Edge following using Kilobots

Abhishek[1] Harsha Priyanka[1] Neelam[1]

[1]M.Tech scholar
Systems and Control Engineering

Indian Institute of Technology, Bombay
March 4, 2020

Overview

Overview

Specifications

- ATmega 328p processor
- Li-Ion 3.7V battery
- One IR transmitter-receiver pair
- One light sensor
- Two vibration motors (1 cm/sec, 45 degrees/sec)

Figure 1: Kilobot

About Kilobots [1]

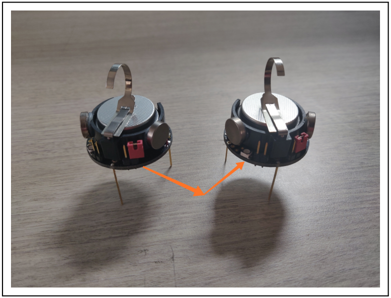

Figure 2: Communication between two Kilobots

- Reflecting IR light
- Communication up to 7 cm (32kb/s) away
- Using over-head controller(OHC)

KiloGUI

- Upload new programs
- Motor calibration of the robots
- Set unique ID manually

KiloGUI

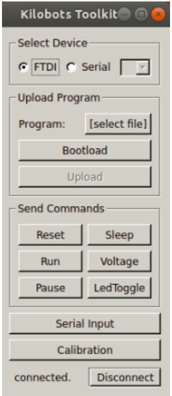

Figure 3: KiloGUI

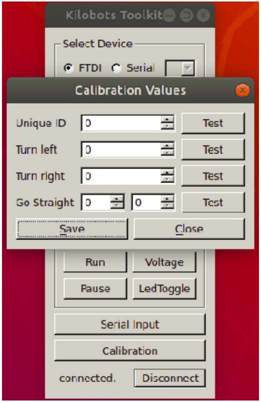

Figure 4: Motor Calibration

Abstract

- Algorithm for self-assembly in Kilobots.
- According to [2], self-assembly algorithm composes three primitive collective behaviors
  - Edge-following
  - Gradient Formation
  - Localization

Previous and Present work

Previous work

- Localization

Present work

- Gradient formation
- Edge-following

Overview

Orbiting

Objective: Algorithm to allow a planet to orbit around n stars from any initial condition.

- **Stars:** Stationary bots around which planet rotates.

Orbiting

Objective: Algorithm to allow a planet to orbit around n stars from any initial condition.

- **Stars:** Stationary bots around which planet rotates.
- **Planet:** Dynamic bots rotating around stars.

With single star
Flowchart

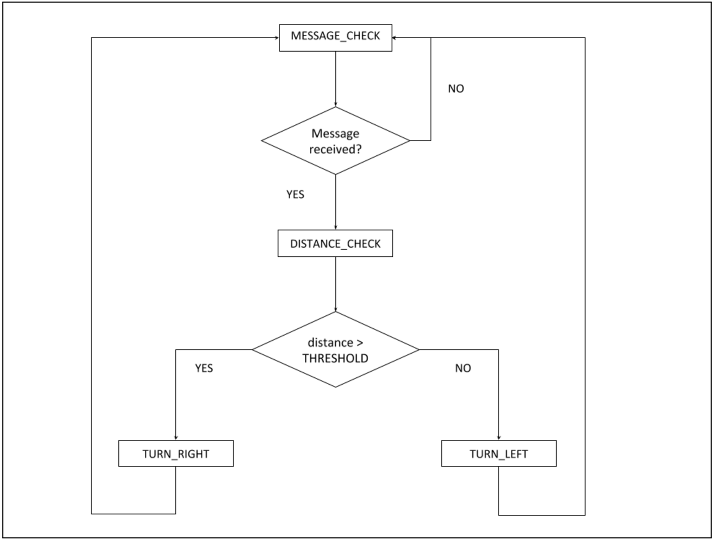

Figure 5: Flowchart for orbiting a Kilobot(Single star)

With single star
Demonstration

Figure 6: Orbiting of Kilobot (Single Star)

With multiple stars
Planet-Star Collision Demonstration

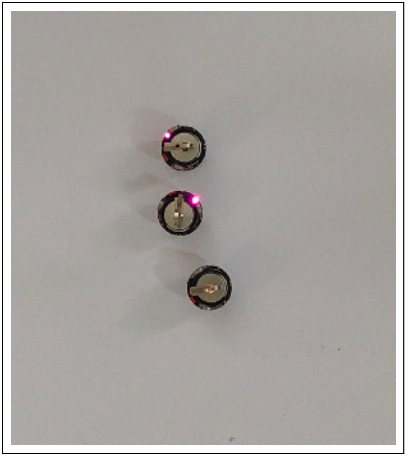

Figure 7: Planet colliding with one of the stars

Objective: Designing a robust algorithm to reach the desired orbit distance without hitting the star.

