SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD)

GAZE TRACKING FOR EMOTIONAL DETECTION

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DEBRECEN, 2020

1 Introduction

The whole idea of this theory revolves around the sensing and detection of emotions. Emotions, as described by Cabanac [1] is anything that allows us to have feelings. This includes happiness, sadness, anger, humiliation and various other types of emotions. As a human being, we deal with emotions on daily basis. We on a daily basis come across such situations which might allow us to express different types of emotions. In psychology and psychological development, a lot of work has been done in order to provide a better resource for the foundation of various principles with the cognitive capabilities of the brain. This includes the role of technology that has influenced the research and provided with a better understanding towards how a human mind can work. A human mind which is also responsible for developing certain linkages between the human body and how we feel everything is a very strong tool which has been analyzed for decades. While dealing with emotions, the major concern is the function of autonomous nerve system within the brain which is connected to the psychological amplitude our mind gives away while dealing with certain emotions, electro-dermal functions and to control the pupillary size while dealing with a certain type of emotion which may counterfeit our eye movement and eye motion. This involves the reaction of our brain through ANS while we deal with any sentimental experience.

Emotions can be described as an important social experience, since while dealing with emotions we tend to make certain acts which describe the nature of humanity we possess. Some people tend to be optimistic or pessimistic, while some people tend to be narcissist and other components and traits of every different individual which is what they carry with themselves. The human experience tends to shape up the brain to develop a certain strategy to avoid or deal with certain types of emotions. However, considering the whole outline, it can be said that the human nature is usually mainstream. People tend to feel differently towards certain ideas and situations and thus, tend to develop a certain type of emotional agenda regarding that situation.

The main constituent that describes the facial expression towards a particular situation is the human eye. Human eye is one of the most important component of our body which cannot only be used to see things but also allows us to develop a certain emotion towards a certain procedure or a situation. Human eye, even though is an important component, however, is considered to be a rather sensitive thing to entangle with and therefore for this research, much care has been taken

in order to determine a proper suitable result for the program [2]. The study related to human eye and its benefits and also its function has been going on since 1980 where the previous researchers used the human eye for tracking and navigating through social cues which is described as gaze, which has been effectively utilized in this research [3].

Gaze is also considered to be used effectively in determining a certain emotion towards something [4]. Gaze is connected to social behavior on a wide scale and depth of social interaction as well which can be used to describe the sympathetic behavior towards a certain individual or a situation which was further used in behavioral analysis [4]. Keeping in mind the various diseases and disorders which might impair the functioning of human eye, such as Autism due to which the basic behavior of human eye cannot be described to be fundamentally proper and profound [5].

2 Expressive Gaze Model (EGM)

The Expressive Graze Model (EGM) is considered to be an effective virtual character enabling within gaming which is used to produce high visual transitions which convey a certain desired emotion to the person playing the game. This basic model consists of a tiered framework which consists of such an algorithm through which simple behaviors can be transformed into emotional outlook through the characters by representing an itch of the trunk, head and especially the eyes [6]. There has been a lot of work done in order to determine the sensitivity of the eye which measures the reaction of eyes to different aspects, such as taking pictures and also such scenarios in which the pupil either dilates or becomes bigger. Furthermore, in order to define the approach for this research, it was important to study the different movements of the eyes. These include free head movement, eye twitching and corrugators displaying uneasiness [7].

3 Objective of the Thesis

The thesis revolves around the distribution and analysis of the gaze, utilizing it scope in tracking with the help of direction through the parts of face. In order to achieve this goal, the eyesight

detection system has been developed, which tested the analysis of the pupils that were included in this study. Both measures were taken under consideration, which include the intensity of light as well as the distance of the eye from the light source. This was done accurately since no margin of error could be possible. Hence, the best parameters were established in order to separately analyze gaze detection in different directions. To put it in a number, we determined possible eight directions of gaze that could be used for this project. From the study and the research that was conducted by us proves that there are possible measures that could be taken in order to provide correct and close to accurate measurement of gaze by the virtue of no contact, however, the two dimensional color video is possible in real life, which described our sole purpose for this project and hence, determined a possible solution as well as defining the limits to our project.

