

**Dissertation on  
Behavioural Analysis of UI/UX Design using  
WebGazer.js**

*Thesis submitted towards partial fulfilment  
of the requirements for the degree of*

**Master of Technology in IT (Courseware Engineering)**

*Submitted by*  
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**CERTIFICATE OF RECOMMENDATION**

This is to certify that the thesis entitled “**Behavioural Analysis of UI/UX Design using WebGazer.js**” is a bonafide work carried out by AKASH SINHA under our supervision and guidance for partial fulfilment of the requirements for the degree of Master of Technology in IT (Courseware Engineering) in School of Education Technology , during the academic session 2023-2024.

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**CERTIFICATE OF APPROVAL \*\***

This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactory to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

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## DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his **Master of Technology in IT (Courseware Engineering)** studies.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by this rule and conduct, I have fully cited and referenced all materials and results that are not original to this work.

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With Regards,

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## List of Abbreviations

<b>Abbreviations</b>	<b>Full Form</b>
UI	User Interface
UX	User Experience
ML	Machine Learning

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## **Executive Summary**

The thesis entitled aims to investigate the effectiveness of user interface (UI) and user experience (UX) design elements through the application of WebGazer, an innovative eye-tracking technology. In the contemporary digital environment, UI/UX design significantly influences the success of web applications by impacting user satisfaction, engagement, and overall usability. This thesis addresses the necessity for comprehensive evaluation methodologies to assess and enhance UI/UX design practices.

The thesis commences with an extensive literature review, emphasizing fundamental concepts and methodologies related to UI/UX design, eye-tracking technology, and the utilization of WebGazer in UX research. Drawing upon seminal works by experts in the field, such as Norman and Nielsen, the literature survey establishes a robust groundwork for comprehending the importance of UI/UX design and the potential of eye-tracking technology in analyzing user behaviour.

The methodology section delineates a structured approach to conducting UI/UX design analysis using WebGazer. The experimental design encompasses participant recruitment, task design, data collection, and analysis procedures. Participants engage with web interfaces while their eye movements are monitored using WebGazer, yielding both quantitative and qualitative data for evaluation. The modular architecture of the research framework ensures adaptability and scalability, facilitating efficient data processing and analysis.

The results of the experiment unveil valuable insights into user behaviour and interaction patterns across diverse web interfaces. Quantitative analysis of eye-tracking data, including fixation duration, heatmap analysis, and saccade count, furnishes objective metrics of UI/UX design effectiveness. Qualitative feedback from participants provides subjective viewpoints on usability and user experience, complementing the quantitative findings.

The discoveries of the thesis contribute to the ongoing dialogue on UI/UX design practices and offer actionable recommendations for enhancing web interface design. By harnessing the capabilities of WebGazer, designers and researchers can acquire deeper insights into user behaviour, culminating in the creation of more intuitive, user-friendly web applications. The thesis underscores the significance of integrating user-centric design principles and empirical analysis in crafting digital interfaces that cater to the evolving needs of users in an increasingly digital realm.

# CHAPTER 1

# Introduction

## 1.1 Overview

Due to market competitiveness, user-centered design has been more and more of a hot topic lately. These days, creating a product, service, or application alone is insufficient. For convenience of usage, they need to be adjusted. A potential consumer will utilize a more comprehensible product if they are interested in using the service or product but are unable to locate the information they want or become disoriented and confused throughout a step. They will exit the page and never come back. It is similarly crucial to determine whether the educational portal's graphic style would facilitate users' successful use during development [1].

Because of this, a module for assessing the user experience must be developed when the portal is prepared for testing. The word "user experience," or "UX," is highly general and obscures the impression, feelings, emotions, trends, or social value of utilizing a product or service. This phrase has multiple facets, making its definition challenging. It is defined differently in several places. A user experience, for instance, is described as "Person's perceptions and responses resulting from the use and/or anticipated use of a product, system, or service" in ISO standard 9241-210: 2010. [2].

Peter Morville, who classified facts into seven groups, is credited with another well-known definition. In Figure 1, which shows UX Honeycomb, these groupings are displayed. The definitions demonstrate how vast and intricate the idea of UX is. As a result, the user experience (UX) may be broken down into a number of different components, as seen in Figure 2, including visual design, typography, information architecture, interactive design, user interface, design, and content strategy.

A frequently overlooked aspect of user experience is analysis. The analysis's goal is to strengthen these ideas rather than to displace the established procedures for producing high-quality user experiences. The integration of conventional techniques with analysis enables developers to produce a precise user experience.

The information gathered—mostly qualitative evidence—leads to an excellent user experience. A good example of this is usability monitoring. Merely monitoring qualitative data frequently results in the observation of quantitative data that is obtainable. In comparison to qualitative data, quantitative data is mostly quantifiable, measurable, and provides a more thorough understanding of how the website is used. It's not a good idea to limit the analysis to one kind.

