Transformation of One RC Car Into a UGV

MECH 471 / MECH 6621

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Problem Statement

- There is an off-the-shelf RC car.
- This car comes with its joystick and undoubtedly needs an operator to go forwards, to gear backwards, make a turn to either left or right or generally speaking follow an adequate path.

- There is an intention of bypassing the joystick, and to put a computer in between to decide for the car.
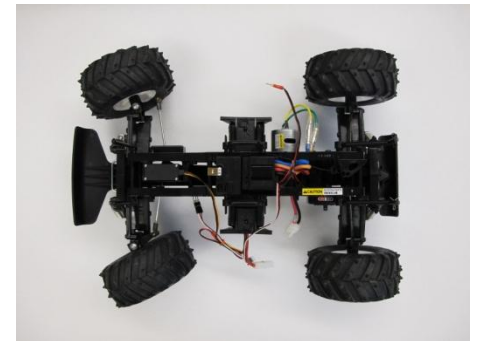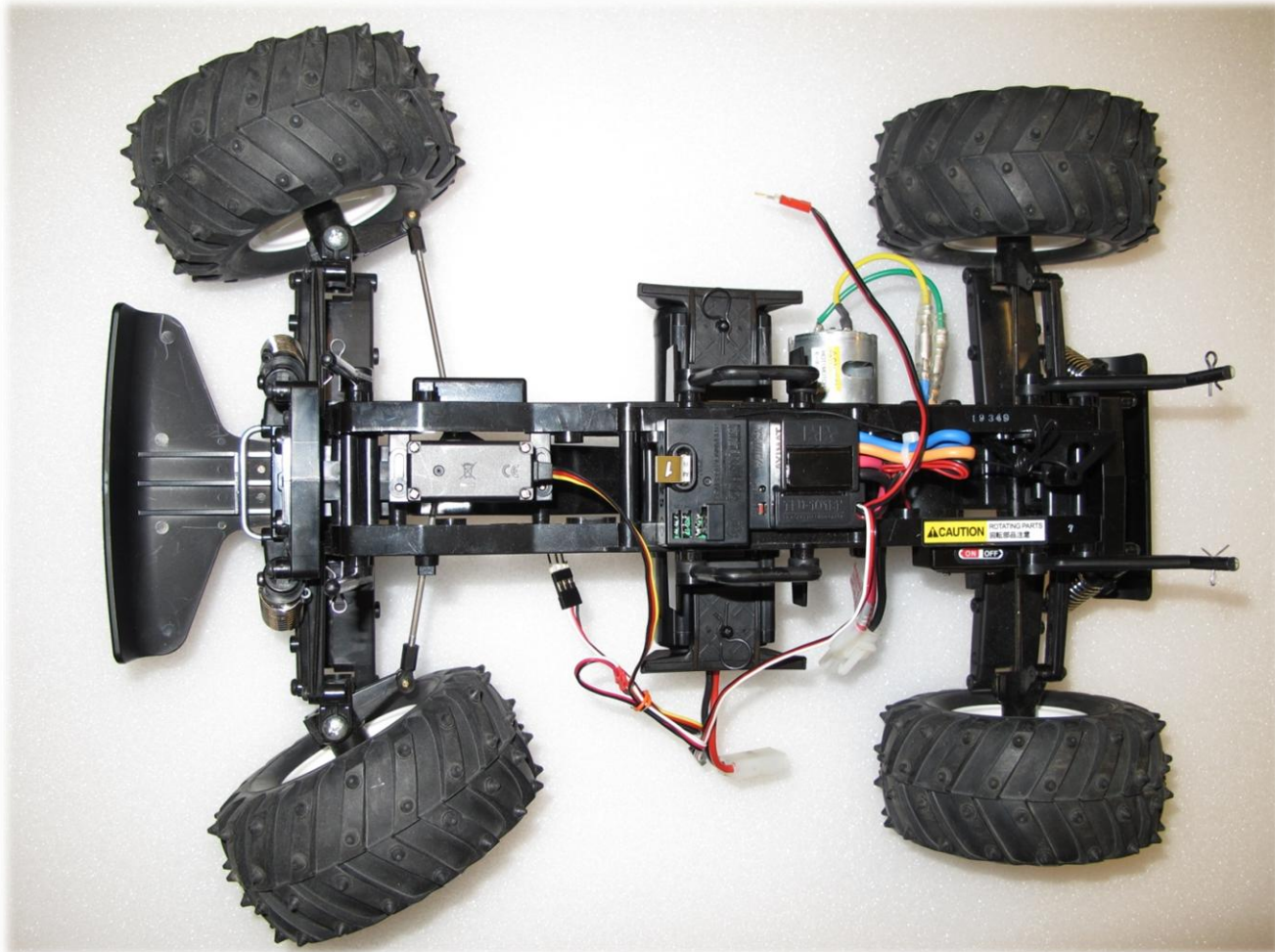
In this Work:

- Problem Statement

- Hardware

- Software

- Manual Control
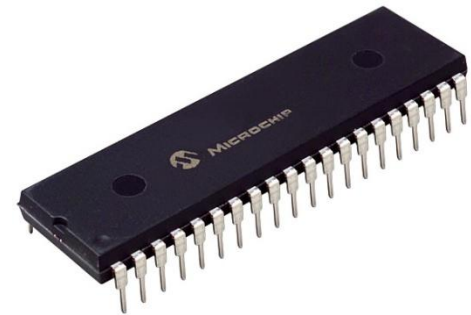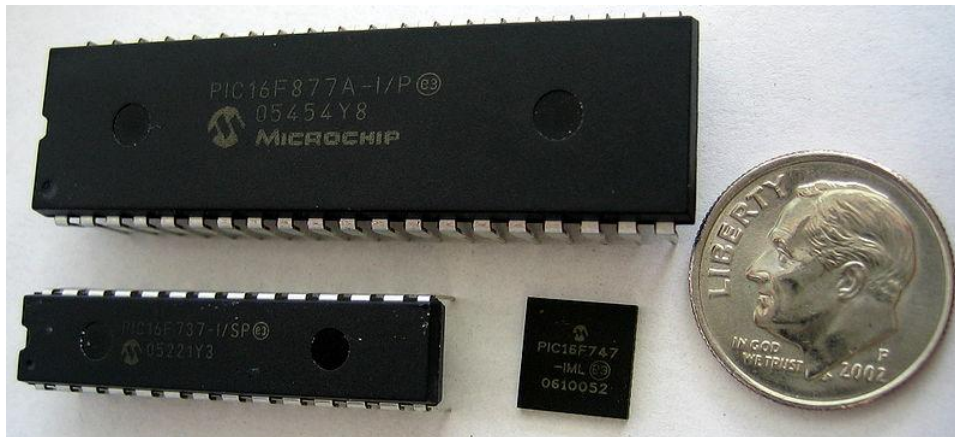
- Tracking Problem

