Title

Bi-axial Autonomous roBot with Obstacle avoidance (BABO)

We thought about the subtitle, but we ran out of time

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Motivation

- A 2009 Paper on Representative Reinforcement Learning (RL) [1]
  - Talks about a simple robot that can be used in classrooms
  - The robot learns to crawl using RL
  - 1-axis movement
- Today, there are more complex RL techniques such as hierarchical RL, deep RL, transfer RL etc.
  - We need a device to test different techniques in real life
  - The device needs to be simple enough for classroom demonstration

Electronics

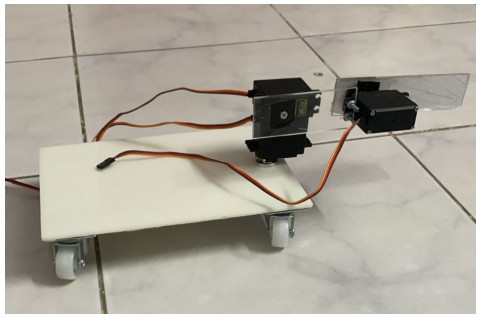
Electronics that we used

- Arduino Nano 2 units
- Sonar sensor 3 units
- Bluetooth Module 1 unit
- SD card Module 1 unit
- Step Down Transformer 2 units
- Battery 2 units
- Motor Driver 1 unit
- Motor 3 units
- LCD Monitor 1 unit

Chassis

Things that we used to make the body structure

- Plexiglass 2 sheets
- Caster Wheel 4 units
- L bracket 2 units

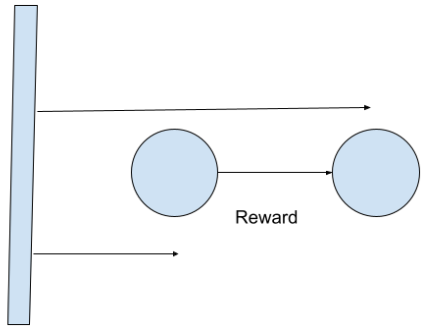


Reinforcement Learning

- We used Hierarchical Q learning Algorithm
  - Agents learns different sub-actions and then uses it to leant a bigger action
  - In this case agent learns to crawl using a 2-joint arm.
  - Then it learns how to avoid facing obstacles
  - Finally it uses these lessons for a bigger task, crawling while avoiding obstacles!
  - Of course, using motors with wheels to avoid obstacles is a no brainer, but that would not represent hierarchical RL.

Reward Functions

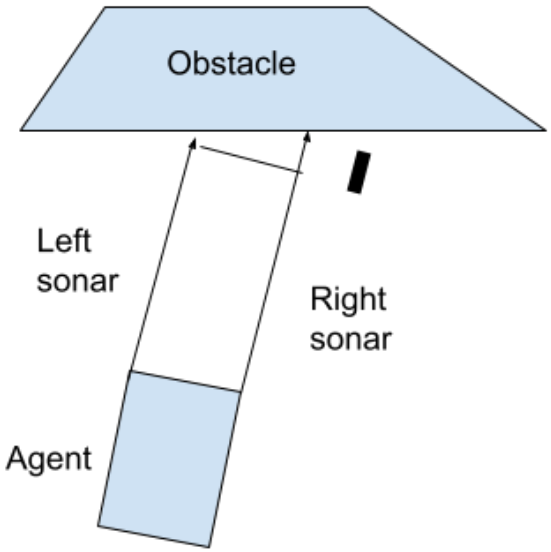
- For crawling learning, the reward function generated positive reward when distance increased from the back.
- It takes approx. 2 episodes of 500 iterations to properly learn the motion