With multiple stars
Flowchart

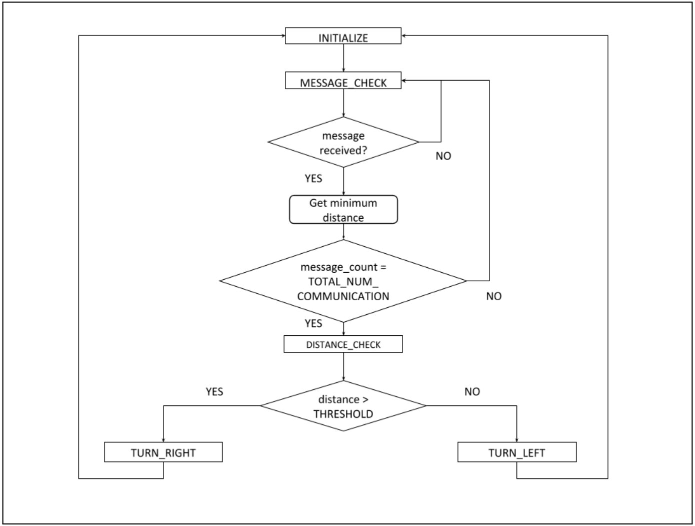

Figure 8: Flowchart for orbiting a Kilobot(Multiple star)

With multiple stars
Demonstration

Figure 9: Orbiting of Kilobot (Multiple Star, *MOTOR_ON_DURATION* = *500*, *TOTAL_NUM_COMMUNICATION* = *4*)

Figure 10: Orbiting of Kilobot (Multiple Star, *MOTOR_ON_DURATION* = *800*, *TOTAL_NUM_COMMUNICATION* = *3*)

Overview

Gradient Formation

Objective: Algorithm to assign unique IDs to Kilobots with respect to a Kilobot using distance as reference.

Flowchart

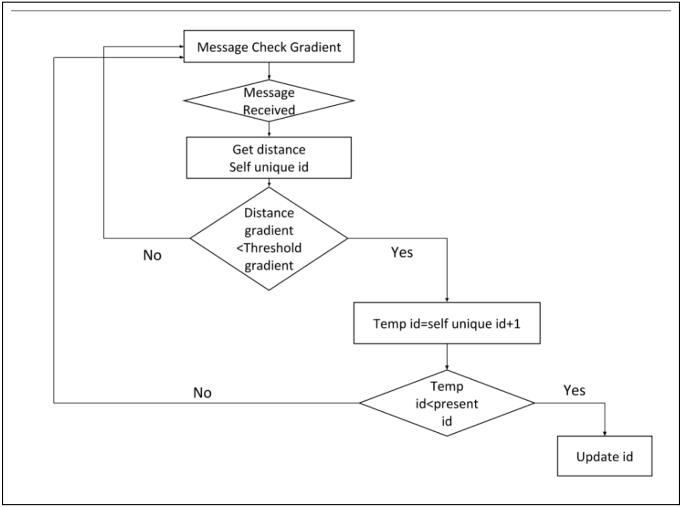

Figure 11: Flowchart for gradient formation

Demonstration

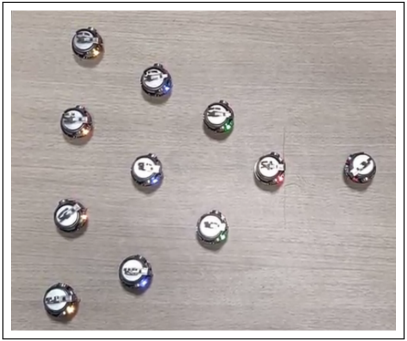

Figure 12: Display of colors as per different ids

Overview

Edge Following

Objective: Algorithm to make the kilobots which are on the outer edge to move along the edge of a group of kilobots by measuring distances without being physically blocked and reach the reference bot.

