University of Kerbala
College of Computer Science & Information Technology
Computer Science Department

Attractive Regions Extraction in Commercial Advertisement Based on Eye Tracking Analysis

A Thesis

Submitted to the Council of the College of Computer Science & Information Technology / University of Kerbala in Partial Fulfillment of the Requirements for the Master Degree in Computer Science

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Certification of the Examination Committee

We hereby certify that we have studied the dissertation entitled (**Attractive Regions Extraction in Commercial Advertisement Based on Eye Tracking Analysis**) presented by the student (**Taisir hazim Alhilo**) and examined him/her in its content and what is related to it, and that, in our opinion, it is adequate with (**Viva Result**) standing as a thesis for the Master degree in Computer Science.

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Dedication

To

The Prophet Muhammad, may God bless him and grant him peace, and his household, the infallible, good, and pure imams

My dear mother, from whom I saw the path of my life and from whom I drew my strength and my self-esteem,

My sister and brothers, who supported me throughout my educational career

A piece of paradise, the holy Karbala, which embraced me, the city of Al-Hussein, peace be upon him.

Taisir H. Alhilo

Acknowledgement

Alhamdulillah rab Al-Almeen, and prayers and peace be upon the most honorable of the prophets and messengers, Muhammad and his good and pure family.

I would like to express my deep and sincere gratitude to my research supervisor, Assistant Professor Dr. Akeel A. Al-Sakaa, for his efforts, scientific instructions, good advice, and keenness to master every detail, small and large, which had a great impact on enriching the message. And show it at this scientific level. Working and studying under his supervision was a great privilege and honor. I am very grateful for what you have given me; may Allah reward it.

I extend my sincere thanks and gratitude to the Dean of the College of Computer Science and Information Technology, all members of the teaching staff, the head of the computer department, and all graduate studies staff in the College of Computer Science and Information Technology at the University of Karbala.

I am incredibly grateful to my family , my mother , my brothers , and Dr. Hiba Jabbar for their moral support and continuous encouragement.

Abstract

In the dynamic landscape of marketing, understanding consumer behavior and optimizing advertisement strategies are essential for success. This study investigates how eye tracking analysis can be help understanding the subtleties of customer behavior and find regions of interest influencing the creation of commercial advertisements.

The comprehensive methodology involves data collection, pre-processing, processing, and Points of Interest. Through eye tracking technology, participants' gaze patterns are meticulously recorded as they engage with images. Subsequent stages encompass noise reduction, data categorization, point recurrence calculation, and identification of points of interest.

The findings present the significance of eye tracking in capturing visual attention patterns, shedding light on the areas that truly engage participants. Principal component analysis (PCA) is employed to Dimension reduction to get more accurate data.

Methodology applied to impose three regions of interest for each image. Presenting three images to a group of 20 participants the effectiveness which has been calculated of each image.

The data generated by the eye-tracking device was subjected to processing, and by calculating the region that contains the most points and the largest number of people who viewed it, the region with the most views and interest was determined.

By comparing the regions imposed as the most important for each image with the resulting regions, it was found that image number two obtained 90% percentage, which is the highest, while image number one obtained 87% percentage, and image number three obtained 70% percentage, which is the lowest.

Declaration Associated with this Thesis

Some of the works presented in this thesis have been published or accepted as listed below.

1) The research paper entitled: “Eye tracking review: importance, tools, and applications” is presented at the International Conference on Emerging Trends and Applications in Artificial Intelligence (ICETAI) held on September 08-09, 2023 and accepted to publish in Springer Scopus (Q4) as a proceedings book volume in the Book Series, Lecture Notes in Networks and Systems (LNNS).

2) T. Alhilo and A. Al-Sakaa, "Handling Noisy Data in Eye-Tracking Research: Methods and Best Practices," 2023 International Workshop on Biomedical Applications, Technologies and Sensors (BATS), Catanzaro, Italy, 2023, pp. 39-44, doi: 10.1109/BATS59463.2023.10303090.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

Abbreviation	Description
Ad.	Advertisement
AI	Artificial Intelligence
AOIs	Areas of interest
ASD	Autism spectrum disorder
DEA	Data envelopment analysis
EDA	Electrodermal activity
EEG	Electroencephalogram
ET	Eye Tracking
fMRI	Functional MRI
ROIs	regions of interest
HR	Heart rate
ERD ET	Entity Relationship Database Eye Tracker
VR	Virtual reality
MWL	Mental workload
PCA	Principal Component Analysis
IQR	Interquartile Range

CHAPTER ONE

INTRODUCTION

1.1 Overview

Human eyes have distinct physical, photometric, and motion properties. These features provide critical information for eye recognition and tracking. In our daily lives, we can determine a person's emotional condition, mental occupancy, and want based on their eye movements. Recognize the qualities of the visual environment and acquire information that is crucial to our existence through our eyes. Furthermore, in the field of image and video processing, the eyes play an important part in face identification and recognition [1].

Eye tracking applications are becoming more common in fields such as cognitive science, psychology, human-computer interaction, web design, e-learning, and marketing research. Researchers might learn more about how individuals explore and learn from their surroundings by analyzing eye movement data and fixation information, and therefore enhance the product or learning theory [2].

There are fewer studies on the use of eye tracking technology in advertisement design. Commercials are extremely important in promoting products and services to customers. Marketers face the problem of efficiently grabbing and holding customers' attention in the age of digital media and the proliferation of advertising platforms [3].

As a result, for businesses looking to optimize their advertising spending, knowing the impact of commercial advertisements and making educated judgments regarding their design and placement have become critical.

The most common method of estimating the commercial is for the advertisement business to gather questionnaires filled out by individuals after seeing the advertisement. To assess advertisement performance, the advertising business organizes and analyzes the responses in the surveys.