- Conclusion

- Future Work

Hardware

- **Remote Control (RC) Car**

Hardware

- **Microcontroller**

✓14-Bit Resolution Power Control PWM module (PCPWM) with Programmable Dead-Time Insertion
✓Motion Feedback Module (MFM), including a 3-Channel Input Capture (IC) module and Quadrature Encoder Interface (QEI)
✓High-Speed 10-Bit A/D Converter (HSADC)
✓The PCPWM can generate up to eight complementary
✓PWM outputs with dead-band time insertion. Overdrive current is detected by off-chip analog comparators or the digital Fault inputs (FLTA, FLTB).

Hardware

- **Opti-Track**

As for any other moving robot demonstrating autonomous motion, decision making on how to go, in which direction to turn, and with what speed to move is strongly dependent on the information regarding position of the vehicle as well as its orientation.

Based on the environment in which the intelligent robot is supposed to work this may be suitable or not.
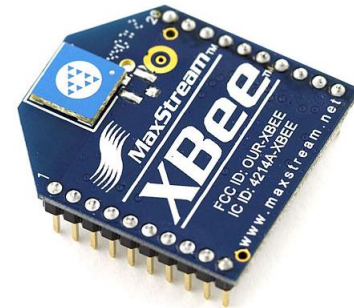
Hardware

- **Joystick**

Hardware

- **XBee RF Module**

The XBee and XBee-PRO OEM RF Modules were engineered to meet IEEE 802.15.4 standards.

They support the unique needs of low-cost, low-power wireless sensor networks.
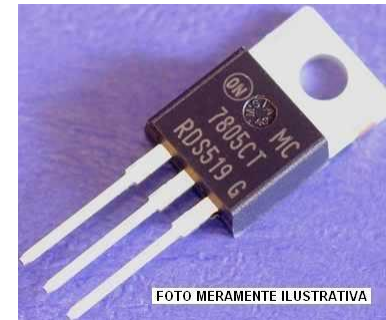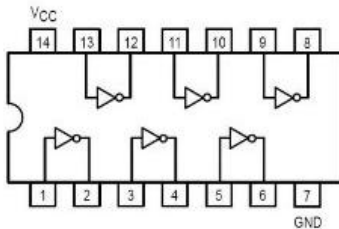The modules require minimal power and provide reliable delivery of data between devices.

The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other.

Hardware

- **Inverting IC (74LS04N)**

- **Voltage Regulator (MC 7805CT)**

Features

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

Software

- Tracking Tool

The Tracking Tools (formerly Rigid Body Toolkit and Point Cloud Toolkit) is a robust, real-time 3D optical tracking solution.

- QUARC Library

Thanks to the arrival of QUARC, Control Design is now accelerated more than ever before.

QUARC seamlessly integrates with [Simulink®](#) for rapid controls prototyping and hardware-in-the-loop testing.
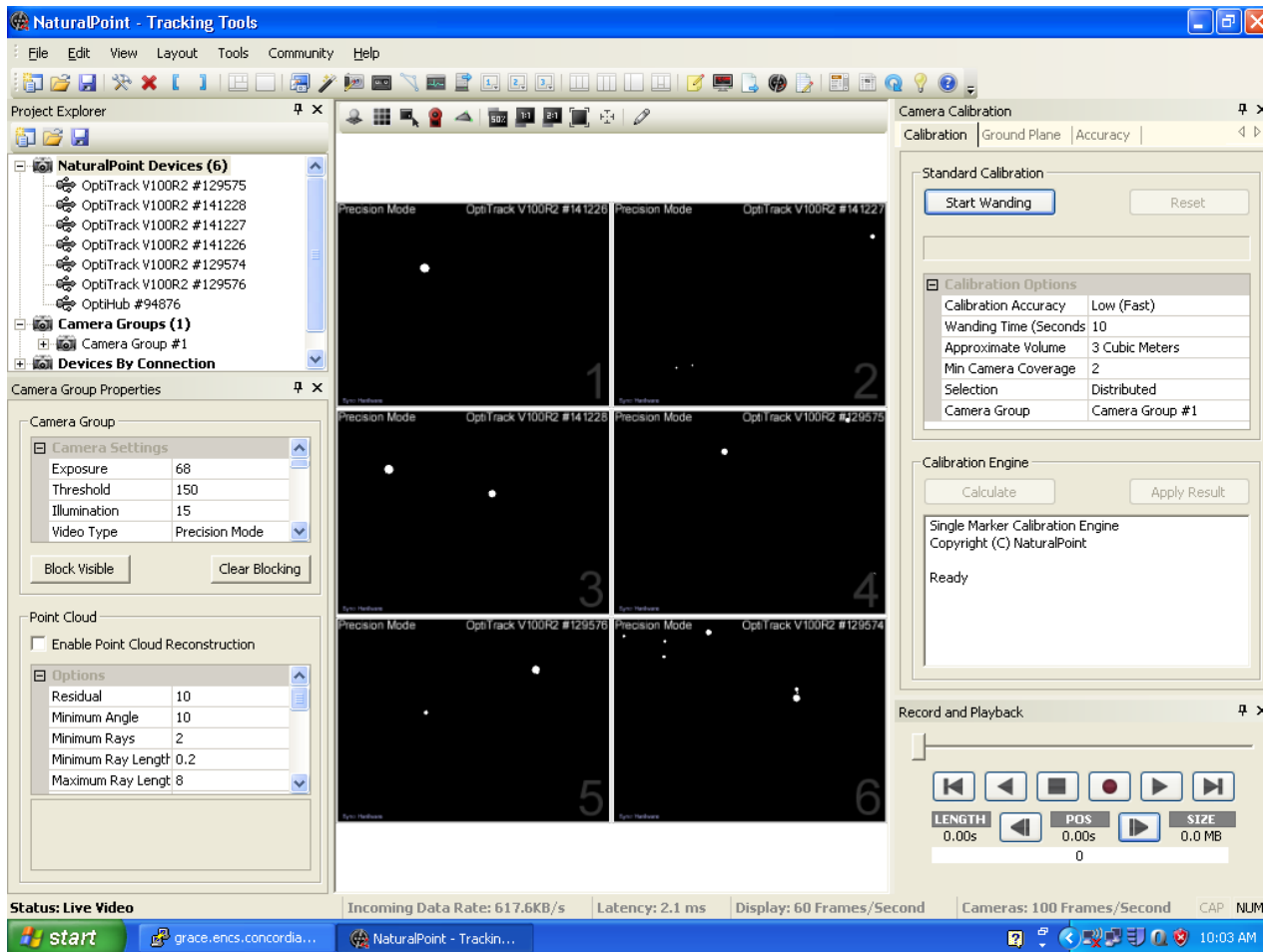
In this work two systems need use of this library.

