# MIROSOT TEAM'99
# Functional Specification

# February 16, 1999


***http://www.fas.sfu.ca/ensc/special***

Submitted to:
Dr. Andrew Rawicz
Steve Whitmore

Micro-Robot World Cup Soccer Tournament

SFU MIROSOT Team'99

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February 19, 1999

Dr. Andrew Rawicz
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**Re: Functional Specifications for Ensc370 and SFU MIROSOT Team'99**

Dear Dr. Rawicz,

The enclosed document is the project functional specifications for the SFU MIROSOT Team'99. The following document describes the problems with the current systems and our proposed solutions.

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.ensc.sfu.ca/research/mirosot.***

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

Sincerely yours,

Arash Haidari-Khabbaz

**Enclosure: Project functional specification 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) is attempting to redesign the current robots and to equip them with partial intelligence on board. The project will be carried out by implementing hardware and supporting software for the purposes of collision avoidance and improved path following characteristics. 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 propose to design and construct the first prototype of the semi intelligent robotic soccer players and associated support systems. We plan to complete this task by 1 April 1999, as most of us have at least three years of post secondary education and at least two co-ops of industrial experience.

The functional specifications for the SFMT '99's proposed system for the MIROSOT competition are described in the following document.

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## 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 15 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 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 MIROSOT project involves students participating through team and individual efforts to directly link the project with engineering science courses, projects and theses. Figure 1 illustrates how different systems in a fully functional MIROSOT team interact and communicate with each other.

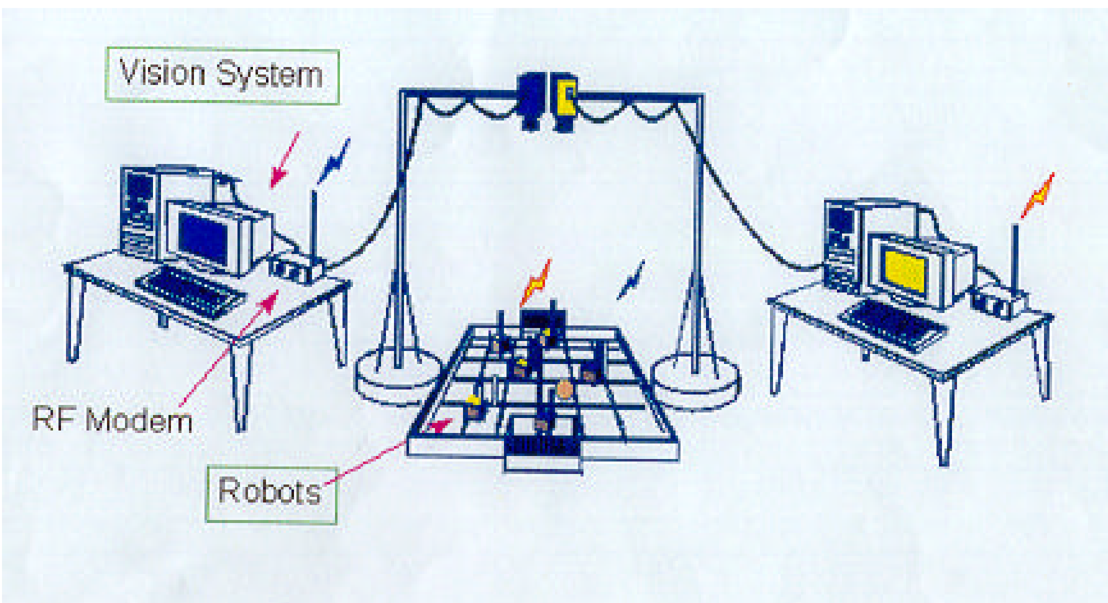


**Figure 1: Overall MIROSOT System**

## Overall MIROSOT System

The MIROSOT project has been divided into four subsystems -- robots, sensory, central control, and communication -- to be developed in parallel. The overall system is illustrated in Figure 2.

