

**EEE 4997 CAPSTONE PROJECT I
FALL 2012**

PROJECT LIST

1. Wireless control of a DC motor

The goal is to control a DC motor from a 100 meters distance using wireless technologies. The parameters that can be controlled may be the speed of the motor, direction of the rotation etc. The students should also develop an interface for user operation.

2. Self Optimizing Network Design, Implementation and Evaluation

In next generation wireless networks, networks will self configure, optimize, and heal. In this project, you will examine networks which can choose among 5GHz frequencies, change modulation parameters, such as beamforms to maximize link quality and minimize interference. You will be provided with Matlab software which can be modified. You will simulate a flat network, a network with subdomain hierarchy and compare cooperative and noncooperative games on the network to evaluate best configuration, optimization and healing performances.

3. Accelerating the PSI-BLAST algorithm with GPU

Protein sequence to profile alignment compares a string of amino acid symbols to profiles to identify regions that have structural or functional similarity. In this project, the goal is to implement the PSI-BLAST algorithm in graphics processing unit (GPU) for efficient parallel processing.

4. Vision based sentry Robot

The objective of this project is to build a target tracking system that uses a camera to track a moving target and use a laser pointer to hit the target. The system will be placed at a fixed point and should be able to track targets in a 3D environment.

5. Draw your effect: Optically controlled audio effects device

Effects processors are hardware devices widely used by musicians who want to alter the sound coming from their instruments. In this project a wah-wah and a tremolo effect processor will be designed which will be controlled by an optical and mechanical system. An opaque plate will be located on a rotating disk and patterns on the plate will be read by using a light source and a light sensor. This information will be used to real time control the parameter of the effect processor.

The project is influenced by the following project:

<http://makeprojects.com/Project/Optical-Tremolo-Box/2276/1#.UEDc0RyZi3Y>

but a different effect than tremolo will be also realized that necessitates design of band-pass filters and controlling the center frequencies of the band-pass filters in real time.

The user will be able to design patterns on the opaque plate and obtain different effects, i.e. design the effect by drawing.

6. Facial Expression Recognition System

In the near future, human-computer interaction systems will go beyond the keyboard and the mouse and will be sensitive to other human signals such as head gestures (e.g. nodding, shaking) and facial expressions (happy, angry, sad etc.). Therefore, it is very

important to develop systems that automatically recognize the facial expressions of a person. Automatic head gesture and facial expression recognition systems have many application areas. For example, such a system can be used for accident reduction. The driver's face can be tracked and an alarm can be turned on if he has sleepy eyes, yawning too much or looking away from the road.

In this project, you will design and implement an algorithm to recognize the basic facial expressions (happy, sad, surprised etc.) from images and/or video (see the below Figure). Once the emotion is recognition **software** is complete, you may design a simple **hardware** setup to control the color and/or intensity of a lighting or music system based on the recognized emotion for an intelligent home application.

The students who want to work on this project are strongly recommended to take the following senior/graduate level course in the fall semester as a departmental elective course: **EEE5541 Introduction to Image and Video Processing**



7. Programmable metronome

Metronomes are devices used by musicians to rehearse with the help of synthetically generated pulses. In conventional metronomes, the patterns are fixed, preset and there is no way to define different patterns of pulses. In this project, a programmable metronome hardware circuit will be designed to let the user define new rhythmic patterns.

8. Facial Expression Recognition Using Kinect

Kinect sensor was initially released as a video game controller for Xbox game console of Microsoft. Using Kinect, it is possible to capture the 2D color video and the corresponding depth map simultaneously at 30 frames per second. In this project, the student will design and implement a system for facial expression recognition using the Kinect sensor and the Kinect SDK. (Kinect is available in our lab). This project requires programming skills in C/C++.

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9. Seam Carving (content-aware image resizing)

The student is expected to implement an algorithm in Matlab for image resizing. The algorithm will find a number of *seams* (paths of least importance) in an image and automatically remove seams to reduce the image size or insert seams to extend it.