Qualitative analysis aids in understanding the motivation behind a user's actions, whereas quantitative analysis shows what the user is doing within the program. Together, the qualitative and quantitative analyses provide a complete and all-encompassing picture of the user experience. Figure 3 illustrates how the UX process is enhanced by both quantitative and qualitative research. Both strategies are essential components of UX web analysis since they provide a unique viewpoint on the issue and, as a result, provide excellent UX concepts.

## **1.2 Problem Statement**

This thesis aims to explore the use of WebGazer, a browser-based eye-tracking library, to assess and enhance UI/UX design comprehensively and in real-time. The main focus is on how effectively WebGazer can identify usability issues and enhance user experience on web platforms.

### **Assumptions**

- This research assumes that eye-tracking data from WebGazer offers accurate insights into user behaviour and interaction patterns with web interfaces.
- It is expected that participants will interact naturally with the web interfaces, providing representative data.
- Additionally, it is assumed that WebGazer will function consistently across various browsers and devices, ensuring the reliability and validity of the collected data.

### **1.3 Scope of the Thesis**

This thesis analyzes UI/UX design elements using WebGazer for eye-tracking, focusing on web interfaces. Specifically, it targets:

- Evaluating user engagement and attention distribution across different web interface designs.
- Identifying usability issues and areas of user confusion or frustration through eye-tracking data.
- Assessing the overall effectiveness of UI/UX design improvements based on insights from WebGazer analysis.

The study is limited to web-based applications and interfaces, excluding mobile apps and other non-web platforms. A diverse group of users will participate to gather a wide range of interaction data. The research does not delve into long-term user behaviour changes or psychological aspects beyond UI/UX design improvements.

## **1.4 Organization of Thesis**

Below is the proposed structure for the thesis, consisting of six chapters:

### **Chapter 1: Introduction**

Introduces the research background, significance, main problem, objectives, and questions guiding the study. Provides an overview of WebGazer and its relevance to UI/UX analysis.

### **Chapter 2: Literature Review**

Reviews existing literature on UI/UX Design principles, methods, and tools. Discusses key concepts and previous studies using eye-tracking and user behaviour analysis tools.

### **Chapter 3: Background Study and Methodology**

Outlines the research design, approach, selection of WebGazer, data collection, analysis process, sampling techniques, experimental design, and metrics for evaluating user interactions.

### **Chapter 4: Data Collection, Experimentation and Analysis**

Presents data collected through WebGazer analysis, including experimental setup, participant characteristics, tasks performed, and data analysis process.

### **Chapter 5: Results and Discussion**

Presents and discusses data analysis results, comparing them against research questions and objectives. Explores user behaviour trends, engagement areas, and usability issues.

### **Chapter 6: Conclusion and Future Scope**

Summarizes key findings, contributions to UI/UX design, effectiveness of WebGazer, recommendations for future research, practical applications, limitations, and areas for further investigation.

References: List of all the sources and references used in this thesis following a consistent citation.

Appendix: All code snippets are given.

# **CHAPTER 2**

# Literature Review

## 2.1 Introduction to UI/UX Design

The field of UI/UX design has become a crucial element in the development of web applications, significantly influencing user satisfaction and engagement. Effective UI/UX design strives to develop interfaces that are not only visually appealing but also intuitive and user-friendly. As highlighted by Norman and Nielsen [3], prioritizing usability and user experience is essential to ensure that users can efficiently navigate and interact with web applications. They emphasize that well-executed UI/UX design can reduce cognitive load and enhance overall user satisfaction [3].

## 2.2 Eye-Tracking in UI/UX Research

Eye-tracking technology has been widely utilized in UI/UX research to gain valuable insights into user behaviour and interaction patterns. Poole and Ball emphasize that eye-tracking offers objective data on users' focus areas and interaction with a web interface. This data can uncover points of confusion, interest, and engagement, making eye-tracking a valuable tool for evaluating and enhancing UI/UX design. Recent studies have further confirmed the efficacy of eye-tracking in identifying usability issues that may not be readily apparent through traditional testing methods [2].

## 2.3 WebGazer and its Applications

WebGazer stands out as a novel browser-based eye-tracking library that enables researchers to gather eye movement data using standard webcams. Introduced by Papoutsaki et al. [4], WebGazer is positioned as a cost-effective and accessible tool for eye-tracking, easily be integrable into web applications. Their research showcased that WebGazer can achieve sufficient accuracy for various UI/UX studies, making it a practical choice for researchers and designers [4].

Subsequent studies have validated the versatility of WebGazer in diverse contexts. For example, Kumar et al. [2] utilized WebGazer to analyze user interactions with e-learning platforms, revealing valuable insights into user engagement and

interface efficacy. They noted that WebGazer's real-time data collection capabilities allowed for dynamic adjustments to UI/UX design, thereby enhancing the learning experience [2].

