Multi Robot Navigation and Mapping for Combat Environment

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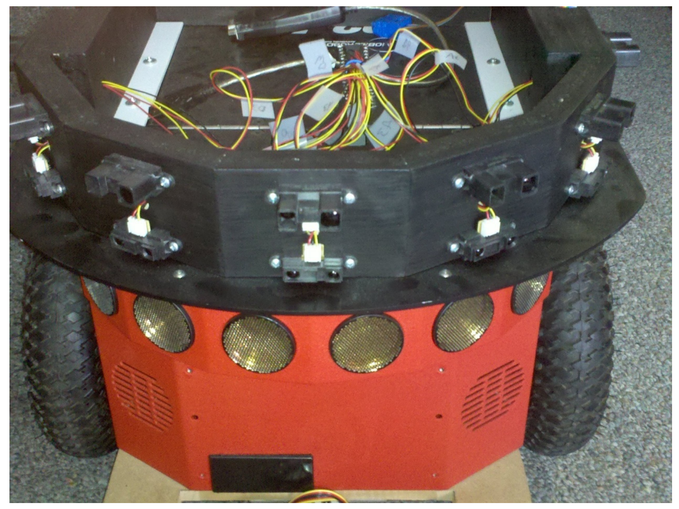
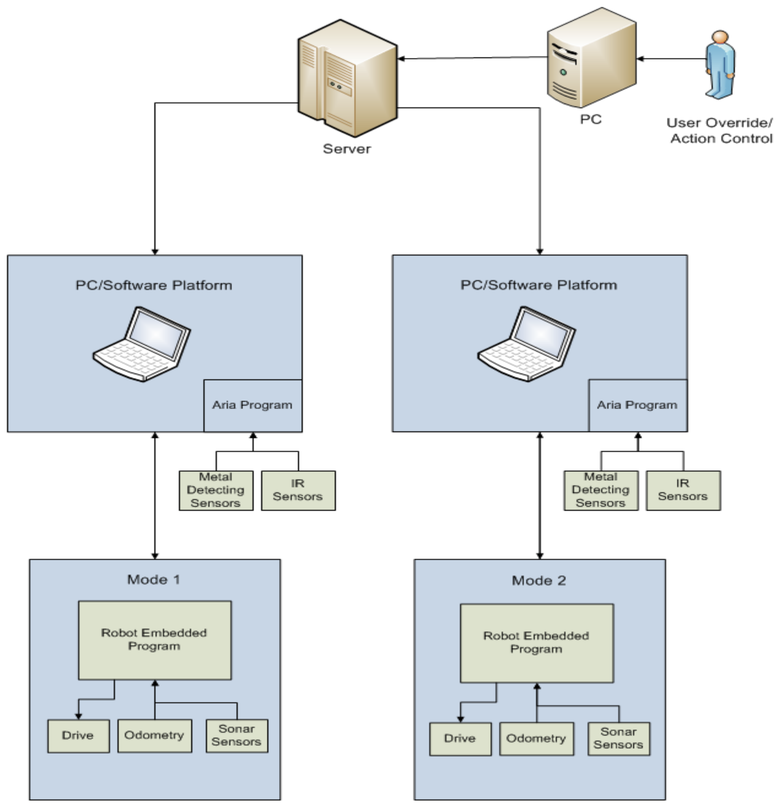
The Multi Robot Navigation and Mapping for Combat Environment project will safely enable a robot to navigate through an indoor or outdoor (urban) combat environment. The idea behind this project is that a relatively inexpensive/expendable robot would first scan an unknown area and relay a map of the area back to central command. Central command would then use that map for safe navigation of a more expensive/comprehensive robot. The first robot will be in charge of mapping the environment and designating a safe route that can be navigated by a second robot while avoiding any obstacles or dangers. The second robot will then use the map generated by the first robot and use a path finding algorithm to determine the best path through the environment that avoids all obstacles and threats. This is a proof of concept project that is aimed at guiding autonomous supply caravans or troops safely through a combat zone.

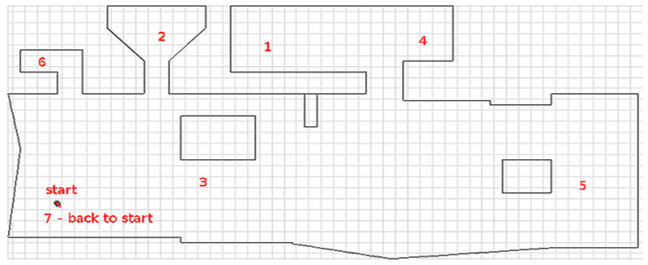
Pioneer 3-DX with added Infrared lasers



High Level Block Diagram

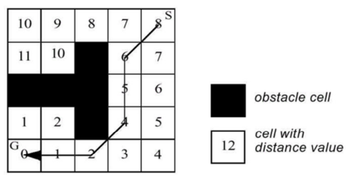


Path Finding Test Course (Mode 2)



The main goal of path planning is to reach a certain destination while avoiding all obstacles. The test course above shows the starting point of the robot along with 7 destinations it is supposed to reach while avoiding all obstacles.

