CS684 Project Report

"Automated Learning Robot"

Group number: 20

Group members:
Pradyumna Kumar (06D05015)
Sharjeel Imam (06D05010)
Jayanth Tadinada (06D05016)

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1. Introduction

1.1. Problem statement

This project involves design and implementation of a self-learning bot. A manually controlled bot performs a specific task in an arena that has a camera mounted on top of it. The camera will capture the task performed by the manually controlled bot using a web-cam. The task once captured will be encoded and sent to the learner bot. Once the learning is complete, the learner bot can perform the same task as the manual bot.

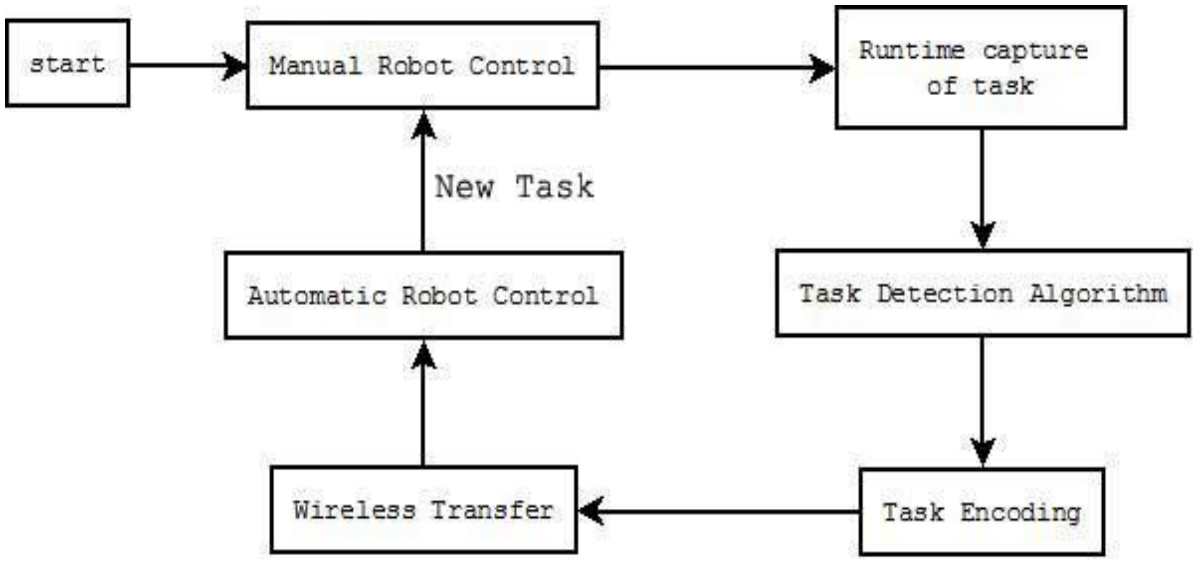
1.2. Requirements specification

Following hardware were needed for this project.

1. Two Firebird V bots
2. ZigBee modules (2)
3. Web Camera
4. High performance computer with Matlab
5. ATMEGA8 microcontroller
6. 7805 5V voltage regulators

1.3. System Design

The following state-chart presents various states that the system can be in and the transitions among them.



