EECS 149/249A Fall 2019

Berkeley | EECS Electrical Engineering and Computer Sciences

Tri-Robot Cooperation

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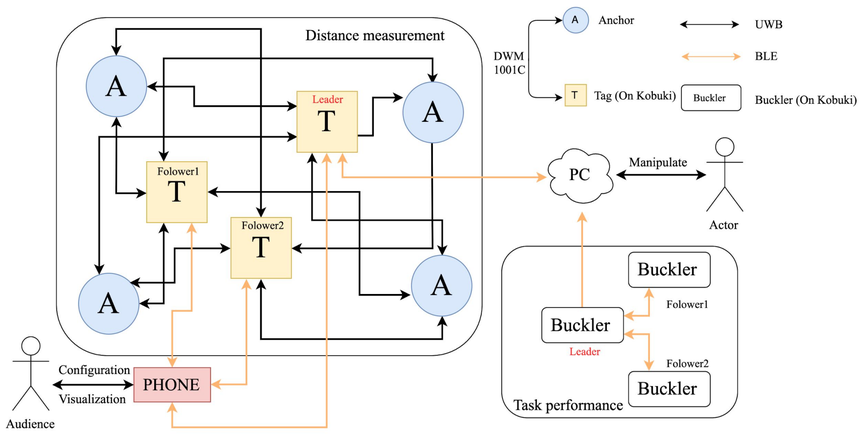
Hardware Architecture

- BLE communication

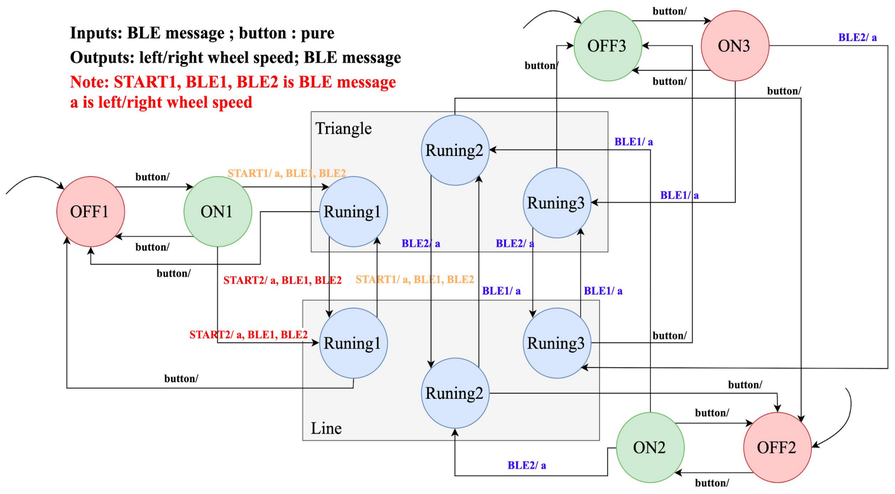
Actor manipulates computer by pressing  to control the Leader Kobuki. He can also send commands to the Leader Kobuki via BLE, and then Leader Kobuki will advertise the commands via BLE to other Kobukis to realize communications between each other.

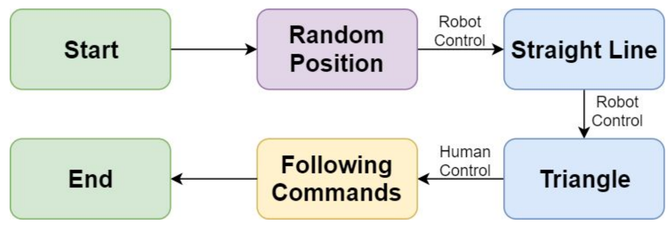
- UWB communication

We will utilize the UWB device (DWM 1001C) to form the distance measurement system to measure the distance between each Kobuki. We apply a "4 anchors + 3 Tags " system in our project, with 4 anchors set in Cory 204 and 3 tags placed on Kobukis. When each tag transmits signals to the anchors, we can quickly get the actual position in the coordinate system established by the anchors.



State Machine & Task Route





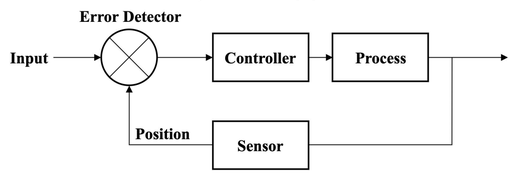
Cornerstone

- Coordinate System

Once we have built the coordinate system, we will allow the robot to move to the certain destination. For the start-up function, the robot will go to the appointed destination. (e.g. (1,0) in (x,y)).

