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A SYSTEM FOR IMPROVING IT OFFICE EMPLOYEES HEALTH USING AN UNCONVENTIONAL USER INTERFACE

Paruyr HARUTYUNYAN[1], Alin MOLDOVEANU[2], Florica MOLDOVEANU[3], Oana BĂLAN[4], Anca MORAR[5], Maria-Iuliana DASCĂLU[6]

Office work related pain is very common nowadays and it is generally agreed that it is associated with complex physical and psychosocial factors. Spending extended periods of time in front of the computer and doing sedentary work severely affects human health. We have decided to seriously consider this aspect in the context of virtual reality and to develop computer-based interfaces that will enable monitoring human health in real time, based on certain physiological parameters. In this way, we aim to create a healthier working environment. We will show all the components of the virtual reality environment and each time the worker deviates from the normal posture the program will react in the most realistic way.

Keywords: activity monitoring, sitting posture, posture detection, ergonomics, context-awareness, posture detection in virtual reality

1. Introduction

Nowadays economy has made serious scientific and technological progress. The society has quickly adopted and applied state-of-the-art computer and mobile technologies, as an inseparable part of our everyday life. As stated in

[1] PhD student, Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania, e-mail: par0308@gmail.com
[2] Professor, Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania, e-mail: alin.moldoveanu@cs.pub.ro
[3] Professor, Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania, e-mail: florica.moldoveanu@cs.pub.ro
[4] Teaching Assistant, Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania, e-mail: oana.balan@cs.pub.ro
[5] Lecturer, Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania, e-mail: anca.morar@cs.pub.ro
[6] Lecturer, Faculty of Automatic Control and Computers, University POLITEHNICA of Bucharest, Romania, e-mail: maria.dascalu@upb.ro

[1], innovative technologies have been intensively integrated into our lives, so that today it is almost impossible to imagine daily activities without them. In fact, IT technologies create lots of conveniences for human life, but at the same time, it can be definitely stated that they also have a negative impact at the physical, mental and psychological level.

Today, almost all office workers, for example telephone operators, remote sales specialists or back-office workers spend most of their working time sitting. It has been shown that workers' sitting time is continuously increasing (comparing to the statistics made 20 years ago), resulting in a growth of the number of people suffering from diseases caused by a sedentary lifestyle. The prevention or improvement of this unconsciously wrong attitude of humans towards their posture, whether sitting, standing or lying, will help creating a healthier working environment and increasing workers' productivity. The results of several researches [2, 3] have shown that humans are rather poorly "protected" from IT technologies at work. As described in [4] studies have revealed that most workers do not even realize the scale of damage caused to their health at work, which, in turn, negatively impacts workers' productivity.

The scope of this paper is to present a flexible, modern and functional system that uses the latest IT devices and approaches in order to improve workers' posture. The hardware used in the system is intended to evaluate the physiological state of humans. Considering the highly progressive trends of the IT industry, we should do our best to always maintain all devices and software used to operate this system up to date.

2. Related Works

There are many opinions regarding monitoring workers' health status at work. However, almost all authors have come to the same conclusion that the domain is rather poorly developed and that it is necessary to control and protect workers' health at the workplace to the greatest possible extent.

In the following paragraphs, we present several systems and devices used for monitoring employees' activity.

Kortuem [5] considers that ubiquitous tracking and monitoring technologies are now routinely used in industrial environments, but very rarely with the purpose of improving occupational health and safety. The authors of [6] indicate that interrupting sustained sedentary working time with short periods of rest results in an improved glucose metabolism in the case of overweight individuals and increased energy expenditure, suggesting that relatively small changes in activity patterns have the potential to modify adverse health risks.

The authors of [7] are concerned about the privacy issues. Most patients, although they may appreciate the increased sense of safety that comes with the monitoring infrastructure, are leery to have their every move monitored.

In [8], the authors provide an overview of researches conducted with the purpose of detecting human body movements and estimating human body postures through video monitoring.