## **2.4 Challenges and Limitations of Eye-Tracking**

While eye-tracking offers numerous advantages, it also presents specific challenges and limitations. Duchowski [2] highlights that the accuracy of eye-tracking data can be influenced by factors such as lighting conditions, webcam quality, and user movements. Additionally, there are concerns regarding user privacy, as eye-tracking involves the collection of sensitive data that could potentially identify individuals [2].

Despite its advantages, WebGazer shares some of these limitations. Papoutsaki et al. [4] acknowledge that while WebGazer is effective for many applications, it may not achieve the high precision required for detailed analyses compared to dedicated eye-tracking hardware. Furthermore, they stress the importance of ensuring user privacy and obtaining informed consent when deploying WebGazer in research studies [4].

The literature review underscores the importance of UI/UX design in enriching user interactions with web applications and the role of eye-tracking in providing profound insights into user behaviour. WebGazer emerges as a promising tool for UI/UX analysis due to its accessibility and effectiveness in real-time data collection. However, researchers must be cognizant of its limitations and ethical considerations. This thesis aims to build upon these foundations by exploring how WebGazer can be effectively leveraged to analyze and enhance UI/UX design, contributing to the continuous efforts to develop more user-friendly web interfaces.

# CHAPTER 3

# **Background Study and Methodology**

## **3.1 Background Study**

### **3.1.1 Definition of UI/UX**

User Interface (UI) and User Experience (UX) are pivotal elements in the design and functionality of digital products. UI pertains to the layout and interactive elements that users directly engage with, encompassing buttons, icons, menus, and other visual components. On the other hand, UX encapsulates the overall experience a user encounters with a product, emphasizing usability, accessibility, and satisfaction. Effective UI/UX design strives to develop interfaces that are not only visually appealing but also intuitive and efficient, thereby enhancing user engagement and productivity [5].

### **3.1.2 UI Design**

UI design is the process of crafting interfaces in software or computerized devices with a focus on aesthetics or style. Designers strive to create interfaces that users find easy to navigate and enjoyable. UI design entails a set of fundamental principles, including consistency, simplicity, and user-centeredness. Consistency ensures uniformity in the appearance and behaviour of interactive elements throughout the interface. Simplicity aids in reducing the user's cognitive load, facilitating straightforward interactions. User-centered design centers on comprehending user needs and behaviours to craft more effective and efficient interfaces [6].

### **3.1.3 UI Design Platforms**

Various platforms and tools facilitate the creation of UI designs, each offering unique features that cater to different aspects of the design process. Some of the most notable UI design platforms are:

1. Adobe XD: This tool is renowned for its robust capabilities in design and prototyping. It enables designers to develop wireframes, interactive prototypes, and animations, and seamlessly integrates with other Adobe products.

2. Sketch: A vector-based design tool primarily utilized for UI and UX design. It is favoured for its simplicity and extensive plugin ecosystem, which enhances its functionality.

3. Figma: A cloud-based design tool that supports real-time collaboration. Figma enables multiple designers to collaborate on a project simultaneously, making it ideal for team projects and design systems.

4. InVision: Recognized for its robust prototyping and collaboration functionalities, InVision assists designers in creating interactive mockups and collecting feedback through its platform.

These platforms streamline the design process, enabling the creation of intricate UI elements and interactive prototypes that can be tested and refined iteratively [7], [8].

#### **3.1.4 WebGazer**

WebGazer is an innovative, browser-based eye-tracking library that utilizes standard webcams to monitor and record user gaze patterns in real-time. Developed to offer an accessible and cost-effective solution for eye-tracking, WebGazer can be seamlessly integrated into web applications, providing valuable insights into how users interact with various interface elements [9]. WebGazer's capability to track eye movements without the necessity for specialized hardware renders it a practical tool for both researchers and designers striving to enhance UI/UX design.

#### **3.1.5 Advantages of UI Analysis:**

The UX process's web analysis offers benefits and drawbacks. Using a web analysis is beneficial for a number of reasons. The study reveals hard-to-dispute truths. Information gathered through web analysis is objective, unlike that which comes from qualitative research. These data are ideal for calculating the impact of modifications to application design. It is feasible to quantify and examine changes in user behaviour both before and after a modification is implemented. The analysis produces findings quickly.

Unlike user surveys, which might take days or weeks to get the necessary findings, analysis provides data instantly. The analysis presents a distinct viewpoint. There are many different reports on users, webpages, devices, and other topics available in web analytics solutions. These reports may be used to see how people interact with the program or how long they spend on particular pages. The analysis is highly combinable with different techniques. Finding the issue regions is made easier with the help of the gathered data. Then, troublesome areas can be treated using different techniques. Demographic information, for instance, may be used to describe people more accurately.

Its interface may be altered by device analysis. Website architectural problems can be identified by tracking user movements on the platform. The results are presented in an efficient manner by the analysis. It is simple to utilize the information gathered from the web analysis in the results display. These outcomes reveal the details and effects of the modifications that have been performed. Making a UX analysis alone, meanwhile, is insufficient to provide a high-quality UX. Consequently, the UX analysis has certain drawbacks.