4 Basic Ophthalmology

In order to understand on a more thorough scale, it is important that we understand the basic ophthalmology of the human eye. Human eye consists of five sensory components which enables the eye to provide a proper vision to both kinds of mammals, humans and the animals. This enables the eyes to instantly determine the surrounding and the sight more properly. It is considered that around 30% of the human brain is continuously engaged in determine the visual availability for the humans. Furthermore, the human brain is able to construct physical image with the virtue of the physical stimuli of the light rays which is included in the structure of the human eye. Another component to consider is that the human stimuli tends to convert this information into electrical and chemical signals so that the brain can properly identify the object and determine the integrity of the object being displayed. The domain of color is controlled by the retina, which is located in the human eye.

5 Function of Human Eye

The basic function of human eye is such that it tends to dilate when a certain subject is close and get bigger when the object is further away so that it can properly focus on the image and produce a proper image in the brain. The human eye works like a camera. The inner part of the human

eye can be related to a certain darkroom where nothing is visible and there is no understanding of that space. The rays emerging into the eyes are collected by the crystalline lens and is passed through the aperture of the eye or in technical terms, the aperture of the camera. The retina helps the aperture to focus on the object properly and the image is eventually processed within the brain [8].

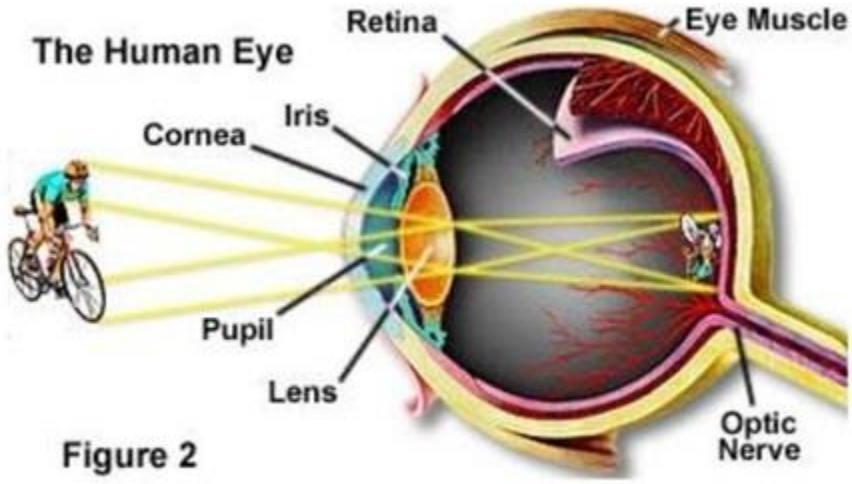

Figure 5.1:How the human eye works

6 Using Human Eye as an Emotional Detector

As discussed before, human eye helps predict a certain expression or a reaction to a certain situation, which in turn helps the people to determine a certain type of emotion they are feeling. The visual processing process of the human eye and the information being used within this function is to be determined and also helps the eye to track the nature of the emotion being displayed with the help technology. The human eye is also considered to be the main component for emotional tracking of a certain individual. In order to determine a certain emotion, various calculations can be made, such as the blink repetition, size of the pupil and the gaze data. Similarly, the sympathetic nervous system can be defined to be coupled with the pupil size and

the emotional reactions. This can be explained in a way that the amount of light entering the eye is the major task whereas the task of pupils come second. However, the correlation of pupil and cognitive reactions is rather complex to explain. On the contrary, the blinking repetition can be related to the reaction of emotional situation, such as defensive reaction and surprised action.

While discussing gaze, it can be described as the influence of natural emotions, such as neutral and fearful situations. This has been approved by various authors, such as that of [9] and [10]. These researches suggest that the facial expressions of a person can be described to be directly related to the emotional expression they give out depending upon the situation, such as sadness, happiness, surprised, intimidated etc. While doing tests with gaze, such as the one described in the thesis which is the direct gaze, it was found that people have been slow in responding to gaze who are usually posed to anxiety or fear and anger as compared to happy expressions where the response of the gaze track was rather quick. Reaction times might be affected in facial expression, but these consequences were qualified through man or woman differences in self-reported anxiety. In contrast, whilst the eyes stared direct ahead, Anxiety was associated with character with a slowdown in response whilst facial expressions portrayed anger. Thus, in individuals who are anxious, interest is likely to be drawn by means of expressing anger, even as attention is more successfully channeled thru horrifying facial expressions.

7 Previous Methods

For the purpose of this thesis to be successful, it was important to determine the previous work that has been done in this field. These include all the research work that has been done on the human eye and its emotional reaction and how it may be perceived. However, studying the researches, it was found that a rather new and unique method had been determined by [11],which included the analyses of the properties of the eye with the help of an eye tracker. This experiment was carried out by using a planned test model and an environment and different images that were displayed to the test specimens. The use of eye tracking in the experiment performed helped measure the real senseless and emotional response which was uncontrollable even sooner than they were perceived. The study of this experiment helped our study to a great extent, since gaze tracking is one of the methods that have been used in this experiment.