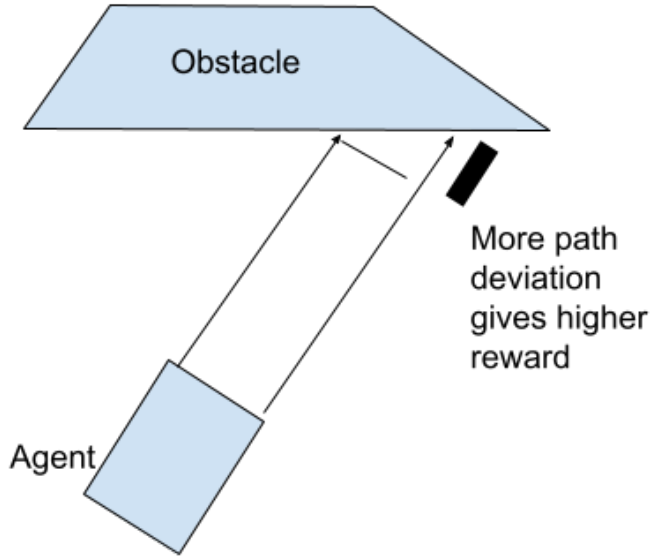


Reward Functions

- For obstacle avoidance, we reward the path deviation from the obstacle
- Barely moving away from the obstacle and going back is not a good idea
- **Turning the other side** is
- We train approx. 6 episodes with strategically placed obstacles to train the motion
- It can be trained more to perfection

Reward Functions





Serial Communication

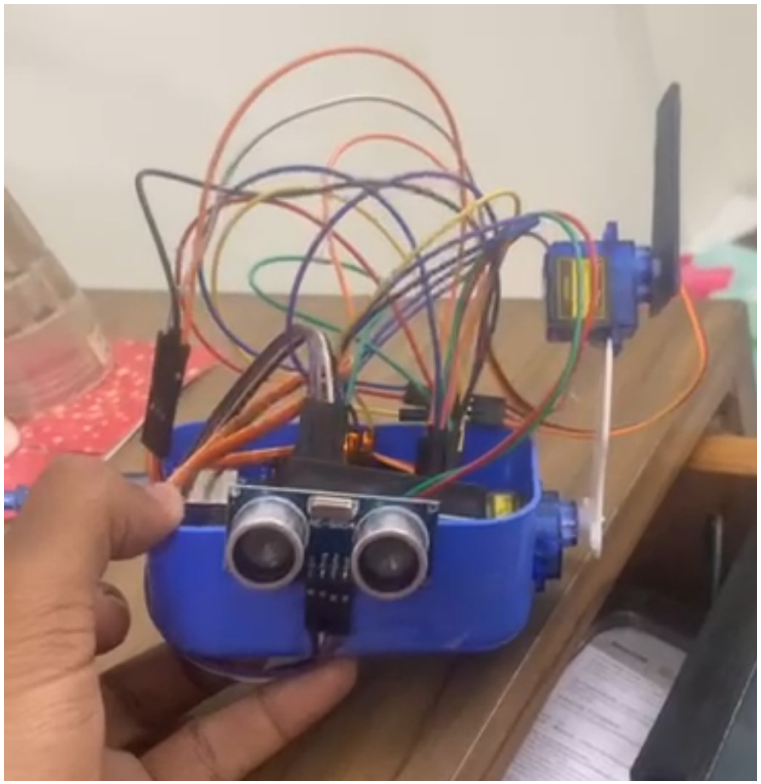
- Serial Communication
  We used serial communication to communicate between two arduino, bluetooth module, LCD module, SD card module

Everything Seems Fragile

- We had to make 3 versions of the chassis
- The first one was too small
- The second one was heavy and did not possess the rigidity required for arms
- The third one was alright

