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Eye-Screen Distance Monitoring for Computer Use

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Abstract—**The extended period many people now spend looking at computer screens is thought to affect eyesight over the long term. In this paper we are concerned with developing and initial evaluation of a wireless camera-based tracking system providing quantitative assessment of computer screen interaction. The system utilizes a stereo camera system and wireless XBee based infrared markers and enables unobtrusive monitoring. Preliminary results indicate that the system is an excellent method of monitoring eye-screen distance. This type of system will enable future studies of eye-screen distance for computer users.**

I. Introduction

The extended period many people now spend working with computers and looking at computer screens is thought to affect general health [1] and also specific functions such as eyesight over the long term [2]. A particular problem is the lack of variation in depth of focus (visual accommodation) when looking at computer screens [3] which in general has been linked to premature loss of eye accommodation capability. Yet there is little quantitative evidence to support these observations. There is therefore a need to provide quantitative data on a) the nature of the visual computer screen interaction and b) the effect of visual computer screen interaction on long term changes to eyesight.

In this paper we are concerned with a), the quantitative assessment of computer screen interaction. In particular, we would like to develop methods to assess the required eye focus distance when looking at a computer screen during normal daily computer use. This will subsequently enable us to assess computer users, for example, in short term trials to gather data on typical eye-screen distance patterns in the computer user population, and also in longer term trials to investigate impact on eye accommodation deterioration.

Our aim is therefore to design a simple system of acquiring the required eye-focus distance and to test its feasibility prior to further in-depth development and subsequent investigative studies. This paper is concerned predominantly with design of the system and preliminary investigation of the nature of the activity, and in particular, the feasibility of using a camera-based system in non-obtrusively monitoring.

II. System overall design

The main system design parameters include the requirement for the system to be used unobtrusively over extended periods and for the system not to interfere with normal computer use behaviour.

Our particular solution is to use a stereo-camera based vision-system to monitor of position of the eyes relative to the computer screen. To ensure simple and reliable tracking, the initial system design utilises infra-red LED based target markers (located on the head of the computer user) and an infra-red sensitive camera fitted with an infra-red filter (to block visible light). The system was controlled by a purpose-written LabVIEW program running on a PC. Multiple markers enable the position and orientation of the head to be established.

III. Marker Creation

Microcontroller based infrared markers were designed and constructed (Fig. 1). These turned on individually on receiving a wireless command from the controlling PC. An XBeePRO communications system (Fig. 2) was used in USART mode to transmit and receive serial communications wirelessly between the controlling PC and the microcontroller on the infrared markers.

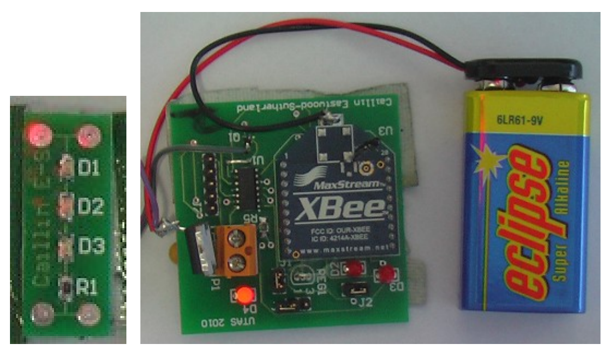

Fig. 1: Wireless infrared tracking marker (left) and control unit (right)

The microcontroller in each marker was programmed to activate the infrared LEDs only when the correctly coded identifying serial data was received, and to deactivate if any other serial data was received (Fig. 3). This simplifies marker detection in the case of multiple markers, and also helps reduce marker power usage as the markers reduce their power consumption when not being tracked.

IV. Point Tracking

An upgraded (higher accuracy) version of a previously developed stereo-vision system [4] was used to track markers placed on the rear of a computer user's head. The vision

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system (Fig. 4) was placed behind the computer user to track the marker in three dimensions. As in [4], the stereo-vision system provided x-y-z data for the markers being tracked. The raw data gives the distance from the camera unit to each marker. Prior to use, the stereo-vision system was used to determine the distance to the screen. This allowed all "head position" measurements to simply be subtracted from the camera-screen measurement to determine the distance between the back of the head and the screen (Fig. 5).