- MPLAB IDE

- C18 Compiler

Extensive library support, including PWM, SPI, I2C, UART, USART, string manipulation and math libraries.
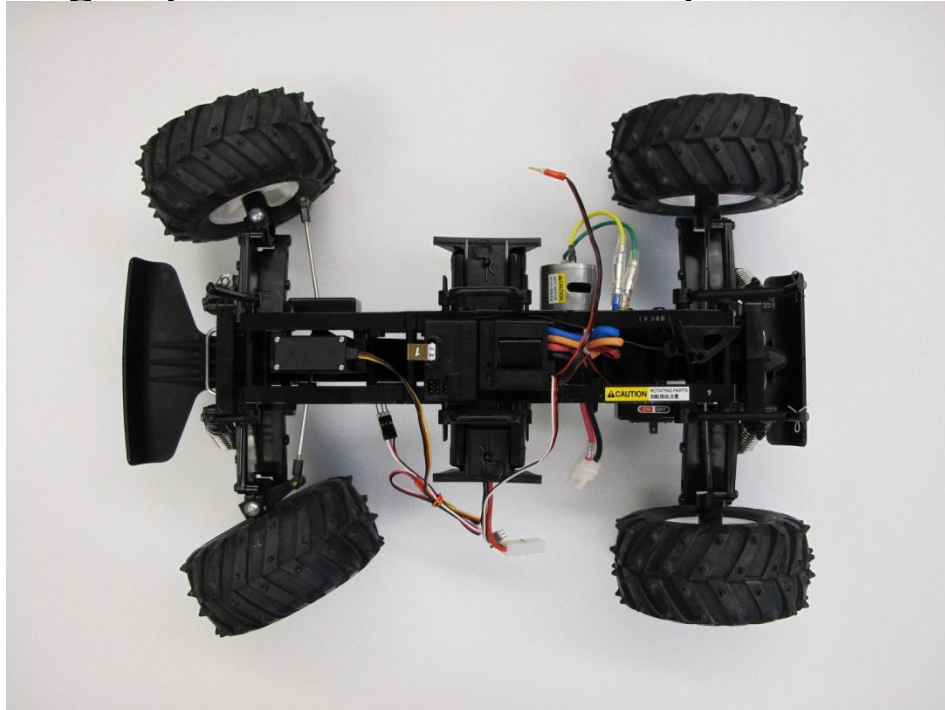
Software

Software

Tracking Problem

- Microcontroller (Basic control of the vehicle)
- X-Bee (Control the vehicle from a remote computer)
- Joystick (Control the vehicle smoothly with a joystick)
- Include set of cameras and use PID controllers to control the vehicle automatically.

Software

Microcontroller (Basic control of the vehicle)

- Steering wheel: servo motor
- Rear motor: High speed DC motor with speed controller

Software

Microcontroller (Basic control of the vehicle)

```
PDC0H: 0x02 XX000010
PDC0L: 0xFC 11111100

PDC0H: 0x02 XX000010
PDC0L: 0xBC 10111100

PDC0H: 0x03 XX000011
PDC0L: 0x1C 00011100
```

Figure .1 The PWM signals for stop, backward and forward motion

Software

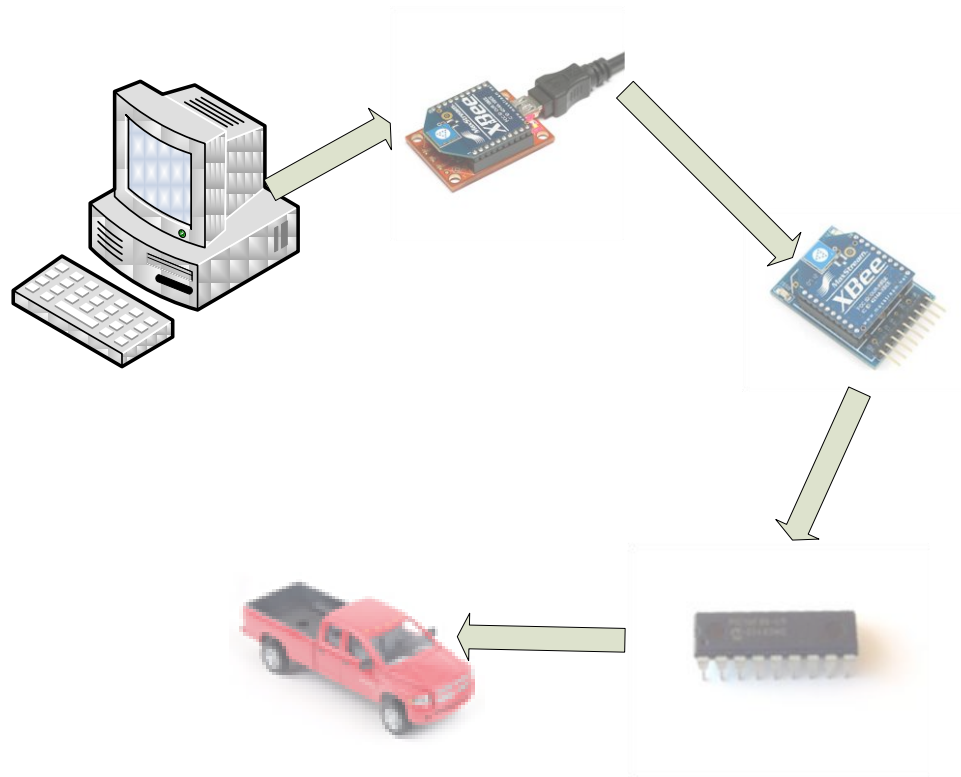**X-Bee (Control the vehicle from a remote computer)**