Based upon the previous work done, the model designed by my team and I is made using an automated innovation in technology which is similar to those that have been used before, more specially, the IET systems that have been used in the previous literatures. Such as, witness experts, psychologists and other specified individuals who were qualified enough to determine the use of IET system. The pupil's size and the flashing characteristics as compared to the emotional reaction index which are used in the modern eye tracking models and the software that utilizes these concepts has been utilized in this thesis. Since the emotional reaction is related to the dilation of human eye, therefore, it was important to study this component of the human eye in order to provide a broader scope of the study being performed. Dilation of the human is further related to the activation and reaction of sympathetic nervous system of the brain. Therefore, it can be said that the relationship will be complicated since the size of the dilation of pupil can also be related to the cognitive relation of the human eye. Hence, it is important to determine the correct target measure of the human eye since the use of pupil is customary in this study and therefore, a very complex hurdle has been disintegrated to solve this conundrum. Also, the relation of cognitive and emotional response can be related to the eye blink startle and has also been used in this study.

8 Gaze Tracking Method

The main component utilized in this theory consists of the Gaze tracking method. This method consists of two models, one for detecting the point of gaze and the second one is used to detect the position and the center of the pupil. However, our research goes beyond this. In our research, we enabled the participants to move their head about freely, thus, with respect to the conventional modes, it was important to signify a new, third model for this project. In order to detect pupil, [12] concluded that it was applicable to recognize the difference between the appearance and the shape of the work on the images containing the area of the eye and also the confined area around the eye. However, more advanced and more applicable model by Hough transform algorithm was more applicable in this field and thus was also majorly utilized in this thesis [13].

In order to include the technical component, various machine learning codes were available and tested, however, the most feasible machine learning was Super Vector Machine (SVM) which

was used to determine the various facial expression and features such as eye, mouth and nose as well as other facial features [14]. While determining the infrared model, it was observed that too much work had already been done to determine the point of gaze, hence, these models are used for estimating the track of the first frame image [15]. Other models use multiple cameras to determine the centre of eyeball and also the 3D head position to determine the cast rays from the eye-ball while performing pupil detection test [16]. On the other hand, various methods need a certain amount of calibration for the gaze estimation [12].Another major hurdle in the thesis was face detection, especially in the computer vision. This was solved by using HAAR features as described by [17]. In this model, all the adverse effects and the approaches that were dependent upon the supply of simple wherewithal to extract image which consist of the eyes region which would eventually lead to the removal of necessity of the eye detection [18].

9 Work Performed

There are various tasks that have been performed in this thesis work to determine the proper implementation of the model designed by us as shown in the Figure 2.

10 Test Result of the Gaze Estimator

For gaze estimation, the first step is to make the eye-tracker to track each eyes. The gaze calibration is performed next. For gaze calibration a white display screen is proven to the user with a few circles on it. The centers of these circles are predefined display calibration points. The user wishes to look at one circle for 30 frames, as the overall body charge is around 10 fps, he/she desires to look at one circle for around three seconds. Then, the consumer should study the subsequent circle and so on. During this calibration process, the person is limited from shifting his/her head. However, the observation is that, even though the person tries not to move his/her head, a motion of some pixels may occur. Therefore it's far necessary to discover the quantity of head movement, that's calculated using the approach described in section 4.4. The quantity of head motion is subtracted from the tracked eye positions to get the real eye movements at some point of the calibration process.After the top motion reimbursement, for each eye the 30 eye positions for every calibration point are handed to a characteristic to get the pleasant candidate factors. The output of this function is then used to teach the KNN classifiers.

Two classifiers are used, one for each eye. The label of those training information is a quantity associated with the predefined role on the display screen. After the calibration process, a gaze estimation screen is proven to the person. In every frame, after head movement repayment, both pupil positions are surpassed to the classifiers. The output of the classifiers is a number associated with the corresponding screen calibration place. A highlighted rectangle is then presented on the display screen to reveal the gaze location of the consumer.