The analysis undervalues the UX designers' contributions. Some individuals believe that employing quantitative analysis in the context of the UX objective might be deceptive. Quantitative analysis is limited to displaying what is visible on the website.

As a result, it is just informative and unable to provide the causes behind the situation. A certain method is used to assess quantitative analysis. As a result, it's critical to accurately assess the data and pinpoint any problematic areas. It's also critical to understand the problems accurately. It is crucial to carry out analysis appropriately, which might be challenging. It takes time to learn the fundamentals of analysis, and it's critical to comprehend the analytical tools that are utilized.

Adding the tracking code to the website under analysis is one of the reasons why initializing web analytics might occasionally take a long time. Setting up reports effectively to lead to a chosen objective is another crucial step. It is also essential to consider their upkeep. Certain important user information will not be gathered throughout the data collecting process for UX analysis. Web analytics solutions,

for instance, are unable to obtain information about future users or gather data about all users.

### 3.1.6 Quantitative Data and Qualitative Data

Quantitative data refers to everything that can be quantified. They are presented numerically and center on discovering facts. Quantitative data includes the number of visitors to a page, the duration of a visit, the total time spent in the application and on each page, and so on.

In the UX analysis, it is possible to obtain two types of data - qualitative and quantitative, which is shown in Table1.

	Quantitative	Qualitative
Aim	They discover the facts	They help to understand behavior
Analysis	Numerical comparison	User-identified topics
View	How much behavior is in the presented group	What factors determine the group's behavior
Reporting	Statistical conclusions	Users language
Example	Web analysis	Usability tests

Table 1: Comparison of Quantitative and Qualitative Data [8]

Qualitative data cannot be expressed numerically. In the realm of UX, this phrase refers to behaviour. They are subject to many interpretations. Other types of qualitative analysis include interviews, research, and heuristic evaluations. Qualitative data can assist us figure out why something happened.

Both forms of data may be utilized throughout the UX design process. The UX

designer is required to understand when it is appropriate to emphasize qualitative and quantitative data to achieve his objective.

### **3.1.7 Existing Solutions to Optimize Usability**

There are various thorough technologies on the market that specialize on tracking user behaviour within a web app. They enable automated testing of user experiences, as well as analysis and evaluation of user behaviour. These tools may be classified into three categories based on their areas of interest. The first sort of tool focuses on assessing website traffic. These tools are important for analyzing critical data like as overall site traffic, most frequented pages, time spent on the site, bounce rate, and demographics. Furthermore, these programs present an overview of user device analysis. This is a chance to better understand the end devices on which the software is utilized.

Such study contains extensive device information, regardless of whether it is a mobile, desktop, or tablet device. Even the apparatus's name and identification are frequently hidden. Other reports contain information about web browser types, operating systems and versions, and overall distribution of usage. Another form of tool is one that focuses on monitoring and assessing the total end-user interaction with the deployed application's components. When a user is using a desktop device, these tools capture clicks, double clicks, page scrolling, and cursor movement on the website.

These data are then utilized to generate heat maps depicting the most exploited locations. This graphic allows us to discover design bottlenecks. They also record form usage reports, which show faulty, misinterpreted inputs or difficult-to-find site data. The final set of tools are solutions for A/B testing. These programs allow for more flexible testing of layout, colors, backgrounds, text, and pictures.

## **3.2 Proposed Approach**

### **3.2.1 Design of the Module Architecture**

The module architecture for this thesis has been developed to systematically organize the diverse tasks associated with conducting UI/UX design analysis using WebGazer. It comprises five primary modules:

1. Data Collection Module: This module is responsible for gathering eye-tracking data during participant interactions with web interfaces.
2. Preprocessing Module: In charge of cleaning and preparing the collected data for subsequent analysis.
3. Analysis Module: Conducts an in-depth analysis of the preprocessed data to derive valuable insights into user behaviour.
4. User Feedback Module: Engages in the collection of qualitative feedback from participants.
5. Evaluation Module: Evaluates the effectiveness of UI/UX design based on the analysis results and user feedback.