10. A system for sound localization

The aim of the project is to develop a system that automatically finds the location of the sound source from audio data received at multiple microphones. Such a product is useful in many areas such as improving sound recording by redirecting microphones, localization of snipers, etc.

A low cost microphone array will be constructed by the student and a system that determines the location in real time will be implemented. Use of a computer is optional for this project.

11. Implementation, Evaluation and Application of Mobile Mesh Network

You will implement a distributed mobile mesh network using 802.15.4. You will design custom software interfaces to measure signal strength and signal quality indicator, and improve relative position estimates using additional information such as finger printing. You will evaluate performance of algorithms using real measurements obtained from a 802.15.4 network on Matlab.

12. White Matter Hyperintensity Quantification using MR Images

The student will implement and test image analysis methods for periventricular white matter hyperintensity (PWMH) volume quantification using MRI FLAIR and T1 contrasts. The main goal will be to investigate if only WMH volume is sufficient for medical experts to assign PWMH grades to patients. Thus, the correlation between WMH volume and expert grading will be investigated in this project. The preferred tools to be used for implementation are SPM, ALVIN and the NIFTI toolbox. Good knowledge of MATLAB is necessary; an interest in Image Processing is also vital.

13. Designing a Global Positioning System (GPS) device for satellite based navigation

Designing a microcontroller based device that shows the position of a vehicle over a map on a computer screen.

14. LTE Network Small Cell Simulation

Long Term Evolution is standardized to replace 3G and HSPA/HSDPA networks. The standard also allows small cells which function much like WiFi hotspots. These small cells will offload traffic from macrocells and allow much greater capacity and improved energy efficiency. You will be provided a simulation framework in Matlab

where you will implement deployment scenarios. The physical layer signaling of LTE is different from 3G/HSPA and this has an impact on interference. You will examine optimum distance between small cells using the simulation tools, and compare with 2G/3G small cell coverage to see if additional LTE small cells sites are necessary.

15. Automatic retrieval of a score from a database for a given sound recording

For many applications like digital rights management, organization of large audio databases, it is important to be able to retrieve/find a song in a given database based on audio/sound data. The target of the project is to design a search engine that uses sound data to find the closest matching piece in a score database. So, given a score database, the input is a sound recording and the output is the closest score found in the database.

To achieve this, first fundamental frequency estimation will be performed on the sound data for every 10 milliseconds. The scores in the database will be in symbolic machine-readable format, so the frequency information can be directly read from these score files. A synthetic melodic contour will be derived from this data. The task is to implement an algorithm that will match the frequency information coming from the sound data and the score data.

The following two approaches will be implemented to find the closest song in the database: matching pitch histograms and matching melodies.

16. Electronic Metronome

The student is expected to design and implement circuitry for electronic metronome. The final system will permit the user to define the tempo that will be shown on a LED display, and count the beats via a loudspeaker.

17. Converting the bioinformatics software package "c3net" to run in parallel

c3net is an open source program that is based on R/Bioconductor platform. It allows inferring large-scale gene regulatory networks from gene expression datasets. It will be enhanced to be able to run parallel both on PC cores and on clusters. This has the potential to be a (possible journal) publication in the end.

<http://cran.r-project.org/web/packages/c3net/>

18. Vision Based Autonomous Robot

The objective of this project is to build an autonomous mobile robot that uses vision as feedback for navigation around an obstacle filled room.

19. Remote meter reading

A sensor placed in a meter should read the data, transmits the data over the air to a processing unit. Processing unit should have an interface to collect the data and monitor the meter activity.

