Technical Design Overview
By
CNM_ST Swarmathon Team

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Abstract

This document contains details on how the CNM team approached the challenge of programing swarmies to compete in the 2016 NASA/UNM Swarmathon. Our team modified a pre-coded swarmie to enhance its capabilities in the hopes that our code would create a robot capable of placing in the competition or at the very least accomplishing the task given to us as effectively as possible. The robot is capable of searching for the home base as well as resource tags and returning them to the home base. The swarmies demonstrated enhanced obstacle avoidance and communication capabilities though neither of these features have been improved to the fullest capabilities of the robots or our team. Our greatest achievement was as a team finally getting the robots to do the task at hand in a reliable and repeatable manner.

Introduction

The CNM Swarmathon Team, or CNM-ST, came together with the goals of being a competitive team this semester at the Swarmathon Event. The teams overall goal was to have each robot collect a minimum of 5 tags in a 30-minute period. This was a basic and achievable goal that we agreed was obtainable given the size of the task ahead of us. The act of getting our robot to collect tags was broken up into all the required sub-tasks that each robot would perform in order to successfully collect a single tag without repeating collection. We concentrated our efforts into mobility, obstacle detection, camera and sensors, GPS, and communication. As we progressed we didn't have much luck reaching this goal at first; taking over a month before we actually had the desired movement we wanted programed. CNM-ST made extraordinary forward progress in this endeavor. It all started with basic circles and straight line movement, to eventually having an octagon shaped pattern that rotated around the center to collect tags. We eventually reached a point where the robots could potentially collect 20 tags apiece in the 30-minute time frame. We, as a group, came together even with our various backgrounds in not just computers but mathematics, engineering, and cloud technologies. Without everyone helping and giving us different points of view, we wouldn't have been as successful as we were.

Methods

Overall Setup: We maintain the same general flow that the original code had with some additional capabilities. The sub-tasks are center search, tag search, obstacle avoidance, tag handling, communication and movement.

Searching: Because of localization issues we have two search algorithms that allow the robot to search for tags as well as the home base tag. This way if the robot returns to a home base location and doesn't see it then it can begin a search for it as its most likely nearby. This search is a simple expanding octagon in both cases designed to skip as little arena space as possible in order to avoid missing tags. However, with further testing we may have opted to allow the possibility of missing tags in hopes of increasing collection rate but multi-robot testing was difficult given our hardware issues.

The Octagon is calculated based on the last recorded location of the home base in order to facilitate driving in circles around it. We felt it best to avoid a square because it seemed to increase problems with location drift as opposed to a more circular shape.

Obstacle Avoidance: Given our simple sensor setup we opted for a simple approach. The robot will halt and wait for 6 seconds. If the obstacle disappears it was either a false alarm or another robot that has moved out of the way. If it's still present its either a wall or a robot that's still maneuvering. Attempt to go around by turning left and driving forward.

Tag handling, communication and movement where left with very few changes. There are some extra checks to improve what mode the robot is as well as some safety measures to prevent unwanted behavior.

Given enough time we would have liked to implement a more in depth communication setup. The robots currently waste a significant amount of effort because they don't communicate their position to each other and they all search the same area. Due to the nuances of tag collection having multiple robots search the same area is beneficial since missing tags is fairly common, however if we make it to the finals 6 robots searching the same space will be overkill.

Experiments

Our experiments where conducted exclusively on the physical robots and involved setting up an area similar to the competition arena. Given our time constraints and slow progress at the beginning we didn't have time to do massive amounts of testing designed to improve performance, rather all of our testing was to make sure we had any performance before we when up on stage. So no statistical analysis was conducted, however if we had the time we would have don't a large number of tests with different values for search radius and collision timers and based our changes of an average of collection times with the changes in place. This testing would have to be extensive to prevent biases due to luck of a particular run and given the 30min time frame would have taken many weeks to complete such a large number of tests.

Results

Out team accomplished our goal of collecting tags and in fact averaged 17 tags per robot per run. The robots consistently returned to the base tag and returned the resource they were carrying. Our robots can successfully navigate around each other as well as along the side of a wall at the edge of an arena. The end result given enough time is 70% of the tags being collected if there is only one robot that number being over 90% with three of course not within the 30 min time limit. Most of the time in the competition is not spend looking for tags but rather trying to find the center base tag again upon returning to it. We were able to almost double our tag collection on the final runs from 12 to 20 just by cutting time to find the center in half. Seeing as the robot has a very narrow field of view it and a low processing rate image recognition our travel speed is severely limited compared to the robots max speed, however given the cramped accommodations of the arena this is less of a problem than we first anticipated. In fact, the low speed helps facilitate more consistent localization and thus doesn't make us feel pressed to drasticly re-write the EKF in order to allow higher speeds to stay competitive since the speed would be wasted. To add to our assessment, we have a video of our team and some of the work we did here: https://www.youtube.com/watch?v=wGDWF86t018

Conclusion

Localization and a good knowledge base of the code are the most important factors when designing these robots for the competition at hand. These where our biggest challenges and triumphs when working with the robots. Being able to see the robots move because of our code for the first time and finally understanding how to get them to work was very satisfying. Then after many more weeks finally overcoming the task of returning to the home base tag successfully regardless of errors in location calculations made us feel like we finally had a robot that might be able to compete in the physical competition and possibly even win.

Next year we hope to be allowed to continue in the physical competition and learn from our mistakes in team organization as well as improve on our knowledge of ROS and the robots.