Grassfire Technique



Potential Field Equations

$$ddx = -Katr * (x - x_{goal})$$

$$ddy = -Katr * (y - y_{goal})$$

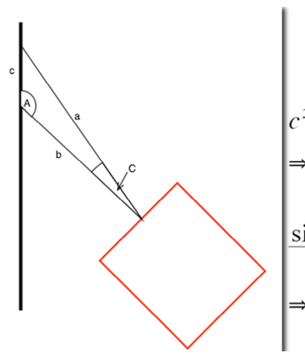
$$dx = Krep\,(x - xo) * \frac{Rrep_{inv} - \frac{1}{\sqrt{dist}}}{(dist)^{3/2}}$$

$$dy = Krep\,(y - yo) * \frac{Rrep_{inv} - \frac{1}{\sqrt{dist}}}{(dist)^{3/2}}$$

Grassfire Path Planning Tests

Potential Field Path Planning

Wall Following Equations



$$c^2 = a^2 + b^2 - 2ab\cos C$$

$$\Rightarrow c = \sqrt{a^2 + b^2 - 2ab\cos}$$

$$\frac{\sin A}{a} = \frac{\sin C}{c}$$

$$\Rightarrow A = \sin^{-1}\left(\frac{a.\sin C}{c}\right)$$

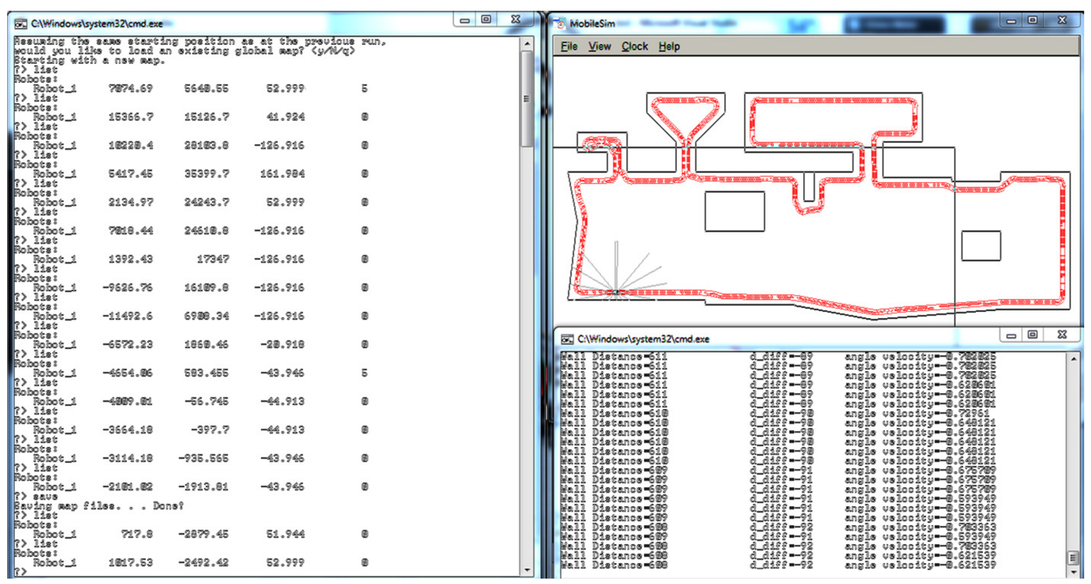
$$c = \sqrt{xr90^2 + xr50^2 - (2 * xr90 * xr50 * \cos(\frac{40\pi}{180})}$$

$$Turnang = \frac{\sin^{-1}(\frac{xr90}{c} * \sin(\frac{40\pi}{180}))}{\pi}$$

$$Turnang = 50 - Turnang$$

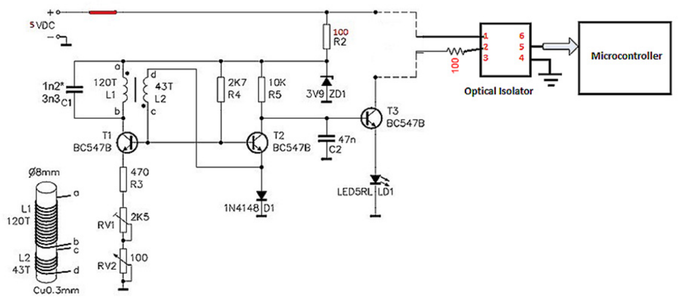
$$Angle\ velocity = -Turnang + 1$$

Central Command Observation and Robotic Wall Following (Mode 1)



The picture above illustrates implementation of central command (window on the left) which is currently monitoring a single robot (windows on the right) and saving the map file of that robot to pass on to Mode 2.

Metal Detector Schematic and Interface



The schematic above shows the modified metal detector interface. Since our microcontroller will be using 5 volts for power, each of the 4 metal detectors was altered using circuit analysis to use a 5 volt power source. An optical isolator was added between the metal detector and the microcontroller to protect the microcontroller from any current overload. The purpose of the metal detectors is to be a proof of concept mine detector in the combat environment, and send this information to the our central command so that the area will be avoided.

Silicon Labs C8051 Microcontroller used for interfacing the metal detectors and IR sensors.

http://cegt201.bradley.edu/projects/proj2010/mrnmce/index.html