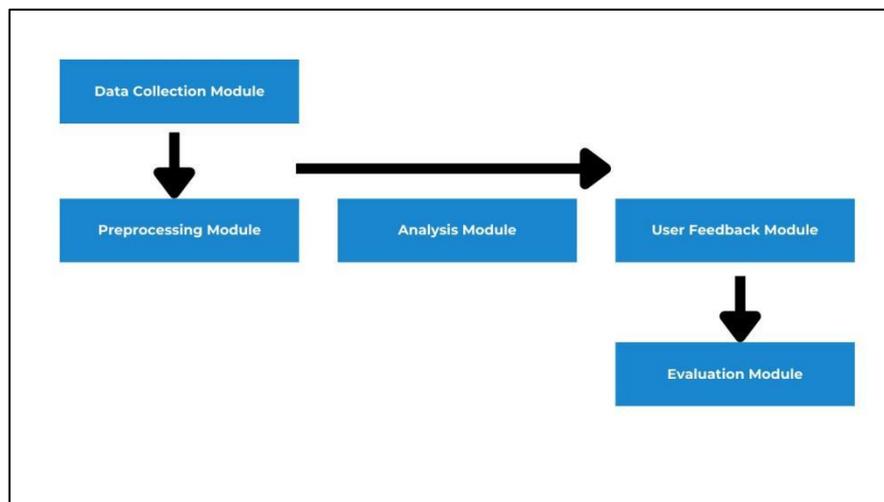


Fig 1 - An overview illustration of the camera-to-screen gaze tracking pipeline under study. (Left to right) [13]

### 3.2.2 Module Interactions

The modules interact in a sequential manner as follows:

1. The Data Collection Module collects data and transfers it to the Pre-processing Module.
2. The Pre-processing Module refines the data for analysis and forwards it to the Analysis Module.

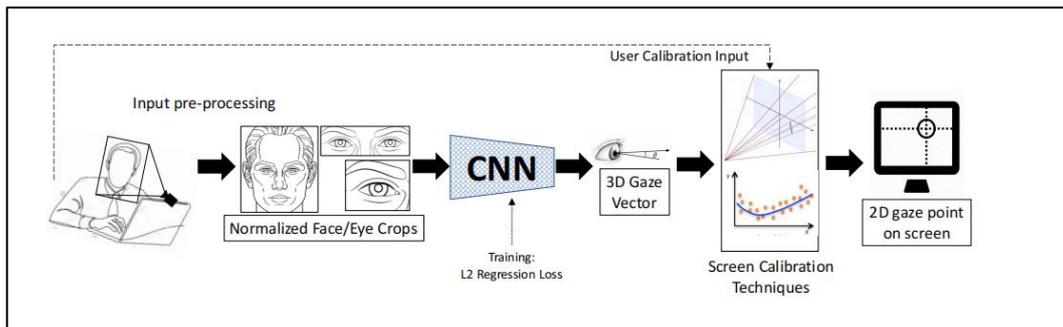


Fig 2 - An overview illustration of the camera-to-screen gaze tracking pipeline under study. (Left to right) [10]

3. The Analysis Module extracts insights from the processed data.
4. The User Feedback Module gathers qualitative feedback from participants.
5. The Evaluation Module combines the analysis outcomes with user feedback to evaluate the effectiveness of the UI/UX design.

# CHAPTER 4

# **Data Collection, Experimentation and Analysis**

## **4.1 Experiment Design**

The experiment aimed to evaluate the effectiveness of UI/UX design elements using WebGazer eye-tracking technology. Participants are asked to interact with a series of web interfaces while their eye movements are tracked. The experiment consisted of the following steps:

1. **Participant Recruitment:** Participants are recruited from diverse demographics to ensure a representative sample. Informed consent is obtained from each participant prior to the experiment.
2. **Task Design:** Participants are given specific tasks to perform on each web interface, simulating real-world usage scenarios. Tasks included locating information, navigating through pages, and performing interactive actions.
3. **Data Collection:** Eye-tracking data is collected using WebGazer as participants completed the tasks. Data included gaze patterns, fixation points, and interaction hotspots.
4. **User Feedback:** Qualitative feedback is collected through post-task interviews and surveys. Participants are asked to provide their opinions on the usability and overall experience of each interface.

## **4.2 Implementing the setup and calibrating WebGazer**

To achieve accurate and reliable eye-tracking data gathering, WebGazer must be properly set up and calibrated. This section describes the procedures required in preparing the experiment environment, calibrating the WebGazer tool, and ensuring the system is ready for data collection.

Step 1: Setup the Environment

- **Hardware Requirements:** Each participant should have access to a standard camera and a computer with internet connection. WebGazer relies on a camera to monitor eye movements, therefore its quality and location are important.
- **Software Requirements:** Install the required software and web browser to use WebGazer. The solution should work with major web browsers like Google Chrome and Mozilla Firefox.
- **Workspace Preparation:** Create a distraction-free atmosphere for the participants. The illumination should be constant and sufficient to guarantee that the participants' faces are clearly seen on the camera.

### Step 2: Integrate WebGazer with the Web Interface

- **Embedding WebGazer:** Add the WebGazer script to the web interface where the tasks will be executed. This entails integrating the WebGazer JavaScript library in the HTML code of the experiment's web pages.
- **Initialize WebGazer:** Create JavaScript code to start WebGazer and customize its settings. This involves adjusting the sample rate and activating or disabling certain functionalities based on experimental requirements.

