

SFU MIROSOT Team '99

**Process Report for
Ensc370**

April 19, 1999



<http://www.ensc.sfu.ca/research/mirosot/>



SFU MIROSOT Team '99 Project Proposal

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Dr. Andrew Rawicz
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Re: Process Report for Ensc370 and SFU MIROSOT Team'99

Dear Dr. Rawicz,

The enclosed document is the project process report for the SFU MIROSOT Team'99. The following document describes our achievements during this course, what we learned, our future plans for the project, things that should have been done differently and/or need to be done differently.

Should you require further information, please feel free to contact our team representative, Arash Haidari-Khabbaz (e-mail: ahaidari@sfu.ca). You may also contact our project faculty advisor, Chao Cheng (e-mail: chao@sfu.ca). For more information on our project, please visit the SFU MIROSOT home page at <http://www.sfu.ca/~chenness>.

Thank you in anticipation of your kind attention to this matter.

Sincerely yours,

Arash Haidari-Khabbaz

Enclosure: Project process report for Ensc370 and SFU MIROSOT Team'99

Executive Summary

The Micro Robot Soccer Tournament (MIROSOT) is an international robotics competition in which teams of robotic soccer players compete against one another. One of the aims of the competition is to promote developments in autonomous robots and intelligent systems that can cooperate as a team to achieve a mutual goal.

The SFU MIROSOT Group (SFMG) is researching, designing and constructing a robot soccer team that will compete according to the rules outlined in the MIROSOT Rule Book (<http://www.fira.net/fira/index.html>). The SFU MIROSOT Team '99 (SFMT '99) redesigned the robots and to equipped them with partial intelligence on board. The project was carried out by implementing hardware and supporting software for the purposes of improved path following characteristics and collision avoidance. Our fields of research are robotics, sensors, wireless communication, data processing, feedback control and related areas of engineering and technology. Possible applications include robot teamwork in manufacturing industries, target search, multiple-object sensing, obstacle avoidance and military operations.

We proposed to design and construct the first prototype of the semi intelligent robotic soccer players and associated support systems. Our prototype was completed by 14 April 1999. The following document is the process report for the SFMT '99's proposed system for the MIROSOT competition

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MIROSOT Background

The SFU MIROSOT (Micro Robot Soccer Tournament) Group was formed in 1996 to provide ongoing research projects for students and faculty at SFU. Currently, the group consists of 23 undergraduate students and 3 faculty advisors. Originally, the group was known as SFBOT but it was later decided to rename as SFU MIROSOT Team'98 for the year 1998 competition in Paris. This year, SFU MIROSOT Team'99, continues with the researching, designing and constructing a robot soccer team that will compete according to the rules outlined in the MIROSOT Rule Book, (<http://www.fira.net/fira/index.html>). A copy of general and the most significant rules can be found in appendix B.

The MIROSOT project involves students participating through team and individual efforts to directly link the project with engineering science courses, projects and thesis. The following is a picture indicating how different systems in a fully functional MIROSOT team interact and communicate with each other.

