Lesson learnt from Smart Home Automation Systems
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ABSTRACT
Home automation applications involve the use of hardware and software components accessed through client-server architectures via network connections. The “smart home” provides for a rich development environment where a variety of applications can be designed and developed under a common theme. This paper discusses home automation applications developed by students and the benefits gained from working on real-world projects.

Keywords: Home Automation, Remote Control, Computer Science Projects

1. INTRODUCTION
Home automation technology is an interesting area of research and development [2] and is one of many areas of Cyber-Physical Systems (CPS), which are integrations of computation and physical entities [7]. It involves the use of state of the art technology for a variety of interesting and useful applications [4, 14].

Home automation has been an excellent framework to formulate problems for student group work. Each group worked on a different aspect of the “smart home” [12, 13, 15]. These include applications involving things such as remote monitoring, control of devices, home security, and energy efficiency. In this paper, we discuss home automation technology, overview some of the student applications developed, and summarize the educational experience of those involved.

In a home automation system, devices are connected with a server to allow control by a client via remote access of the Internet as shown in Figure 1. Through the integration of information technologies with the home environment, systems and appliances are able to communicate in an integrated manner, which results in improved convenience, energy efficiency, and safety benefits [5, 11].

Fig 1: Home Automation Architecture
A client-server model consists of two parts, a client system and a server system, both communicating over a computer network [10]. In a typical client-server relationship, a client makes a service request from the server; the server can accept these requests, process them, perform some activity, and return requested information back to the client.

One of the recent trends in home automation systems is installation of web server in system controller to provide a web based interface to the clients, usually including specialized devices and controllers. A device can serve as an actuator such as a rice cooker or can be attached to sensors for use in motion detection such as a camera [1, 3]. A controller such as a general purpose personal computer is required for operating and controlling the devices. Home devices are connected to the server via cables (wired) or through wireless connections. Many home automation application areas meet a variety of needs including energy efficiency, appliance control, security, healthcare, entertainment, and lighting control.

2. HOME AUTOMATION PROJECTS
Design and development of home automation applications provide useful knowledge and skills for computer science majors, extending their software knowledge into the “real” hardware domain. Since these projects involve both hardware and software, students gain experience with interrelations, the control of physical devices, and the communication and networking necessary to achieve the desired results. We discuss several of the home automation projects in this section.

2.1 Put Your Lights On
The project "Put Your Lights On" is a home automation lighting control application. Students developed a web-based application for controlling the home's lights and other appliances from a distance. To accomplish this, a customized circuit board was connected to a personal computer. When the web server is running, this application provides a graphical interface for users to control devices at the home through the Internet.

As shown in Figure 2, the Surface-Mount Device (SMD) circuit board has an ATmega328P microcontroller (MCU) and an Auto-MDIX (Medium Dependent Interface crossover) jack for the Internet cable connection. The MCU chip is an 8-bit RISC-based Avon Valley Railway (AVR) microcontroller. A cell phone charger with a 5.9 volt regulator was soldered onto the SMD board as a power supply. A single LED is turned on or off to indicate
if the web server is available and running. The small white lamp is soldered onto the board for demonstration purposes.

![Image of a small white lamp soldered onto a board]

**Fig 2:** The “Put Your Lights On” Project

Developed in the C programming language, this project provides graphical interface for controlling home lights automatically and manually. In automatic mode, users can set dates and times for turning lights on or off. Users can also manually control lights through Internet. The application also includes password protection so that unauthorized users cannot access the lighting control service.

### 2.2 Sensory Driven Camera

The project titled “Sensory Driven Camera” provides an extra layer of home security. This application helps obtain identification on potential home intruders. As part of home automation, a digital security camera is connected to motion sensors to automatically secure in a certain area. A motion sensor is a device that detects moving objects. It triggers the red light camera after it detects unauthorized movement.

As shown in Figure 3, this project consists of a Netduino platform, sensors, and a security camera. Netduino is an open-source electronics prototyping platform based on the .NET Micro Framework. It uses a 32-bit Advanced RISC Machine (ARM) microcontroller. This project was developed using C# programming language of Microsoft Visual Studio for coding Netduino. The Passive Infrared (PIR) sensors are used to measure infrared light radiating from objects in their 180 degree range of view. In this system, motion is detected within its range. The PIR sensor communicates with the connected Netduino board and automatically activates the red camera to capture images. The standard Canon Rebel XS is a Digital Single-Lens Reflex (DSLR) camera that can automatically focus and set the shutter speed depending upon conditional variables. Images then captured through Netduino are recorded and uploaded into database.

