Jivan Chandan, Lidia Kojic,
Natassia Novelletto,
Simony Stock

Supervisor: Dr. B. Balasingam

Virtual Low-Cost Eye Tracking Tool for Marketing Research Applications

Capstone 2022 - July 29th
Department of Electrical and Computer Engineering - Team 2

University of Windsor

ABSTRACT

Consumer visual patterns and behaviour can be beneficial for improving e-commerce materials. This project is a low-cost eye tracking tool, designed using Python, OpenCV (Dlib), HTML (Bootstrap), and JavaScript, to virtually collect, measure, and analyze eye gaze data. From this data, identification of eye fixations at four designated Areas of Interest (AOI) on a computer screen was achieved with an 85.3% accuracy.

INTRODUCTION

The objective of this project is to create a webcam-based tool that tracks eye movements by capturing normalized eye height and pupil location. Eye gaze data is analyzed to determine eye fixations within AOIs on the screen.

This tool is a low-cost design alternative that can be implemented remotely without the physical constraints of resource intensive alternatives. Existing alternatives include state-of-the-art eye tracking tools based on infrared technology, like Gazepoint GP3, which are more costly and less accessible.

DELIVERABLES

Constraints
- Low-cost
- Eye gaze and eye fixation data output for marketing application
- Internal webcam operates at maximum of 30fps
- Constant distance of the user from the screen

Deliverables (Figure 1)
- Identify the location of eye fixation and eye gaze within quadrants with accuracy
- Data analysis
  - Locations of eye gaze within AOIs
  - Points of eye fixation

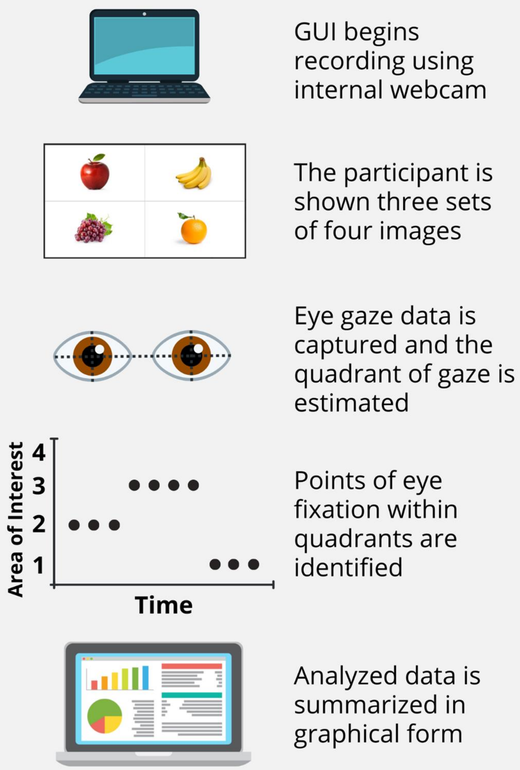

Figure 1: Project overview and deliverable flowchart

EXPERIMENTAL RESULTS

After comparing a few design alternatives, the following data capture and analysis process provided the most reliable results.

Step 1: Record the normalized eye height and pupil location in Figure 2.

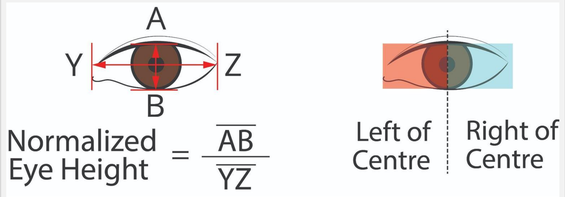

Figure 2: Method for obtaining eye height and horizontal pupil location for right eye

Step 2: Group the data into their corresponding rows and columns in Figure 3.

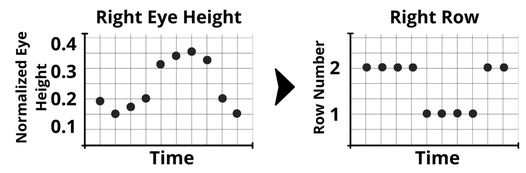

Figure 3: Categorizing raw data into rows

Step 3: Calculate the relative AOI (Figure 4) and average every 9 points to obtain points of fixation.

1	2
3	4

Figure 4: AOIs referencing convention

To calculate the points of fixation, the eye gaze tracking tool was calibrated to the environment and user. For one user, calibration and validation tests were run.

The calibration and testing methodology was divided into two phases.

Phase 1: Calibration Test
To categorize the data collected, threshold, minimum and maximum values for the normalized eye height and pupil location were needed. These values were determined by analyzing eye gaze data per quadrant.

Phase 2: Validation Test
A set of tests observing unknown AOIs were used to validate the calibration values. A sample of validation test results are shown in Table 1.

After completing 100 trials of the designed tool for validation, average accuracy values were observed.

Table 1: Sample of validation test results

Trial	Expected	Actual	Fixation Points			
			Identified	Correctly Identified	Accuracy (%)	Length (ms)
ji51	2 4 3	2 4 3	39	38	97.4	394.5
ji52	2 3 4	2 3 4	42	42	100	363.0
ji53	1 4 2	1 4 2	28	25	89.3	544.1
ji54	4 1 2	4 1 2	27	24	88.9	562.8
ji55	3 2 4	3 2 4	35	34	97.1	438.8
ji56	1 2 3	1 2 3	41	33	80.5	369.8
ji57	4 2 1	4 2 1	32	31	96.9	463.5
ji58	1 4 2	1 4 2	30	26	86.7	513.3
ji59	1 4 2	3 4 2	27	21	77. 8	574.8
ji60	3 1 2	3 1 2	31	29	93.5	394.5
Average		96.7%	33.2	30.3	90.8%	461.9

The following parameters were obtained:
- AOI identification accuracy: 85.7%
- Average number of eye fixation points per test: 33
- Eye fixation accuracy: 85.3%
- Eye fixation average length: 474.2ms

CONCLUSIONS

This innovative contribution applies a hybrid pupil point and eye height methodology to identify eye gaze. An eye fixation average length of 474.2ms was obtained. The accuracy of eye fixation identification was 85.3%. This was comparable to the desired absolute accuracy.

FUTURE WORK

In the future, the eye tracking tool may be improved by including a calibration to individual eye shapes, observing additional AOI, and increasing the overall accuracy and precision. In addition, working with different cameras, such as infrared cameras, may be experimented with to improve image quality.

ACKNOWLEDGEMENTS

We would like to thank Dr. Balasingam and Prarthana Pillai for their continued support and guidance on the project.