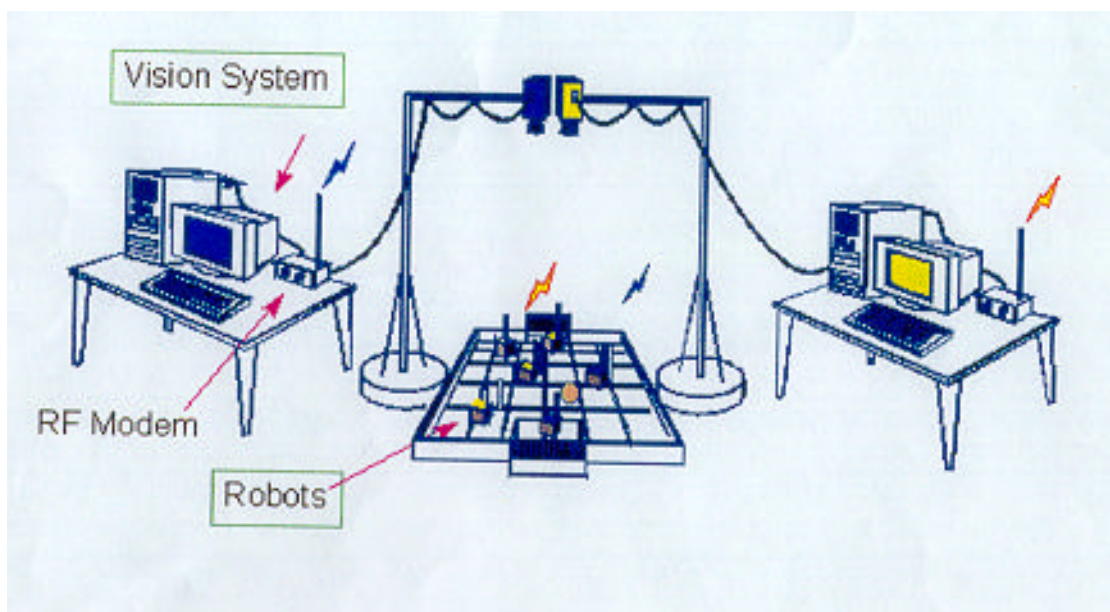


Figure 1: MIROSOT Overall System

The Competition

The MIROSOT is an international robotics competition, which pits teams of robotic soccer players against one another. Each team consists of three robots (maximum dimensions of 7.5 cm x 7.5 cm x 7.5 cm), which can only communicate with their “coach” computer through wireless communication. The robot’s positions are fed to the “coach” computer through the use of a camera mounted above the playing surface. The purpose of the “coach” computer is to determine the movements for each of the robotic soccer players. For further information, please visit our home page at <http://www.ensc.sfu.ca/research/mirosot/>.

The Goal: Olympics, 2000 (Australia)

Every year, the competition is held in conjunction with major events around the world. In year 2000, the competition will be held in conjunction with the Olympics in Australia. In year 2002, the competition will be held in Korea along with the World Cup of Soccer.

The 1999 World Cup is to be held in Brazil. We are planning to have a team prepared for the year 2000 competitions. Our appearance in those games is going to attract lots of attention to our school and to our team members and to our sponsors.

With continuing support from our sponsors and continuous hard work of our team, we feel confident that our team can achieve the above goals.

Project Goals

Some of our goals for this project are to:

- Promote Simon Fraser University and establish ties with other universities worldwide and within Canada, while attracting some good students in the process.
- Apply the skills that we learned through our education and gain practical experiences.
- Use robot soccer to introduce people to engineering and technology, hopefully attract some undergraduates.
- Establish industrial contacts.
- Develop and test new methods for autonomously controlling a team of robots.

We are hoping to meet most the goals outlined above by [preparing a team for participation at the year 2000 competition in Australia.

Benefits to SFU

We had a lot of support from SFU last year but we would really like SFU to support us better as most of the cash funding came from industry last year. As a result of the industrial funding, names of our sponsors were mentioned along with SFU, an act that caused disagreements among some parties at SFU. The following are some of the benefits that SFU will have by supporting us:

- Promotion of SFU worldwide that will hopefully attract new graduates to SFU from other universities.
- Provide on going research for students at SFU engineering school and any related studies.
- Future ENSC 351/385 course work along with already present Ensc370 course work. Also special project courses and thesis work for undergraduates.
- Robot system demonstrations at the SFU open house and at Science Alive that will hopefully attract new undergraduate students to SFU.
- Our team, the SFU MIROSOT team will be better known.
- International and local SFU promotion thorough MIROSOT booklets and newsletters.

- And other means of promoting SFU as they evolve.