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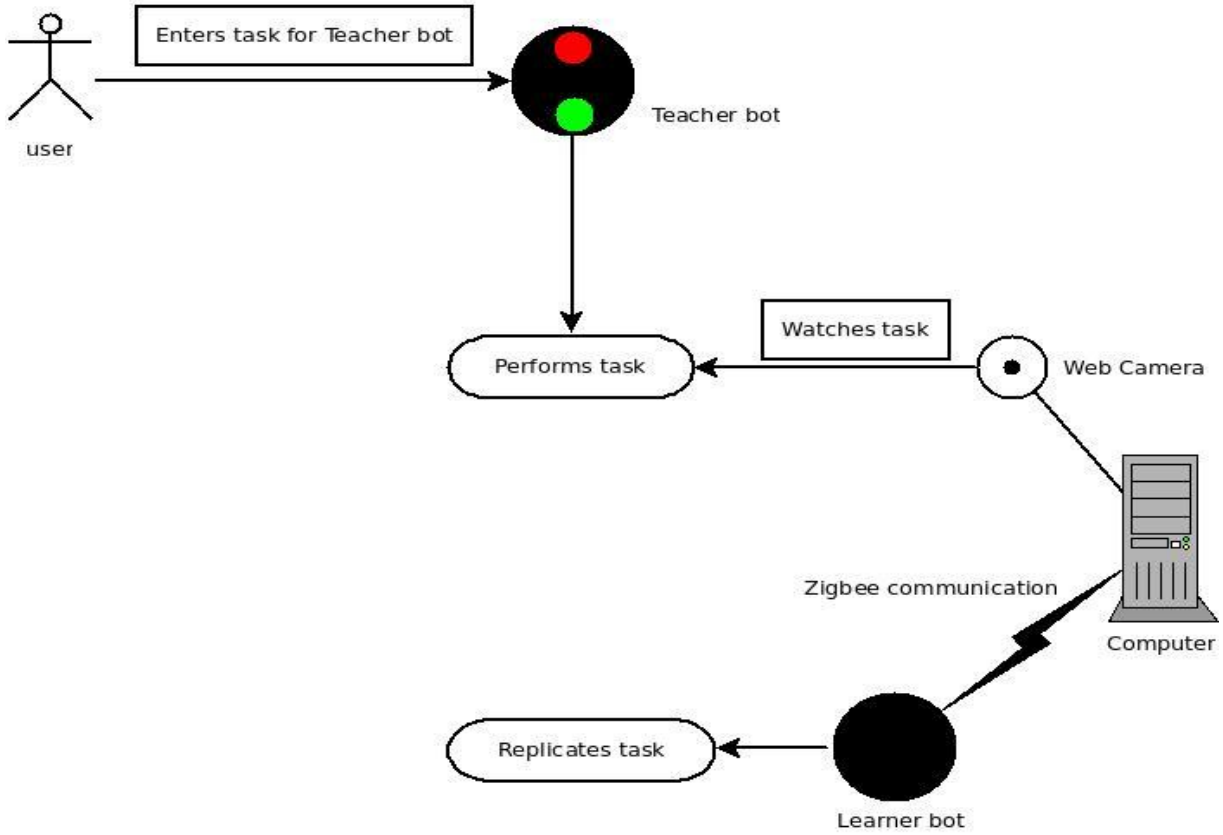
The use case for the system is as follows.



1.4. Assumptions and limitations

- Zigbee wireless module will have a range over the entire arena
- There should be no interference for the zigbee module
- A good camera is required to identify the task and distinguish colors clearly

1.5. Setup and extensions implemented on the robot

- The Firebird is covered with black paper; orange disk denotes the front and green disk denotes the back of the bot
- Zigbee module is attached to the robot

1.6. Additional hardware used

- 1.3 MP Web camera
- Zigbee communication module
- ATMEGA8 microcontroller
- 7805 5V voltage regulator

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2. Present Status

2.1. Project current status + requirements completed

We have completed the following parts of the project:

1. The teacher bot is controlled through serial communication using Zigbee.

2. We process the image in Matlab based on the input given by an overhead camera. The processing is aimed at identifying the change in coordinates of the teacher bot.

3. Finally, the server, after encoding the moves of the teacher bot in a particular fashion sends it to the learner bot.

4. Then a decoder in the learner bot interprets the signal sent through Zigbee and performs the required function.

The main variable in this project is the set of task that we can train our server to interpret and recognize. Currently, it can anticipate movements in the two dimensions and are able to encode elaborate set of instructions and send them successfully.

2.2. Delays, Issues and Critical Steps in the project

Delays

We had our DDP presentations in the last two weeks of October and since all our team members happen to be computer science dual degree students, we had over lapping deadlines and time constraints which led to a slow start. But once we were done with our projects, we have given a lot of time exclusively to this project to make up for the late start.

Issues

1. **Lighting conditions**: The simple 1.3 MP web camera used was not able to differentiate between colors under normal lighting condition. The black colored chart paper which was used for the arena and for covering the bot reflected ambient light and appeared white on the camera. To overcome this problem, we had to shift the arena to a relatively dark corner of the lab and provided diffused light using an inverted table lamp.

2. **Identifying Color**: Due of the reflected light from the colored papers under normal lighting conditions, both the orange and green appeared in the camera as a shade of gray. This problem was corrected when we solved the lighting condition problems.

3. **Measuring angles**: Measuring the angle through which the bot rotated was a little tricky because of the differences between our coordinate system and the camera's coordinate system.

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4. **Zigbee communication**: Matlab appends a 'line feed termination' character for serial communication after every character. We had to take that into account while decoding the signal that is received by the learner bot.

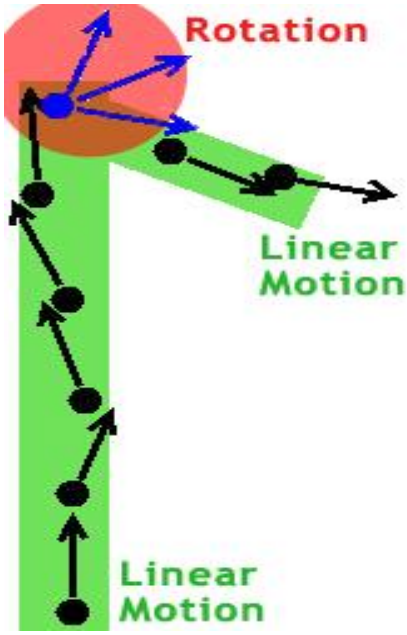
5. **Interrupts**: For some reason, interrupts on the robot were getting disabled after Zigbee communication. To solve this problem, we are re-enabling the interrupts after every Zigbee transmission.