![Image of the “Sensory Driven Camera” project setup]

**Fig 3:** The “Sensory Driven Camera” Project

This project is not only useful for home security, but can also benefit other applications such as photography. For example, if the photographer is trying to capture an instantaneous image such as that of lightning or the tiniest drop of water falling to the ground, he must rely on nothing other than chance. This can also be problematic if the photographer is attempting to capture imagery in which the photographer’s presence could in any way alter the probability of capturing the image, such as is the case with wildlife photography.

### 2.3 Controlling RC Car Through Internet

The project entitled “Controlling RC (Remote Control) Car through Internet” is a home security application designed to wirelessly control a RC car with a wireless mobile camera.

The hardware, an RC car with mBed, XBee, iPhone, and 9V battery, is shown in Figure 4. The RC car is used as the chief mechanism for movement purposes. There are two electric motors inside of the RC car. One motor turns the front wheel right or left, while the other motor turns the rear wheels to go forward or backward. The mBed NXP LPC1768 is a microcontroller development board, accompanied by associated tools for programming the device. The mBed has the entire development environment available online with full suite of C++ libraries. An iPhone camera, although not a typical camera used for security, is effective, lightweight, and powerful enough to provide live feedback. The Mobiola [9] application found on the Apple iTunes store is an easy way to get live feedback from the camera. The RC car is controlled with a web application user interface with buttons for controlling the direction of the car. The live camera feed is displayed in the application itself.

The web application is a highly effective concept because it can be accessed by any Internet driven device anywhere in the world. Two XBees are used as the source of wireless communication between mBed and the computer [6, 8]. They have data rates of 250kbps for...
sensing and controlling the RC car. The distance separating the two XBees, one for mBed and the other for the computer, must be within 100 meters for wireless communication to be established. XBee complies with IEEE 802.15.4 standard and operates at 2.4 GHz. In this project, two XBees communicate with each other, sending and receiving signals. The XBee module communicates wirelessly between a remote computer via a USB port and the mBed in order to operate the data acquisition system.

This project required data to be transferred online, a web server to be set up, and coding in PHP for accessing the MySQL database. Additional coding in the C# programming language was needed in order to gather information from the online database and to tell the car to perform some action.

2.4 Sol Trak: Tracking the Sun

The "SolTrak: Tracking the Sun" is a project related to home energy efficiency through solar panel technology. It is used to track the sun in its motion across the sky. Hardware for this project includes three circuit boards as shown in Figure 5, starting from top to bottom.

- The Ardumoto L298 motor driver shield allows for controlling two motors.
- The WiFly GSX is a wireless Internet module. It is configurable via serial commands. The SPI-UART bridge allows a serial signal to connect and talk with 802.11A/B/G.
- The Arduino Duemilanove is the primary control unit of the device. This board contains an ATMega8 chip, which is an 8-bit RISC-based AVR microcontroller.

Coded in the C programming language, the Duemilanove takes in sensor values from the two photo sensor arrays divided by the plastic board. Then, it decides which direction to turn the servo motors so that the device will face the direction of maximum light exposure. The sensor values sent by the WiFly GSX are automatically recorded on the server.

Fig 5: The “SolTrak: Tracking the Sun” Project

This prototype system increases the amount of energy that a solar panel can receive throughout any given day, since the solar panel will always be achieving maximum exposure to sunlight.

2.5 Clouduino

This project, entitled "Clouduino", controls appliances and implements video surveillance for home automation. It provides a graphical interface as shown in Figure 6. Lights and video surveillance systems are provided for each room. For example, a user can remotely “see” the game room and control the light through a web browser. He can also see, control the light, and lock or unlock the garage door or start a rice cooker in the kitchen so that rice will be cooked before arriving home.

Fig 6: The “Clouduino” Project

A communication hub incorporating Netduino, XBee, and a 9V battery is attached to the server machine.
Netduino is the microcontroller for devices, and the XBee chip provides wireless communication capability. This project required the development of a web site requiring PHP programming, a MySQL database, and coding in the .NET framework.

3. CONCLUSION

Home automation has proved to be a rich environment for student projects involving hardware and software. A wide variety of project ideas have been designed. Students could choose topics including aspects of interest to them, and they learned to create systems to be used in the real world. Students gained skills in hardware, software, networking, and architecture. Their programming skills were enhanced as they learned new languages for special devices, and they faced challenges with integration of hardware/software technologies and communicating across networks. Projects resulted in real, working applications, and many of these are being used by the student developers in their own homes. These types of projects make our students more desirable as potential employees over graduates from universities without such experience.

REFERENCES


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