Figure .2 Structure of X-Bee system

Software

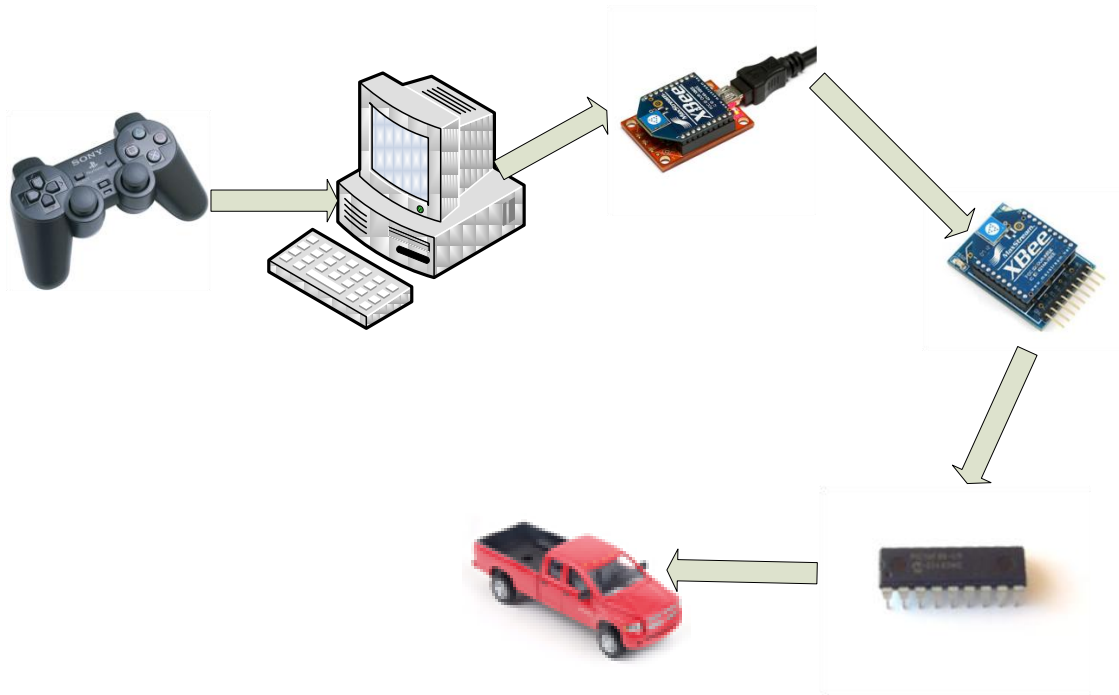**Joystick (Control the vehicle smoothly with a joystick)**

Figure.3 Joystick system

Software

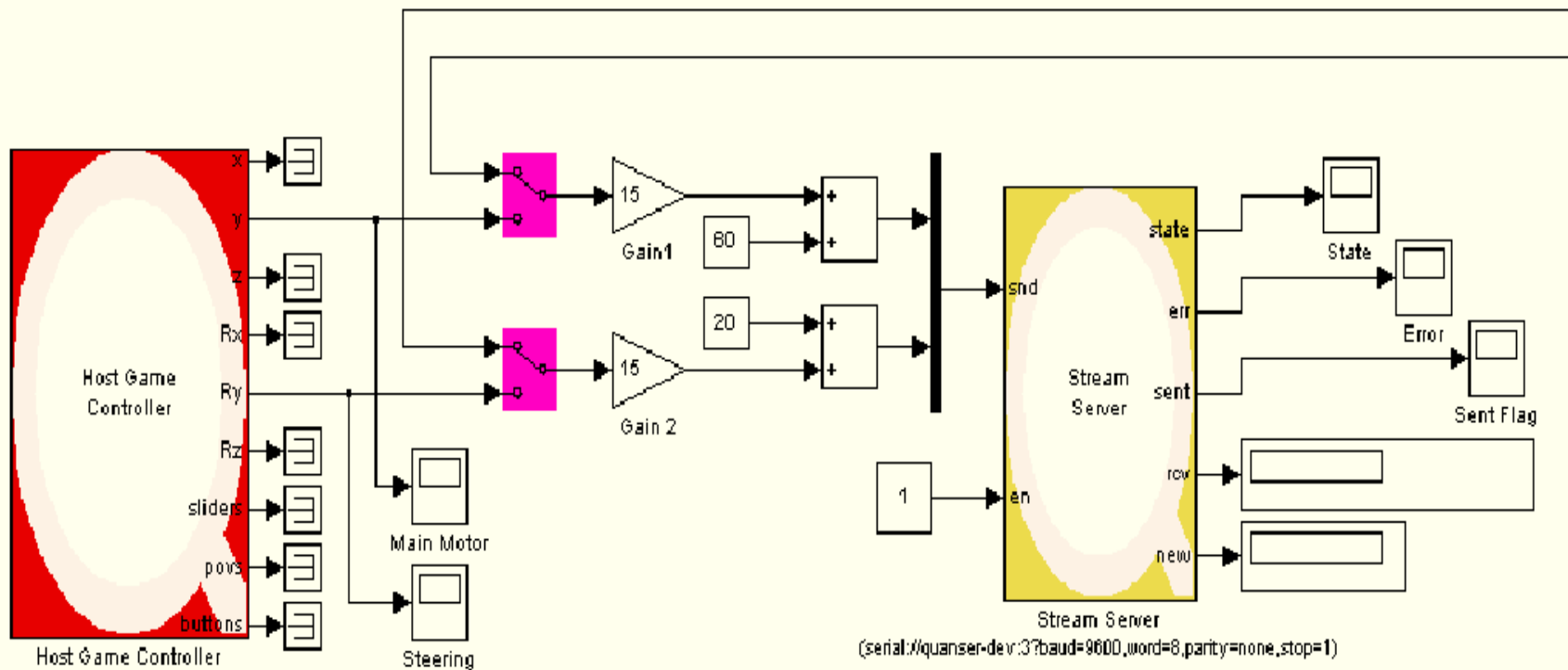**Joystick (Control the vehicle smoothly with a joystick)**