The aims find the regions of strength that most attract attention in advertisements through eye tracking of participants using a device "Tobii EYEX" in order for advertising companies to use them to design more accurate advertisements and interact with the people concerned.

The study's findings will provide marketers and advertisers with useful insights into the design and optimization of commercials. Marketers may use eye tracking analysis to make data-driven decisions about ad placement, graphic components, and content, thereby improving the overall success of their advertising campaigns. Furthermore, the findings of this study have the potential to aid businesses such as digital marketing, retail, and media, where understanding customer attention and response is crucial to corporate success.

1.2 Problem Statement

- Human eye movement and the psychological mechanism of visual information processing are inextricably linked. Users will perform a series of quick eye movements during the product cognition process. The user's perception, and ultimately the human cognitive mechanism and behavior, may be explained by examining the user's initial effective visual fixation point. When observing product modeling design, eye movement represents the consumer's visual techniques, and it also serves as an objective representation of the subjective thinking process.

- The problem addressed by this research is the search for strengths and weaknesses by showing a group of people a picture of a specific advertisement. Then take data from the eye tracking device and extract information from it that helps companies benefit from it later when working on a future design.

- Find the strengths and weaknesses of advertisements using eye tracking data, providing insights for more effective future ad design and marketing strategies.

- This work gives the data that advertising businesses require to illustrate the level of people's interaction and attention to their design and its strengths in order for them to be able to submit a bid to create an advertisement.

1.3 Thesis Organization

There are five chapters in the thesis. Every chapter starts with a synopsis that highlights the major contributions. The following are the chapter summaries:

Chapter 1: Briefly introduce the thesis topic and its importance. Outline the research objectives and the structure of the thesis.

Chapter 2: Define eye tracking and its fundamental concepts; discuss types of eye tracking technologies, eye movements, and applications. Eye tracking is used in the advertisement and Principal Component Analysis PCA algorithm.

Chapter 3: Detail the methodology used for the eye tracking study. Explain the data collection process, including participant selection.

Chapter 4: Presentation of the findings from the eye tracking study Use charts, graphs, and visual aids to illustrate the results.

Chapter 5: Explains Conclusion Statements and Future Work.

CHAPTER TWO

THEORETICAL BACKGROUND

2.1 Overview

This chapter explores eye tracking, a crucial tool for understanding consumer behavior and optimizing advertising strategies. It discusses various tools, eye movements, and metrics, with a focus on their use in advertising. The chapter also discusses the classification of eye tracking data, focusing on supervised and unsupervised learning techniques. This knowledge will be used in subsequent chapters to understand consumer behavior and optimize advertising strategies.

Eye tracking is the measurement of gaze point or eye motion towards contact and has gained significant attention for understanding human visual attention in various fields such as reading, perception, memory, attention, ophthalmology, neuroscience, animal research, human-computer interaction, human factors, consumer behavior, and optometry [4].

Eye tracking is expected to become a standard feature in computers and augmented reality headsets, with its prevalence expected to grow. It relies on corneal reflection, where a small infrared light is emitted into the eye [5]. The camera captures the image and determines the light source's reflection on the cornea and pupil, calculating a vector based on the angle between the reflections [6].

Eye-tracking studies assume that fixation aligns with attention, but empirical evidence suggests otherwise. Participants' fixation can be decoupled voluntarily when instructed to maintain a fixed gaze while attending to peripheral vision stimuli [7].

2.2 Eye Tracking tools and equipments

Eye tracking solutions involve capturing and analyzing eye movement data using gear and software. Eye trackers use infrared light sources, cameras, and sensors. Recent advancements in hardware and software have transformed traditional equipment into affordable, wearable devices that can be quickly analyzed using sophisticated software [8].

2.2.1 Eye Tracking Hardware

Eye tracking hardware includes infrared illuminators, high-resolution cameras, and sensors to accurately measure eye movements. These devices can be monocular or binocular and can measure eye properties like pupil size and corneal reflection. Mounting hardware is needed for stable data collection, and eye tracking devices can be categorized based on their form and usage. These components are essential for precise eye movement monitoring in low-light conditions [7].

A. Mobile Eye Tracking Devices:

Also known as head-mounted devices, these are wearable gadgets equipped with a secondary scene camera to capture the user's field of view.

These devices, illustrated in Figure (2.1a-c), take the form of headbands, glasses, or helmet-mounted systems, allowing users to move freely during experiments. Mobile devices, primarily binoculars, tend to offer greater accuracy compared to remote equipment [9].