20. A Smart Home Prototype

One of the biggest challenges of dealing with global warming is energy efficiency. Energy efficiency can be defined as using the minimal required energy at the required time for a task. Since electrical energy cannot be stored, it must be consumed as soon as it is generated. Smart Grid is an umbrella term, which covers the application of Information and Communication Technologies (ICT) to the control of electrical grid to improve its efficiency. One of these applications are the Smart Homes, which

monitor and control the various electrical appliances in the houses to increase the electrical efficiency. In this project the students are asked to design and implement a software and hardware prototype of a Smart Home. Controllable electrical plugs are to be connected with a central server via a communication technology such as Zigbee. The consumption information will be gathered in the server database, and displayed to the user. The user then will define certain rules to increase the electrical efficiency, that will be implemented via the controllable electrical plugs, that will turn on or turn off devices according to the rules.

21. Design of a Microstructure Polymer Optical Fiber for Optimum High-speed and Medium-distance Applications

Polymer optical fibres are more flexible, and easier/cheaper to use than optical glass fibers. They are best suited for use in short-distance, low-bandwidth applications, e.g., for making an optical connection from the trunk network to a building. Furthermore, they can be made having a microstructure, like a photonic bandgap optical fiber, which will give them additional advantages like lower attenuation and lower dispersion, for use in medium-distance optical communication systems, e.g., local-area-networks.

This is a theoretical research project, which involves extensive literature search and original design. It is aimed to produce an international journal paper if it is carried out with dedication and skill.

The student doing this project should be taking the course “EEE 4611 Optical Communications” concurrently so that he/she has the necessary knowledge background for dealing with this project. EEE 4611 will be offered in the first semester of 2012/13 academic year.

It is recommended that the student taking this project works together with the student taking the project titled “Design of a Fiber Optic Sensor using a Polymer Optical Fiber for a Particular Biomedical Application” because there are substantial commonalities between the two projects which can be dealt with more ease if worked as a team.

22. Design of a Fiber Optic Sensor Using a Polymer Optical Fiber for a Particular Biomedical Application

Polymer optical fibres are more flexible, and easier/cheaper to use than optical glass fibers. They are best suited for use in short-distance, low-bandwidth applications, e.g., for making an optical connection from the trunk network to a building. As well as being widely used in optical communication systems, polymer optical fibers are also commonly used in optical sensing applications which require accurate measurement and can provide ease of measurement. In particular, if designed properly, a special type of optical fibre can have a low refractive index which can render it suitable as a biomedical sensor because of strong optical coupling with bodily fluids like blood. The student is expected to determine a suitable application for which he/she has designed the sensor.

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23. Accelerating the Smith-Waterman algorithm with FPGA

Protein sequence alignment compares strings of amino acid symbols to identify regions that have structural or functional similarity. In this project, the goal is to implement the Smith-Waterman algorithm in field programmable gate array (FPGA) for efficient parallel processing.

24. Design and Implementation of an Automatic Web Based Capstone Project Assignment System

In this project the student will design and implement a web-based automatic capstone project assignment system. The topics that are proposed by the professors will be entered into a database. Then the students will logon to the system and indicate their selections. Finally, the system will automatically assign one project to each student, considering their preferences and other limitations, which will be specified during the design process.

25. Accelerating the Floyd-Warshall algorithm with FPGA

The Floyd–Warshall algorithm is a graph analysis algorithm for finding the shortest path in a weighted graph. It has many applications from finding optimal routing in wireless networks to biological network analysis. In this project, the goal is to implement the Floyd-Warshall algorithm in field programmable gate array (FPGA) for efficient parallel processing.

26. Automatic Album Creation

Motivation: Digital cameras are widely used today, and our picture taking habits have also changed since we do not have film costs any more. We take at least two (or generally more) shots of a scene, just to make sure that at least one of them is the “perfect picture” that we want. This is especially important when taking photos of high-motion objects and scenes such as children, and sports scenes etc. When taking a picture, we want to avoid unwanted artifacts in our photos such as closed eyes, motion blur, insufficient light and people looking away from the camera. We also may want to catch a smile on a portrait photo if possible.