Applications of MIROSOT Technology

The following are some applications of the MIROSOT technology:

- Real time data communication and mobile communication.
- Real time autonomous control. (QNX Inc. had invited us to promote our QNX software and control programs for one of their trade shows).
- Cooperative teamwork among robots to achieve a mutual goal (e.g. mining and manufacturing).
- Exploration and actions in manned and unmanned environments (e.g. Mars exploration using a team of robots).
- Multiple-object tracking and target search for machine vision (machine vision is a complex problem that still lacks a simple solution).
- Educational robotics applications (At this time, we are looking at possible ENSC351 course work within the next two years).

Project Introduction

MIROSOT Team'98 robots were built without a feedback system. This prevented them from being able to control the robot effectively. Their robot was unable to follow an instructed path by itself. They had to use the camera as a feedback system to compensate for this problem. Thus, a large amount of excess load had to be carried by the computer, slowing down its processing time.

MIROSOT Team'99 proposed to redesign the robots with a feedback system onboard the robot. Thus, given the beginning and end points a path the robot should be able to follow that path.

Our project was divided into two parts. The building of a soccer playing robot prototype with path tracking capabilities and the construction of a collision avoidance circuit that is supposed to be used for testing purposes only. Our main focus was on the building of the robot prototype since that was the actual goal of forming MIROSOT Team'99. While two of us (Craig and Arash) constantly worked on the robot, only person (Shankar) worked on the collision avoidance circuit. Our software expert (Heidi) worked with both groups to provide them with the required software to operate their hardware.

SFU MIROSOT TEAM '99 Description

The following is a short description of the members of the SFMT '99.

Heidi Lam	Software Engineer Software designing, testing and implementation for both collision avoidance and motion control circuits.
Arash Haidari-Khabbaz	Hardware Engineer Motion control hardware designing, testing, and implementation. Team manager.
Shankar Kamath	Hardware Engineer Collision Avoidance circuit design and implementation
Craig Hennessey	Hardware / Software Engineer Motion control hardware designing, testing, and implementation. Preparing motion control software pseudocode.

It is to be noted that this is just a general and short description of each team members responsibilities. Each member had to do a lot of complicated tasks to carry out what their were assigned to do.

What We Built

Robot Prototype

The feedback for the robot is provided by optical encoders. We managed to fit the encoders in the old MIROSOT chassis by slightly modifying them. The feed back is then fed into the motion controller circuit. The motion controller for the robot is based on the National Semiconductor LM629 Precision Motion Controller. Initially we interfaced to the chip using the Basic Stamp for ease of programming. The Stamp code was almost pseudo-code for our final software. We, then, prototyped the motor control and feedback circuitry and completed initial testing. With both the hardware and software prototyped, we, then, had to convert the code to PIC assembly and the prototyped hardware to a vector board and robot chassis. A block diagram of the robot circuit is given in figure 2.

