Project List

The projects listed below are all, to some extent, open-ended design problems. There are a number of extra features that can be added to each of these projects to enhance the final design and useability. Students have the freedom and should challenge themselves to embellish the projects beyond the listed specifications. There will be multiple groups taking the same project, so each group should try to differentiate their design from others. In evaluating the design project, the level of difficulty of the project will be taken into account. A straightforward project will attract lower marks than the successful implementation of a challenging one.

The Projects include:

1. Microprocessor Controlled Synchronous Machine (x2 available)
2. Exercise Bike with Heart Rate Control (x2)
3. Electrical Assist Bicycle (x2)
4. Autonomous Intruder Detection Vehicle (x6)
5. Search-and-Rescue Robots (x3)
6. Autonomous City Vehicle (x10)
7. Energy Efficient Smart Home Systems (x3)
8. Automatic Reverse Parking Vehicle (x1)

1. Microprocessor Controlled Synchronous Machine

In this project, students are required to design and implement a microprocessor-based system for the control of a synchronous machine. The function of the controller will be to automatically connect the machine to the mains power supply and, once connected, provide power factor correction at a user specified level for a local load. This project will utilise the school's 41.5 Volt laboratory scale machines.

Features to be considered in the design of the system include, but should not be limited to:

- Manual control of synchronisation to the mains power.
- Measurement of AC voltage, AC current and frequency.
- Automatic synchronisation to the mains power.
- Display of real and imaginary power delivered by the synchronous machine.
- Power factor correction.

A basic block diagram of the microprocessor controlled synchronous machine is shown in Figure 1. Existing infrastructure for this project includes a DC motor, synchronous machine and various microprocessors/microcontrollers.

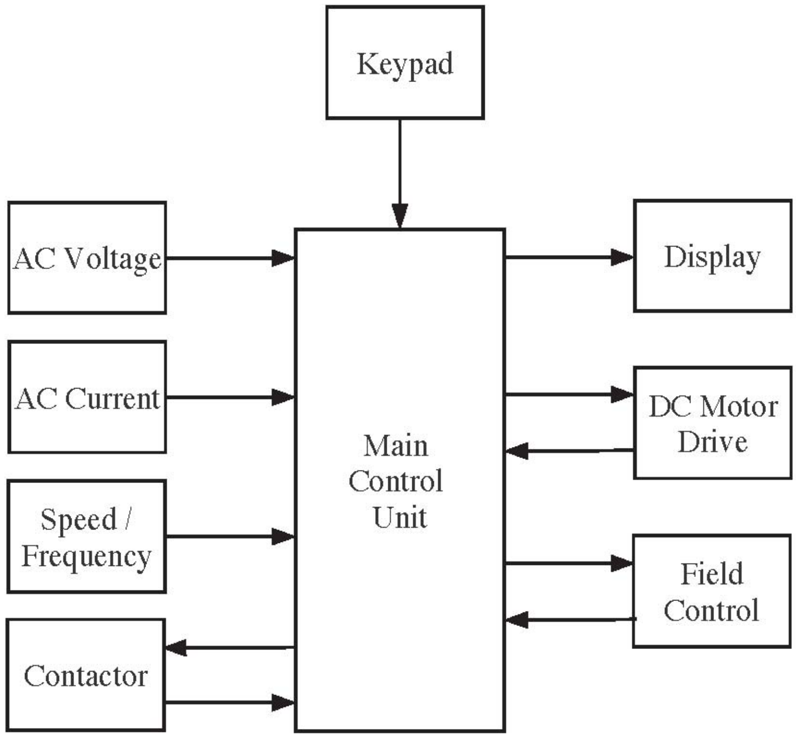

Figure 1: Example Block Diagram of the Microprocessor Controlled Synchronous Machine

2. Exercise Bike with Heart Rate Control

The idea of this project is to allow the rider of an exercise bike to be able to select a desired heart rate, for a particular cadence, to which the exercise system will seek to maintain through the application of an external load to the bike. A basic block diagram of the exercise system is shown in Figure 2.

The idea of this project is implement a control system to maintain the rider's heart rate at a user-specified level for a particular cadence by adjusting an external load. A basic block diagram of the exercise system is shown in Figure 2.

Features to be considered in the design of the exercise system include, but need not be limited to:

- Ability to enter
    - a desired heart rate and cadence into the system, or
    - a desired (constant) load, in watts, for the system to maintain.
- Smooth application and removal of load when controlling heart rate.
- The heart rate and cadence sensors are to connect to the main control unit using wireless communications to facilitate an easy connection and disconnection of the device from the bike. Sensors must be battery powered.
- Data storage and connection to a PC is to be implemented to allow the user to download previous exercise sessions.
- Speed and distance travelled are to be calculated, displayed and stored for the user.
- A facility to inform the user that their cadence rate is reducing.