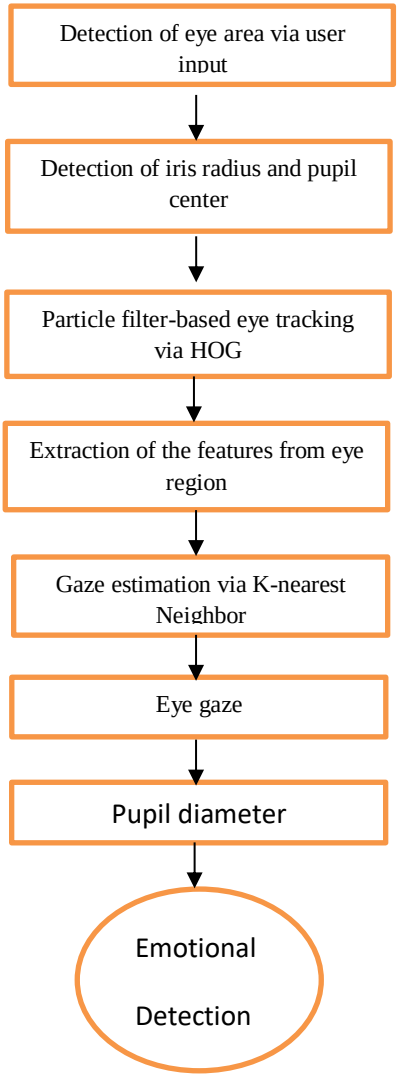

Figure 2: Overview of the current system

11 Experiments and the results for emotion detection

The system that which presented in our thesis is developed under windows 10 operating system by using visual C ++ programming language and OpenCV library. Open Source Computer Vision (OpenCV) is programming functions library which developed by Intel company for computer vision in real-time aim. It is free open source for both commercial and academic. The images are captured with 'hp laptop webcam', with 640 × 480 pixels of resolution. The system is implemented on an Intel(R) Core(TM) i3 processor at 2.4GHz with 4GB of RAM.

The user is asked to sits around 30 cm from the camera, facing the monitor. After the tracker starts tracking the eyes, the user is free to move his/her head. The data obtained from the eye tracker is recorded in this experiment. The video is also recorded and hand-labeled later. The length of the first video sequence is 500 frames, in a real time, frame rate of 10 frames per second.The row positions of the right and left pupils in each frame for both tracked and hand-labeled pupil positions are shown in Figure 3 and Figure 4

Figure 3 : Right Eye (Row) Positions data that extracted from the eye tracker.

Figure 4 : Left Eye (Row) Positions data that extracted from the eye tracker.

For pupil detection, from the region of the eye tracked by the particle filter is used [19], the iris is detected first. Then the center of the iris is considered as the pupil center in this eye-tracking design. To determine the parameter of the iris, a half circular mask is used which is described in [20]. To approximate the shape of the irises as circles when the irises are at the corner of the eyes, a three pixels thick half circular annulus mask is used to detect the iris boundary. The pupil is determined by the center of the mask, for which the number of edge pixels located in the annulus region is maximum. As a result, it is possible that the tracked pupil center position can be three pixels apart from the original pupil center. Again, while hand-labeling the pupil center, a deviation of few pixels may occur in both row and column directions. So, if the Euclidean distance (error) between the tracked and the hand-labeled pupil position is in between zero pixel to three pixels, then the pupil is considered as tracked correctly in that frame.The pupil measurements of the objects vary from 2.21 to 4.93 millimeters in the time during which the nice and disagreeable video clips are shown. As shown in Figure 5, it has been observed that the average pupil size in unpleasant excitement is approximately higher than pleasant excitement.

