Assistant Eye

Team #9

Progress Report IV

Yunus Burak Sucsuz	CEO
Behic Bugra Bacanli	CFO
Caglar Varan	Product Manager
Mevlut Turker Garip	Software Designer
Burak Isik	Hardware Designer
Melik Koray Uster	Marketing and Sales Manager

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Introduction

This report is prepared to give an insight about the current progress of the Eye Cue Company's latest product Assistant Eye. The detailed plan of the second semester is presented with its various parts. In this report, possible schedule is given for clarifying the possible future plan. In addition to that, latest product specification can be found since there exists some new additions to the system. Furthermore, workpackages of the Assistant Eye are represented with its partitions. Lastly, a time table is provided to demonstrate possible the activities and milestones.

Semester Plan

At the end of last semester, we have presented a prototype of the product. Our prototype consisted of two parts, which are; software module and hardware module. We delayed to make a connection between software and hardware modules to next semester. In the software module part, we wrote a program in MATLAB which uses photographs that are taken by bullet camera as input and gives an output of where users' eye are looking. In this code, we uploaded some eye photographs of our software designer to the program and we got messages if it is in right, left or middle position. In the hardware module part, we use buttons instead of signal outputs of our program as input. When we press the right button, our motor turns right, and when the left button is pressed, it turns left.

Within this semester, we are planning to finalize the project and evolve it to a product. Until some certain time, we are going to continue our studies in a two separate modules, which are software and hardware modules as last semester. After all, we are going to implement them and equip the Assistant Eye.

In the hardware module part, we are planning to use a motor with redactor and a motor driver. Most of our work is about motor and running it. Before we start to work on motor, we need to purchase a motor first. In the last week of February or first week of March, we are planning to run the motor as we desire to. In order to test the motor, we need to have a wheelchair. We are planning to discuss how are we going to purchase a wheelchair with the professor as soon as possible. At the same time, we are going to buy a bullet camera, which our software designer feels comfortable when working on it. At the middle weeks of March, we are planning to connect the camera with our FPGA that conducts commands to the motor. At the end of February, rest of the requirements, one of which is batteries will be purchased after finishing the tests on simulations.

During the software design and implementation in the second semester, we will first try to solve the focusing problem in the general purpose cameras located very near to an area. Afterwards, in the allocated one-month for the final implementation, we will implement the MATLAB code, which was presented as a prototype in the first semester, in JAVA. Three weeks will be allocated for the implementation and 1 week will be spent for the final testing and calibration.

Product Specification

Size

Total size of the product will be approximately the same size as the wheelchair dimensions sine it is the biggest, the other components are thought to be located inside empty available spaces. There are several types of patients. Thus, to be able to usable by everyone, height to the ground should be 90 cm for handles and 55cm for seat, height of the back side should be 40cm and seat width should be 45 cm. Since it will be used mostly indoor, the maximum overall width shouldn't exceed 75cm in order to avoid situations like getting stuck to other stuff while moving. Other components such as batteries, circuit are planned to be located under the seat and DC motors will be located just behind of wheels.In addition to these components, the user will also interact with an helmet that circles the above part of head and holds the camera for eye tracking. The helmet's size can be adjustable for the user to arrange its comfort. Its dimensions are estimated to be 43 to 53 cm length and 2 cm height. Furthermore, the distance between camera and eye may be 10-15 cm so this means that an extra part that holds the camera in that helmet is needed. Camera should be as tiny as possible with its infrared feature.

Weight

There are several major factors that effects how total weight will be one of which is batteries weight that one of them is about 5 kg. Another factor is wheelchair's own weight which is assumed to be at most 25kg so as to be carried if need. Additionally, there exist two DC motors with their approximately 10kg each. Last but not least factor is the user. His/her max kg is considered as 100kg. When these major parts are gathered together ;5kg x2(batteries) + 25kg(chair) + 10kg x2(DC motors) + 100(user) = 155 kg. (total) For convenience the total weight is expected to be 160kg since the system also includes a camera, a helmet and some other hardware.