The existing infrastructure for this project includes a mountain bike, exercise stand and a permanent magnet DC motor/generator. The mountain bike is clamped into the exercise stand such that the rear wheel is coupled through a roller, two sprockets and a chain to the DC generator. Loading of the system will consist of applying an electrical load to the generator.

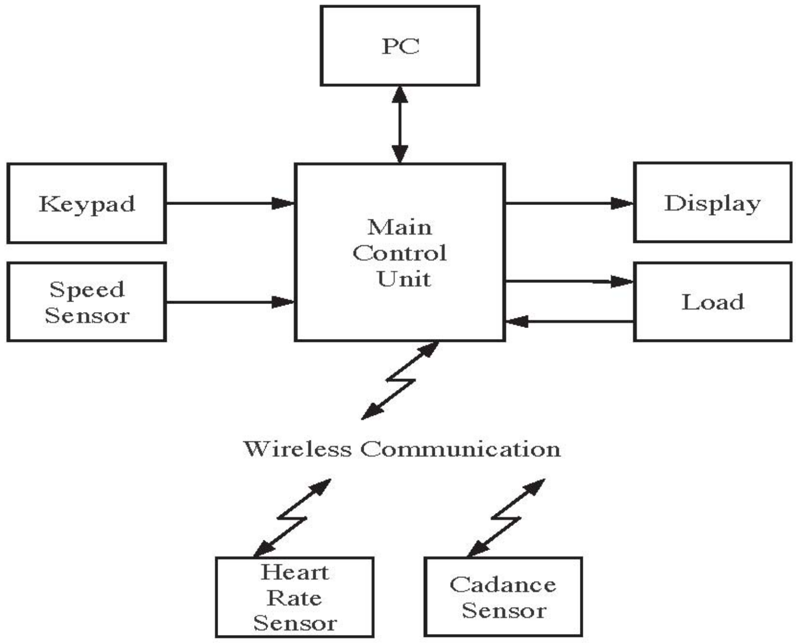

Figure 2: Example Block Diagram of Exercise System

3. Electrical Assist Bicycle

The goal of this project is to create a system that allows the rider of a bicycle to select how much assistance is to be provided by an electric motor coupled to the rear wheel. The basic system, for example, may consist of four modes that can be selected by the rider:

- Mode 1: No assist.
- Mode 2: 50% assist (i.e. For every 1 watt of power provided by the rider 0.5 watts will be supplied by the electrical assist system)
- Mode 3: 100% assist
- Mode 4: 200% assist

Features to be considered in the design of the electrical assist system should include, but not limited to:

- Measurement (or real time estimate) of the rider's power output.
- Smooth application and removal of the electrical assistance.
- Display of rider power output.
- Facility for a connection to a PC.
- Speed, distance travelled, total rider energy and energy supplied by the electrical assist system are to be calculated, displayed and stored for the user.

A basic block diagram of the electrical assist bicycle system is shown in Figure 3. The existing infrastructure for this project includes a mountain bike, exercise stand and a permanent magnet DC motor. The mountain bike is clamped into the exercise stand such that the rear wheel is coupled through a roller, two sprockets and a chain to the DC motor. Load will be applied through the rear wheel of the bike.

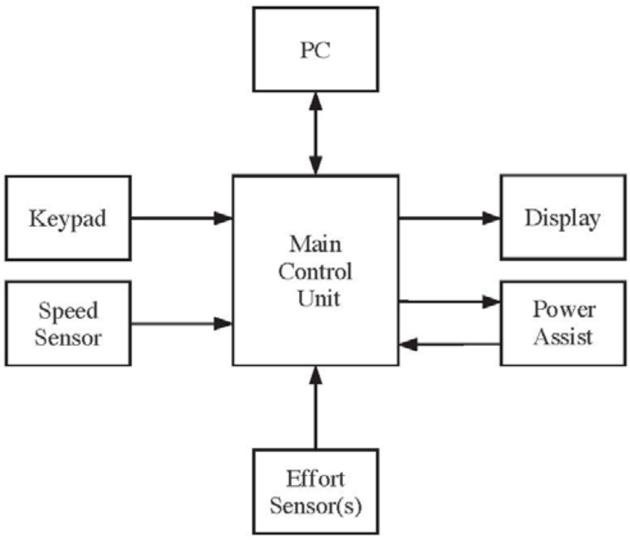

Figure 3: Example Block Diagram of Electrical Assist Bicycle System

4. Autonomous Intruder Detection Vehicle – (Challenging)

The goal of this project is to modify a remote control car to make it autonomous and able to detect an intruder. The vehicle should also avoid collision with walls or any other objects that may be present within its patrol area. An image of the intruder, when detected, should be captured and transmitted to a personal computer (PC) for display.