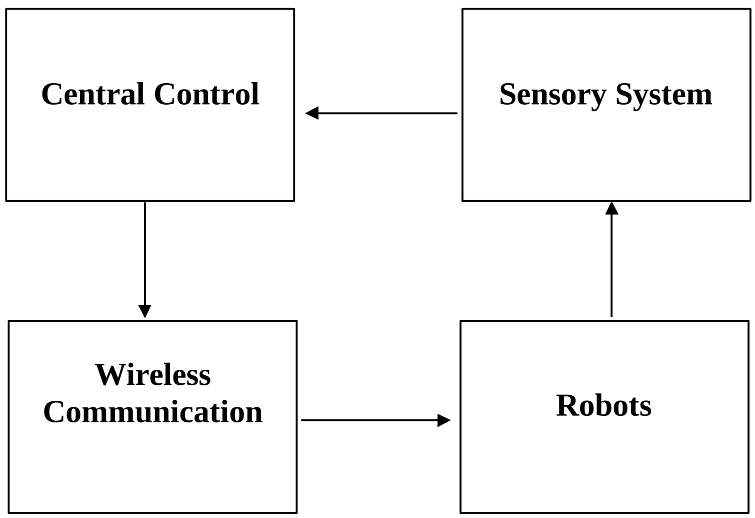


**Figure 2: Overall System Block Diagram**

Position/orientation data from the playing field is fed from the sensory system to the central control ($C^2$) module through a wired communication subsystem. The $C^2$ module -- using the sensory data -- develops or revises a global strategy for the soccer team, and transmits movement data to the robots on the field through a wireless communication subsystem. The actual robot positions are captured by the sensory subsystem, thus forming a closed loop control & feedback system.

MIROSOT Team'98 was responsible for developing the system up to its current stage. At this time, individual teams work on different sections of the project to improve the overall system to meet our goal, which is winning the world cup 2000 in Australia. MIROSOT Team'99 has been formed to redesign the existing robots and to equip them with some intelligence onboard.

## Current Robots

The robots act as the body of the players to play the soccer game. The functional specifications of robots are described in later sections. As shown in figure 2, in the current MIROSOT system, the computer sends data to the robots through the wireless module. Each robot has a receiver, two independent motors (one for each wheel) and a controller onboard. The transmitter sends data which is received via the air and then passed to the controller unit. The controller then translates the received data into two speed values (one for each motor). The controller uses these values to drive each motor and thus the robot is to move in a specified direction, defined as a separate "bit" in the protocol. A block diagram of the current existing robotic system is shown in figure 3.

As shown in figure 3, we expect the robot to move from point A to point B if it is instructed to. However, we observed that it would not follow a straight path and there was a difference of several centimetres between the robot's actual position and its commanded position. The problem is that the two motors on a robot can never be exactly the same in reality. If we apply the same voltage to two identical motors, they should theoretically run at the same RPM. But since no two motors can be exactly identical, they will run at slightly different RPMs. In order to correct this problem, MIROSOT Team'98 had to program the computer to check the robot's path all the time through the camera (refer to figure 1). This checking process puts a great load on the computer and thus reduces its speed to control the game. The problem occurs because the computer has to process the images taken by the camera, decide whether or not the robot is on the correct path and, if not, calculate the new path for it and send the instructions.