Figure .4 Block diagram for Joystick and X-Bee

Software

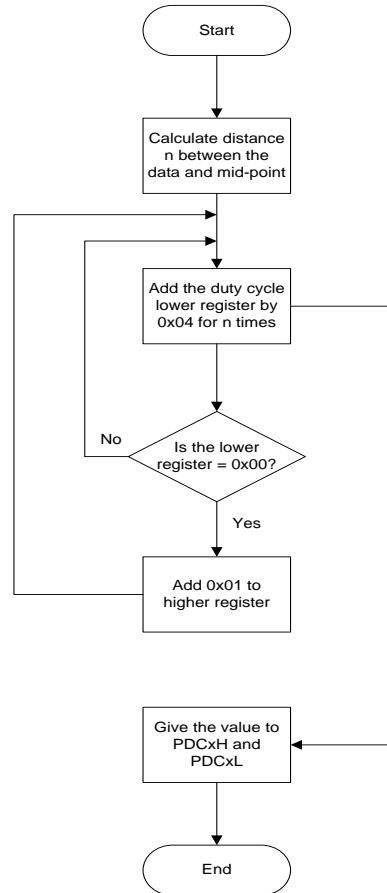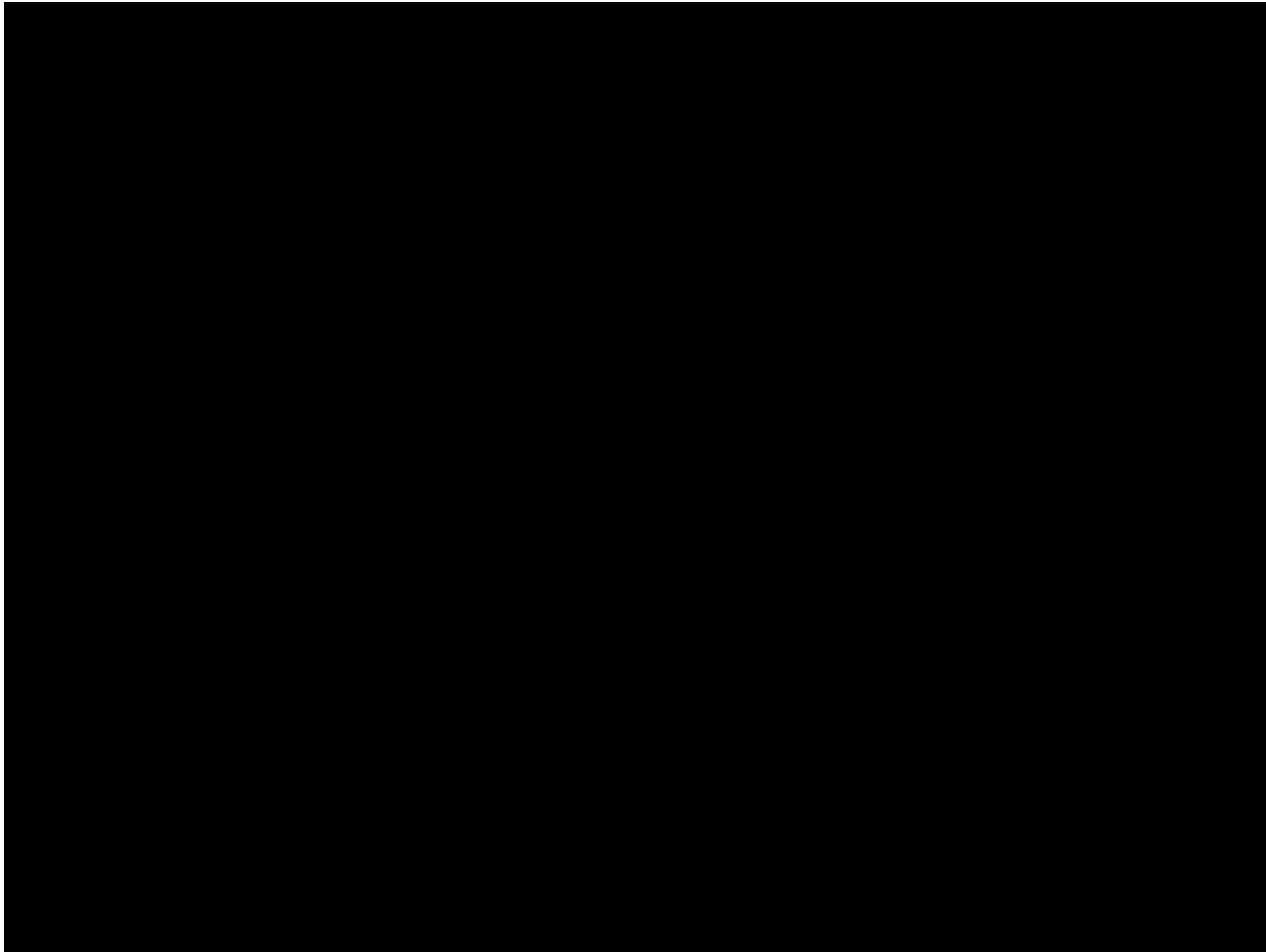**Joystick (Control the vehicle smoothly with a joystick)**

Figure .5 Flow chart for function forward()

Joystick (Control the vehicle smoothly with a joystick)

