# Robotic Probabilistic Occupancy Mapping

Aven Bross & Max Hesser-Knoll

UAF Department of Computer Science

## ABSTRACT

The objective of this project was to research and implement a system for robot localization and mapping in a flat environment. The RobotMoose web framework is used to interface with physical robots over a network. We developed a system for generating a probabilistic occupancy map of a robot's environment using a rotating range sensor. In addition, we examined several systems for robot localization.

## INTRODUCTION

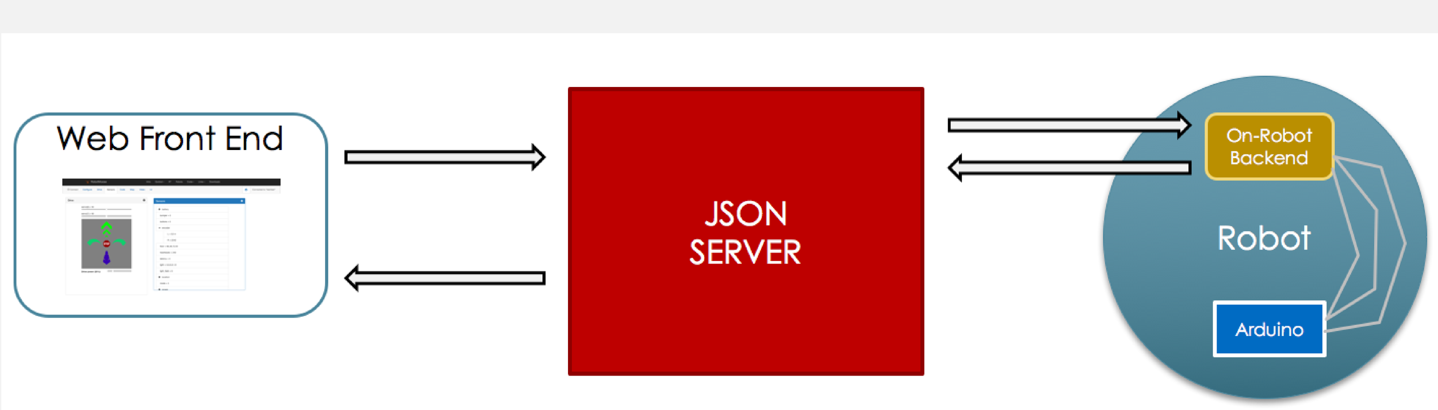
There are two main problems that must be overcome when designing a robotic mapping system: map construction and robot localization. Map construction is the process of generating a digital representation of the environment to be mapped from robot sensory data, while robot localization is establishing the position and orientation of the robot(s) on the generated map. Accomplishing both of these goals simultaneously has been an important problem in robotics research and is commonly referred to as SLAM (Simultaneous Localization and Mapping).

One method of solving the SLAM problem is through the use probabilistic modelling techniques. These methods use data collected by robot sensors to predict the most likely location of the robot and obstacles in its environment. The models continually update as more sensor data is collected. Furthermore, the dynamic nature of probabilistic models allows for self-correction of the model and the detection of moving objects. While computationally intense, probabilistic methods allow large quantities of information to be accounted for and condensed into efficient representations.

## ROBOTMOOSE

RobotMoose is a modern networked robotics infrastructure being developed at UAF. It is designed to be simple, flexible, web-centric system to control robots outfitted with Arduino microcontrollers. RobotMoose is a NSF-funded ITEST research project headed by PI Dr. Orion Lawlor of the UAF Department of Computer Science.

The RobotMoose system [1] consists three parts: a web front end, a central JSON server, and an on-robot back end (Figure 1).




RobotMoose System Architecture

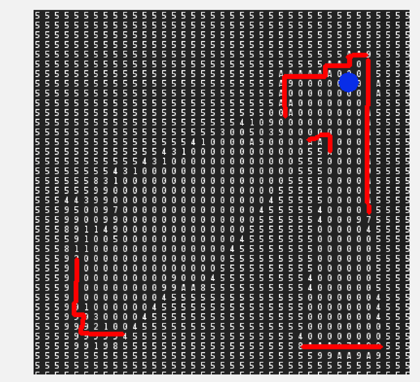
The RobotMoose infrastructure currently lacks an integrated simultaneous localization and mapping system.

## PROBABALISTIC OCCUPANCY MAPPING

Occupancy maps represent an area as a discrete grid of cells. Each grid cell marked as either occupied, or unoccupied.

To generate occupancy maps on the fly, sensor data must be analyzed to determine the occupancy of each cell on the grid. Sensor data is noisy and imprecise and grid cells may be only partly obstructed, so it is impossible to know with absolute certainty the occupancy of each cell on the grid.

Probabilistic occupancy maps solve this problem by assigning probabilities indicating how likely it is that a given grid cell is occupied.

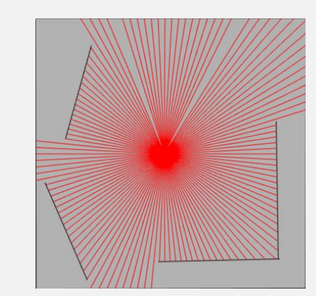


Numerical representation of occupancy grid map.