- Closed-loop Control

We have the closed-loop control to check the position of the robot every certain time to make sure the robots are to be where they are supposed to be.



- Drift Elimination for UWB Sensing

We designed an algorithm for the computer to choose the most accurate position for each robot, that is, select the median of all sensing data in a brief period (high frequency), and update this value instantaneously as the position of each sensor (robot).

Project Goal

Tri-Robot Cooperation focuses on cooperative robots. It was created to be self-controllable, intelligent and accessible to human control.

- Cooperation
  - Create a self-control system between robots
  - Construct internal connections without human control
- Interaction
  - Bridge gap between humans and robots
  - Integrate intuitive human interface into robotic movements
- Practical purpose
  - Potential use in package delivery and logistic industry

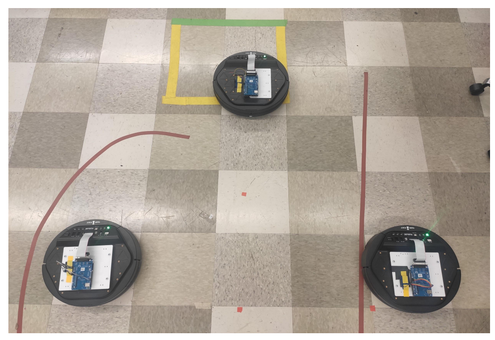
Implementation

Hardware

- Kobukis
- Nordic nRF52832 Development Kit
- DWM1001C ultra wideband transceivers
- Berkeley Bucklers

Software

- Buckler repo
- BLE libraries
- NRF SDK
- DWM1001C API libraries
- SPI example code from lab11



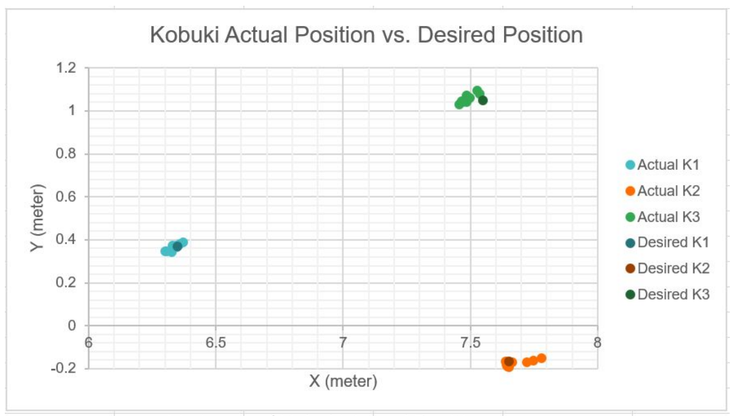
Evaluation

- UWB Accuracy

Obtaining Kobuki orientations within ±5°, positions within (±0.06, ±0.06).

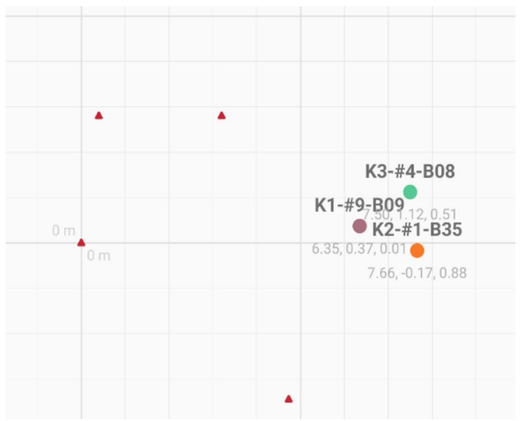
- BLE Accuracy

Time delay for ending BLE messages from the leader to the followers is about +0.2s



Variance of Kobuki Actual Position

Kobuki	$X-\sigma^2$	$y-\sigma^2$
K1	0.0041816	0.0019444
k2	0.0228721	0.0013561
K3	0.005806	0.0035389



Position information of each robot

Connections to Course Topics

State Machines

- Kobuki internal control system is a heavily modified variant of state-machine based Kobuki control system from lab

Sensors and Actuators

- Ultra wideband (UWB) transceiver: position sensor
- Kobukis (sensors & actuators): motors used for movement

Networking and Communications

- Bluetooth low energy (BLE): Internal Control System to Kobuki communication and Human Control system are established through BLE.

Input and Output

- Analog inputs for sensor readings and serial peripheral interface for reading data from DWM1001C
- Transfer data to gpio pins and compute data on nRF52832

Memory Architectures

- Reading data from different registers
- Using buffer for data caching