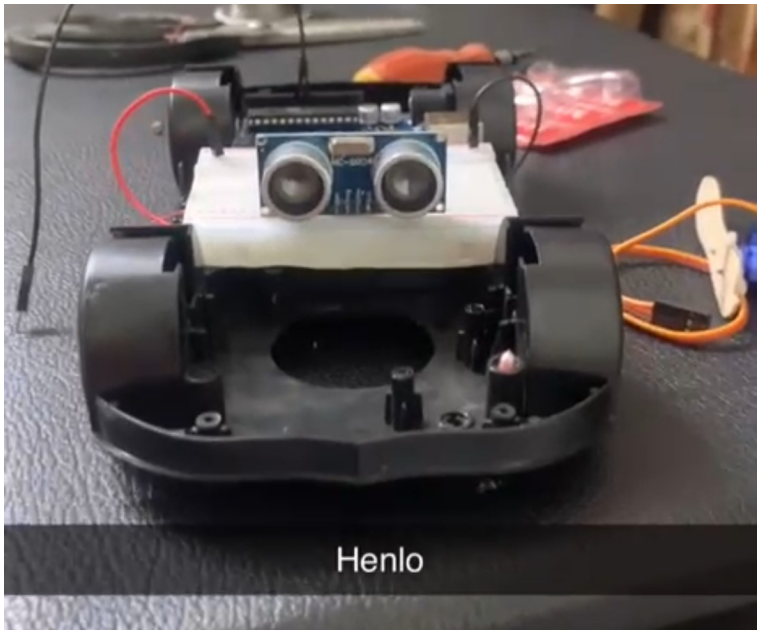
Everything Seems Fragile

First chassis



Everything Seems Fragile

Second chassis

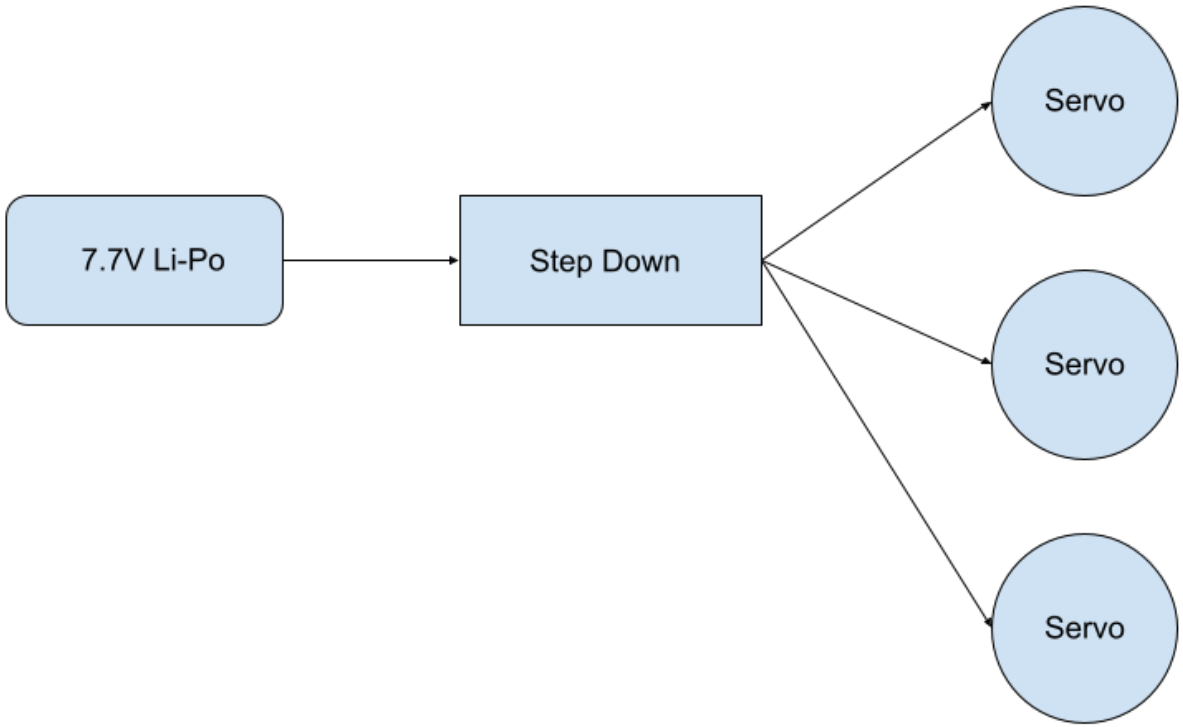


Servos Won't Serve!