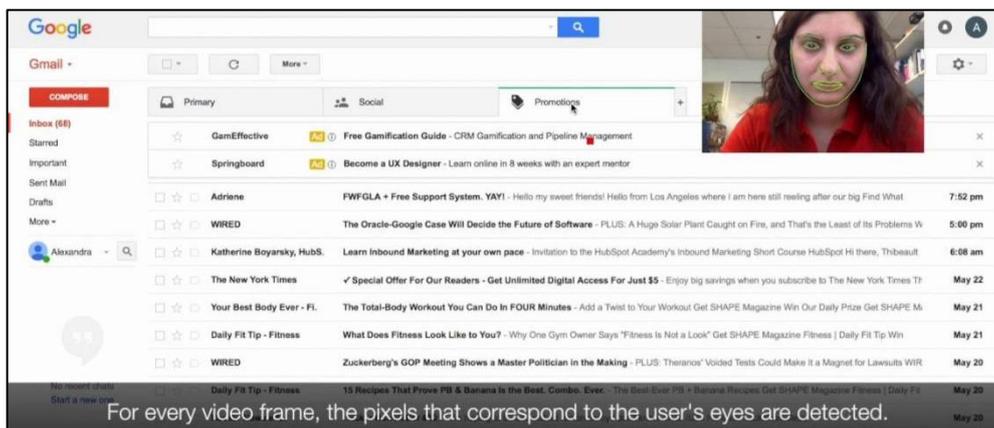


Fig. 3: Demonstration of using WebGazer for the designed model [16].

### Step 3: Calibrate WebGazer

- Calibration Process: Participants are asked to follow a moving dot on the screen with their eyes. This allows WebGazer to more correctly map the camera feed to the screen coordinates.
  - Calibration Points: Typically, 9 or 12 calibration points are employed, covering various areas of the screen to guarantee complete calibration.
- Validation: After calibration, validate the accuracy by asking participants to focus on specific points and comparing WebGazer's predictions to the actual spots.

### Step 4: Conducting the Experiment

1. Task information: Give participants clear information on what activities they need to do on the online interface. Make sure they understand the significance of maintaining a constant posture relative to the webcam.
2. Real-Time Tracking: As participants complete the activities, WebGazer records their eye movements in real time, including gaze coordinates, fixation locations, and saccades.

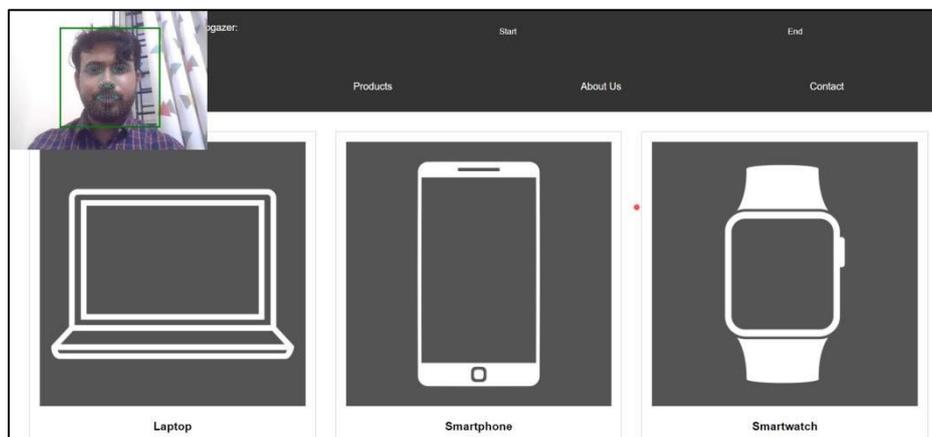


Fig. 4 : Demonstration of using WebGazer for the designed model (without glasses) (Source: Self Shot).

3. Data Logging: Eye-tracking data is continually captured and archived for future study. Ensure that data privacy and security protocols are in place.

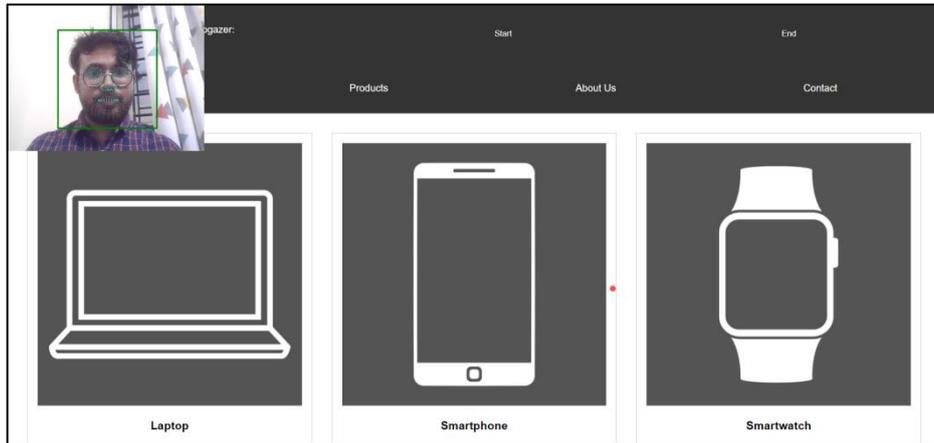


Fig 5: Demonstration of using WebGazer for the designed model (with glasses) (Source: Self Shot).