Some other examples of image estimations are described in [9-12], including the ones based on video monitoring from the same or multiple points and monitoring using static images. In [9], the authors introduce an algorithm which, based on a static image, helps to determine human body postures. The research described in [10] aims to create a three-dimensional human body model based on image sequences taken by one camera. A very useful and effective method is described in [11], where human body images are received in a three-dimensional space using different video cameras.

Schwartz et al [12] have introduced the "active chair" solution for workers doing sedentary work. They aimed to evaluate and develop a special device with integrated sensors, which could be used for every office chair. The research described in [13] refers to the early detection of the signs of fatigue and sleepiness while driving. It states that the analysis of certain biological and physiological variables may detect the signs of alertness loss before the driver falls asleep.

3. System goals

From the previous chapters, we already know that there are other tracking methods that are using either one or multiple cameras in order to obtain a more detailed graphical representation of human body. We have used a Microsoft Kinect camera in our system to collect information regarding the ergonomic conditions in the workplace and monitor the worker's posture. Microsoft Kinect provides more precise information regarding the worker's presence in the room, his/her movements and degree of attention. The collected data enabled us to create a graphical representation of the worker. For any deviations from predefined norms, the system sends a warning to the worker in a form of a pop-up window opening on the computer screen, a signal or an animation. Also, additional warnings are provided, aimed at reminding the worker to maintain a safe distance from the computer screen, to do eye exercises in order to relieve eye strain, or to take a break. All data is processed locally, so that the privacy of the worker is respected.

4. System description

Virtual reality is a computer-simulated reality perceived by humans through sight and hearing. Virtual reality is represented in real time. Our system is a virtual reality based system. The virtual worlds represent three-dimensional interactive environments with animated characters, called avatars. In this specific case, an avatar is attributed to the worker, through which the worker acts in the virtual reality. The virtual reality may contain different objects, which we can manipulate as we wish. In this case, we have created a 3D room model similar to the office room in which when the employee works at his/her desk in the office, the same is done by his/her avatar in the virtual reality. Thus, we aim to create an environment which will help workers monitor their own behavior at work and follow predefined health rules and norms. Our system consists of different types of sensors used to monitor workers at work. They are installed at a certain distance from the worker and do not interfere with the his/her work (only Microsoft Band is worn around the worker's wrist as a wristwatch).

Kinect processing

One of the most important points was the worker's sitting posture at work (the head should not be tilted to the back, left, right or forward). Another important point was the spine position, which should not be curved (this does not refer to people suffering from scoliosis or with inborn spinal deformities). Kinect starts monitoring workers whether sitting or standing since the beginning of the working day (let's assume it is 9 a.m). Kinect V2 also provides (X, Y, Z) coordinates of 25 joints (Fig 1).

In order to measure the JointType.Neck, we consider the X and Z coordinates. These coordinates are then filtered and brought to a common unit measure. As the worker's neck goes forward, coordinates grow positive (1,2,3,...16,17,…,n) and as the neck goes back, coordinates become negative (-1,-2,-3,…,-16,-17,…,-n). In this specific case, (-15; 15) are assumed as normal values. In the case when these values are exceeded, the worker will be therefore notified.

The same principle is applied for the determination of JointType.SpineBase value. Here, the X coordinate should be considered. In this specific case, the (-15; 15) value will be considered as an acceptable norm, as in fact the user cannot tilt his/her spine the way he/she does with his/her neck.