- We first used SG90 servo
- But it did not have the torque required
- So we chose MG995 servo
- But we could not power it without external power item So we chose to power it through a step down transformer from a 7.7V LI-PO (as 7.7v directly will fry the servos)

Servos Won't Serve!

Power Diagram



Nano Justifying Its Name In Memory

- To build a system that can retain its learning which is transferable, we needed to implement an sd card solution
- The problem is, Arduino Nano has only 2kb of RAM!
- The q table barely fits into the memory
- Now The sd card buffer wants 512 bytes
- Result

```
Global variables use 2731 bytes (133%) of dynamic memory, leaving -683 bytes for local variables. Maximum is 2048 bytes.
Not enough memory; see https://support.arduino.cc/hc/en-us/articles/360013825179 for tips on reducing your footprint.
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- Arduino Mega is an obvious choice
- But it is too big
- So we decided to go with two Nanos
- We rebuilt the entire circuit and connected the Nanos using serial communication

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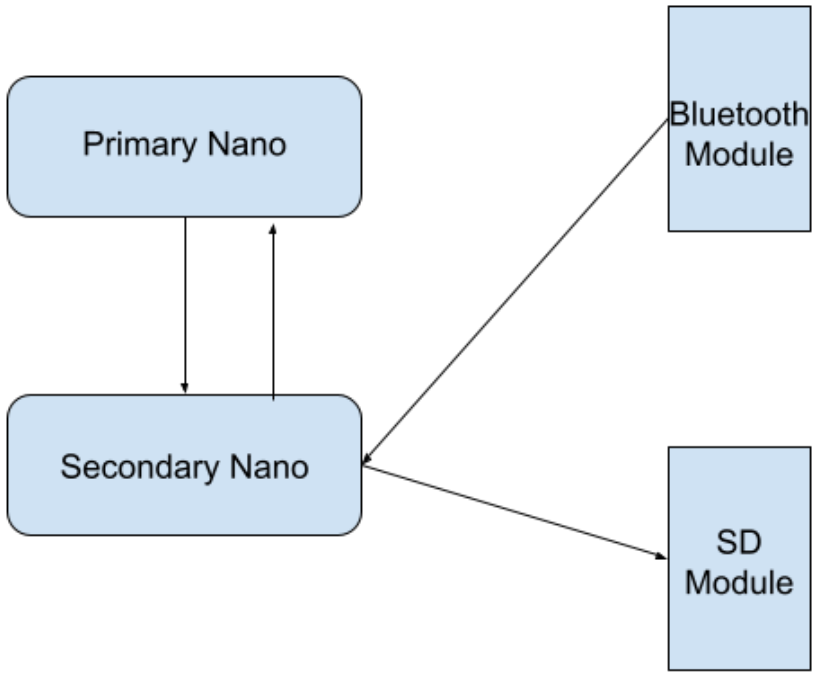
Dataflow Diagram



Metrics

Here we present some metrics we encountered during our implementation

Execution	Time in Seconds
Saving in q table in a file	115
Loading q table from SD	96
1 Iteration	0.4
1 Episode	364

Future Work

- WiFi communication with a remove server.
  - Will not have to depend on arduino's computing power
  - Can test any algorithms in the robot
- Similar to MIT's Duckietown, but much cheaper
  - Recently talked to Prof. Jim Whitehead(Computational Media, University of California Santa Cruz, California) and his PhD. student Golam M. Muktadir.
  - Need your help

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Contribution

- Raihan and Avro was in charge of the the chassis
- Rayan and Emtiaz was in charge of the electronics
- Ikram was in charge of planning and codes
- The project was a collaborative effort, and everyone in the group contributed equally.

Thank you

Thank you for listening. We thoroughly enjoyed the course. We thank you for that.