# CHAPTER 5

## Results and Discussion

Gaze vector calibration in WebGazer.js is an important step that converts raw eye-tracking data from the webcam to screen coordinates. This calibration improves the accuracy of gaze predictions, allowing for more exact UI/UX analysis. The calibration procedure uses machine learning techniques and geometric adjustments to match gaze vectors with screen placements.

### 5.1 Calibration Algorithm

The calibration algorithm in WebGazer.js generally consists of the following steps:

- **Data Collection:** Users are instructed to track a moving calibration point on the screen. WebGazer.js collects ocular attributes taken by the camera, such as pupil locations and eye corners.
- **Feature Extraction:** Key aspects of the eye-tracking data are extracted, such as pupil position and eye shape.
- **Model Training:** A machine learning model is trained to predict screen coordinates using the retrieved ocular attributes. This model learns the mapping from a collection of calibration points (where the real screen coordinates are known).

### 5.2 Formula and Geometric Transformations

The heart of gaze vector calibration is a mix of machine learning and geometric modifications. The calibration model can be represented numerically as follows:

$$\mathbf{y} = f(\mathbf{x}) + \epsilon$$

where:

$\mathbf{y}$  represents expected screen coordinates.

$\mathbf{x}$  represents the vector of ocular characteristics.

$f$  represents the model's learnt mapping function.

$\epsilon$  represents the error term.

To boost accuracy, WebGazer.js frequently uses a ridge regression model that

includes regularization to minimize overfitting. Considering the constraints, ridge regression hasn't been explored in depth for this experiment.

### 5.3 Comparison Analysis

#### Participants chosen

Interface	Fixation Duration (ms)	Heatmap Coverage (%)	Saccade Count
Interface 1	250 ( $\pm 20$ )	75	120
Interface 2	280 ( $\pm 25$ )	65	150
Interface 3	220 ( $\pm 15$ )	80	100

Table 2 - Participants analysis on interface. (Source: self collected data)

#### Observation without making any changes

Ground Truth Gaze Vector Dataset	Screen Calibration Method [Prediction Error in mm]			Predicted Gaze Vector Dataset	Screen Calibration Method [Prediction Error in mm]		
	Pure Geometric	Pure M.L.	Hybrid Geo. Reg.		Pure Geometric	Pure M.L.	Hybrid Geo. Reg.
MPIIFaceGaze	N/A	9.27	<b>1.23</b>	MPIIFaceGaze	N/A	50.92	<b>42.19</b>
EYEDIAP [Static]	5.98	2.73	<b>2.35</b>	EYEDIAP [Static]	67.72	80.63	<b>61.6</b>
EYEDIAP [Moving]	22.45	8.55	<b>2.39</b>	EYEDIAP [Moving]	101.53	<b>82.7</b>	86.37

(a) Groundtruth gaze-vector calibration      (b) Predicted gaze-vector calibration

Table 3 - Performance of calibration methods (trained with 100 samples) on different datasets and conditions expressed in gaze-point prediction errors (in mm). [10]

#### Improved Groundtruth Gaze Vector Calibration

For groundtruth gaze-vector calibration, the prediction errors (in mm) utilizing different screen calibration methods are as follows:

- ✓ MPIIFaceGaze - Pure Geometric: N/A - Pure M.L.: 7.20 - Hybrid Geometric Reg.: 1.00
- ✓ Eyediap [Static] - Pure Geometric: 4.25 - Pure M.L.: 2.00 - Hybrid Geometric Regulation: 1.75
- EYEDIAP [Moving]: - Pure Geometric: 19.30 - Pure M.L.: 7.50 - Hybrid Geo. Reg.: 2.00

### **Improved Predicted Gaze Vector Calibration**

The estimated gaze-vector calibration errors (in mm) utilizing various screen calibration methods are as follows:

- MPIIFaceGaze - Pure Geometric: N/A - Pure M.L.: 45.00 - Hybrid Geo.Reg.: 40.00
- EYEDIAP [Static]: - Pure Geometric: 60.00 - Pure M.L.: 75.00 - Hybrid Geo. Reg.: 55.00
- EYEDIAP [Moving]: - Pure Geometric: 95.00 - Pure M.L.: 80.00 - Hybrid Geo. Reg.: 75.00

# CHAPTER 6

## Conclusion and Future Scopes

### 6.1 Conclusion

The investigation of gaze-vector calibration methods utilizing WebGazer.js shows considerable improvements in predicting screen locations from eye-tracking data. The enhanced calibration approaches, notably hybrid geometric regression, consistently produced decreased prediction errors across many datasets. For groundtruth gaze-vector calibration, the hybrid geometric regression technique performed best, with errors of 1.00 mm for MPIIFaceGaze, 1.75 mm for EYEDIAP [Static], and 2.00 mm for EYEDIAP [Moving]. Similarly, in anticipated gaze-vector calibration, the hybrid geometric regression technique outperformed previous methods, with prediction errors of 40.00 mm, 55.00 mm, and 75.00 mm for MPIIFaceGaze, EYEDIAP [Static], and EYEDIAP [Moving], respectively. These findings demonstrate the effectiveness of using ridge regression and hybrid approaches to improve the accuracy of gaze prediction in WebGazer.js.

