Algorithms for Determining the Centre of the Pupil, for the Detection of Eye Movements for Work with Mobile Devices

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Abstract

Human-Computer Interaction researchers and phone vendors are continuously searching for new approaches to reduce the effort users exert when accessing applications on limited form factor devices such as mobile phones.

This work is devoted to assessing the convenience graphic interface of software for mobile devices. Score convenience GUI software is sufficiently complex and ambiguous challenge. There are many methods which help to overcome this issue such as measuring, registrational, organoleptic, calculated, expertise, and sociological. As a rule, all mentioned methods require participation of experts or testers [1].

In this article we propose the method of assessing the convenience graphical user interface (UI) that does not require the participation of third parties, i.e. process will be automated. To automate the process you can use the trajectory of user's eye movement over the test object. By analyzing this trajectory, we can draw conclusions about the most uncomfortable elements for user and decide to change them.

For mobile devices, this challenge could be solved by using the front built-in camera which is very weak today. So in the early studies used simple digital camera. But we believe the rapid development of communication technologies enable mobile devices to perform this task only from their own resources.

We present a prototype implementation our system on a Nokia N900 or Netbook with MeeGO [6], which is capable of tracking the position of the eye on the test image, mapping this position.

Index Terms: eye - tracking, eye movements, saccades, mobile devices, machine learning.

I. Introduction

As smartphones evolve researchers are studying new techniques to ease the human-mobile interaction. We propose expert control system of convenience of UI for adaptation of it to a specific user, because this task is one of the most important in the development of software but implementation of this feature is complicated by people's wide range of interests, attitudes, and other variables. The solution can be realized by monitoring and analyzing the user’s eye movement.

Nowadays there are variety of methods for estimating the convenience of a graphical interface, such as measurement, registrational, organoleptic, calculated, experiences and sociological methods, some of them imply the existence of several qualified experts, the presence of testers, the rest working directly with the user but all of them takes a longer time and relatively high costs. Some methods are based on the analysis of attention, but the tools for it are also expensive.

The paper is organized as follows. In MAIN PART, we discuss the challenges encountered in the development of eye-tracking technology and we discuss about the physiological of eye movement. We present the design of the system followed by its evaluation. In CONCLUSION PART we present some concluding remarks and the future research direction.

II. MAIN PART

A. EYE–TRACKING

Eye tracking is the process of recording the fixation and movement of the point of gaze. It offers analyze the cognitive processes involved in user interaction with websites, physical products, and video, printed media materials and other.

Nowadays tracking eye movements (eye tracking) is closely linked with the technology of infrared radiation [2][3]. Eye illuminates by harmless to view infrared beam and a special camera captures the reflected gleam of the cornea and the position of the pupil of the eye, passing the data to the computer, which, in turn, makes the necessary calculations, which give an indication on the status of the eye. Another way to study eye movements, including coverage of eye light source, receiving the video eyes on a computer screen, binarization of each recorded video frame, with subsequent analysis.

However, those devices that operate reliably and with high accuracy using infrared cameras have a high cost. This increases the price of such systems and prevents their spread.

The aim of our study is to establish a system for monitoring eye movements, which could work with existing user cameras (digital camera, webcam, camera, built into a laptop or phone).Now we use camera Nokia N900 tablet or web –camera Netbook with OS MeeGo for our experiment.

As part of this work, we create the algorithm, which takes into account the peculiarities of mobile devices. Algorithm determines the coordinates of pupil of the eye under the condition of fixed user's head and using the camera Nokia N900 or web – camera Netbook.

At the beginning of the experiment the user's head is fixed, and then the user ought to look at the screen or test image. The camera Nokia N900 tablet or web –camera Netbook registers the displacement of the eye movement. The video save on the computer and analyzes with a computer program.

B. ALGORITHM

Algorithm purpose of eye-tracking is to find an eye with high accuracy. Also an algorithm should be robust to illumination changes, eye occlusions and variance of eyes among the people. There are low-cost solutions of these problems but none of them can track eyes robustly with high accuracy. So we need to develop our own solution.

The main idea of our algorithm is an eye has a very discriminative shape – a circle (in front view) or an ellipse (in other case). So we apply Sobel filter to work with edges and shapes instead of color and texture. It is a classic way in computer vision for this task. Then we need to find a circle in the edge map.