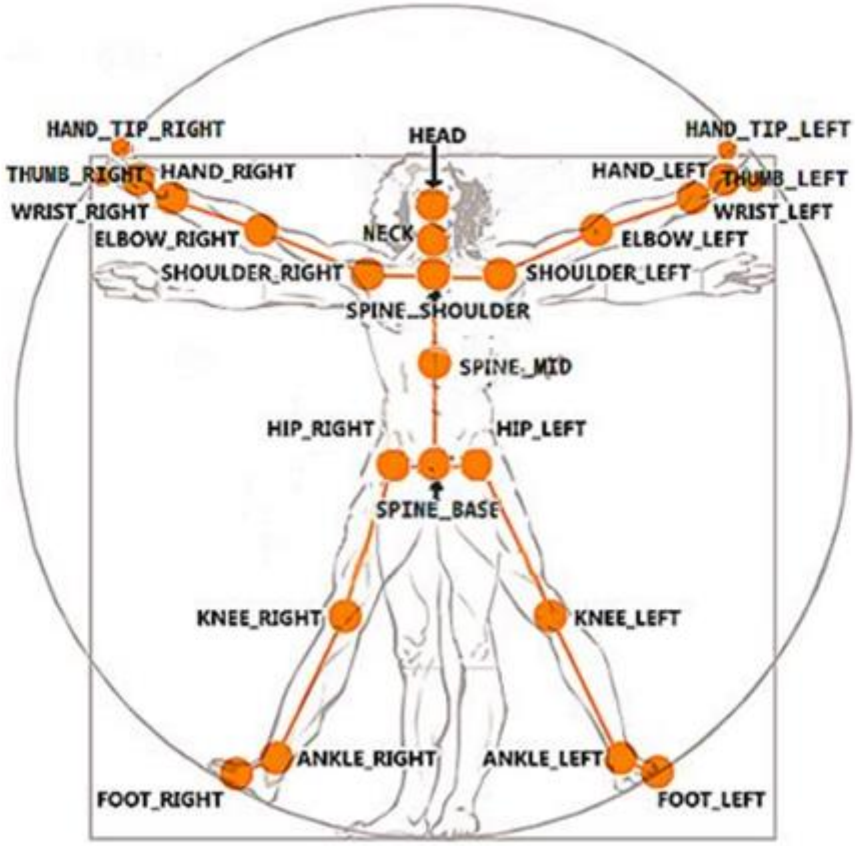

Fig. 1 25 skeleton joints [14]

Here we present the pseudocode of the used algorithm:

Set all parameters to zero
if Kinect is running and it detects the worker then
    Start to monitor the worker
else
    Notify "no user was found"
if the Neck and/or Spine is not in correct position
    Notification "You hold your neck in an awkward position"
    Notification "You hold your spine in an awkward position"
else
    Continue to monitor
Add the coordinates average rates for every 5 minutes into a file

The Tobii eye tracker processing

Eye gaze is a potentially powerful tool, if used accurately. Eye movements are also a very important research topic that enables us to measure the productivity and potential of user interfaces as an input device [15].

The Tobii Eye Tracker enables new functions that revolutionize the field of human-computer interaction. It enhances the user experience to point with his/her eyes naturally and intuitively. This caters for a much more natural and intuitive interaction with the device. Thanks to Tobii Eye Tracker now it is possible to identify the points the user is looking at.

The device extracts the eye-related attributes of the user, including gaze direction, distance from the screen, eye blink, as well as the duration and frequency of blinking. By using the data extracted from the eye tracker we can determine the user’s coordinates and identify head direction and orientation. Based on the head position and orientation we can calculate a vector representing the head direction as a proxy for the gaze direction. We then project the estimated gaze vector onto the computer monitor and calculate gaze angle. According to ergonomic rules, the user’s gaze angle in human-computer interaction should be around 15-17 degrees.

It is very important to maintain proper distance from the monitor, in order to avoid eye fatigue at the workplace [16]. Using the data received as a result of face tracking, we can easily determine the distance between the user and the computer. This distance can suggest possible changes in the user’s computer viewing habits, according to the ergonomics guidelines. Tobii Eye Tracker identifies the user from the distance of 45-75cm. We should send three infrared beams to identify human eyes. If the distance is <45cm or >75cm, the system will be unable to identify human eyes and will send a corresponding warning with the following text: “Please keep proper distance from the computer”. However, if the user is within the range of 45-75cm, it does not mean that he/she follows the ergonomic rules. According to these rules the proper distance should be 55-65cm. In this case the system double checks the location of the worker and if he/she is within the range of 55-65cm, the distance is considered normal and the worker may continue working, but if the distance varies between 45-55cm or 65-75cm, the worker is warned about it. The warning text contains the following information: “The permissible distance is exceeded, please maintain the correct distance”.

Microsoft Band processing

Another device used by our system is Microsoft Band. The role of this device is vital to our system's performance, as with Microsoft Band we can collect data about the physical activity of humans: number of steps, travelled distance etc. Thanks to this device the system not only collects data, but also reminds the worker from time to time to do some physical activity, in this specific case, to walk.