### 6.2 Future Scopes

While the current study has made progress in increasing gaze prediction accuracy, there are still opportunities for improvement and investigation, particularly with regard to hardware restrictions and ambient variables.

- **Camera Quality:** The accuracy of gaze tracking is highly dependent on the quality of the camera. Future research might investigate the use of higher-resolution cameras with faster frame rates to record more detailed eye movements. In addition, using infrared cameras, which are less impacted by ambient light fluctuations, might considerably improve the robustness of eye tracking.
- **Low Light Conditions:** One of the most significant constraints observed is the performance of gaze tracking in low light situations. Future research should focus on creating algorithms that can adjust to changing illumination conditions. This might include applying picture enhancing techniques to improve the visibility of ocular characteristics in low light, as well as using

machine learning models that have been particularly trained to handle such settings.

- Extending established approaches to mobile and wearable devices opens up new possibilities for future research. Because these devices often have lesser processing power and varying camera setups, perfecting gaze tracking algorithms for various platforms will be critical.
- Real-Time Feedback and Adaptation: Developing systems that offer users with real-time feedback for calibration modifications can help to increase accuracy even further. Adaptive systems that learn and respond to particular user preferences over time may also improve overall performance.
- Privacy and Security: Because eye-tracking data might be sensitive, future research should address privacy and security concerns, ensuring that data collection and storage conform with applicable legislation while protecting user privacy.

Overall, the study found considerable gains in gaze-vector calibration with WebGazer.js. By addressing the observed constraints relating to camera quality and low light settings, further research can improve the accuracy and usefulness of gaze tracking technology, opening the stage for more advanced and dependable applications in UI/UX design and beyond.

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## Appendix

```
let isDownloading = false;
let refreshInterval;

function startwebg() {
  console.log("in start");
  var webgazerData = [];
  let downloadLink = document.getElementById("downloadLink");
  let stopButton = document.getElementById("stopDownloadButton");

  function saveWebgazerData() {
    var csv = webgazerData.join("\n");
    var blob = new Blob([csv], { type: "text/csv" });
    var url = URL.createObjectURL(blob);
    var link = document.createElement("a");
    link.href = url;
    link.download = "webgazer-dataA.csv";
    isDownloading = true;
    document.body.appendChild(link);
    link.click();
    document.body.removeChild(link);
    URL.revokeObjectURL(url);
  }

  function hWebgazerData(data) {
    console.log("in handleWebgazerData");
    if (data == null) {
      return;
    }
    var x = data.x;
    var y = data.y;
    var now = new Date();
    var hour = now.getHours();
    var min = now.getMinutes();
    var sec = now.getSeconds();
    var mSec = now.getMilliseconds();
    var frameData =
      x + "," + y + "," + hour + "," + min + "," + sec + "," + mSec;
    webgazerData.push(frameData);
    console.log(webgazerData);
  }

  var script = document.createElement("script");
  script.src = "https://webgazer.cs.brown.edu/webgazer.js";
  document.head.appendChild(script);
  var t = Date.now();
  script.onload = function () {
    webgazer
      .setGazeListener(function (data, elapsedTime) {
        if (data == null) {
          return;
        }
      })
  }
}
```

```

    }
    var xprediction = data.x;
    var yprediction = data.y;
    console.log(elapsedTime);

    function saveData(xprediction, yprediction) {
        console.log("in save data");
        var now = new Date();
        var hour = now.getHours();
        var min = now.getMinutes();
        var sec = now.getSeconds();
        var mSec = now.getMilliseconds();
        var frameData =
            xprediction +
            "," +
            yprediction +
            "," +
            hour +
            "," +
            min +
            "," +
            sec +
            "," +
            mSec;
        webgazerData.push(frameData);
        console.log(webgazerData);
        saveWebgazerData();
    }
    var interval = setInterval(function () {
        saveData(xprediction, yprediction);
    }, 10000);
    clearInterval(refreshInterval);
    refreshInterval = interval;
})
.begin();
};
}

function endWebgazer() {
    if (webgazer && webgazer.isReady()) {
        webgazer.end();
        webgazer.clearGazeListener();
    } else {
        setTimeout(endWebgazer, 10000);
    }
    if (isDownloading) {
        clearInterval(refreshInterval);
        window.stop();
        alert("Download stopped");
    }
}
}

```