Flowchart

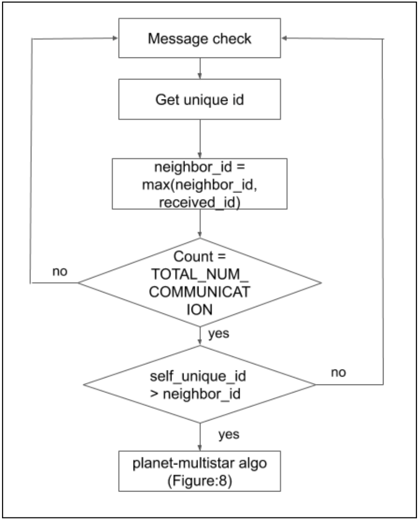

Figure 13: Flowchart for Edge following

Demonstration

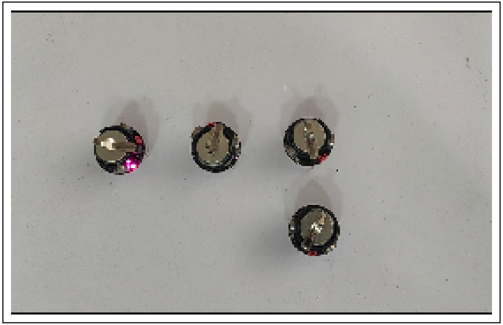

Figure 14: Edge Following with *TOTAL_NUM_COMMUNICATION=5* and *TOTAL_NUM_COMMUNICATION_ORBIT=3*

Overview

Edge Following

Objective: Algorithm to form gradient with respect to reference robot first and then bring the farthest robot near the reference robot by using edge following algorithm. We are integrating the gradient formation and edge following experiments performed earlier.

Flowchart

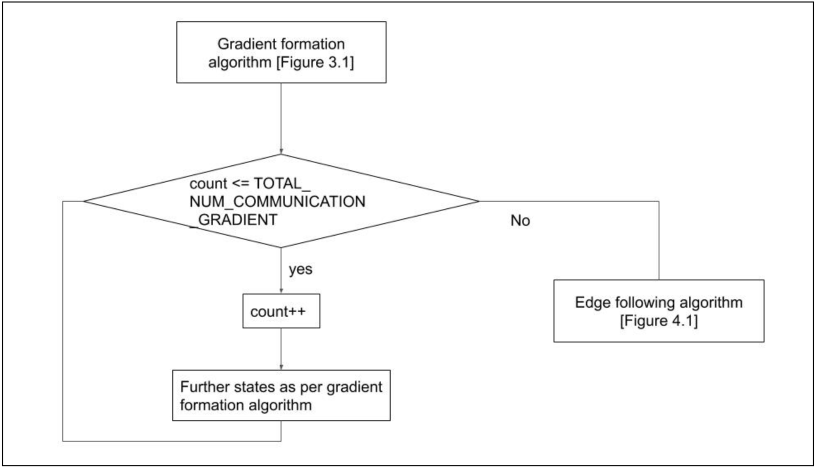

Figure 15: Integration of gradient formation and Edge following

Demonstration

Figure 16: Gradient formation and Edge following integration with *TOTAL_NUM_COMMUNICATION_GRADIENT=20* and *TOTAL_NUM_COMMUNICATION = 15*

Conclusion

Future Scope

- Integration of work done by two batches
- Corner robot detection for a general shape

Challenges

- Multiple reference kilobots
- Multiple kilobots with same unique ID

Reference

K Team. *Kilobot user manual*. URL: https://ftp.k-team.com/kilobot/user_manual/Kilobot_UserManual.pdf.

Michael Rubenstein, Alejandro Cornejo, and Radhika Nagpal. "Programmable self-assembly in a thousand-robot swarm". In: *Science* 345.6198 (2014), pp. 795–799. ISSN: 0036-8075. DOI: 10.1126/science.1254295. eprint: https://science.sciencemag.org/content/345/6198/795.full.pdf. URL: https://science.sciencemag.org/content/345/6198/795.

THANK YOU!