Every 60 minutes the system measures the data on the physical activity of worker. This data is received from the Microsoft Band. Generally, we compute the number of steps he/she walks. The number of steps, however, is not as important as the fact of tearing the worker away from the computer and making him walk for a while. If the system can tear the worker away from the computer and make him/her walk, it already means a success. The worker will be notified of any necessary action to be taken via notifications popping up on the computer screen.

The heart rate level varies among people between 60-80 beats per minute. In this specific case, the system measures heart rate every 30 seconds. If the above-mentioned threshold is exceeded, the system sends a warning to the worker and gives corresponding recommendations, such as: "Go outside and breathe some fresh air." If the deviations from the before-mentioned norms are greater, the following recommendation is given: "Consult a doctor".

All the data on every single movement is recorded and stored in a corresponding file. Regardless of the worker's sitting position, whether right or wrong, he/she can continue working without paying attention to the system. Thus, the system does not interfere with his/her work or personal life. Moreover, the system provides a maximum level of confidentiality and does not provide data without user's approval. The users do not explicitly interact with the system, as it is designed to passively compute and present data. It is assumed that the employee's working day begins as soon as he/she turns on his/her computer and beginning from that moment, the system starts monitoring the worker.

5. Experiments performed with the proposed system

The system sends the collected data in real time. However, this is not the case with Microsoft Band, which updates the data every 30 seconds. In the beginning, we store all data in the database, but after receiving first range of data from three devices we saw that it is not effective as millions of data transferring every second and computer capacity goes down. So the structure was changed, and all data the system store in CSV (comma-separated values) files.

Fig 2 shows the workflow logic overview. The data received from different devices are sent to the model processing module. The latter is responsible for making all logical calculations. It compares the data received from different devices with predefined values entered in the system as normal values. These values are the norms that should be respected in the workplace (sitting posture, distance from the computer, etc.).

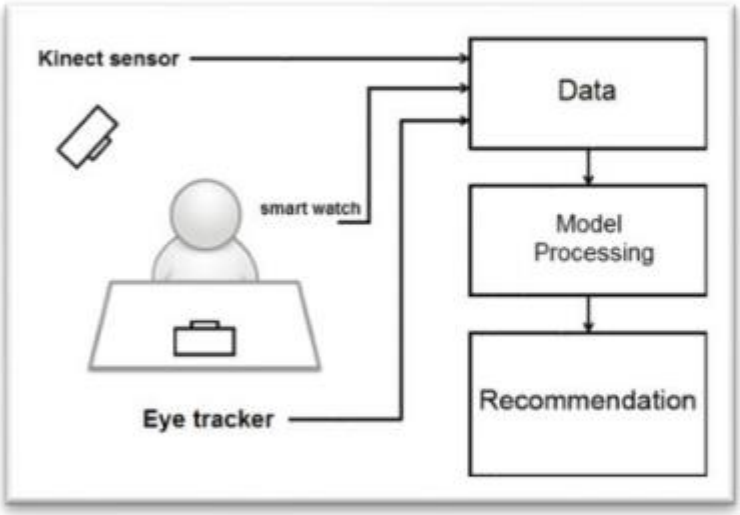

Fig. 2 System overview

This part of the paper is dedicated to the pilot prototype testing in an organization where the employees work for 8 hours per day. The experiment was conducted in November 2015. The sample group of the experiment consisted of 3 workers (2 females and 1 male) with an average age of 27, height – 168-175 cm and weight – 57-75 kg. All the participants were informed in advance about the experiment and signed a consent form. After having obtained their consent, the whole process was explained to them and they were asked to use the system during normal office hours. As not all organizations allow embedding any software or hardware in their systems, we had to use our own laptop to ensure system performance. With this experiment, we had set the goal to evaluate (i) worker' body posture while doing a sedentary job as well as (ii) more critical behaviors and when exactly they reach the critical point during office hours.