User Interface In Engineering Terms

Initially, user will interface with wheelchair, a comfortable seat is waiting. After user sits, a special helmet that carries infrared camera that is used for detecting eye movements both nights and daylight and send data to the digital signal processor component will be placed to the user's head. Camera should carefully located in the way that its vision includes the pupil of eye since its major works is to detect the movements of the pupil of eye that can be either left or right. It is important to recognize that our system keeps its turn off position, in other words, the system is not started yet. On the wheelchair's suitable part, a button can be found. What this button has got to do with our system is that when the user or helper presses it, it turns on the system and camera is going to detect the movement of eye. In order to understand whether the system in on or off, a led is placed on wheelchair. When LED is on that means the system is on and otherwise the system is off. After location and turning on processes are completed, now the user has the ability of control the movements of the wheelchair with his eye movements. User will move his/her eyes left or right to move the wheelchair left or right, and up or down to accelerate or slow down it. In order to stop system, not turn off, just closing eyelids for 3 seconds will work. If system wanted to be stop permanently, again the button should be pressed. It will also turn off led and by this way user understands that system is turned off. Apart from this, an emergency button is also placed on wheelchair for unexpected situations. When this button is pressed it will directly cuts the electricity of the system and make camera detection and wheelchair movements to stop.

As different from the original product specification report, we will use FPGA rather than DSP card and utilize the computing power of a laptop or netbook for image processing because DSP card has lower memory and speed than we expected. Moreover, there are two things, which may change during the software implementation process. One of them is the distance between camera and the user's face. It may increase during the implementation since most of the cameras have focusing problem when the distance is very low. The other possible change is the method that we will track the eye. In the first term, we observed that the accuracy of the program is highly changeable with both the angle and amount of light coming to the face. Besides, the color of the eye is too variant in different people. Therefore, we may need to use a lens, which has a unique color, to prevent confusion when the color of the eye is different.

Power Supply Specification

We are going to work on 12 v voltage on circuit. We are planning to draw voltage from battery, since our device does not have a plugged connection. Our mission is to move our vehicle with an acceptable level of acceleration. In order to achieve this goal at least 0,25 kW motor will suitable enough. We are going to use a battery which will provide power to 3 different part of the circuit including, each wheels and the microprocessor with the collaboration of voltage regulator and camera.Because we will work with DC Motor, we are going to work with DC Current and the drawn current interval planning to be between 0 A -14 A. 12v is the maximum limit of the operating voltage but the output voltage will be adjustable 18v ~ 26 v, and the device will not work below 5v, which we will use this limit as a switch in some point. Approximate battery dimensions are 10 cm / 5 cm / 20 cm.

Video or Audio Signal Characteristics

For eye-detection software, infrared camera will be used to enable the user drive the wheelchair even at night. Camera will capture 1 image for each 0.1 second to be used in the software. The format of the images will be JPEG, which preserves the quality of them while keeping the size of the files relatively small. The resolution of the camera will be at least 3.2 MP in order to provide 800px X 600px images. In order to optimize the processing power, the images taken may be cropped to smaller sizes, which contains the eye part of the picture. Discrete signals at the specific time intervals will be taken from the infrared camera with the frequency 10images/second. This frequency can be changed during the software test process to adjust the responsiveness and accurateness of the eye-detection for developer's convenience. The images will be given to the processing unit to be analyzed in digital format.

Functions of the Product In Measurable Statements

When the start button of the system is pressed, the system will turn on in 4 seconds. Unlike the system start-up, the eye-detection process and response of the system accordingly must work in real-time efficiency. Therefore, after the movement of the eye is detected, the engine must response by turning, accelerating or slowing down in 1+/-0.5 second. On the other hand, emergency button on the wheelchair must be able to stop the movement in 0.4 seconds and shut down the whole system in 3 seconds. The infrared camera should take the picture in slightly less than 0.1 to be able to achieve 10images/second frequency.