Software

Straight line
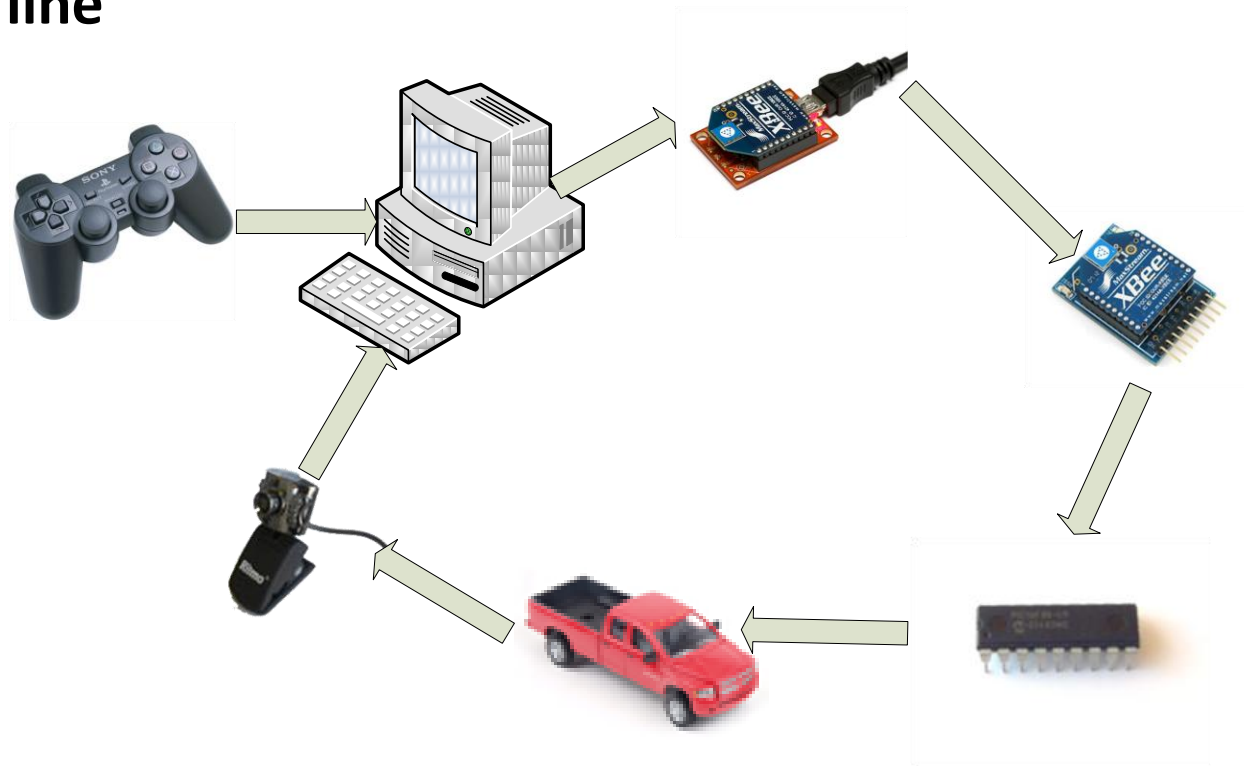

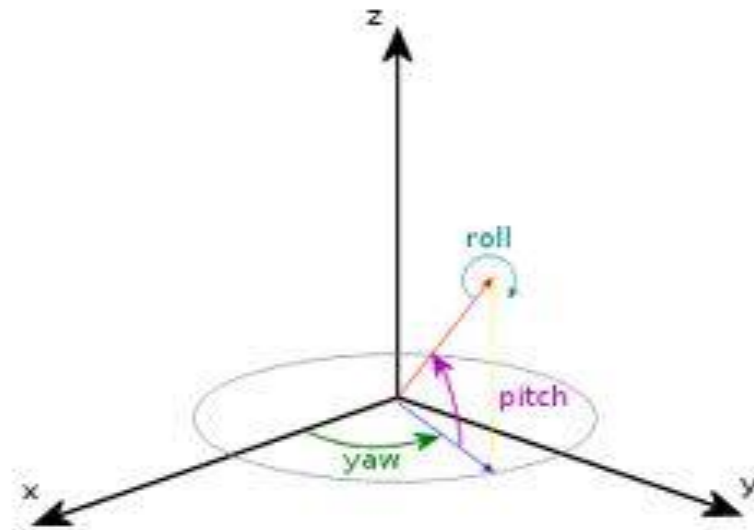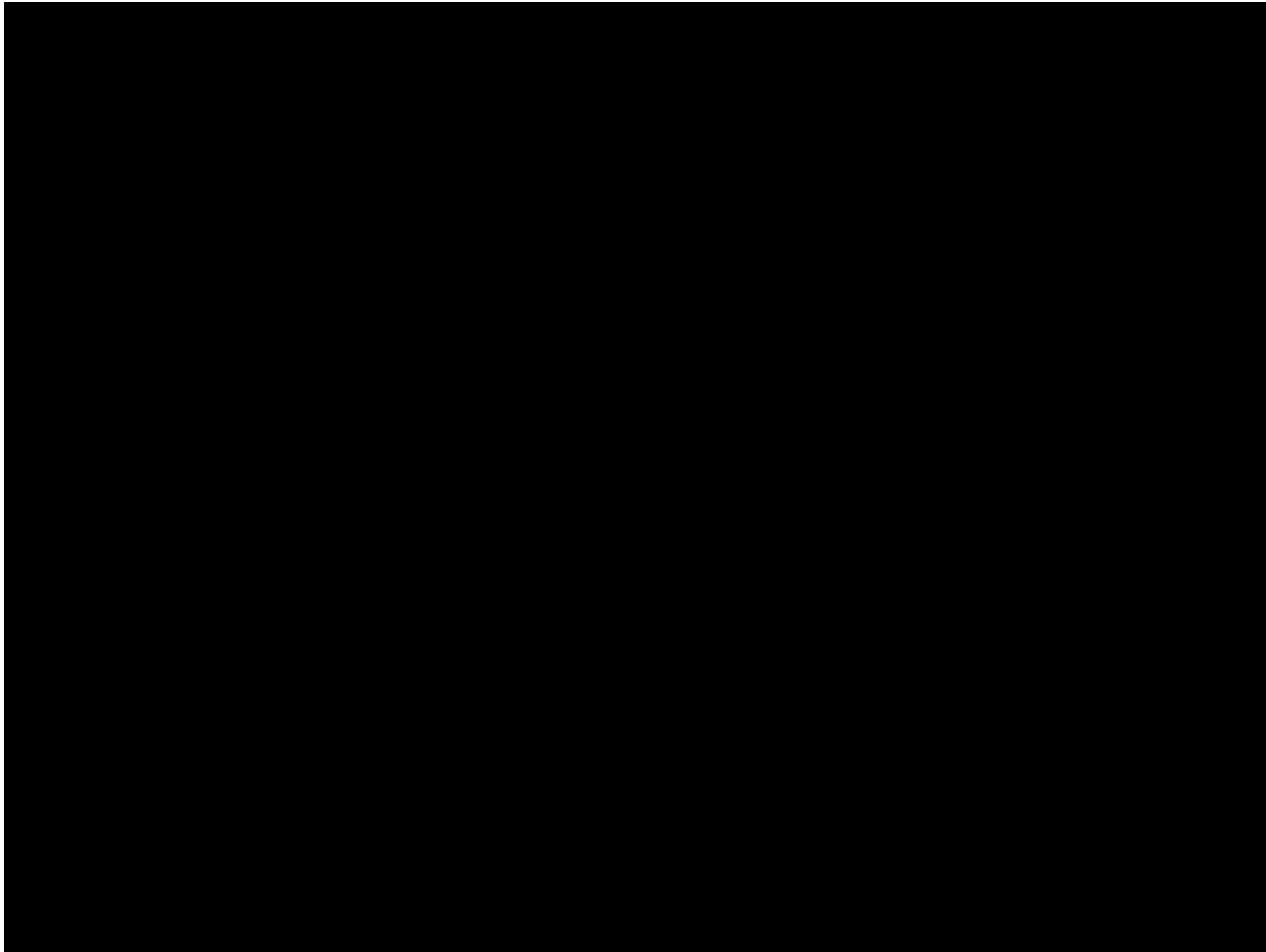Figure .6 Final structure of system