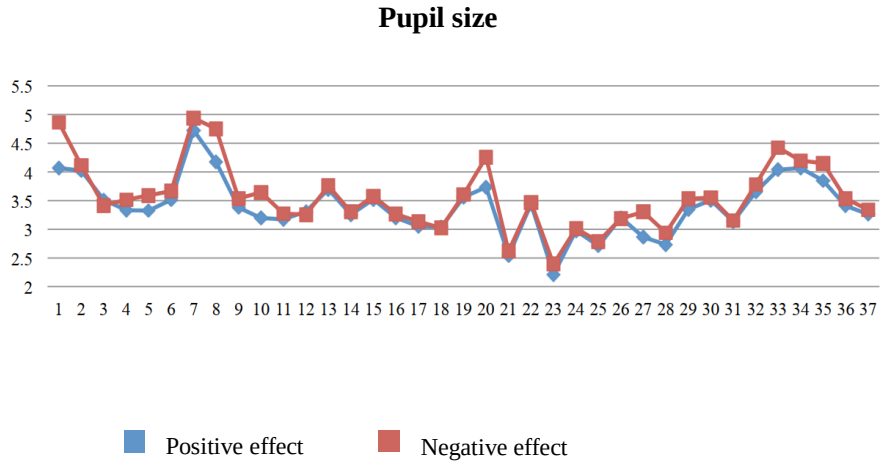

Figure 5: Pupil size in pleasant and unpleasant clips

12 Results of Emotion Detector

Considering the limitations that were provided in the literature, it was discovered that the use of short length videos is preferred, thus, this was approached in the same way. The size of the pupil was measured, which revealed that the objects vary from 2.21 to 4.93 millimeters during the time where pleasant clips were being displayed. However, in depth, the average pupil size during an absurd or disagreeable movie clip was greater than the arousal of the pupil during a certain scene as much as 89.6%. Nevertheless, the case is not the same for all the observers. Some observers showed a distinction of almost 11% from other participants. The clips which were displayed were 25% of the scoring and satisfying clip for a better upshot, 4 out of 10 and 50% of the clip ranking were considered to be disagreeable.

While determining the fixation period, it was ranged from 0.11 to 1.54 millisecond and the average was 0.24, while in the pleasant scenes, the fixation time was ranging from 0.021 to 1.441 millisecond and the average was 0.29. This led us that there is no huge different between the unpleasant and unpleasant videos. However, it is to be noted that there was a slight difference in the mean of average fixation duration between the unpleasant and pleasant clips. Mean of the fixation duration in unpleasant clips was ranged from 0.17 to 0.57, while in the pleasant clips

was ranged from 0.14 to 0.79. The following graphs show a better image of the results for the emotion detector.

In our result, we find that the viewer decide a target of gaze is direct through a wider range of deviations from looks when the faces are shown in the out bonders than in the fovea, and this results in a great agree with previous studies[21]. We find that the neutral faces are judged as looking in the periphery only while the unpleasant face is looking directly through the range of sight distractions as shown in Figure 6.

The final results that showed the relationship between the size of the pupils and the direction of the gaze was spectacular, promising and interesting in the same time and open a new window - that is not shown in the previous studies- in our understanding to the gaze-pupils reaction and its impact on the way we apply this thesis in real life