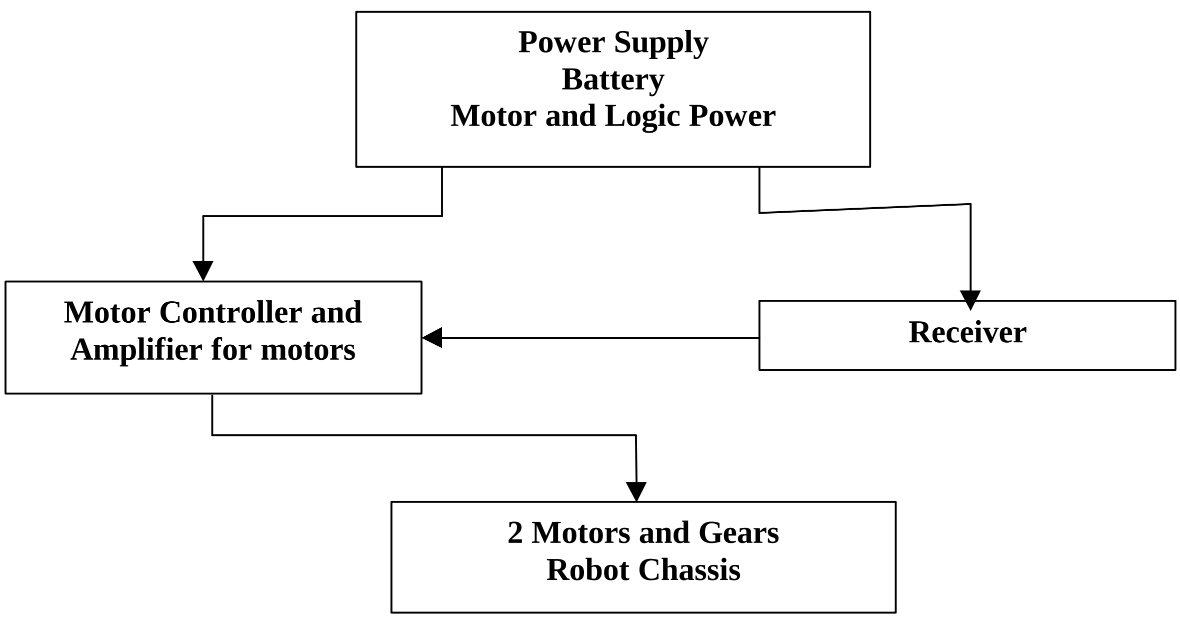


**Figure 3: Current Robot Block Diagram**

## MIROSOT Team'99 General Solution

In this project we are aiming for an accuracy of 1cm deflection in a 120 cm path. This means that if the robot is at point A and is instructed to reach a target at point B, minimum 120 cm away, it is allowed to miss point B by only 1 cm.

Our proposed solution is to implement some sort of feedback system onboard each robot using optical encoders. This feedback loop allows the motor controller to read the output of each motor and determine whether or not it is having exactly the required RPM. If not, it will adjust the RPM. A block diagram of our general solution is given in figure 4.

As figure 4 illustrates we will also implement collision avoidance sensors onboard each robot. These sensors are turned on manually and are used for testing purposes only. They will allow computer testing on its collision avoidance algorithms.