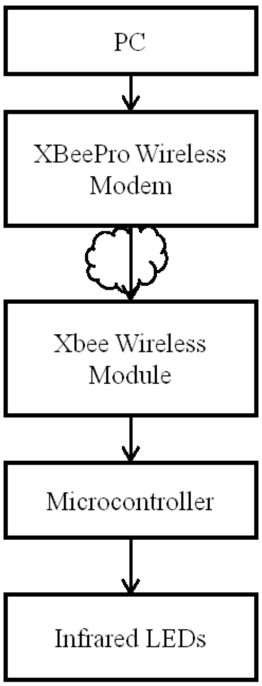

Fig. 2: Block Diagram of Communications System

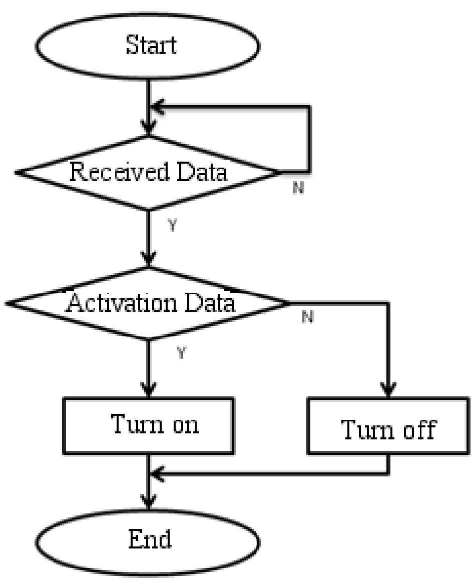

Fig. 3: Microcontroller program flowchart. This is continually looping while the microcontroller has power

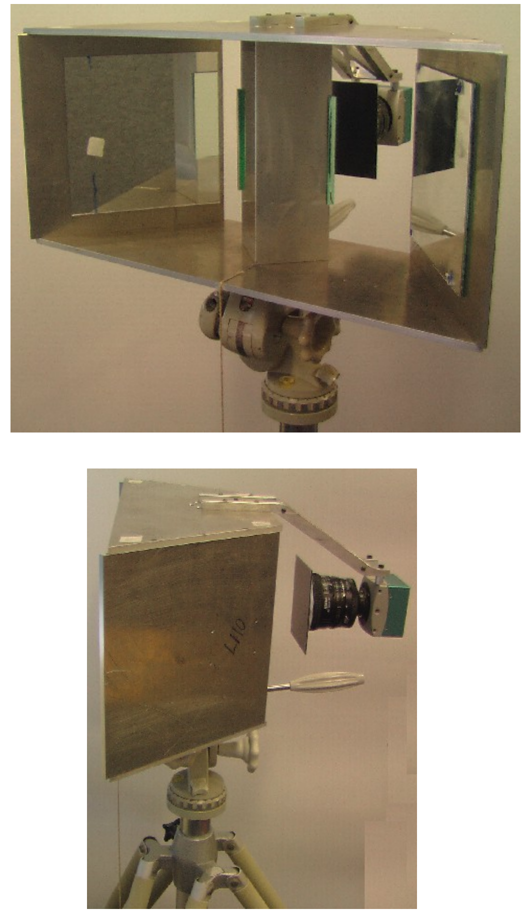

Fig. 4: Single camera stereo-vision unit used to sense head location relative to the computer screen. This stereo-vision unit is described in [4].

The distance from the back of the head to the eyes was then measured, to allow the distance between the eyes and the computer screen to be calculated for the case when the user is looking at the screen.

V. System Evaluation

The system was evaluated by tracking eye-screen distance while performing typical computer-related activities. Typical results will be presented for an example set of computer-activities for a single user.

In this test, several computer-related activities were performed at the user's desk over the course of about 15 minutes. These activities were; setting up the tracking software, reading some pages on the internet, writing in a word document, and then some miscellaneous activities. These represented typical tasks which would affect many researchers, and especially post-graduate students who can be under strict deadlines to get things completed, and may therefore be using the computer for extended periods of time!

While these activities were being performed, back-of-head position data was captured at about 7 Hz. This capture frequency was sufficient to capture typical head motions and provided accurate data.

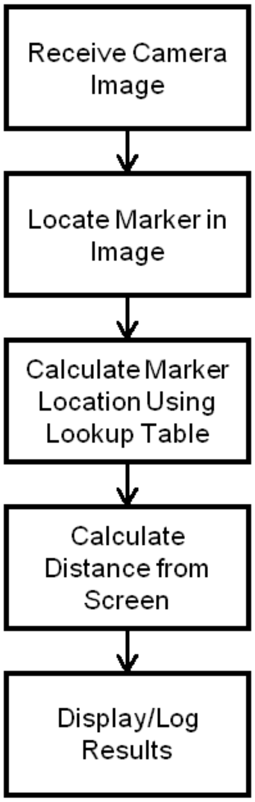

Fig. 5: Flow chart of software based calculation of distance between the screen and eyes.