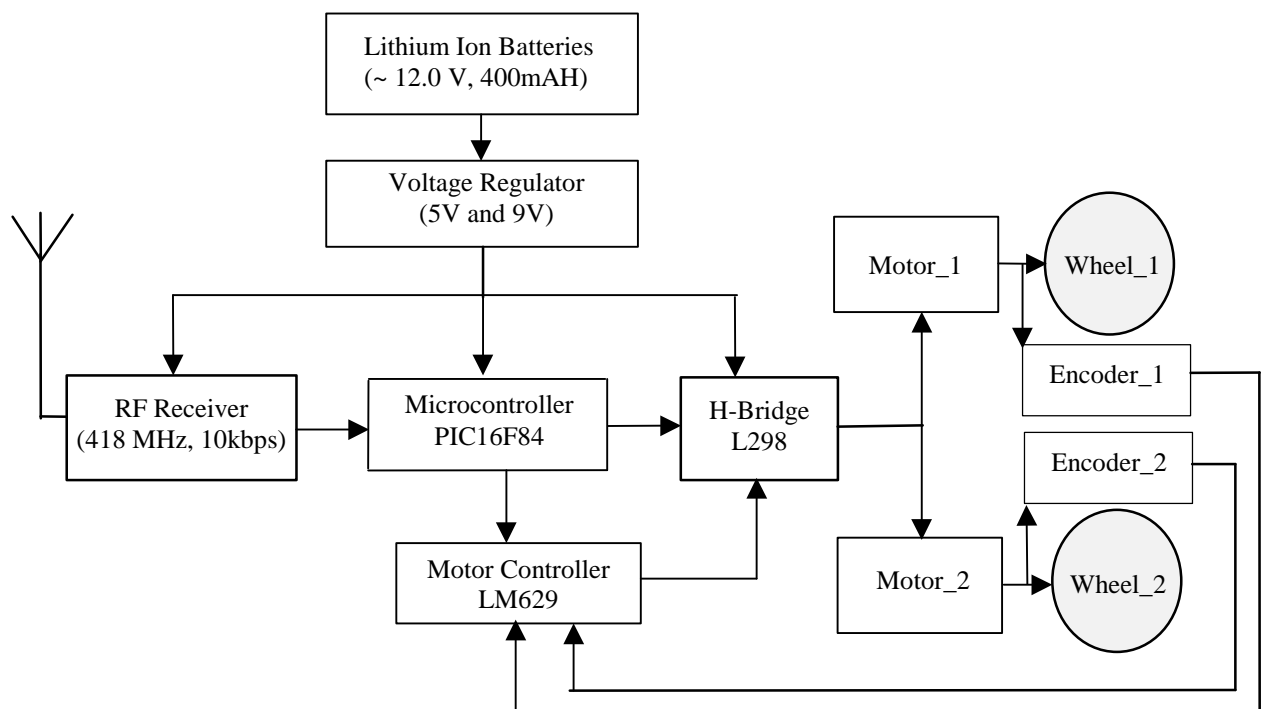


Figure 2: Robot Block Diagram

At this point we started to test the robot and prepare it to perform the desired functionalities. We had to do filter tuning, and path programming. The robot controller system provides us with the following features:

- Exact path following at a desired speed for any length of time.
- Exact path following at a desired speed for any distance.
- Path correction upon the insertion of an external force.

- Onboard programmable PID controller allowing to get different responses for different tunings.
- Forming a complex path with one instruction.
- Independent wheel control.
- Ability to report its current position and velocity.
- Ability to report its distance from target.
- Ability to interrupt once reached the target velocity
- Ability to interrupt when a position error occurs.
- Ability to stop abruptly or smoothly.

Many of these features are now being used by the host processor onboard the robot to perform different maneuvers.

Collision Avoidance

The collision avoidance system will be used for testing purposes on robots for the Micro-Robot World Cup Soccer Tournament. An imaging system is being developed for the robots; however, the robot runs into walls when the imaging system fails. Therefore, it is desirable to have a 'back-up' during testing of the imaging system to avoid damage to the robots. To accomplish this SFU MIROSOT Team'99 developed a collision avoidance system based on ultrasonic sensors. When the robot is approximately 10-15cm away from a wall the collision avoidance system will stop the robot to prevent damage. Processing occurs through a microcontroller, which will determine the distance between the robot and the wall. This circuit is equipped with its own microcontroller. Since it is used only for testing, it does not require the dimension specifications for MIROSOT games. The circuit is designed in a way that it can manually be mounted on the robot whenever required. The collision avoidance block diagram is given in figure 3.

