering
Faculty of Engineering and Architectural Science

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Haptic Feedback Controlled Robot for Maneuvering in Large Spaces Engulfed by Fire

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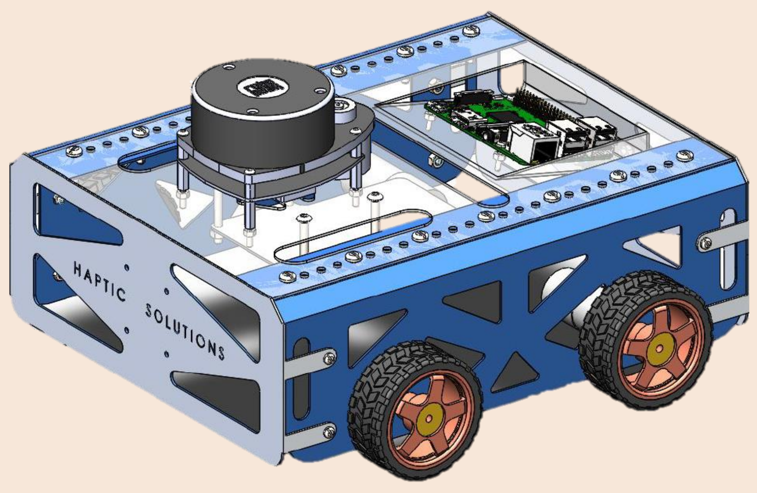
SUMMARY

This study proposes design and development of a surveillance robot which would survey fire engulfed large spaces using obstacle avoidance technology integrated by a LIDAR sensor and haptic feedback to a remote operator. The motivation for this robot was to increase the surveillance capabilities of fire engulfed spaces by implementing an obstacle avoidance system to reduce the collisions encountered by surveillance robots. The haptic feedback can be in the form of kinesthetic or force feedback by a haptic device or vibrational feedback provided by motors. Based on the data acquired from the LIDAR, a compliant virtual fixture is designed and overplayed on the workspace of the mobile robot. This virtual fixture generates and applies force to the operator's hand when the mobile robot is in proximity of obstacles. The magnitude of force depends on the distance between the mobile robot and the obstacle. The stiffness or compliance of the virtual fixture can be defined for different environments and tasks. By utilizing Raspberry Pi, 2D LIDAR, Arduino, aluminum chassis and mechanical hardware, an algorithm is developed to alert the operator of approaching an obstacle by vibrating one of four motors on a hand glove. Further experiments are required to test if haptic feedback can significantly reduce the time of surveillance of an obstacle-filled area compared to automated robots or infrared controlled robots.