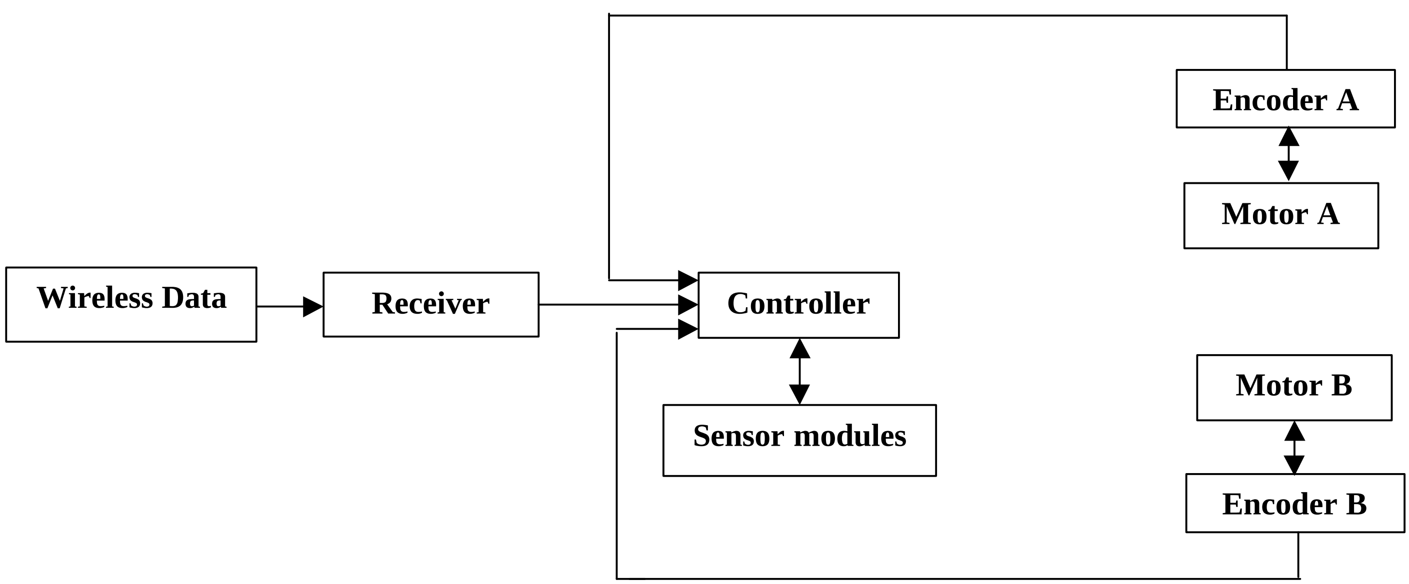


**Figure 4: MIROSOT Team '99 General Solution**

# Robot Functional Specifications

## 1. Software

The software on the robot must be able to:

- Handle real time data reception.
- Identify packets for the current robot
- Reject packets for other robots.
- Offer sufficient error correction to overcome errors resulting from transmitting through the channel.
- Translate the received packet to motor speeds and provide the controller output
- Read in feedback input from the optical encoders and adjust the motor speeds so that the robot follows the desired path.
- Support collision avoidance algorithms for testing purposes.

## 2. Hardware

The robots act as the body of the players to play the soccer game. To play the soccer game successfully, these robots must have a certain set of functionality. Additional constraints on the functional specs are imposed by the official competition rules. Table 4 shows the functional characteristics that our robot must have.

**Table 1: Functional Characteristics**

| Functional Characteristics | Description |
|---|---|
| Movement | from 0-100cm per second |
| Turning | as slow as 180° per second |
| Stopping | full speed to full stop in 7.5cm |
| Robustness | must survive collision at 300cm/s |
| Carry Sufficient Energy | last at least 5 minutes |
| Wireless | Receive at least two different frequencies |

## Requirements to meet the functional specifications

1. Power supply:

- Supply enough power to meet the specifications indicated in the power budget table 5 for a minimum of 5 minutes.
- Small enough to fit inside the robot.

**Table 2: Power consumption summary**

| Part | Voltage | Current | Power |
|---|---|---|---|
| 2 Motors + Encoders | 10.0 V | 2 x 0.5A | 10.0 W |
| Voltage Regulator | 5.0 V | 100mA | 0.5W |
| Motor Controller | 5.0 V (logic) | 50mA | 0.25W |
| Amplifiers | 5.0 V (logic) | 50mA | 0.25W |
| Sensors | <10.0 V | 50 mA | <0.5 W |
| Receiver | 5.0 V | 50mA | 0.25W |
| Total | | | Max. 11.75 Watts |

3. Receiver
    - Receives control instructions from the central computer.
    - Output control instructions to the motor controller.
    - Support at least 2 communication channels, ability to select the channels manually.

4. Motor Controller:
    - Decodes speed/direction input from the receiver.
    - Output control signal for two DC motors in PWM format.
    - Support input capture for two channels (for encoder input).

5. Amplifier for motors:
    - Amplifies the control signals from the motor controller.
    - Apply amplified signals to the motor terminals.

6. Movement:
    - Two large driving wheels.
    - Two independent DC Motors.
    - Balance casters.

7. Feedback:
   - Encoders with quadrature output
   - Generates PWM from quadrature input
   - Fast respons

8. Collision avoidance:
   - Be able to detect an object at least 75 mm away.
   - Low power consumption.
   - Be put ON/OFF line manually.
   - Used only for testing the collision avoidance algorithms.