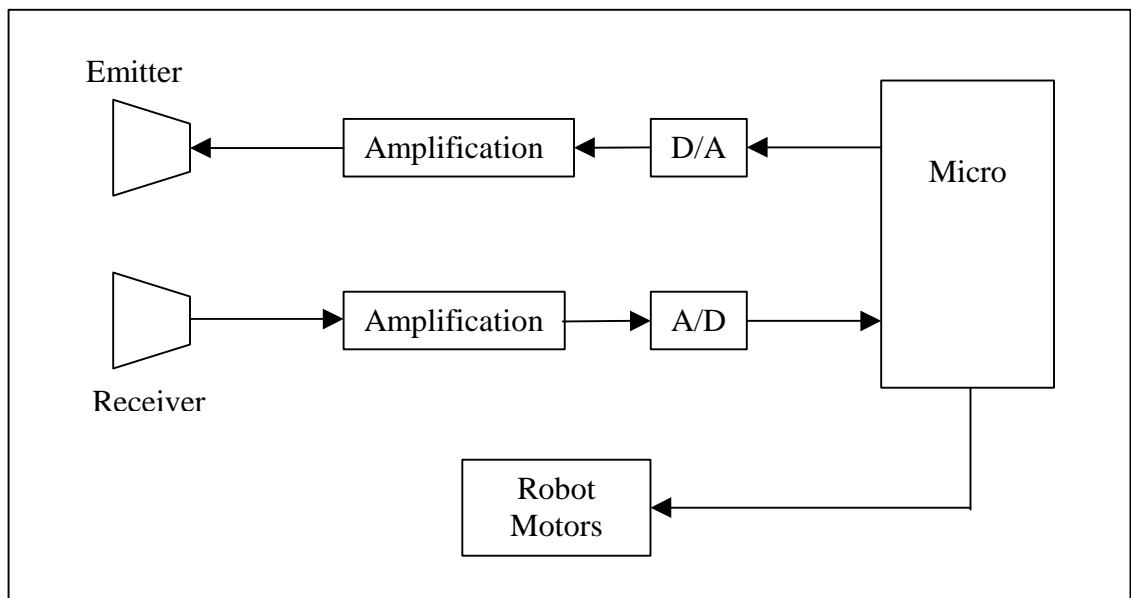


Figure 3: Block diagram of the collision avoidance circuit

We managed to build the circuit and prepare the software for it. We also tested its functionality. However, the circuit failed a few times as its multiplexer got burned.

Problems Encountered and their Solutions

Robot Prototype

We encountered many problems while developing the system. The problems are listed as follows:

- **Communicating with the LM629 (Precision Motion Controller chip)**
A large amount of our time was spent on solving this problem. We had to take the timings, and the LM629 programming issues into consideration.
- **Filter Tuning**
We found out that for each motor we had to tune the filters separately. That is because the motors are mismatched. There are long time-consuming procedures for tuning the filters and we went through them for each motor. We were able to compensate for almost all the factors that disturb the control of the robot: friction, motor mismatches, wheel mismatches, weight imbalance of the robot, inertia, and non-uniform field. The only problem that we partially were able to fix was slipping at the starting moment.
- **Slipping**
At the starting point the robot tends to slip as we start to accelerate from zero velocity. It was observed that this slipping affects the path of the robot for very high values of acceleration. One way to get around this problem is to load the robots with lower values of acceleration.
- **Sourcing Encoders**
Our encoders must be small enough to fit into the chassis. Unfortunately, encoders with dimensions small enough to meet our specifications are not manufactured in North America and have to be ordered from Korea or Japan. This process wasted a great amount of our time during this semester.

Collision Avoidance

- **Sensor Directionality**
One of the main problems with the collision avoidance circuit is that the sensors are too directional. This means that if we are transmitting the pulse out at an angle, we won't be able to receive it unless the angle is very small.
- **Multiplexer Sourcing**
One problem that we had was that we burned a multiplexer near the end of the semester and we did not have a replacement. There was no outlet in Vancouver that sold one so we had to get one delivered from California. This halted the project for a while.

What Should Have Been Done Differently

Robot

There is not much different that we could have done with the robot prototype. We basically got all the functionalities that we wanted and even more. It would have been better if we had used 68HC11 microcontrollers rather than PIC microcontrollers. We are very pleased with our design both from the hardware and software point of view.