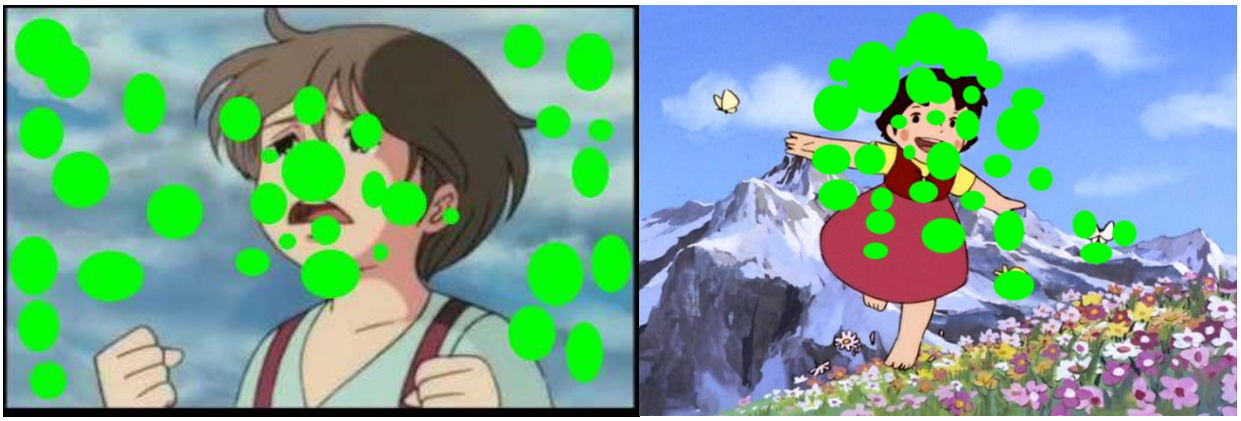

Figure 6:Gaze point for both pleasant and unpleasant images

Methods	Ages of the Volunteers	Procedure	Comment
Elaine Fox, Andrew J. Calder, Andrew Mathews method 2009 [22]	18 and 32 years old	- Selected on the basis of levels of trait anxiety rather than state anxiety because they wanted to investigate the more enduring effects of anxiety on emotion perception -Using the direction of the eye for emotional detection -Two letter T and L for watching on it and the user ask to follow them on the monitor - Distance The stimuli were presented on a 43.18 cm far from monitor	-Additional equipment was needed PsyScope software (that just work in Apple Macintosh) also It will only work under systems up to 10.14.x (Mojave). -Ask the user to press on the letter increasing the stress for the user and we will not have the correct result also using just the direction of the gaze and do not pay the attention for the pupil diameter also will affect the right result
Lassalle, A. and Itier, R.J., 2015 [23]	mean age =19.3 years	-All volunteers were females - All participants gave informed consent and were unaware of the goal of the study. - The stimuli were presented on a 15-inch monitor placed 60 cm away from the participants and controlled with E-Prime software. -A white fixation cross was presented on a black screen for 600 ms. - All volunteers respond as quickly and as accurately as possible by pressing the “c” key on a standard keyboard with their left index finger and the “m” key with their right index finger for left and right targets	-Depended on one gender is not good idea -Did not inform the Volunteers from the aim of the experiments maybe will this confuse them and increasing the stress feeling - E-Prime software tools was used here and this an additional equipment - Using a black screen may be will affect the result of the experiments -Ask the volunteers to quick response and press some bottoms, this will create for the Volunteers some stress and this will increase the bad emotion
Our research	19 and 45 years old	-Using webcam -Not extra light need -Using image processing techniques -Ask the Volunteers to watch the clips in their language -No additional equipment need or third software program -Using the direction and also the diameter of the pupil for more accurate results. -Choice the volunteers randomly and in different ages. -Give free head movement for the user -Inform the Volunteers from the aim of this study	-For future work more additional status will be detection depended on this study -In our study we create a cheapest gaze tracking system , which using only usb or built in webcam

13 Conclusions

- Three significant issues were classified: The exogenous against endogenous nature of the biasing attention to emotional motive, the deliberate capture time course of emotional visual scenes, and finally the type of the influential content (unpleasant and pleasant) that is capable of attracting attention selectively. The result has shown that both subsequent intentional participation and initial orienting are tended toward both unpleasant and pleasant emotional stimuli to attend to a neutral image displayed simultaneously.
- Throughout this experiment, we have tested whether eye movement can be a useful instrument to distinguish various adaptive states in a nice and unpleasant stimulation. Taking the advantages of the pupil size (change in the pupil diameter) and analysis the direction of the gaze to improving the performance of our methods give us an incredible result quality with no extra equipment with normal environment light.
- Outcomes of our results from pupil diameter recommend that practice of mental meditation modulate the reaction of the autonomic sensory system, pupillary response reflection react to unpleasant images and quick physiological retrieval to base lines levels, recommending that pupillometry could be utilized to survey the potential medical advantages of these practices in patients.
- The dissertation touched on a topic head movement positions, head movement detection has been seen as a characteristic method for interaction. It very well may be utilized as an elective control strategy and gives openness to users when utilized in human-PC interface arrangements, by applying some image processing techniques it is possible to build software that can help users to interact with the computer without any physical connection, also this is will give a huge opportunity for a people with a permanent disability to adapt with them life.
- The present dissertation was constrained in the absence of consistently producing emotions in Arabian films. Future studies will study Arabic film beyond that and offer specific emotions such as rage disgust and shock. Future research should take account of the scale and focuses of the eyes coupled with the signals of Brian Machine (BCI) as they

sense emotional situations and assess the cognitive mechanism that takes place in the field of interest. This will be important to demonstrate in real-time charts of brain-behavior the results of multiple emotional conditions.

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Subject: PhD Publikációs Lista

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List of publications related to the dissertation

Foreign language scientific articles in international journals (5)

1. Alhamzawi, H. A. M.: Control Mouse Cursor by Head Movement: Development and Implementation.
   Appl. Med. Inform. 40 (3-4), 39-44, 2018. ISSN: 1224-5593.
2. Alhamzawi, H. A. M.: Faces and eyes Detection in Digital Images Using Cascade Classifiers.
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Foreign language conference proceedings (1)

6. Alhamzawi, H. A. M., Fazekas, A.: Assessment of Patients Emotional Status According To iris Movement.
In: Contemporary Computational Science : proceedings of the International Multi-Conference on Computational Science (CS 2018). Eds.: Piotr Kulczycki, Piotr A. Kowalski, Szymon Lukasik, AGH University of Science and Technology, Kraków, 160-176, 2018. ISBN: 9788366016224

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