Software

Straight line

Figure .7 Coordinates of Toy Truck

Straight line

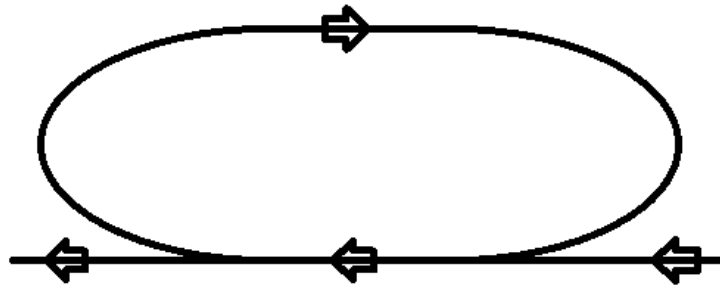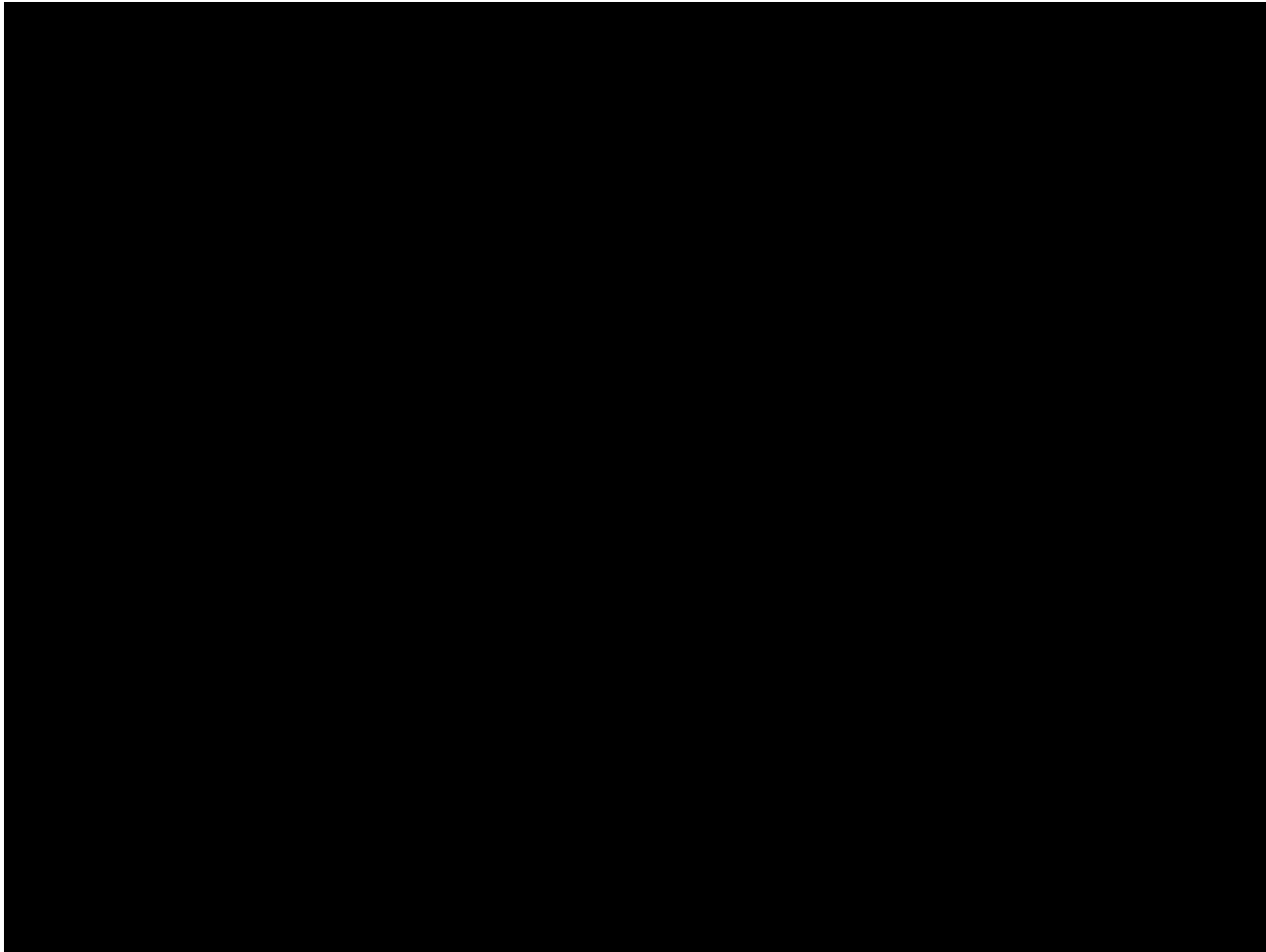# Software

