**Queen’s University**

2008/2009

**ELEC 490 Proposal**

**Smart TV Set**

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# Executive Summary

 This document summarizes the proposed plan to design a “Smart TV”. The goal of this project is to research, design, and build a working model of a television stand that adjusts the TV volume and rotates to achieve an optimal viewing position by sensing the position of its viewers. This project has several possible applications. It can be used in operating rooms and within the home, since most LCD televisions have a limited viewing angle.

The team proposes a three-part framework: a sensing system to determine to position of viewers, a controller to compute the ideal position and volume of the TV, and a drive system to accurately rotate the TV to the previously calculated position.

 The Smart TV should be able to detect a viewer within 10 degrees of accuracy. It should be able to smoothly rotate 180 degrees. The sensor range should be a minimum of 2 metres and the entire system should be entirely self-contained. This means that no external components, such as a computer, will be required for operation.

 The team will evaluate their design by developing several test cases, taking into account the motion of the viewers, the number of viewers, the lighting conditions in the room, and the distance of the viewers from the system. All sub-systems will be independently tested throughout the design process. Then the complete system will be integrated and subjected to additional rigorous testing.

 A three phase schedule has been planned for the project. The team will spend the next month in the research phase, testing existing sensors and researching possible solutions. They will then use this information in the design phase, where a detailed system design will be produced. In the winter semester they will begin the construction phase, with an estimated completion date of mid-March. The team expects that the total project budget will be $400.

# Introduction

## Purpose

This proposal is intended to summarize the ELEC 490 project being undertaken by group eight for departmental approval. The intended audience is the Course Instructors, Dr. Hashtrudi-Zaad as well as any interested parties.

## Work Objectives

Modern television sets, although technologically advanced in picture and sound, are generally stationary. If the viewer wishes to watch the television while moving around a room, the television must be manually rotated to face the viewer. Similarly, in an operating room a surgeon must be able to move freely around the room but must also be constantly in view of any monitors. A system that allows the monitor to follow the surgeon would be beneficial. The project would also have applications in the home and sports bars, where the change to from CRT screens to LCD screens has lead to a decrease in the viewing angle.

 The goal of this project is to design a Smart TV which can rotate to optimize the viewing position of all viewers. In addition to following the viewer around a room, it should also be able to adjust the output volume of the television according to the distance between the viewer and the screen. The system should be non-intrusive, meaning that the television’s electronics will not be altered.

 An override mode of operation is included. This means that the user has direct control over the rotation of the television. For example, the user could use the television’s remote control to communicate with the Smart TV controller which would then adjust the angle of the television. This would allow the user to rotate the television with minimal effort.

 The proposed solution hardware will include a drive system to rotate the television set and a series of sensors to locate the viewers. A controller will be used to process the information received by the sensors, and adjust the position and volume of the television accordingly.

## Work Scope

By the end of the course, the team plans to have developed a working model of the Smart TV. The project includes both a hardware and a software aspect. It will include a series of sensors to collect information about the environment. A filtering system will be needed to condition the signals prior to interpretation by the intelligence algorithm. The intelligence algorithm takes the sensory system input and deduces the location of the viewers. Using these results, it sends a signal to the motor controller in order to rotate the television. The intelligence algorithm will also adjust the volume by sending a signal to the infrared receiver on the television.

# Functional Description

## General

The Smart TV design will use a combination of electronics and mechanics to build a rotating television stand. A motor-driven turntable holds a TV on its deck and is armed with sensors. The sensors locate the viewers in a room and orient the television to best suit their location. It also adjusts the volume to reflect the distance between the viewers and the television. A diagram of all system components can be seen in Figure 1.

The mechanical implementation should use of a type of controllable motor such as a stepper motor. The electric drive system connects the electric motor to the turntable base using a gearing system such as pulleys, chains or gears. The turntable should have the capacity of holding a conventional television or monitor. It should have smooth rotating characteristics.

 The electrical system consists of sensors whose information is relayed back to the controller board to locate the viewers. With the availability of many sensor types, such as infrared, laser, ping (ultrasonic) and image, the team will aim to achieve detection of a viewer within a 2 metre radius of the sensors. The sensors should have range of 135 degrees. The on-board controller will be responsible for receiving these sensory inputs and filtering the signals. The software will use an intelligence algorithm to analyse this information to locate the viewers. This information is then used to rotate the television to an optimal position for all viewers. A secondary feature of the Smart TV is to calculate the distance to the viewers and adjust the volume accordingly.

 The system should be robust and accurate. It should be able to achieve a 10 degree tracking accuracy. It should have smooth tracking movements with very little jitter that could distort the image. It should also have the ability to account for multiple users in a room.



Figure 1: System Overview

## Interface Specifications

 In order to perform the action of tracking a viewer, the Smart TV will require several sensory inputs. The type and the interface of the sensors are still being researched by the team and will be selected at a later date. The team will use a controller board to acquire and analyse the sensory data. Then, using a motor controller, the controller board will engage the electric motor and rotate the television. The Smart TV will have an override option, allowing the user to rotate the television using a remote control.

The design will require only the standard 110 Volt AC connection. By having all the electronics and controller parts on-board, the Smart TV will be self contained and non-intrusive to the existing television.