After we take a lot of pictures, on a holiday for example, we generally want to create an album out of them, for our archives or to share with our friends. Selecting the “best” picture out of many similar pictures of a scene is time-consuming and tedious for people. Therefore, it is important to make this time-consuming and boring process as automatic as possible.

Project Description: In this project, a user-interactive software will be developed for automatically selecting the best (one or two) pictures out of a set of similar pictures of a

scene. An example is given below, where we want to select the last picture for our album out of the four similar pictures of the child, since it is blur-free and the child is looking directly towards the camera. This project has four main steps:

- This project is suitable for one or **two** students.
- The students who want to work on this project are strongly recommended to take the following senior/graduate level course in the fall semester as a departmental elective course: **EEE5541 Introduction to Image and Video Processing**



Figure 1. An example for automatic photograph selection. We want to automatically choose the best photograph out of these four. The best photo is the last one above, since it is blur-free and the child is looking directly at the camera.

27. Vessel Segmentation in Coronary CT Images

Medical Imaging and Image Analysis have become two crucial fields in recent years. Vessel Segmentation in CT images is essential for diagnosis of many cardiovascular diseases. To this end many image processing solutions have been proposed for segmenting the aorta, pulmonary vessels, and the coronary arteries. In this project the student will work towards understanding, implementing, and testing one of those methods (namely the Hessian Matrix based Frangi vesselness filter) for the segmentation of these vessels. The project requires 3D Computer Vision, MATLAB Image Processing Toolbox and basic C++ (ITK and VTK libraries) knowledge.

28. Accelerating the HHsearch algorithm with GPU

Protein profile alignment compares sequence-profiles of proteins to identify regions that have structural or functional similarity. These algorithms are more sensitive than sequence alignment algorithms but are slower. In this project, the goal is to implement the HHsearch algorithm in graphics processing unit (GPU) for efficient parallel processing.

29. 2G/3G Antenna Design

The goal of this project is to study currently used 2G/3G base station antennas theoretically and experimentally. Then, design a dual band antenna covering both 2G and 3G frequencies. Fabrication and characterization of the designed antenna will be a merit.

30. Automatic identification of yeast cells in DIC microscopy images

High rate algal ponds are simple and energy efficient waste treatment systems in applied microbiology. For such systems, automatic methods are needed to estimate

the biomass directly from the microscopy images. In this project, the goal is to identify the location and count of yeast cells in DIC images. Different software that automatically performs edge detection, segmentation and cell identification will be compared and the one that performs the best for the yeast images will be identified.

31. Designing a professional "Autonomous Back Counter" device for pedestrians

Designing a microcontroller based device that shows the remaining time for the traffic light to change. It should be able to work on any light unit for any time durations just by connecting it to the unit without the need to reprogramming it.

32. Photonic Crystals

Photonic crystals are periodic artificial nano-structures, which can control and manipulate the flow of light. Especially one and two-dimensional photonic crystals are commercially used and attract significant amount of interest due to their unique dispersion characteristics. Photonic crystals have band diagrams, which may exhibit band gaps over certain frequency ranges. Therefore computation of band diagrams of 1D and 2D photonic crystals are quite crucial to analyze and design such structures. In this project, the student is expected to implement plane-wave expansion method software with GUI to obtain band diagrams of 1D and 2D photonic crystals efficiently. (Matlab is preferred.)

33. Smart Room Technologies

Unobtrusive Smart Room Technologies (SRT): monitor and infer important clues about users in specific environments such as their spatial position. You will develop solutions to:

1. Estimate positions of people/speaker using cameras/microphones on different notebook/desktop computers.
2. Use location information to zoom cameras and microphones to speaker

34. Designing a "Mobile Controller Unit" for remote controlling a servo motor over a mobile phone

Designing a microcontroller based device that allows controlling a remote device over the phone. In this case the device is a servo motor.