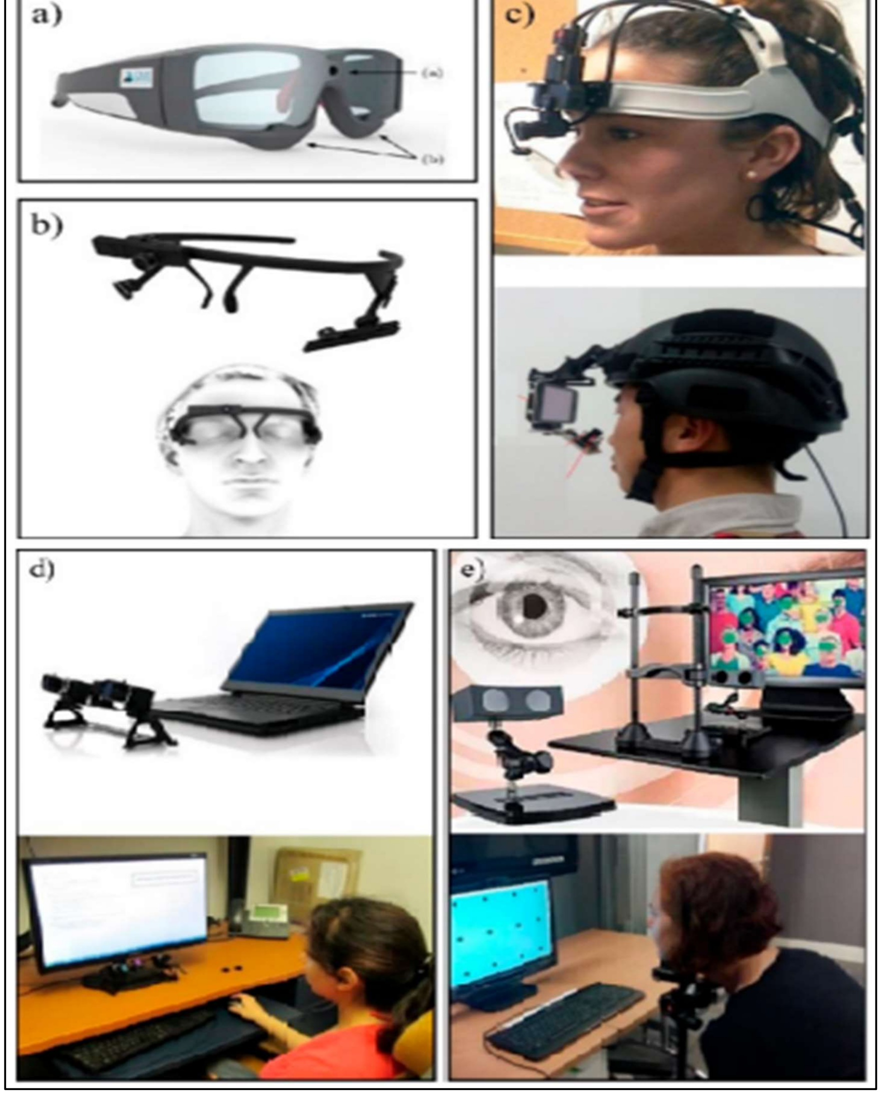

Figure 2.1 Types of eye tracking devices: (a)eye tracking glasses, (b)headband,(c)helmetmounted,(d)remote or table,(e)tower-mounted [10]

Mobile eye tracking devices are suitable for real-world investigations, tracking gaze across the field of vision. Head-mounted devices are comfortable and can be paired with EEG.

However, they have limitations such as difficulty in direct sunlight, windy or wet conditions, and less precise peripheral eye movements [11]. Additionally, they lack an absolute coordinate system, causing data inaccuracies [12].

B. Remote Eye Tracking Devices:

They are also sensitive to infrared (IR) sources, such as sunlight, especially when reflected in the participant's eyes. Remote eye tracking systems use head-supporting towers to enhance accuracy by restricting head movement [14], as illustrated in Figure (2.1d-e).

These towers, which can achieve saccade resolution two to five times greater than head-free ones, are less realistic but yield high-quality data. However, their limited placement options limit their application in dynamic contexts, making them more suitable for high-precision investigations where participants focus on a stationary screen [13].

Table 2.1: Comparison between some devices

Device	Tobii X2-60	Tobii X2-30	Tobii glasses	The Eve Tribe	Tobii EyeX
Sample rate	60 Hz	30 Hz	30 Hz	30 Hz / 60 Hz	30 Hz
Latency	< 35 ms	50-70 ms	-	<20 ms / 60 Hz	< 50 ms
Recommended screen size	Up to 25" (16:9)	Up to 25" (16:9)	-	Up to 24"	Up to 27"
Working distance	40-90 cm	40-90 cm	60-250 cm	45cm–75cm	60-90 cm
Weight	200 g	200 g	75 g	70 g	200 g
Size	184 ×28 ×23 mm	184 ×28 ×23 mm	123 ×83 ×32.5 mm	20 ×1.9 ×1.9 cm	184 x 28 × 23 mm
Software included	S1	S1	S1	S1	S1
SDK	Si	Si	Si	Si	Si
Price	> €40,000	> €20,000	€18,798	€75	€1,249
Connection	USB 2.0	USB 2.0	-	USB 3.0	USB 3.0

In this research, used the Tobii EyeX device which is relatively inexpensive device that allows applications and games to be controlled by the user and is based on a controller with built-in infrared micro-projectors and a camera that tracks the user's eye position see Figure (2.2). The software complex allows the program to track the direction of the user's gaze and identify a user-selected control.

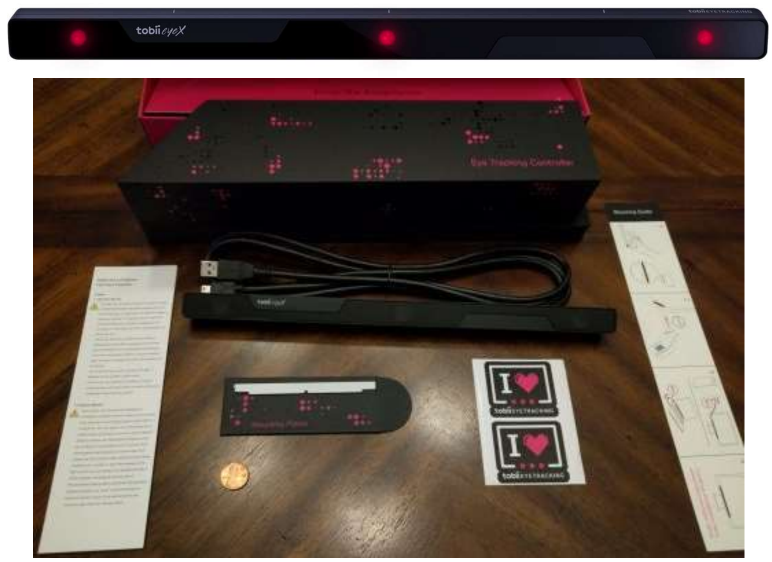

Figure 2.2 Tobii EyeX Device

This device works on Windows 7, 8, 8.1, and 10 operating systems and requires a USB 3.0 port. Recommended specifications: Intel i5 or i7 processor with a frequency of 2.4 GHz or higher, 8 GB of RAM. This controller works with displays that are 27 inches or smaller. The device can be attached to a lower part of your display and requires 1.27 cm (0.5 inch) of vertical clearance.