9. Robot Chassis[1]

   - The size of the robot chassis must stay within an envelope of 7.5cmX7.5cmX7.5cm.
   - The chassis must be designed in such a way that 70% of the ball diameter is visible all the times.
   - The MIROSOT robot consists of a rectangular parallelepiped body with a large driving wheel and a smaller balance caster on either side. The 2 driving wheels are controlled by 2 independent motors. Figure 4 shows the exterior views of the robot.
   - The chassis must be durable enough to withstand collisions that often occur during the play.
   - The robots must be heavy enough to provide enough inertia not to be pushed easily by the opponents.

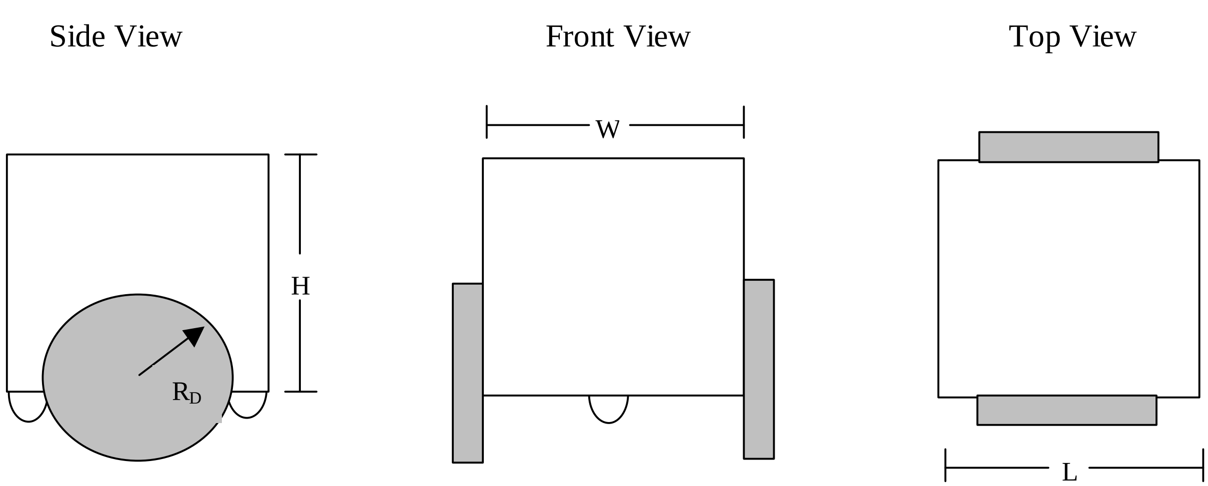


**Figure 5: Robot Exterior Views**

[1] Complies with MIROSOT official rules

## Test Plan

The following test plan describes the tests that our robots will undergo in order to meet the main specifications.

- Movement: The computer will instruct the robot to move in different directions. The robot’s movements, change of orientation, change of speed, change of direction, and acceleration will be measured and compared to the proposed specifications.

- The robot must be able to stop from full speed within a robot length (7.5 cm). We will instruct the robot to move at maximum speed. When the max speed is reached the robot will be instructed to stop. The distance is then measured.

- Although another team is responsible for the wireless part of MIROSOT porject, different data packets will be sent to the robot in order to make sure that it can interface with the $C^2$ module.

- We will leave the robots running for 5 minutes minimum to test the power consumption. Occasionally we will stop the motors and run them again. Each stop will drag extra power from the batteries. The robot must last five minutes with one set of batteries.

- The robot, once instructed to move from point A to point B, must reach point B without further help from the computer. The inaccuracy allowed for this test is 1 cm for a 100 cm distance.

- If the robot is manually set to collision avoidance mode it must be able to detect a barrier 7.5 cm away and stop without colliding with it.

## Summary

The robots act as the body of the players in the soccer game.  Each robot must fulfil eight basic functional requirements:

- Able to move, turn, and stop
- Wireless, and carry sufficient power on-board for five minutes of play
- Be able to reach a target by itself once instructed
- Be put on manual testing status for collision avoidance testing

The above system fulfils a single functional aspect of the overall MIROSOT system  that is being developed by several individuals and teams.  Once integrated (and debugged), we believe the resulting system will be capable of competing in the MIROSOT competition this summer.

Of course, we will have a simplified feedback system operating by mid-April for our 370 demonstrations. ☺