Features to be considered in the design of the autonomous intruder detection vehicle include, but should not be limited to:

- Autonomous navigation without collision.
- Sensing of an intruder.
- Image capture of an intruder.
- Wireless transmission of an intruder alarm and image to a PC.

Further extensions could include:

- On-board camera streaming real time video to a display unit.
- Wireless communications for remote control of the vehicle.
- Developing a robot that is able to lock onto an intruder and follow them as they move.

An example block diagram of the Autonomous Intruder Detection Vehicle is shown in Figure 4. Existing infrastructure for this project includes a remote control car, batteries and battery chargers. Several types of microcontrollers, wireless modules and cameras are available in the laboratories.

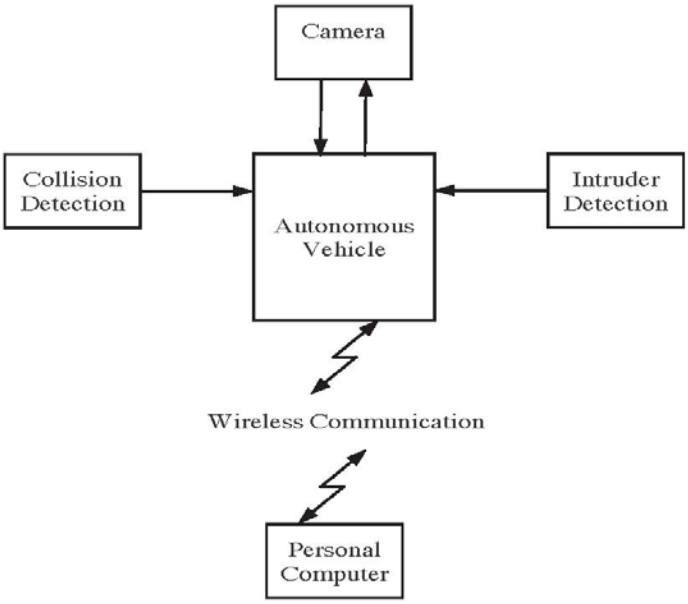

Figure 4: Example Block Diagram of an Autonomous Intruder Detection Vehicle

5. Search-and-Rescue Robots

The goal of this project is to transform the School's existing warehouse robots into search-and-rescue robots. Modifications will need to be performed to enable the existing robots to detect and pick up an object 'marked' with an infrared LED and/or distinguished by pre-determined colours. The robots will also need to be capable of detecting steel ball bearings. It is required that the marked objects be collected with a robotic gripper whilst the steel ball bearings be collected with an electromagnet. The robot should also avoid collision with walls or any other objects.

Features to be considered in the design of the search-and-rescue robots include, but should not be limited to:

- Sensing of infrared light.
- Sensing of colour (red, green and blue).
- Sensing of steel ball bearings.
- Construction of an electromagnet.
- Design/control of a robotic gripper.
- Autonomous navigation
- Anti-collision sensors.

Further extensions could include:

- On-board camera streaming real time video to a display unit
- Wireless communications for remote control of the robots. Ideally this project will use a Tablet PC for both the control of the robot and robot arm along with displaying the video stream.
- Developing a robot that is able to lock onto a target. The robot should be able to remain locked on the target as it moves.

This project may also serve as a competition between different teams to see whose robots can collect and deliver the most 'goods' to the correct destinations, in a predetermined time. To obtain a coordinated fleet of robots (in this case 2 robots) it will be necessary to establish a wireless communication link between the robots. This will allow the robots to work together as a team and hence collect and deliver more 'goods'.

An example block diagram of the search-and-rescue robots is shown in Figure 5. Existing infrastructure for this project includes a robot and servo motors for the robotic gripper. A walled area of approximately 1.5 m^2, will be used to test the operation of the warehouse robots. Goods will be placed at selected locations within the boundaries. The robots will be expected to retrieve and classify the goods then place them into pre-specified containers.

