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**I. Introduction**

Product Specification Report is a report that analyzes the product from the engineering approach. Before implementing project, an important design and analyses procedure should be followed. However, before starting these procedures, there should be specifications about the product. The specification specified in this report will be an initial starting point for design procedure. Simply, this report will introduce the limitations and specifications about Intelligent Drowsiness Sensor(iDS).

In the previous report, “Product Requirement Document”, expectations of customers are introduced. In this report, the technical specifications and limitations will be introduced. In “Product Requirement Document”, QFD table was created. QFD table includes the customer’s need as well as the limitations originated from them. The engineering approach takes place at the top row of QFD. Surely, QFD can be updated after this report; therefore, not only the top row of GFD, but also the left most column of GFD should be considered where needed. However, as main purpose of this report, top row of the QFD will be specified in detail.

There is direct correlation between customer’s needs and system specifications since system should be specified according to customer needs. Therefore, how a certain specification helps to meet customer’s demands should be explained in this report. In other words, not only technical specifications, but also how it works for customer demands will be explained in this report.

**II. Specification of iDS**

iDS has three main parts and a software. These parts are iDS head band, iDS station and iDS dock station. Wires makes a connection between head band and iDS station.

***iDS Head Band***

Head band has sensors on it to receive EEG signals from two points. The radius of the band will be 9 cm and it will have 5 cm height and minimum thickness possible. This head band will be made from a material which will not disturb the driver while using long hours(silk or cotton). For thesame reason, the weight of iDS head band is also very important it is estimated to be around 30 grams.

***iDS Station***

iDS Station is the place where acquired EEG signals are amplified and processed to understand the frequency of the signal. iDS Station is a box with dimensions 4 cm x 7 cm x 15 cm. The amount of power needed to run iDS Station is around 1 Watt. iDS station operates with 12V and it draws 60 to 80 mAs. One side of the iDS Station will have ventilation problem since it will be placed on head band or a surface. Therefore estimatingly the power dissipated will cause 1-2 Celcius per hour, where iDS Station can operate between -45 to 80 Celcius.

***iDS Dock Station***

Dock station is a 19 cm × 9 cm x 3 cm unit. It is placed on the dashboard to detect blink duration of eyes of the driver. It weights 82 gram. It allows the Android device to be placed on itself. It operates in 5V and draws 600 mAs.

***iDS Software***

iDS software does not really have an user interface because the user just opens the application and places it as the camera on Android device can see the driver's face. By getting the EEG signal from iDS Station, iDS software determines the drowsiness and uses the Android device to alert the driver.

iDS Software will be using a camera and do image processing on the captured images in order to compute the eye blinking time of the driver. An appropriate image capturing frequency should be chosen, and the processing algorithm should be developed in such a way that processing of an image is done before the next image arrives. For convenience of our product, the possible simplest image-processing algorithm should be implemented. The image resolution should be lowest, providing that the resulting image is good enough to find out if the drivers eye is close or open. Overall, the image processing part will be kept as simple as possible in order to make the software able to run on older and less capable devices.



 Table 1: QFD Table of iDS

**III. Quality Characteristics**

In this section, each of the quality characteristics will be analyzed and specified according to QFD.

***1) Quality of Amplifier Circuit***

The quality of amplifier circuit depends on the quality of the components used. The quality of the components are important for two reasons:

Amount of amplification is important because the signal of interest has magnitude in range of 10 to 100 microvolts. To be able to process the signal properly it is needed to get within range of 1 volt which means the amplifier should have a gain around 2000. To get the gain to desired level with minimum noise the choice of opamp is of crucial importance (even if amplified in multi stages). The opamp should be multichannel differential to be able to find the difference of two input signals. The research has shown us that the better the quality higher the price. Therefore, it is negatively related to cost.

Filtering noise is really important because the signal of interest are around 10 to 100 microvolts and very vulnarable to noise especially 50Hz signal. Since the signal of interest has lower amplitude than noise after amplification we may lose input signal.Therefore, it is pretty important to design the circuit. Better filtering means better quality of components or more components where better filtering provides better accuracy for the signal and better quality of components or more components increases cost. Therefore, reliability is positively and cost is negatively related to quality of amplifier circuit.

***2) Efficiency of Image Processing Algorithm***

Our image-processing algorithm must be efficient and well implemented. For the worst-case scenario, our image-processing algorithm should be able to evaluate the last image before taking the next sample image to provide a reliable detection of eye blinking time. Moreover, every android device has a different processor. Therefore, the algorithm should be implemented well enough that it can run on android device with worst processor. It is positively related with compatibility with different devices.