Critical Steps

1. **Image processing:** This is the crux of the project as the entire task detection and task encoding only depends on the quality and efficiency of image processing.

   We are finding the center of the bot by calculating the midpoint of centers of the orange and green disks. Also, we are storing the angle of orientation of the robot at every instance. We have observed that when the robot is in linear motion, the absolute angle gap between successive points is less than 5 degrees. So we are using this as the threshold angle to differentiate between linear motion and rotation.

   The bot is in linear motion as long as the angle gap is less than 5 degrees. Once it is more than 5 degrees, rotation motion has started and will continue till the angle gap again falls below 5 degrees.



   To remove arbitrary error points, we have assuming that the angle gap can be a maximum of 70 degrees. Any point which is at a greater angle than this is discarded.

2. **Encoding and decoding:** An efficient encoding and decoding model is important to ensure that even complex tasks can be sent easily.

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We are encoding the task as a string of commands. An example task string can be: *20**F**30**R**25**B**90**L*** which means: 20 cm forward, 30 degree right turn, 25 cm back and 90 degree left turn. All the measurements are in the actual arena frame.

3. **Zigbee communication:** Setting up the communication links was also important as it is a critical functional requirement.

2.3. Individual roles and contributions

work Division — Pradyumna — Sharjeel — Jayanth

Task	27th Sep	4th Oct	11th oct	18th Oct	25th Oct	1st Nov	8th Nov
Requirement Analysis							
Project Scope Analysis							
SRS							
Run time capture of task							
Task Detection Algorithm							
Task Endocing							
Task Parsing							
Task Decoding							
Manual Bot Control							
Finetuning task detection algorithm							
Wireless Transfer							
Integration							
Testing							
Documentation and Report Writing							

2.4. How much time devoted to project so far?

Each member of the team put in an effort of 8-10 man days.

3. Demonstration - Live demo + Video

The team recorded its final video demo on Wednesday as per the schedule announced.

4. Final Road map of Project

4.1 The road map to completion

We started with the design of the image processing module. The web camera was mounted on the arena and tested. It took considerable amount of time to find the right lighting conditions and colors to detect the orientation of the bot by trial and error.
Simultaneously, we have coded the encoding and decoding algorithms which will be used for serial communication. By the end of the first demo we were able to get each module work independently.

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For the final demo, we have worked towards improving the algorithms for image processing and also experimented with different lighting conditions to design the most optimum arena for the project. All the elements were then integrated and tested together. All the documentation is also complete.

5. Innovation, Creativity and Reusability Index of your Project

5.1 Innovations in project

1. Detecting the path of the teacher robot using image processing.
2. Using an inverted table lamp as a source of diffused light.
3. Using strips of colored paper to determine the front and back of the robot for image processing.

5.2 How you have enhanced re-usability in project

To ensure the re-usability, we have

1. Documented in detail the design and set up of the arena and the lighting conditions.
2. We have also documented in detail the obstacles we have faced and how we overcame the obstacles.
3. We have commented the code and explained in detail how to execute it.
4. Ensured that the design of the system is modular so that changes can be made to one part of the system without affecting the rest of the system.
5. Used intuitive names for functions and variables.

6. Help us in improving the process

6.1 Any comments on the current schedule of events

The schedule is a little crammed as we come towards the end of the semester but there is little we can do about it as the project starts only mid-sem.

6.2 Are you satisfied with the way the course activities have gone – specially the project?

Yes, the course has been interesting and the project is the defining part of the course where we get to apply everything we have learned in the course. The TAs and lab staff have been very helpful too.

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7. Future Scope

The model can be a base upon which a lot of interesting things can be done

1. Correcting the learner bot when it is performing the task, by monitoring its motion through camera
2. Better noise reduction for robust performance
3. Transmitting commands to learner bot just after the teacher bot has finished performing a segment of the task
4. Detecting and encoding more complex paths (like arcs)
5. We can add a few LEDs using which we can also encode complicated tasks that involve using one or more sensors.
6. We can add a pen to the learner bot and scale it's movements to convert the whole system into a pentagraph

8. Learnings

- Hardware interfacing
- Zigbee transmission
- Image processing using Matlab
- Vectorization
- To describe behavior of systems using State charts, and other state diagrams

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