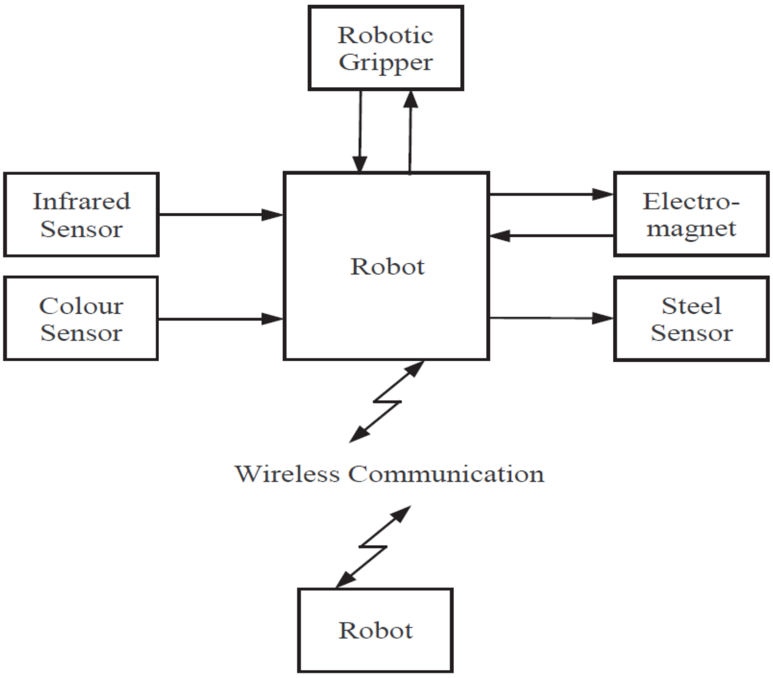

Figure 5: Example Block Diagram of Warehouse Robots

6. Autonomous City Vehicle

The goal of this project is to design a prototype vehicle that can navigate around a predefined track marked by yellow divided lines (simulating a city). The vehicle must travel autonomously and avoid all obstacles and other vehicles. At the very basic level, students should be able to remotely/wirelessly control the vehicle (speed and steering) from a computer or phone/device. At the next level, the vehicle should be able to autonomously follow the track without any assistance. Additional challenges include stopping at intersections, parking in designated areas and yielding to emergency vehicles (which wirelessly broadcast an emergency signal). Note: Full marks are only obtainable by attempting these additional challenges.

The vehicle comes with the following components:

- Microcontroller: STM32F407 Discovery Board
- Chassis: Shadow chassis; Wheel - 65mm rubber tire, pair; Hobby Gearmotor - 200 RPM (Pair)
- Wireless: Xbee 1mW wire Antenna - Series 1 802.15.4
- Camera: Pixy CMUcam5
- Battery

Basic components are available from EE lab store. There will be 10 sets of equipment available. Students have the freedom to design certain parts of the project by themselves (hardware, software, wireless communications), instead of simply assembling different provided components. For example, other methods for object recognition can be used in addition to the Pixy Cam.

The road rules that the vehicle must obey include:

- Keeping to the Left Hand Side of the yellow dividing line and maintaining this position while crossing intersections. The vehicle is able to deviate from the lane only to park or avoid obstacles.
- Stopping for a minimum of 1 second at intersections (marked by a solid yellow line perpendicular to the lane) before proceeding.
- Stopping immediately when an emergency vehicle is detected unless they are in the middle of an intersection, in which case, they should clear the intersection before coming to a complete stop.

An example road surface will be provided in the lab early in the semester for students to test their vehicles with.

7. Energy Efficient Smart Home Systems

A smart home is to use advanced ICT technology to integrate various appliances in a home so as to achieve information sharing and communications within as well as outside home. The objective is to provide energy efficiency and comfortable living environment.
There are two aspects of the project.

- To design a system including a telecommunication network within the house, selecting smart power point, and develop a computer interface to achieve remote monitoring and control of the appliances inside the house. You may consider the following functionalities: monitor electricity and water usage, achieve automatic power off for equipment's in standby mode to save power, switch on and off specific devices connected at smart power point, display energy saving status, sending alarm signals, monitor real time electricity prices, etc.
- To develop smart phone applications for smart home energy management system. The applications will enable monitoring and control of smart home appliances and home energy management system on an iOS/Android phone or iPad.

Note: EE lab store does not have parts/equipment available for this project, but students are free to source suitable parts, e.g., a wireless solution to interface with a microcontroller, etc.

8. Automatic Reverse-Parking Vehicle – (Challenging)

The goal of this project is to modify a remote control car (with trailer attachment) to autonomously reverse park into a predetermined position.

The system should work as follows:

- 3 beacons will placed to mark out the desired parking spot:
  - 2 at the front through which the trailer must pass through when reversing, and
  - 1 at the rear to indicate how far back into the site to park the trailer.
- The vehicle must reverse from its current position into the parking spot, or indicate if it is not possible from the current position.
- If it is not possible from the current position, the vehicle may move forward until it reaches a position it can safely park from (without aligning it for a simple straight line reverse).

Features to be considered in the design of the reversing system include, but should not be limited to:

- Detection and location of parking beacons.
- Sensing of trailer angle and relative position.
- Input of system parameters:
  - Distances between wheels on vehicle and trailer.
  - Distance of towball from the last set of wheels of the vehicle.
  - Distance of the towball from the wheels of the trailer

This is a challenging control problem, a model and simulation of the parking system should be completed before it is implemented physically.