Tobii EyeX was developed to make working with PCs faster and easier for those who lack motor activity. Coupled with specific software solutions (various virtual keyboards and some other apps), this eye-tracking system can easily be turned into an assistive technology for completely paralyzed patients.

Tobii EyeX Device Features

1- The device offers exceptional accuracy in capturing a participant's eye movements. This enables the recording of precise gaze points and facilitates a comprehensive analysis of visual attention patterns.

2- Participants' eye tracking data is captured in real-time. This not only provides immediate insights but also allows for dynamic adjustments in experimental conditions, enhancing the reliability of the collected data.

3- The device is designed with user-friendliness in mind, ensuring that participants can comfortably interact with the interface while their eye movements are being tracked.

4- versatile and can be applied to a range of research contexts, including studies related to consumer behavior, decision-making, and user experience analysis.

2.2.2 Eye tracking steps

Although the features differ from one company to the next, the following are the key features and capabilities of eye tracking software:

a. Data Collection: Software makes it possible to capture and synchronize eye movement data with other factors such as stimulus presentation or task performance.

b. Calibration and Validation: Software guides the calibration process in eye tracking research, ensuring accurate gaze-to-screen mapping and providing validation tools to assess the quality and reliability of eye tracking readings, thereby enhancing data dependability.

c. Data analytic: Software provides a variety of analytic tools for extracting eye movement measurements, creating visualizations (such as heatmaps or gaze plots), and doing statistical analyses on the acquired data.

Dedicated software may be required (depending on the developer)

- Different forms of eye trackers (spectacles versus screen-based)
- A unique eye tracker
- Distinct stimuli (static vs. dynamic)

However, various integrated software solutions for data collection and analysis are available, as illustrated in Table (2.1).

Table 2.2: A list of eye tracking software currently used, their characteristics, and their applications [15]

Software/hardware	Hardware	Supported Platforms	Applications
EyeSeeCam	Goggles		Medical
Tobii Pro Glasses2	Mobile portable device like laptop	Unity	Professional performance, consumer behavior, assistive technology, and scientific research
FOVE	headset foam pads and Mask	Unity, Unreal, Xenko	It is the first VR headset to have embedded eye-tracking, Gaming, education, healthcare and medical, movies, social communication, and development.
Varjo	headset foam pads and Mask	Unrea, OpenXR, and Unity	Design, training, simulation, and research.
Eyegaze Edge	Screen with Infrared camera and sensors	NA	Locked-in users to communicate with the world via robust, accurate eye tracking devices, and software

Eye tracking software is becoming increasingly popular and affordable, making it more accessible to a wider range of users. As eye tracking technology continues to develop, we can expect to see even more innovative and useful applications for eye tracking software in the future.

2.3 Eye Movements and Metrics

It includes different types of eye movements, including fixations, saccades, bending, and pupil dilation or constriction [16], as shown in Figure (2.3).

These movements have been closely associated with cognitive processes, guided by the eye-mind and immediacy assumptions introduced by Just and Carpenter in 1980.

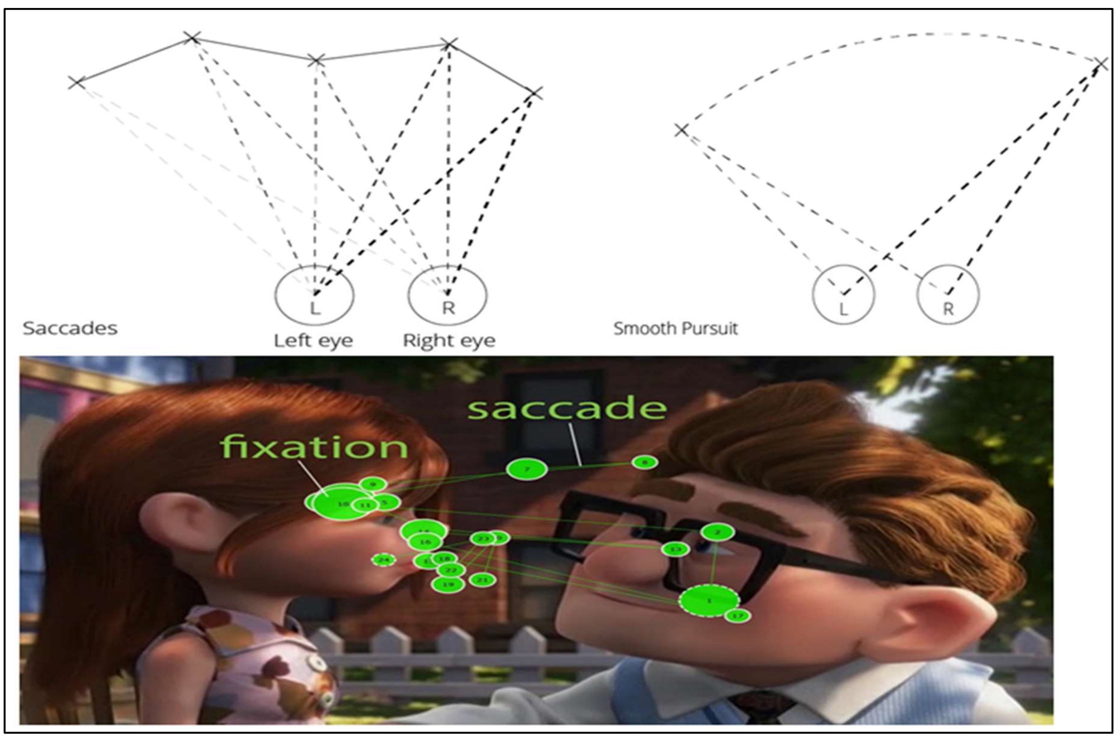

Figure 2.3 Eye Movements (Fixation, Saccades, Smooth Pursuits) [17]