Collision Avoidance

One of the main problems with the collision avoidance circuit is that the sensors are too directional. We should have tried to find sensors that have a greater range or use several of the same sensors to cover a greater range. This may not be feasible due to size constraints. Also, it would have been better to use infrared sensors. The cost was the limiting factor in this case, but if relatively cheap infrared sensors can be found that work for our application then they should be tested. One problem that we had was that we burned a multiplexer near the end of the semester and we did not have a replacement. There was no outlet in Vancouver that sold one so I had to get one delivered from California. If we were to do the project over again, we would have at least two spare parts for components that are not readily available.

Also we should have integrated the software and hardware earlier in the semester. We had insufficient time at the end of the semester to do this, and it would have been advisable to make preliminary attempts at integration a few weeks earlier than we did.

What we did Different From Design/Functional Specifications

Robot

We decided to use two PIC16F84 micro controllers rather than one PIC16C73, as the flash chips allowed for much faster developing. We used one micro controller for each wheel, right and left.

Collision Avoidance

The collision avoidance circuit was not changed significantly from the design specs. The only changes that were made were adding a few capacitors to reduce noise and well as finalize the pin layouts for the PIC. Also, we added a voltage regulator to convert the 9-10V input into 5V.

What we Learned

Each of us gathered a lot of experience during this project. The following outlined most valuable experiences that we had.

- The PIC chip: programming language, debugging (including simulation), and programming and testing with actual hardware.

- Motor controller design
- Tuning a PID controller.
- Basic Stamp Programming
- Integrated Circuit to micro controller interfacing.
- Data communication in between two chips.
- Coming up with test plans to test our software with actual hardware.
- Working with ultrasound sensors.
- Recovering data from the air, amplifying it and prepare if for digital processing.
- Working as a team with people we did not know before the start of the project.
- Managing a project a supporting other group members.

Future Plans

Robot

The robot at this stage is fairly complete. A few minor improvements are listed as follows:

- **Microcontroller**
We are planning to change the Micocontroller to the Motorola 68HC12. This micro not only provides us with more than IO pins that we need, but it also supports math functions and fuzzy logic. Thus, most the path tracking and motion control calculations can be done onboard the robot. These functions can reduce the load of the computer by a great amount.
- **Clock Chips**
We need to find clock chips that provide 6MHz square wave clock for LM629 chips. At this time we a re using a third microcontroller to provide us with the clocks.
- **PCB**
We need to layout for the robot PCB and have it built. Many of the chips are going to be surface mount and thus PCB is going to be double sided.

Collision Avoidance

There are a few changes to be made to the collision avoidance.

- The circuit needs to be debugged or possibly redesigned so that we do not burn more components.
- We should try to find sensors that have a greater range or use several of the same sensors to cover a greater range.
- Looking into the possibility of using infrared sensors instead of ultrasound sensors.

MIROSOT Project

The MIROSOT Group is going to be active throughout the next few semesters. We are now recruiting new software programmers to start working on the software for robot control and game strategy. At the same time we are planning to update our current unidirectional RF

system to a bi-directional system so that the robot can also communicate back to the computer. New data communication transmission protocols need to be defined since the robots can now support a lot of features. New imaging system is to be built. There currently people in MIROSOT who are doing the research on that.

The management of the team has to be reconsidered. The team members are simply not given enough freedom to carry out their work. We were not provided with enough information on the status of our funding proposals and when it came to a point where dealing with someone outside the student body, the matter was simply taken out of our hands. Sometimes we found out that the matter was not even followed up. We were kept out of the loop when it came to problems such as the ones mentioned above. We strongly recommend this method of managing the MIROSOT team be changed because the team members will simply lose their interest and motivation.

Conclusion

MIROSOT Team'99 was able to provide a robot prototype with the functionalities noted in our functional and design specifications. This robot has now motivated the faculty advisors and managers of the SFU MIROSOT to contribute more seriously to the project. Teams are now being formed to continue working on the Communication, Sensory and Software parts of the project. All this activity now is because these groups know have a robot with a design that meets the main game-winning requirement: It can be easily controlled. We are pleased with our design.

Our collision avoidance circuit is partially functional. Slight improvements are going to make it ready for use in our testing.