According to our plan, a full working day (09:00–18:00) was provided to each employee, except for lunch time (13:00–14:00). The collected data was computed within subsequent time-windows of five minutes. Thus, for the standard hours of work, i.e. 8 hours, we received 96 different samples of sedentary behavior of for each employee. According to the predefined plan, our experiment consisted of 2 parts: the first part was fully dedicated to the familiarization with the system (1 full day) and the second was fully dedicated to the process of monitoring the employees during office hours.

In order to efficiently evaluate our system, enormous amounts of data were collected. The experiment started in mid-November 2015 and data collection ended at the end of the same month.

Here we present the experimental setups and discussion of results for three employees (User A, User B and User C). Because of time and resources limits we run the experiments only for the "neck monitoring" and "eye distance" functionalities. In the following figures User A, User B and User C are represented in blue, red and green colors accordingly.

A. Neck monitoring

Our system is able to receive thousands of lines of data every second. Conditioned by this, we have collected and averaged bunches of data every 5 minutes. Fig 3 and Fig 4 show the neck monitoring data for three employees. The conventional normal coordinates for neck we consider to be (-15; 15).

So, if we compare the data from our test users we will see that each user passed the acceptance range of coordinates many times. If we analyze all the three users we will see that all have the same behavior. We can also notice that User B has more wrong positions than User A and User C. Even in this case, there is little difference between them. User B has 15 before lunch and 20 after lunch time, User A and User C have 16 (12 after lunch) and 15 (19 after lunch). Further experiments will allow us to see a clearer image of the critical hours during full working time.

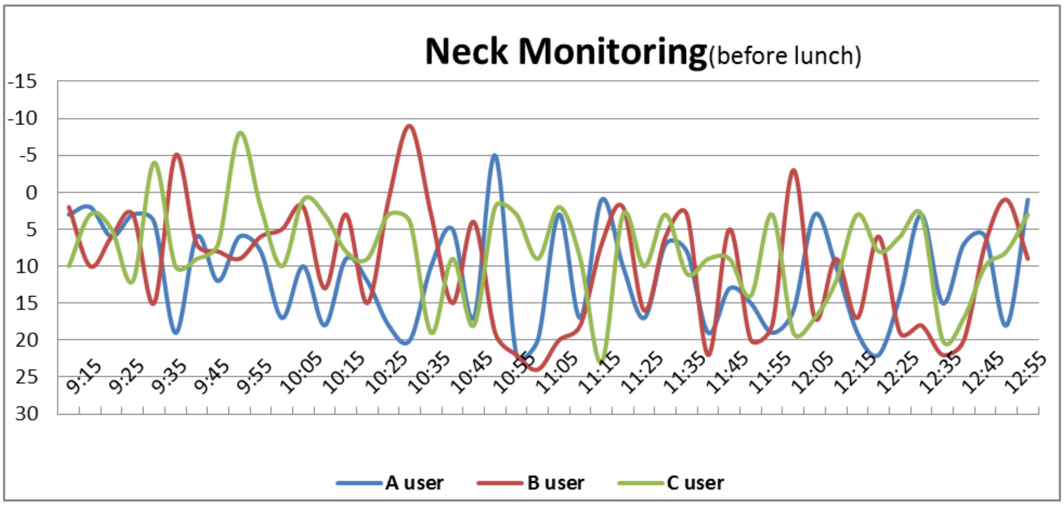

Fig. 3 Neck monitoring before lunchtime (User A, B and C)