These assumptions suggest that what we focus on is promptly processed without any discernible delay. However, it is essential to acknowledge that these assumptions have limitations, particularly in explaining phenomena like mind wandering that can occur independently of eye movements [17]. Despite these limitations, they serve as the foundational theory behind eye tracking.

Utilizing visualization techniques such as fixation, saccade, scanpath, and heat map analysis, various parameters such as gaze points, pupil size, and mouse location can be extracted.

This technology empowers businesses to monitor the eye behaviors of numerous customers in real time. Therefor it enables data-driven decision-making in diverse fields like marketing, accounting, banking, stress level analysis in patients, and IT personnel management [18].

A plethora of eye metrics have been identified and associated with various cognitive, emotional, and physiological states. These metrics hold the potential to provide a deeper understanding of the human mind, opening doors for applications that can interpret an individual's mental and emotional state based on their eye movements.

2.3.1 Fixation

Eye movements, particularly fixations, serve the vital function of stabilizing the retina when focusing on a stationary point of interest [20]. A fixation occurs when the eye remains still and the pupil remains stationary for a duration of approximately 180-300 milliseconds [18],[19]. During a fixation, individuals gather new information from an object, stimulus, or location [20].

Various measures related to fixations, including fixation frequency, fixation duration, fixation duration max, and fixation duration standard deviation, have been linked to human performance and various cognitive attentional processes [20]. For instance, the distribution and length of fixations on areas of interest (AOIs) can offer valuable insights into a pilot's situation awareness (SA) performance and skill level [21].

Studies in the construction industry have revealed that workers with a heightened perception of risk tend to have longer fixations on objects they initially identify as threats [22].

Moreover, a higher number of fixations on relevant AOIs has been associated with a greater frequency of detecting failures [24]. Conversely, shorter fixation times have been connected to anxiety and a heightened state of alertness [23].

Fixations are instrumental in decision-making processes, facilitating the acquisition of fresh information related to prior decisions and validating judgments for future reference. Additionally, fixations act as nodes in the decision-making network, connecting various cognitive processes that influence decision-making [25]. This relationship between eye fixations and mental processes highlights their potential utility in generating a wide range of insights. Research conducted by Glaholt and Reingold [26] has explored the impact of eye movement tracking as a process tracing methodology in decision-making research.

2.3.2 Saccades

Rapid eye movements occur when a person shifts their gaze between fixations [27]. These movements are typically brief, lasting approximately 10-100 milliseconds, during which the transmission of visual information is inhibited [28]. Consequently, saccades are not directly linked to cognitive processing [18].

However, specific saccade characteristics have been associated with various mental states. Saccade velocity, for instance, has been correlated with feelings of lethargy, tension, and fatigue [29], [30].

The saccade rate tends to decrease with fatigue and demanding tasks [31]. Additionally, saccadic length has been used as an indicator of mental workload (MWL) and observed to increase with higher MWL, with very short saccades indicating the presence of cognitive conflict [32].

2.3.3 Smooth Pursuits

A critical ocular motion is used for tracking moving targets. These pursuit movements are akin to control systems with built-in negative feedback mechanisms. Rather than pinpointing the exact position of a user's gaze on the interface, these interfaces rely on the gaze trajectories resulting from the user's eye tracking of a moving object for object recognition [7].

Users engage in tracking a moving object with their eyes, and the resulting gaze trajectory is compared to those of moving objects displayed on the interface. An essential advantage is that this approach is invariant to the gaze's starting position, effectively eliminating the need for a calibration phase [33].

In their initial implementation of a smooth-pursuit-based interface, Pearson's product-moment correlation was used to establish a connection between the gaze trajectory and the moving objects in the interface. It was observed that detection rates were lower when interface items followed linear trajectories as opposed to circular ones.

To enhance detection performance, researchers have developed interfaces based on linear pursuit eye movements and other techniques. For instance, Cymek et al. [34] applied smooth pursuit eye movements to enter a PIN code. Their interface featured 16 dynamic components, each moving in three segments with alternating horizontal and vertical motions. Target identification relied on the combination and categorization of gaze trajectory sequences.

This interface concept was later adopted by Lutz and Ruff [35] in the creation of smoovs, a gaze-typing system based on two-segment pursuit eye movements. Typing efficiency was further improved by incorporating word prediction capabilities [36].

Additionally, Schenk et al. [37] developed a system that integrated multiple eye movements, such as fixation for object selection and linear smooth pursuit motions for object activation. Freytag et al. [38] conducted tests on two identical smooth pursuit-based interfaces and found that detection accuracy decreased when the interface displayed a high number of items.

2.3.4 Pupil Size

The pupil, a prominent feature of the human eye, offers a straightforward means of acquiring data regarding its size and location through video capture [18]. Lighting affects pupil size, which controls the quantity of light that penetrates the retina. Emotions, muscle tiredness, cognitive processes, and MWL all have an effect on pupil size [21].

Current eye-tracking technology employs the corneal reflection method to accurately depict and understand eye movements. This method involves directing infrared light sources into the eye, followed by capturing high-resolution reflections with a camera [35]. When assessing visual activity using an eye tracker, three primary features are examined: position, duration, and movement.