The microprocessor must process and analyze two consequent images in 0.7+/-0.2 second in order to have time for engine to response on time. The angular speed of the turn of wheelchair must be at most 30o/second for the user comfort. The acceleration amount in speed up should be 0.5m/s2 to prevent the wheelchair from falling back. The acceleration amount in slowing should be -0.5m/s2 to prevent the user from falling out of the wheelchair. The engine should response to the signal from microprocessor in 0.3 second and must be eligible to stop immediately in case the emergency button is pressed without getting damaged. The signal must be transmitted from the microprocessor to the engine in less than 0.1 seconds with guaranteed delivery in each time. All components must be error-free and latency-free otherwise the user can end up with very dangerous situations while driving the wheelchair.

Test Plan

Design Verification and Compliance Tests

Those are the tests that are performed during the development and at each stage. We are planning to verify if our design requirements are satisfied at each stage some of which are; during simulations, after implementation etc.

Manufacturing Tests

Those are the ones that are performed during preparation. We are planning to control our product's quality and during this semester, we are planning to fix if there will be a problem when we are going to apply to a quality certificate.

Performance Tests

During the project and after the production we are planning to test the performance of Assistant Eye whether or not it satisfies what we expect from it such as maximum velocity or battery life etc.

Documentation Tests

Documentation tests are surviving during the project and also after the project, when there will be some upgrades, it still continues. We are planning to test our reports, user manuels etc. and upgrade them as long as we keep upgrading product.

User Acceptance Tests

This test aims, how accurate our product's delivery to the user and how effective its installation. At this point we cannot test acceptance, because we don't do mass production. However, we can take accuses to acceptance.

Integration Tests

During the project we are planning to use the modules that can be integrable with each other and we designed our modules in this manner. In the integration part, we are planning to test if they can work together or how much delay will be caused due to integration.

Real World User-Level Tests

After we get an Assistant Eye in user level, we are planning that our product should be tested by a real world user. In this way, we may come up with some errors that are escaped from observation during preparation.

Software Tests

In this type of tests, we are planning to test the codes that we'll write and debug them if they cause some kind of defection.

Workpackages

Motor Selection

In the last semester, we have designed our prototype based on by using DC servomotors to move the wheelchair. We were going to attach the front wheels and the rear wheels to each other by using a shaft. Therefore, when the person who is driving the wheelchair wants to turn left/right, the wheels were going to move at the same time. However, we figured out that, for example when the vehicle is turning right, the wheels at left side should move faster and with the system we designed for the motors, it wasn't possible to do so in an easy way since the product will be designed for indoor places. Therefore, after some research, we have decided to use reducer motors, which will provide wheels to move with different speeds while turning left/right so that the motion of the wheelchair will be smoother. In addition to this, we can use gears to turn the wheels to provide the same motion. However, since we are not experienced with motors, we will need to search for detailed information and technical properties.

Coding and Integration

After determining the motors and their technical properties, we will develop our motor driver to use the motors in line with the requirements. While we are developing our codes, we will also design a PCB to implement these codes into our system. To make sure our code and motors work properly, we can add buttons to our circuit to check if there are any errors.

Camera Selection and Integration

We will need to select the cameras that will be used to detect and observe the motion of the eyes. We will design such a mechanism for the cameras that they will be attached to the user's head, so that there will not be any errors occurred by head movements. The camera will be connected to our system through FPGA, which is running our eye detecting software.

Choosing Wheelchair

We will buy a wheelchair, which serves our purposes in the best way as they were stated in the previous reports. We will need it to have a separate partition below the seat, because we will need a space to locate our system.

Integration and Testing

After testing the components one by one, and making sure that they all work properly, we will start to integrate them with each other to complete our system. First, we will test if we can take data with the cameras and forward them to FPGA. If there are no errors, we can skip to other part and connect our motor driver circuit and motors to the system. Then, we will test if the taken data can move the motors properly. Lastly, we will integrate our system to the wheelchair and make test drives with different people. If there will be any errors while testing process, we will have to go over the previous parts and fix the problem.