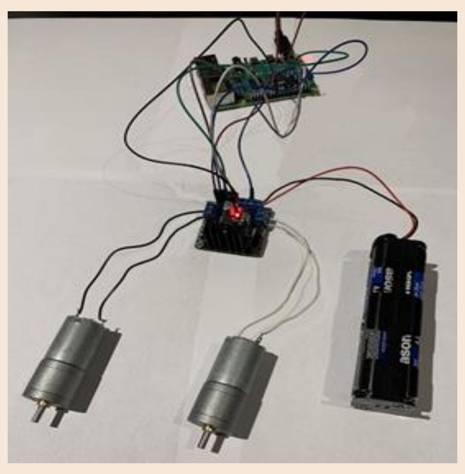
DESIGN



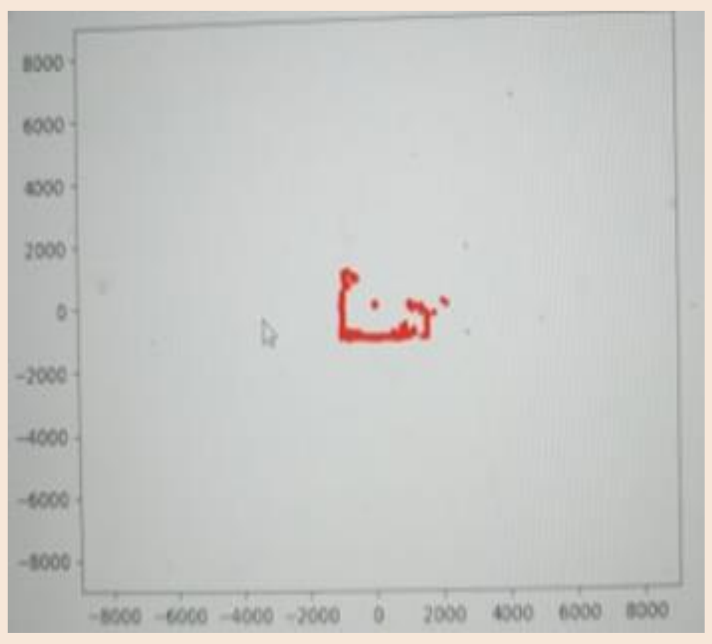
CAD Assembly of Robot

CAD model of the robot was created using Solidworks. The robot is approximately 12''x8.5''x4.5'' and is constructed using 0.05'' aluminum and 0.08'' Lexan (polycarbonate). The robot houses a revolving LIDAR sensor on the Lexan plate to take coordinates of the surroundings. Two DC Motors, a motor driver, and a battery holder are secured to the inside of the robot to shield from any atmospheric debris. The robot is to be controlled remotely by a controller that will receive haptic feedback from the LIDAR coordinates.

For the final design of the motor components, two DC motors were connected to the motor ports on a L298N motor driver which was in turn connected to a Raspberry Pi. The Pi is controlled wirelessly by using a built-in program known as VNC, which allows remote connection with a laptop through a shared Wi-Fi connection. The laptop can access the Raspbian terminal and execute the program used to control the motors using arrow keys on the keyboard.



DC Motors System

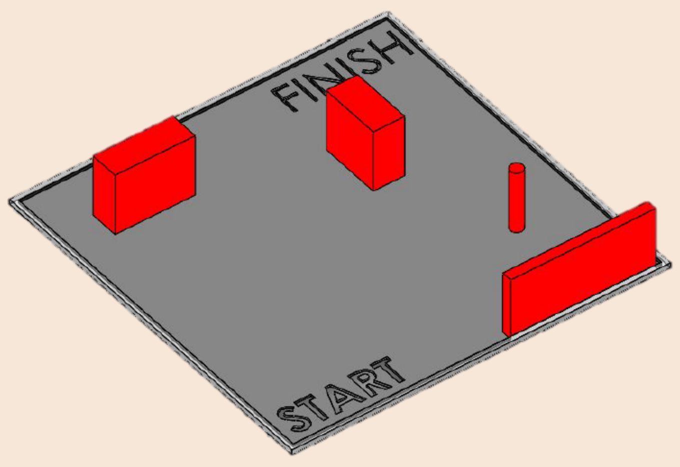


LIDAR Reading and Haptic Glove

The design for tracking objects and notifying the user includes a X4 YDLIDAR, an Arduino, a second Raspberry Pi and 4 haptic motors/drivers. The LIDAR sends readings to a hardwired Pi, which in turn sends this data to a second Pi located at the user through an Ad Hoc network. The Pi then connects to an Arduino board, whose program is constantly checking serial values that would determine if an object is detected at a quadrant. The haptic motors are connected to the back of the operator's glove and situated in an orientation to induce vibration in the direction relative to where an obstruction is detected. This induces a haptic response.

FUTURE WORK

Future work to further develop this design would be to implement a working prototype, refine its software and add some extra hardware components. One of the main stages of work would be to calibrate sensory data with the relative distance of the robot from an obstruction. The software can be refined to implement a stronger vibrational response by rotating the haptic motors faster as the robot gets closer to an obstruction. Infrared sensors and RGB cameras could be added to provide the user with visual feedback and the keyboard replaced with a joystick to enable speed variation. The aesthetics of the glove would be revised to give a more appealing look for users.



Testing Field

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