Fixation serves as the fundamental measure of eye position, representing where the eyes were focused at a specific moment. It's essential to note that recording a fixation doesn't necessarily imply that the subject actively viewed or processed the recorded image [39].

The number and distribution of fixations are two indicators that can reflect the subject's engagement with the object. The average fixation duration can be calculated by dividing the total fixation time by the number of fixations. Additionally, revisits, which indicate instances where the gaze returns to a previously fixated location, can be identified [40].

2.4 Eye Tracking Applications

Eye tracking is an invaluable technique for various fields of human behavior research and has applications spanning a wide range of sectors. These include healthcare and medical, psychology, marketing, engineering, education, and gaming. Furthermore, eye tracking can significantly enhance human-computer interfaces by enabling navigation and control using the eyes.

2.4.1 Eye-Tracking and robot

In the realm of human-robot interaction, head posture is commonly used as a substitute for direct eye gaze, primarily due to its simplicity in extraction [41]. However, "head gaze" does not convey all the nuanced information that "eye gaze" provides. Therefore, incorporating eye tracking capabilities into robots can substantially enhance their functionality and improve human acceptance.

Human-robot interaction studies often use external eye tracking devices. Integrating 3D gaze tracking into robotics allows for more natural, collaborative interactions [42]. Machines with depth-sensing cameras and eye tracking software generate a 3D gaze vector, detecting and predicting human intentions.

Various types of robots, including collaborative robots, instructional robots, service robots, and assistive robots, can benefit from 3D gaze tracking, especially in scenarios where extensive movement and interaction with physical objects are required. This technology holds promise for advancing the capabilities and usability of robots across various applications.

2.4.2 Healthcare and Medical Applications

Eye tracking has become a prominent research tool in the healthcare and medical sectors, with recent studies showing its potential to improve medical decision-making. Integrating eye tracking techniques into medical practices has enhanced the quality and effectiveness of medical procedures, as well as the adoption of new technologies. Accordingly, it is simplifying the study of the human mind and body and thereby improving medical decision-making [15].

Eye tracking technology has also proven to be a valuable tool for studying the visual attention and decision-making processes of medical professionals and students when interpreting medical images. Figure (2.4) illustrates the differences in diagnosis between radiologists and students, highlighting the potential for eye tracking to enhance medical education and practice.

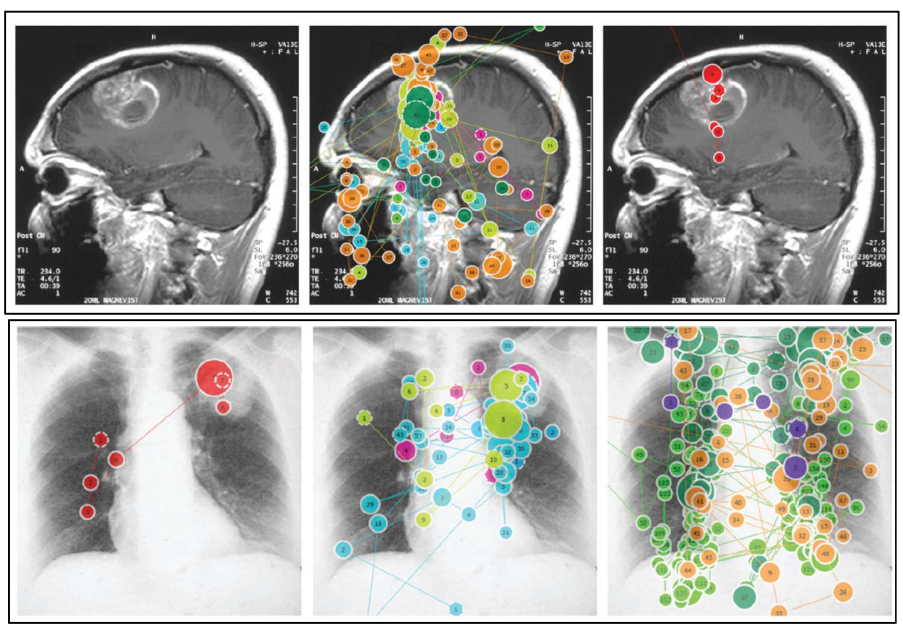

Figure 2.4 Healthcare and Medical Applications [44]

Finke et al. [43], employed video games and Tobii eye tracking devices to observe the behavior of children with and without autism spectrum disorder (ASD), as well as to monitor their facial expressions and emotions. Their findings revealed that children with ASD were drawn to video games in a similar manner to other children.

Furthermore, many researchers have harnessed machine learning (ML) and eye tracking technology to develop medical solutions for elderly individuals and those with special needs.

2.4.3 Consumer Psychology, Marketing & Advertising

Eye tracking has gained significant popularity and importance in market research, particularly in understanding why some products resonate with customers while others do not. The ability to explore new avenues through both laboratory and real-world neuromarketing experiments empowers researchers to collect objective data from customers' eyes and brains as they interact with products or services [45].

Many prominent businesses actively utilize eye tracking to analyze various aspects of their products, such as performance, design, packaging, and the overall customer experience. Additionally, it helps monitor customer attention to critical messaging and advertising. When deployed in physical stores, eye tracking provides insights into in-store navigation ease, search behavior, and purchase decision-making see Figure (2.5).

Figure 2.5 Advertisement for Tobii eye trackers showing a possible application for their product [46]

Emerging marketing and advertising strategies require customer involvement in product and service creation and evaluation. This approach yields valuable information regarding customer satisfaction, engagement, and design decisions.

Portable eye tracking devices enable individuals to regularly engage with their surroundings, facilitating a better understanding of how specific attributes are perceived and enabling improved decision-making.