Integrating a Bullet Camera to the Software

In the software, synchronizing the camera to the desired frequency which is 10 images per second is important because the camera must be able to capture the images of the eye before the movement finishes. For this purpose, special JAVA libraries for video streaming and camera instructions will be used.

Implementing Image Digitizer Module

The captured image must be converted to a special type in JAVA BufferedImage array to be processed by the software. Afterwards, the image will be filtered with a threshold and be converted to a grey scale format to differentiate shapes more easily.

Implementing Image Area Partitioned Module

In this work package, the software will analyze the image and differentiate the partitions that have same colors in themselves. The special recursive algorithm will be implemented to label those partitions as different connected components. This procedure is like separating the rice from rocks inside.

Implementing Shape Pattern Detector

This part is the hardest part of the software implementation, which aims to identify the circular shapes among connected components. To detect the circular shape, all areas of the connected components will be compared to the theoretical areas if they were circular and the nearest area will be selected.

Detecting the Motion of Circular Shape and Testing the Software

The software will monitor the coordinates of the selected circular shapes in different captured images and the characteristics of the movement will be detected. The corresponding signal will be given as a final output periodically from the software. Finally, the software will be tested before the integration with the hardware starts.

Timetable

Week Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Submit Progress Report IV (Detailed plan of the second semester)		■													
Interview IV		■													
Final HW Design and Implementation			■	■	■	■	■								
Motor Driver Implementation			■	■	■	■	■								
FPGA Implementation with input& output signals for communication between buttons and motor driver			■	■	■	■	■								
Preparation of Final HW design and implementation Report (Progress report V)			■	■	■	■	■								
Design and Construction of the final product Package (Box)			■	■	■	■	■								
Hardware components & Ordering Process		■	■	■	■	■	■								
Motor Selection and Ordering Process		■	■	■	■	■	■								
Motor Selection(Selection of its torque,require ampere,voltage, size etc.)		■	■												
Ordering Process				■	■	■	■								
Accumulator Selection and Ordering Process			■	■	■	■	■								
Acumulator Selection (Selection of its voltage, ampere, weight, size etc)			■	■											
Ordering Process			■	■	■	■	■								
Camera&Camera Tools Selection and Ordering Process		■	■	■	■	■	■								
Camera&Camera Tools Selection (Selection its features such as auto focus capability, frame rate etc & additional component that enable connection btw camera and PC)		■	■	■	■										
Ordering Process						■	■								
Wheelchair Selection and Ordering Process		■	■	■	■	■	■	■	■	■	■				
Wheelchair Selection (Selection of its size, weight, possible available space)		■	■	■	■	■	■								
Ordering Process						■	■	■	■	■	■				
Other basic components (OPAMs, Resistors etc.) ordering process		■	■	■	■	■	■	■	■	■	■				
Helmet for camera ordering process												■	■		
Interview V							■								
Final SW Design and Implementation			■	■	■	■	■								
Camera Integration to software			■												
Implement image digitizer module that will initiate buffered image array and convert it to greyscale format.				■											
Implement image area partitioner module that will separate images into different connected components.					■										
Implement shape pattern detector to differentiate the biggest circular area among connected components.						■									
Detect the motion of circular shape and test the software as a whole.							■								
Preparation of Final SW design and implementation Report (Progress report V)			■	■	■	■	■								
Interview V							■								
Stock Market Opens						■	■	■	■	■	■	■	■	■	■
Integration of HW and SW								■	■	■	■				
Camera and Software calibration&tests								■	■						
Camera &Software&FPGA connection test through serial port library										■	■				
FPGA output ports connection to motors' drivers&test software with drivers										■	■				
Preparation of the Common Integration Report (Progress Report VI) for EE and CS								■	■	■	■				
Interview VI											■				
Testing and corrections the latest product as a whole part												■	■	■	■
Preparation of the common final report (Progress Report VII) for EE and CS												■	■	■	■
interview VII															■

Activities specific to HW (EE) engineers	■
Subprocesses for HW part	■
Activities specific to SW (CS) engineers	■
Subprocesses for SW part	■
Activities common only to HW and SW engineers	■