35. Multi Criteria Pattern Recognition for Driver Safety

One of the main causes of traffic accidents are tired or sleepy drivers. In this project the students will design and implement a multi sensor pattern recognizer that will recognize if a driver is getting tired or falling asleep. The minimal number of sensors to be used is two. The students must design a complete control loop with sensors, a decision maker and an alarm that will indicate the tiredness level of the driver.

36. Design of a Battery Charge System with high efficiency

37. Designing a speech processor

Designing a microcontroller based device that displays human speech on an LCD screen.

38. Roomba Serial Tether

Roomba is a robotic sweeper built by iRobot. We have a few Roomba sweepers (400x). It has a mini-DIN 7 pin connector which uses The Roomba ROI is a serial interface protocol to let you control your Roomba, it does not conform to serial port standards. Build a conversion circuit to connect a Roomba to a PC with a serial port or USB. You will develop solutions to:

1. Convert ROI to standard RS-232 serial standard signaling.
2. Build a cable/PCB interface to a computer equipped with RS-232.
3. Demonstrate serial control through text commands.

39. Dielectric Mirror Design

Dielectric mirrors are essential components in photonics since the resonator of the lasers contains mirrors and in almost all cases, mirrors are produced by using dielectric materials. A dielectric mirror consists of multiple thin layers of different optical materials and the reflection from many interfaces results in a very high overall reflectivity in a specified wavelength range. Depending on the desired laser performance, different types of dielectric mirrors are required. In this project, the student will develop a software tool (preferably written in Matlab) to design a dichroic and/or a chirped mirror by developing analytical analysis of the layered structure and performing numerical optimization. Good knowledge of Matlab and an interest in computational electromagnetics are required.

40. Simulink Model of the PV System

41. Cellular communications

Implementing a system where there are two cells with omnidirectional base station antennas. A mobile unit in one cell should communicate to a mobile unit in another cell. This communication should at least be in the form of a text message.

42. Virtual rehearsal room: a mixer and amplifier system for quiet rehearsal at home

Music group rehearsals are usually performed in places with sound isolation because a large amount of sound is emitted which is disturbing for the neighbors. One alternative is to use a mixer and headphone amplifier system that is the product targeted in this project. The system will accept multiple inputs from keyboard, electric guitar, digital drum pad and provide multiple headphone outputs for each player/musician. Each musician will be able to adjust the general volume control for his/her headphone as well as the mixing levels of the different signals. One of the outputs can also be used to record the whole session which is another advantage of the system.

43. Vision-Based Security System

Today we are surrounded by security cameras everywhere, especially in crowded places such as metro stations. The recorded videos are monitored by security personnel for unusual event detection. However, this is a tedious and labor-intensive job. In this project the student will develop algorithms to analyze the video automatically and detect unwanted events (such as a person walking in a forbidden zone in a metro station etc)

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44. FDTD

Finite Difference Time Domain (FDTD) method is one of the most widely used full-wave techniques to solve problems in electromagnetics. In this project, the student is expected to implement FDTD method in one and two dimension and develop a tool with GUI where the user can perform the electromagnetic analysis of one and two-dimensional structures of his/her interest. (Good knowledge of Matlab is required.)

45. Ottoman Ceramic Tiles Processing

The student is expected to design and implement an algorithm for analysis of Ottoman ceramic tiles. Color image data will be provided to the student who then will create a Matlab software to automatically find tile regions, extract color features, and cluster the tiles into distinct groups.

46. RF Antenna Design, and Manufacture using Inkjet

The need for small and miniature antennas has increased due to the reduction of sizes of communication devices. In this project, you will design and implement a low cost printed antenna suitable for use in low cost circuitry. The antenna will be dual band, cover both 2.4GHz and 5GHz bands. You will develop solutions to:

1. Deposit suitable material on paper/acetate etc.
2. Use antenna on a practical device to verify it works.

47. Robot That Tracks a Red Ball

In this project you are expected to design a low cost robot that can track a red ball. You will utilize a webcam, a microcontroller and motors to drive your robot. As the red ball moves around, the robot is expected to turn and follow the red ball.