VI. Data Processing

For each of the four time action periods, the mean, median and standard deviation of eye-screen distance were calculated. This allowed each of the actions to be directly compared to each other in terms of how far away from the screen the user was while performing that action, and also how similar different activities are to each other in terms of distance to the screen.

VII. Results

Typical real-time eye-screen separation data displayed on the screen of the controlling PC is shown in Fig. 6.

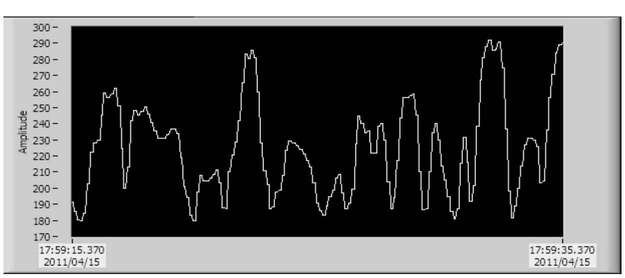

Fig. 6: Sample output of eye-screen separation data

The recorded data is plotted in Fig. 7. It appears clear that there are differences between the first three time periods. The middle time period which was recorded while browsing the internet has a recorded distance much lower than the two either side of it. Although the first and third time periods appear to be similar, there is still a noticeable difference between the two. The final time period is very similar to the third one.

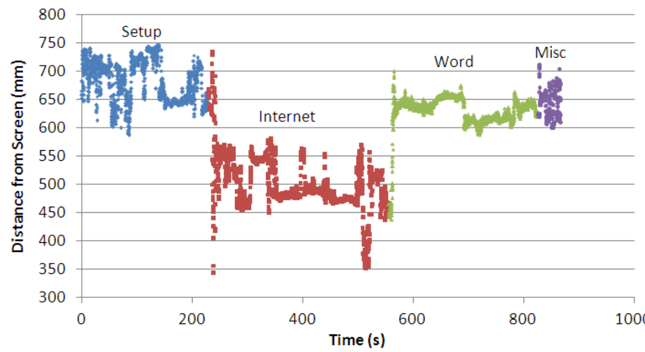

Fig. 7: Data showing the proximity of the user's eyes to the screen for each activity

The constant movement associated with the activities is clearly seen in Fig. 6 and 7. The calculated mean and standard deviation (Table I) were found to be significantly different between browsing the internet and the other tasks. The small standard deviation shows that the user maintained a relatively constant distance from the screen during each activity type.

The difference between the activities is clearer when examining the mean values graphically (Fig. 8). For example, there is a significant decrease (around 26.5%) in the mean between the setup and general internet browsing.

TABLE I Statistical information relating the eye-screen distance for the four different computer based activities performed in the system evaluation.

	Setup	Internet	Word	Misc.
Mean (mm)	681.5	500.8	629.0	642.8
Median (mm)	685.5	486.2	636.2	646.5
STDev (mm)	36.2	45.6	31.0	25.0

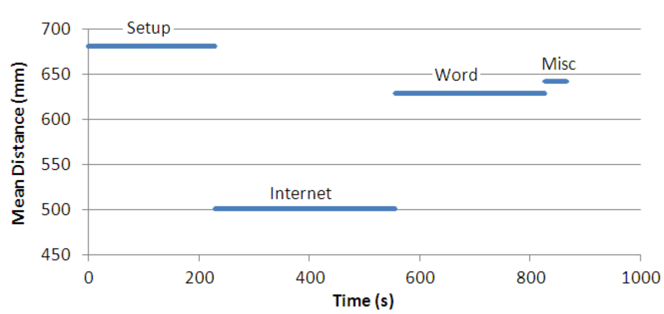

Fig. 8: Graphical representation of the statistical data contained in Table 1.

VIII. Discussion

It is interesting to note that there were two main "types" of activities recorded. The first of these is the "doing" category which contains the setup, word and misc time periods, while the "reading" category contains the internet time period.

When comparing these super-categories the difference is even clearer. This is obvious simply by looking at the plot of the mean values for each category. In fact, there is about a 23% decrease between the "doing" super-group and the "reading" group. Although smaller than before, this is still a significant amount.

It is possible that when "doing" a broader view of what is happening on screen is needed, and while reading, the focus is on one section of the screen, and may need more careful attention.

IX. Conclusion

Although the system is in its very early stages, it has presented potential to be developed into an effective, non-obtrusive system for assessing eye-screen distance when using computers. From the data it appears clear that there is a link between activity and average proximity of the eyes to the screen.

This type of system appears suitable for performing trials to gather data on typical eye-screen distance patterns in the computer use population. Once proven further, the system may find application in medical research to investigate the impact of computer use on eye accommodation deterioration in heavy computer users.

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