U-turn path

Figure .8 U-turn path

U-turn path
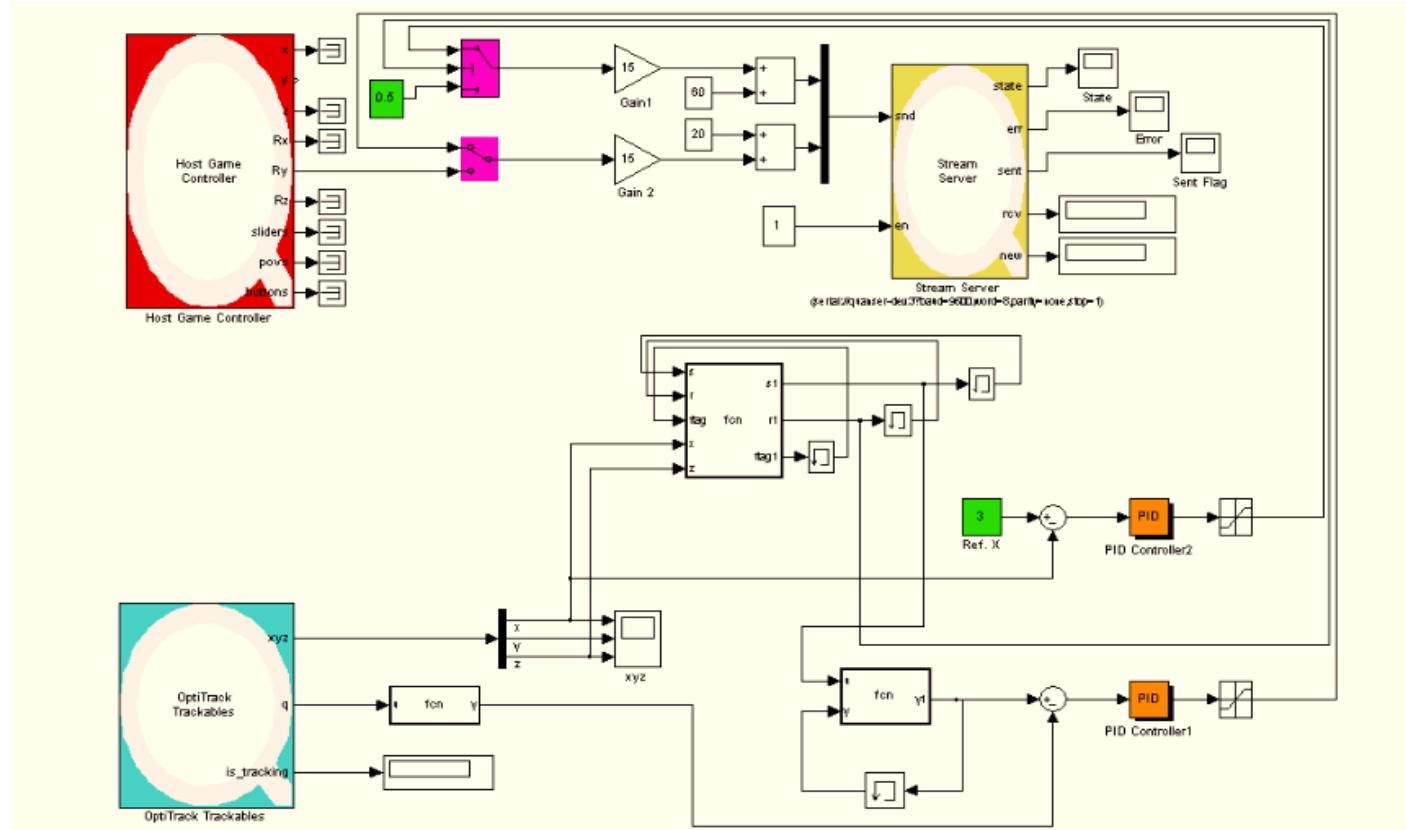
Software

U-turn path

Figure .9 Final Block diagram

Conclusion

- In this work, attempt has been made to change a hobby RC car into an Unmanned Ground Vehicle which is capable of patrolling along a straight line autonomously.

- This has been achieved by means of a PIC18F microcontroller functioning as the onboard computer.

- Though this tiny onboard computer does not really decide for the car nor does it accommodate the pertinent controller governing motion of the vehicle, it receives processed data, the output of both PID controllers, does a proportion of processing and produces two proper Pulse Width Modulated signals at right a time to drive both the main motor as well as the steering wheel servo.

- Fully autonomous motion of the car or trajectory following capability of the system cannot be claimed since this system, the system of a car like robot, is essentially an under-actuated system which requires further investigation and effort to have it fully under control.

- Also, this system has three state variables; those are two degrees of translational motion namely, X and Z and one degree of rotational motion namely, Yaw; on the other hand there are two actuators one to drive the car backwards and forwards and one to do steering towards left or right. This is straightforward that such a system is multi input multi output system which cannot be controlled by a simple PID controller. A PID controller is a good solution for single input single output systems. However, use of a PID controller eliminated the need for differential equations governing dynamics of this car.

Further Work

- Replacement of the opti-track system with either a GPS module or ultrasonic sensor. Despite all the advantages mentioned for employment of the system of opti-track it is apparent that this system can be served for academic purposes. Once one steps out of the laboratory there is n provision of such cameras for navigation purposes. The same downside applies to ultrasonic sensors, kind of.

- Application of 'Image Processing' techniques for navigation purposes. However this calls for help from Computer Engineering Students or the ones majoring in the field of Vision-based Control. This is a new era in the field of control and needs much work.

- Next, will be implementation of other control algorithms rather than PID to address the problem of multi input-multi output system. That can be either a linear control to initiate the work or a nonlinear control to further expand this work.

- Last but not least, trajectory planning. If the car is supposed to function quite autonomously, it should be provided just with an equation of the specific trajectory and then, switch on, it should perform the task along the path.

Reference

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- XBee Datasheet
- PIC18F4431 Datasheet
- Inverting IC (74LS04N) Datasheet
- Voltage Regulator (MC 7805CT) Datasheet

Thank You for Your Attention