## Performance Specifications

The Smart TV should be accurate within ten degrees. This should be sufficient to support a comfortable viewing position for all viewers and is an achievable goal. The team is aiming for a 180 degree rotation capability. Lastly, the Smart TV should have very smooth movements. Any jittery movement from an under-damped system will ultimately take away from the viewing experience of the user.

# Design and Production Approach

## Process

Since this project has been attempted in the past by other ELEC 490 project groups, there are some hardware components already available. We will begin by testing all sensors available to determine that they are in working condition, as well as to determine how they can be used to acquire the required positioning information.

In the past, a stepper motor was used to rotate the television. Previous ELEC 490 teams were unable to build a motor controller that both provided accurate positioning of the monitor and a smooth rotational motion. The team will therefore have to re-design the motor controller.

It is also possible that additional sensors will have to be purchased. The team will develop a sensing system using the existing sensors and determine what sensors will need to be acquired. The power and interface requirement of each sensing device will be taken into consideration.

Alongside the development of the sensing system, the logical framework of the system must be developed. A controller board will be used for all logical calculations. The team will have to develop software that can interface with the sensors and provide appropriate output to the motor and volume controller. It is possible that not all sensors will be able to interface directly with the microcontroller, so appropriate intermediary hardware will need to be investigated.

An intelligence algorithm to determine the position of the viewers and the appropriate position of the television must be developed. The team will have to collect information from all the sensors and determine how each signal can be used. The team will develop a analysis program to store and view signal information. The data should be in a format readable by Matlab or another suitable plotting program. This will allow the team to visualize the data and recognize patterns necessary for the development of the intelligence algorithm.

Time permitting, it is desired that a remote controller be provided to the user to override the system’s automatic mode. This will require both receiving hardware as well as additional software development.

## Division of Labour

 A table summarizing all tasks can be seen in Table 1. Each task has been assigned a primary team member and, if needed, a supporting team member.

Table 1: Task Assignments

|  |  |  |
| --- | --- | --- |
| Task | Primary Team Member | Supporting Team Member |
| Test existing sensors | Jonathan | Liliane |
| Research new sensors | Jonathan | Liliane |
| Motor Controller | Michael | Jonathan |
| Intelligence Algorithm | Liliane | Michael |
| Turntable Inspection | Michael | Jonathan |
| IR Volume System | Liliane | Jonathan |
| Data Acquisition | Michael | Jonathan |

# Testing and Evaluation

The team will develop a series of cases to evaluate their design. The cases should consider:

* Stationary and moving viewers
* Single and multiple viewers
* Different room lighting levels
* Ambient room temperature
* Distance the viewer is from the system

When designing the sensing system, the team will have to consider all of the above conditions. Especially important will be the room lighting levels, viewer distance, and ambient temperature. This is because many sensors utilize thermal radiation for operation.

When developing the software, the logic to consider stationary, moving, and multiple users will need to be tested. This can be done using simulated inputs to the software. This input could be pre-recorded from the sensing system, or created manually. Once the simulation models work, the software will be tested using the actual sensing system. Sensory input data will be collected and stored so that it can be plotted and analysed using software such as Matlab.

During all phases of development, the components of the system will be evaluated to ensure that they are functioning within specifications. They will be re-evaluated as they are connected together to form the complete system. Once the system has been fully built, all cases will be tested to ensure that they meet specifications.

# Scheduling

We have broken the schedule down into three phases: research, design, and prototyping. A Gantt chart can be seen in Appendix A. Before we research any new components, we will test existing components from previous years. We will then investigate any new components required for the volume control, viewer detection, and motor controller. Using this information we will enter the design phase. In this phase we will use all researched material to prepare schematics and plan for the evaluation of our design. This is where the software design will begin, as the logic to for the system must be developed. In the winter semester we plan to begin prototyping, ending two weeks before the presentation and final report.

# Resource Requirements

The team will require both hardware and software resources. A television set, turntable, power supply and stepper motor are already available, but materials will be needed to build the motor controller, infrared system, and control systems.

As seen in Table 2, it is estimated that purchasing new sensors will cost approximately $140. This cost may vary depending on the condition of previously purchased sensors. The motor controller is being designed and built using only new components. It is expected that the cost for it will be about $70 including components and PCB manufacturing. To minimize costs, the team will use the prototyping workshop in the Integrated Learning Centre. Some upgrades to the turntable may be required to accommodate a new design.

 A controller is required but has not yet been selected. An interface board to the sensor system will also be designed. This could include A/D converters, D/A converters, serial inputs, etc. A typical microcontroller evaluation board may be used to satisfy this requirement.

**Table 2: Proposed Project Budget**

|  |  |
| --- | --- |
| **Component** | **Price** |
| **Sensing System**Sensors | $140 |
| **Motor Control**Motor ControllerPrototyping boards for Motor ControllerTurntable Upgrades | $20$50$30 |
| **Control System**ControllerSensor InterfaceEvaluation Board | $50$10$100 |
| **TOTAL** | **$400** |

# Conclusions

In this proposed project, the team will research, design, and build a Smart TV capable of tracking and orienting itself towards multiple viewers. It will also adjust the volume control of the system in relation to its distance from the viewers. The design will include a sensing system, a motor controller with a turntable, and a control system. Time permitting they will also implement a remote control that will allow the user to override the system. The project is expected to be completed in mid-March with an estimated budget of $400.

# Appendices

## Appendix A – Gantt Chart