***3) Quality of electrodes***

Quality of probes is actually choice between active and passive electrodes. Active electrodes provide preamplifier which reduces the amount of noise the signal is vulnarable. Moreover, there are kinds of active electrodes with gold and silver. Using one of these active electrodes eliminates requirement of usage of conductive solution. Since the signal cannot be measured well enough with passive electrodes, conductive solution needs to be used. Therefore, quality of electrodes positively related with comfort. As expected, quality of electrodes is negatively related to cost where it positively affects the reliability.

***4) Placement of Electrodes***

Placement of electrodes is one of the most crucial aspect of our device. Since we are not getting a complete EEG from all points from the head the 2 place we will get the signal are very important. One of them should show alpha signal as much as possible where the other should show it as least as possible since we will get the differentiation of the signals. Differentiating will provide us filtering unwanted signals coming from brain. We have examined some sample EEG signals as shown in Figure 1 and we determined to place electrodes on points FP1 and F8.

The place where electrodes are placed directly affects the accuracy of the desired signal. Therefore, it is closely related to reliability.

 Figure 1: EEG Signals at different points of skull(Fei 1)

Moreover, as seen in Figure 1 , the best place for an electrode would be O2 to observe alpha waves however O2 lies in back of the head and covered with hair. Therefore, it is needed to shave to get better observations and it is disturbing. Therefore, it has a relationship with comfort. For the same reason, according to where we place the electrodes the physical apperance will change nonnegligibly. Moreover, it is directly affect the amount of movement restriction caused by the device.

***5) Detection Time***

Detection time is the time required for the device to understand that the driver is drowsy. It should be as low as possible for reliability of the device. Moreover, alpha waves are becoming more dominant before sleep to prepare the body for sleeping. Therefore, the driver can be warned before he goes asleep. The processing time should be as low as possible to warn the driver on right time. For blinking time, the research states that blinking more than 0.5 seconds is counted as microsleep. (Schleicher 2) Therefore, for both inputs detection of desired incident should be 0.5 seconds where procesing time should be negligible, which positively affects to reliability.

***6) Number of Electrodes***

Normally a complete EEG signal is measured with 23 electrodes. However, rather than interpreting whole response of the brain, we specifically determine the alertness of the driver. Therefore, relating to studies we can reduce this number to 2, which requires a better design of a circuit to have almost same accuracy. Therefore, it is slightly related to reliability positively. However, it is strongly related with comfort negatively. The more electrodes the less comfortable the head band is. Since each electrode will have additional price it is positively related to cost. Moreover, we can assume that each elecrode will cause additional weight. Number of electrodes is negatively related to light-weight of the head band. An additional electrode may change the physical apperance since the placement of electrodes may change totally.

***7) Choice of head band material***

The driver will wear head band for EEG part of the device to work. Therefore, the material the head band is made of is quite important. If a material which wil disturb driver to wear hours(polyester etc.) is chosen, it will definitely reduce comfortability. Moreover, each material will cost differently. The more comfortable the material(silk,cotton etc..) the more expensive it is. We can conclude that it is positively related with comfort where it is negatively related to cost.

***8) Temperature Rise of iDS Station***

The temperature of iDS station is quiet important because current estimations we have made shows that it rises unnegligibly over usage. This led us to take iDS station away from the head band. Our current estimations states that iDS station's temperature rises 1-2 Celcius every hour. Considering that this head band will be used hours, it is unnegligible. It is easy to conclude that temperature rise is negatively related to comfort. However, the rise in temperature is not in a level which will prevent it to be in car. To develop the project further, one of the future acknowledgement would be eliminating this restraint.

***9) Power Requirement of iDS Staiton***

The estimations states that iDS station will spend 0.7 to 1 Watt by operating on 12V and drawing current 60 to 80 mA. This values can be satisfied by a battery for 20 hours. However, since temperature rise of iDS station limits mobility enough supplying the voltage from the car is a choice which reduces cost and provides limitless usage. However in case of mobility(assuming the restraint of temperature rise iDS station is eliminated), the comfort,weight and physical appeance of head band is closely related to power requirement of iDS station.

**IV. Conclusion**

In conclusion, the general design specification is introduced. Surely, design will consist of more detailed specifications, however, at this level, we should just introduce the general specifications that meets with the customer’s needs. All specifications are determined according to demand of the customers and all demands are covered. Under the condition that conflicting specifications is detected, specifications may be revised.

In specification determination procedure, there was always trade-offs which means that we cannot fully use two parameters in these kind of designs. We should optimize than and maximize the total utility since we cannot full utility from both of them. This conflict occurred between many parameter and demands however, we founded a reasonable set of solutions for system specifications.

In this report, all the features and technical details which are realizing these features were given. Moreover, we believe we clarified what our products will do and on top of which background working principles.

As a last note,, the designer for this project should have knowledge about EEG, low amplitude signal amplification and signal processing as well as Android programming.

**V. References**

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