We chose Sobel filter because this filter have the best intensity of edges. You can find results from different filters on the Figure 1.

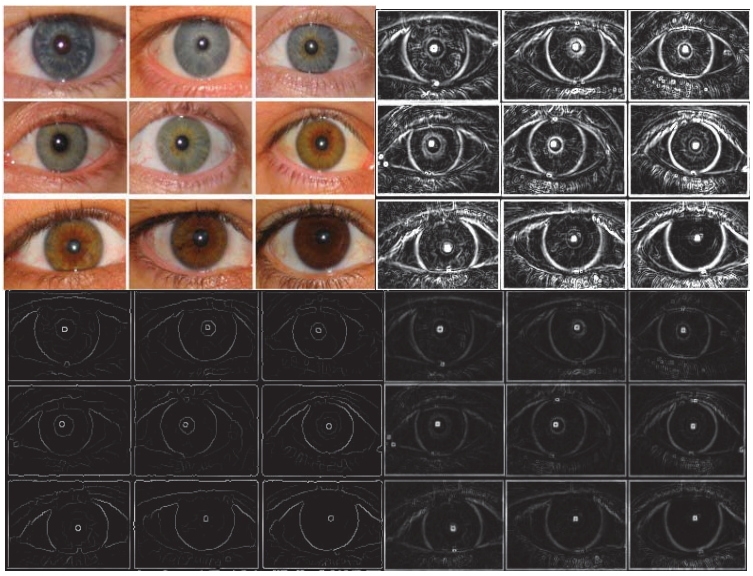

Figure 1. Reference image, Sobel, Canny and Difference filters

Hough transform is a good tool to find geometric primitives such as lines and circles in an image. So we use it to find a best circle in the edge map. The center of this circle is a center of an eye.

We use Sobel filter and Hough transform as the base of our algorithm. Advantages of these tools are robustness and high accuracy and these properties are the most important for effective eye-tracking. Our algorithm works with per-frame of video uses computer vision and machine learning techniques, after algorithm creates record the trajectory of pupil of the eye [3][4][5].

The results of the algorithm figure 2. A video of the demo can be found at site www.fruct.org[11].

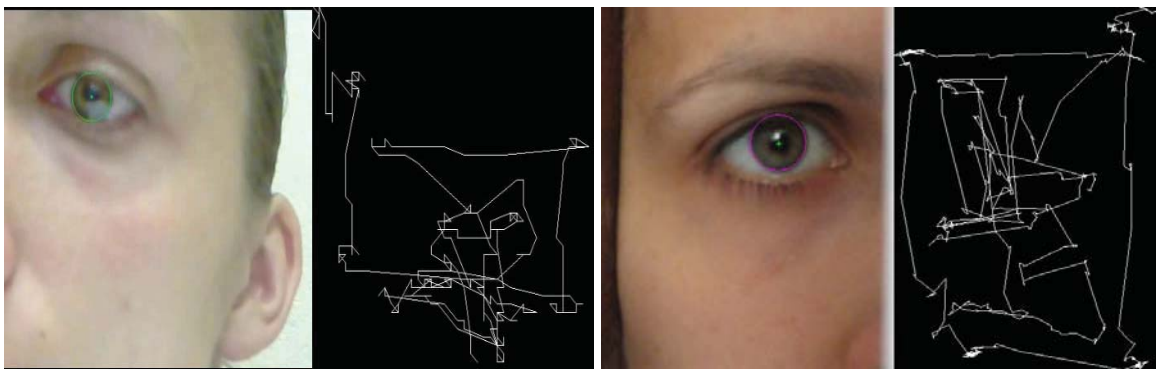

Figure 2. Eyes-tracking algorithm work, which using of the camera mobile devices

III. Conclusion

Usability is now recognized as an important software quality attribute, earning its place among more traditional attributes such as performance and robustness. In this paper, we have focused on developing a system for adaptation of an interface to a specific user. The solution realized by monitoring and analyzing the user's eye movement (eyes-tracking technology solely using one of the phone's growing numbers of

onboard sensors, i.e., the camera Nokia N900 tablet or web –camera Netbook with OS MeeGo).

We presented the implementation of the proto-type our system. We are currently working on improving the algorithm definition of the boundaries the pupil of eye. Preliminary, our results indicate that our system is a promising approach to adaptation of an interface and for driving mobile applications in a hand-free manner.

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