2.4.4 Education and E-learning

Eye tracking technology is increasingly valued for its multifaceted role in education. Its applications encompass assessing cognitive levels, enhancing interface design, gauging reader comprehension, and evaluating student focus [47].

By analyzing students' visual attention during classroom instruction, valuable insights emerge regarding what elements capture their focus and what distracts them, as depicted in Figure (2.6).

Figure 2.6 Education and E-learning [47]

Prieto et al. [48], used eye-tracking data to assess the cognitive load experienced by teachers in different classroom scenarios.

For instance, it answers questions about slide reading, teacher attention, or note-taking. These insights, derived from eye tracking data, are pivotal for instructional design and resource development. Such data-driven improvements in educational experiences are supported by numerous studies, showcasing eye tracking's efficacy in detecting cognitive changes and enhancing learning environments [8].

By utilizing representative and reliable data, we can gain a deeper understanding of students and create meaningful learning experiences for them. For example, Rasmussen & Tan [49], investigated reading progress using eye gaze tracking in combination with speech recognition to enhance language models. Their results showed a 10.6% improvement in error rates compared to using speech recognition alone.

2.4.5 Computer gaming and Entertainment

The gaming industry has seen remarkable advancements through the integration of eye-tracking technology. Designers and developers can now analyze player interactions, especially visual attention and reactions during critical gameplay moments, greatly enhancing the overall gaming experience [7].

This technology has introduced innovative features, including foveated rendering and optimizing graphics quality by focusing rendering on the player's gaze point. It also enables real-time adjustments like dynamic lighting and sound effects based on the player's gaze, further immersing players in the gaming world [50].

Looking ahead, ongoing trends and advances in eye tracking technology may soon enable players to control games using even more nuanced actions, such as pupil dilation and fine-grained eye movements. These innovations hold the potential to revolutionize how games are played and experienced, further blurring the line between the virtual and real worlds in the realm of gaming and entertainment.

2.5 Eye Tracking used in Advertisement

Advertising plays a pivotal role in marketing, serving as a potent tool for promoting and selling products or services [51]. Businesses utilize advertisements to accomplish several objectives, including increasing customer awareness, shaping perceptions of products, services, or organizations, and stimulating purchase intent [52].

However, the effectiveness of advertising can be compromised if the target audience is not precisely defined. Consequently, two main approaches are employed to gauge the efficacy of advertisements [53]. The first approach centers on customer attitude and behavior metrics, which encompass factors such as customer awareness, likability, satisfaction, and loyalty. The second approach involves assessing financial metrics, which include metrics such as sales, market share, revenue generation, return on investment, and cash flow [54].

In addition to these traditional methods, there is a growing trend toward utilizing neuroscience to evaluate the impact of advertisements [55]. Neuroscience has the capacity to reveal emotions in the human cognitive process.

2.5.1 Neuromarketing

Situated at the intersection of neuroscience, psychology, and marketing, it is an interdisciplinary field that concentrates on evaluating consumers' cognitive and emotional responses to various marketing stimuli [56]. Eye tracking is a prominent neuroscience technique employed in neuromarketing. Understanding consumers better and leveraging neuroscientific tools to uncover brain or physiological responses are vital for the application and evolution of marketing concepts. Advances in neuroscience and neuropsychology extend our comprehension of brain functioning [57], as well as how reality is perceived through everyday experiences, environmental interactions, and daily decision-making.

Consumer neuroscience is a subfield that utilizes tools like electroencephalograms (EEG) and eye tracking to assess the brain's reactions to marketing stimuli. In recent years, the integration of neuroscience principles into consumer research has made significant contributions [58].

Karmarkar and Plassmann [59], delve deeply into incorporating neurophysiological data into consumer research, primarily addressing the ability to predict consumer behavior and decision-making, pushing boundaries beyond traditional methodologies.

Neuroscience approaches offer the advantage of recognizing implicit measures that are not influenced by conscious processes [58]. These implicit measures have advanced consumer research, with various physiological measurement techniques being regarded as valuable tools for understanding consumer behavior, surpassing conventional self-report methods [60]. It commonly used tools for physiological measurements in consumer research encompass (EEG), functional MRI (fMRI), electrodermal activity (EDA), heart rate (HR), and eye movement (eye tracking) [63], [62],[61].

2.5.2 Learning Attention

It is a key indicator of advertising efficacy and represents an advertisement's capacity to attract an individual's attention. Attention, which has also been characterized as selective perception [64], plays a significant part in decision-making, as it has been proven to be positively connected with intent and decision-making [65].

Eye tracking is a more reliable method of measuring attentiveness. Eye movement or gaze attention is a frequently used measure for assessing people's behavior, especially youngsters, in order to determine which visual stimuli are preferred. Mitsura & Glaholt [66], illustrated how gaze operates differently in a like choice vs. a disliking decision. Measuring gaze and how it influences decision-making gives valuable information on the nature of stimuli, and attention level can influence consumer choice [67].

Color, brightness, size, shape, and motion are visual input properties that are employed to determine the saliency of stimuli [68]. The most crucial information is included in salient cues, which will be subjected to additional processing and hence have a major influence on consumer behaviors [70]. Milosavljevic et al. [69], discovered, for example, that the brightness of food packaging was substantially connected with customers' real meal selections.

2.5.3 Gesture and Emotion

The emotion created by advertising draws viewers' attention to the commercial, the product, and the brand, as well as increasing a product's perceived attractiveness and brand memory [71].

As a result, emotion is recommended as an important determinant of advertisement efficacy. According to previous research, advertising that elicits higher emotional responses has a greater impact on viewers' views, behavior, and recall [72]. It has been proposed, for example, that pleasure is connected with an ad-like and approach (rather than avoidance) propensity [73].