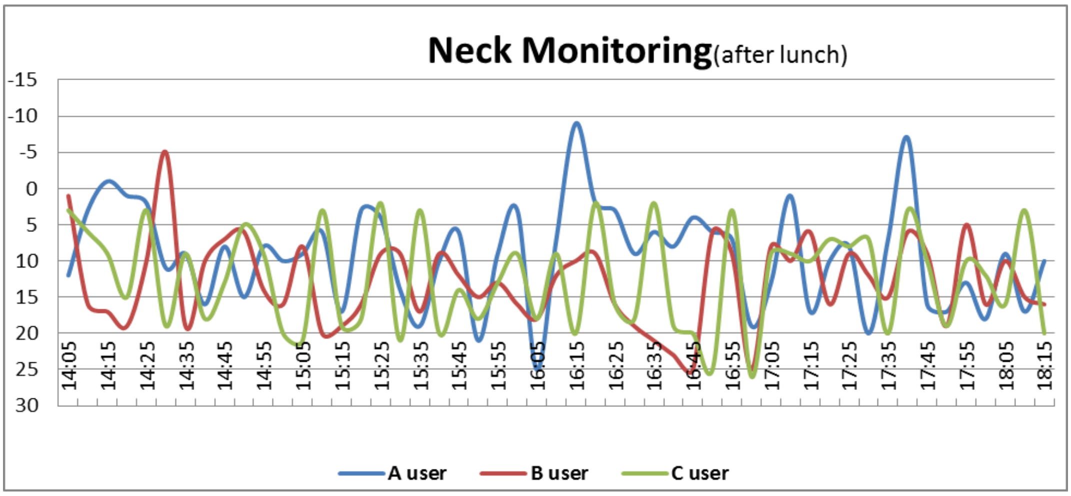

Fig. 4 Neck monitoring after lunchtime (User A, B and C)

B. Screen Distance Analysis

The plot of the screen viewing distances for our test users is shown in Fig 5 and Fig 6. We also divide all data into two parts, before lunchtime and after. We account the distance when the user's face is in view and he/she is looking directly at the screen. When the worker is in front of office desk but not looking at the monitor the eye tracker can't track his/her eyes gaze, so the distribution of viewing distances can be slightly skewed. As you can see in Fig 5 and Fig 6, zero value was registered for User A and User C. As in this case the test refers to the distance between the employee and the monitor, the zero value can be recorded in two cases: the employee has either been so close to the monitor that he touched it or the system has not recorded the employee's gaze (if the employee has not been in front of the monitor). Taking into consideration these situations we chose to average the values every 5 minutes.

This distance can suggest possible changes in the users' computer viewing habits when compared to ergonomics guidelines. Our system identifies the user when he/she is within the distance of 45-75 cm. However, if the user is within the range of 45-75 cm, it does not mean that he/she follows the ergonomics rules. According to these rules, the proper distance should be 55-65 cm. In this case the system double checks the location of the worker and if the latter is within the range of 55-65 cm, this distance is considered normal and the employee may continue working. If the distance varies between 45 and 55 cm or between 65 and 75 cm, the worker is consequently notified about it.

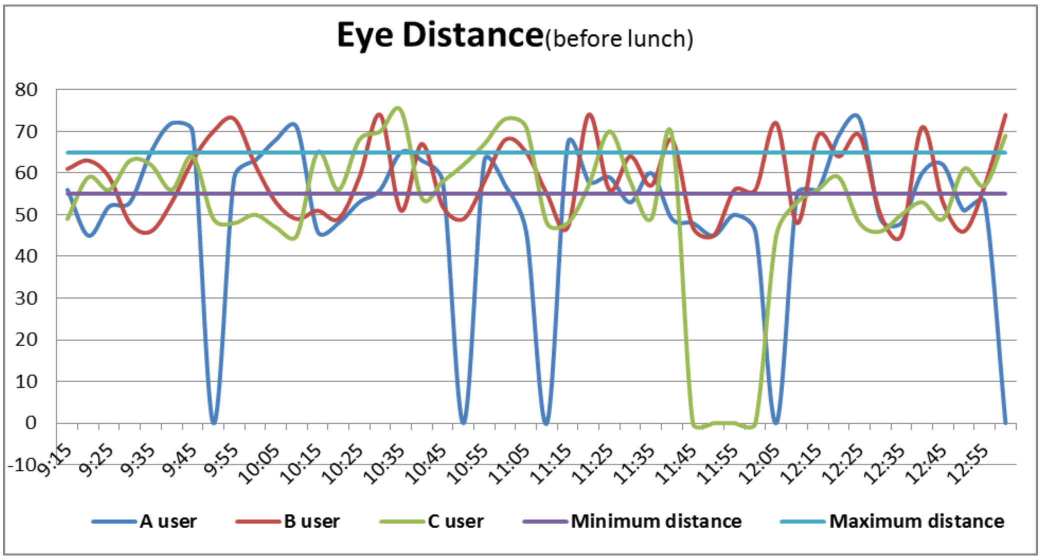

Fig. 5 Eye Distance for three users (User A, B and C)

In Fig. 5 and Fig 6 we marked with Purple and Light Blue the normal minimum and maximum range as a normal value. It is clearly underlined that all the three users have a problem with keeping the correct distance when they are in front of the monitor.