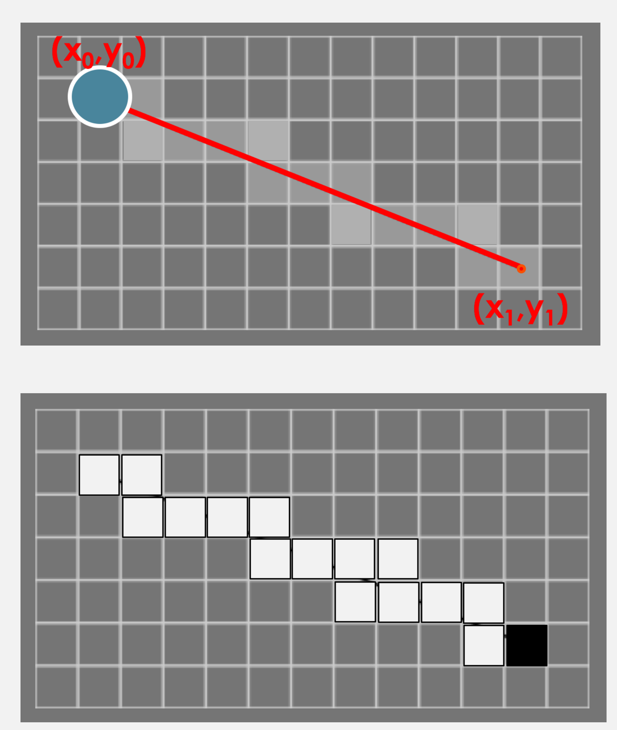
## IMPLEMENTATION

Our robot receives data through a Neato XV-11 parallax range sensor which provides a full 360° set of distance readings.

Robot outfitted with Neato XV-11 range sensor.



Simulation of Neato XV-11 range sensor readings.




Occupancy grid generation.

Each of the individual distance readings is considered as a vector from the robot's current known location. We then rasterize each vector into the discrete grid using a modified version of Bresenham's algorithm.

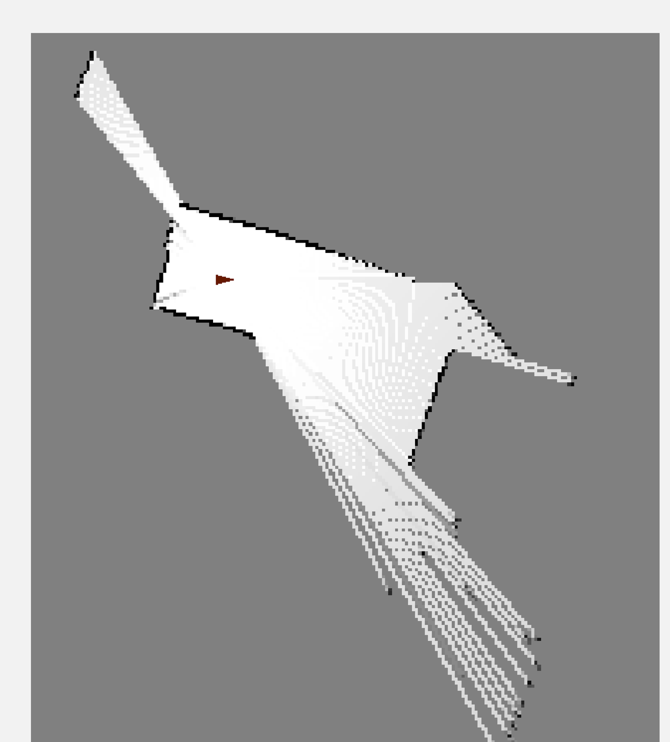
Each grid cell that is passed through by a range vector should be unoccupied, so it's occupancy probability is reduced. The cell at the end of the range vector should be occupied so it's occupancy probability is increased.

## LOCALIZATION

In order to update an occupancy map with new range data, it is necessary for the robot to estimate its position within the map. This is the problem of robot localization.

The most basic method for robot localization is to utilize motor encoders and track the robot position based on the reported wheel rotations. This method can be extremely accurate for short driving sessions on uniform surfaces. However, any errors made cannot be corrected and will therefore propagate through all future location estimates.

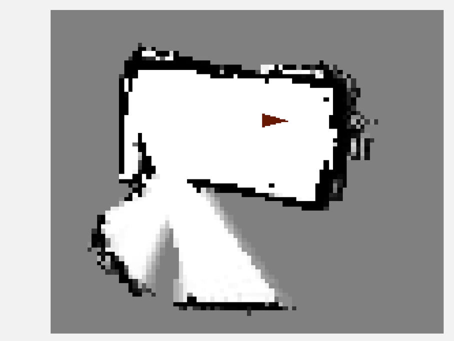
In order to more accurately estimate robot position over time, it is necessary to use range sensor data.



Graphical representation of occupancy grid map.

## RESULTS

Our system utilizes the RobotMoose web framework to pull sensor data from the robot over a network. The probabilistic occupancy algorithm is then utilized to procedurally generate a map of the area traversed by the robot.



Another occupancy grid map.

Late renditions visualized the map by darkening pixels the higher the occupancy probability of the underlying grid cell.

## CONCLUSIONS & FUTURE RESEARCH

Localization and mapping is of great importance in all robotic fields. This project achieved a simple system for localization and mapping a single robot in a flat, single level environment. There are numerous other algorithms available to achieve localization from an occupancy map.

In addition, our system utilizes the RobotMoose system to track robots over the network. A future project would be to extend this mapping system to track multiple robots and generate a collective map.

An original goal of this project was to achieve autonomous robot exploration. There is a great deal of research in this area, and future work could implement an algorithm such as frontier exploration to generate movement routes.

## REFERENCES

[1] Orion Lawlor et al. "RobotMoose Web Robotics System." Internet: https://github.com/robotmoose/robotmoose/blob/master/README.md, Aug 14th, 2015 [Aug 25, 2015].

[2] R. G. Brown and B. R. Donald "Mobile robot self-localization without explicit landmarks", *Algorithmica*, vol. 26, no. 3/4, pp.515 -559 2000.

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