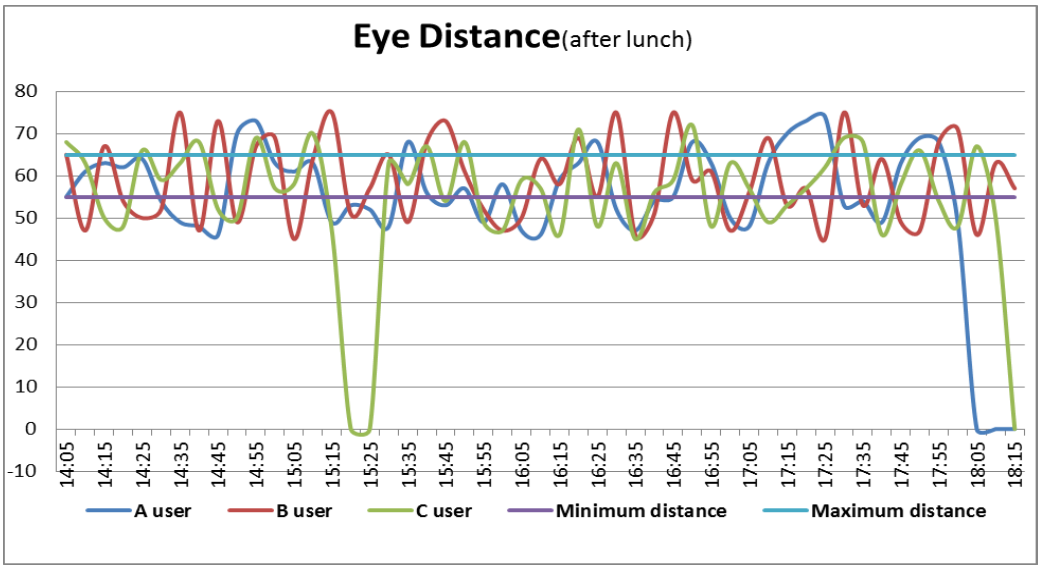

Fig. 6 Eye Distance for three users (User A, B and C)

The experiment will be extended by testing the system using up to 10 users, for a period of 6-12 months continuously. We will record the entry data in the first days and compare them with the results obtained after 12 months. In that case, we are confident that for some users we will record a significant progress.

6. Conclusions

The technological development and particularly the development of computer technologies provided humanity a great range of tools for facilitating and speeding up the accomplishment of daily working tasks. With the development of computer technologies, we got unique possibilities and advantages in our professional development processes, but unfortunately it brings a variety of disadvantages, such as serious health associated problems.

As discussed previously, nowadays almost all office employees spend most of their working day doing sedentary work. With the advancement of computer technologies, the time spent by employees in a sitting position continually grows. The proposed system enables monitoring office employees posture and distance to the monitor through an accessible and friendly user interface. At the same time, it provides valuable real-time information concerning the means of improving posture during the 8 hours working time. The experiment previously presented demonstrates that the system can be effectively used for enhancing the ergonomics working conditions and training postural self-control.

The main goal we'd set to ourselves in the scope of this research was to monitor human behavior during office hours. Hence, as a step forward, we may consider new parameters for further monitoring, such as physiological and ergonomic parameters. As a new psychological parameter, we may consider the factor of human fatigue revealed through EEG study, as well as changes in the electrical resistance of the skin caused by emotional stress through new sensors. As for new ergonomic parameters, desk placement, chair height, room illumination, air humidity and others can be considered.

Considering the aforementioned development trends, our system should be continually upgraded, in order to keep abreast with those trends, but before adding any new features to the system, we should first of all test it for a long period of time. It means that we should monitor workers' behavior for months long, in order to find out if positive changes are observed in their behavior during office hours or see if workers have given up bad habits and adopted good ones.

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