Engagement (i.e., the emotional reaction that the stimuli elicit) is another indicator of an individual's emotional response. It has been shown that advertisement design, such as the use of language and images, may evoke emotional involvement, which can influence client decision-making and behavior [74].

The more pleasant emotional reactions an advertisement elicits, the more likely a person will adopt a favorable attitude toward the commercial, which in turn influences behavioral intention toward the brand and the product [75].

2.6 The Interquartile Range (IQR):

A statistical measure used to assess the spread or variability of a dataset. It is calculated as the difference between the third quartile (Q3) and the first quartile (Q1). The IQR provides insights into the dispersion of the middle 50% of the data, making it a robust measure of variability, especially in the presence of outliers.

$$IQR = Q3 - Q1$$

Outliers are defined as data points outside below the lower quartile (Q1 - 1.5 * IQR) or above the upper quartile (Q3 + 1.5 * IQR) and can be eliminated. The IQR approach can successfully handle skewed or non-normal distributions [76], Figure (2.7) show the schematic representation of outlier detection (IQR).

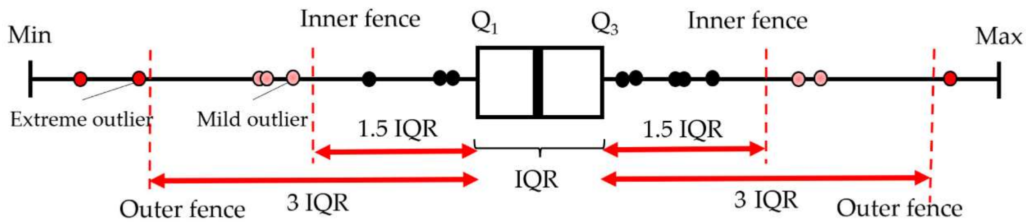

Figure 2.7 The schematic of outlier detection (IQR) [77]

IQR is a critical tool in both data cleansing. It helps identify and manage outliers—data points significantly different from the main dataset—which can distort analyses and predictions. By leveraging the IQR, analysts can effectively detect outliers and decide how to handle them. In eye-tracking research, calculating the IQR for metrics like fixation duration or gaze points ensures data quality and reliability. This process helps detect outliers due to errors or anomalies, enhancing the validity of findings and providing deeper insights into viewer behavior and cognitive processes during visual stimuli exposure. Thus, the IQR plays a pivotal role in advancing our understanding of human visual attention and perception in eye-tracking research.

2.7 Principal Component Analysis (PCA):

is a statistical technique that employs an orthogonal transformation to convert a set of correlated variables, into linearly uncorrelated variables [78], Although PCA is fundamentally a statistical method, it finds applications in various domains. Often, the number of principal components is fewer than the original variables, as shown in Figure (2.8).

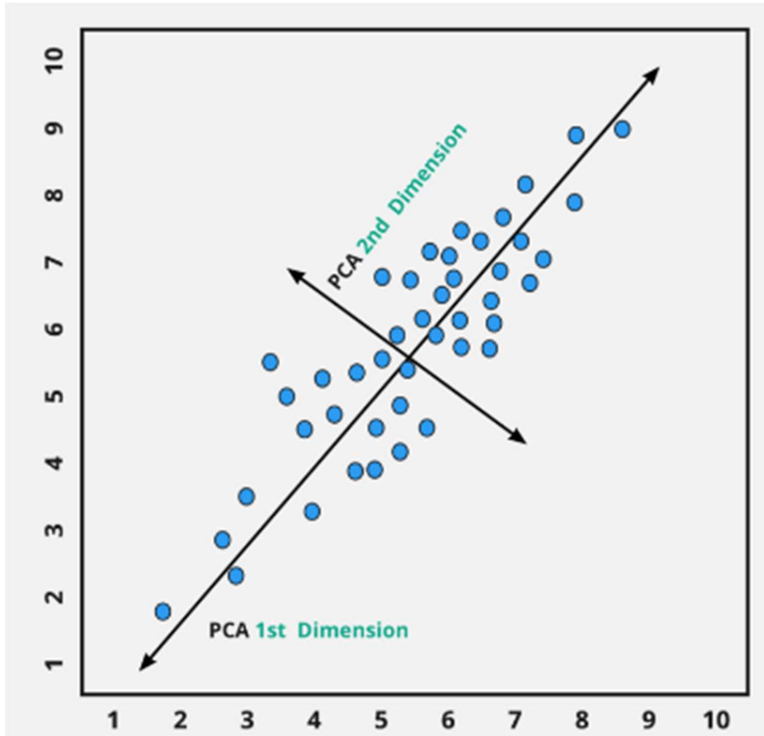

Figure 2.8 Principal Component Analysis [79]

```
// Create a PCA object
PrincipalComponentAnalysis pca = new PrincipalComponentAnalysis();
// Analyze the data using PCA
pca.Learn(data);
// Retrieve the principal components
double[][] components = pca.Components;
// Retrieve the variance contribution for each principal component
double[] variances = pca.Variances;
// Retrieve the transformed data
double[][] transformedData = pca.Transform(data);
// Retrieve the scores for each observation
double[][] scores = pca.Transform(data, AnalysisMethod.Center);
```

Applications of PCA:

1- Exploratory Data Analysis: PCA helps uncover hidden patterns and relationships in data, making it a valuable tool for data exploration.

2- Predictive Modeling: PCA can be used to preprocess data before feeding it into machine learning models, reducing noise and redundancy.

3- Dimensionality Reduction: In fields like image processing, PCA reduces the dimensionality of data while retaining important information.

4- Feature Selection: PCA can identify the most important features in a dataset and eliminate less relevant ones.

Because of its capacity to decrease dimensionality, extract key features, permit visualization, and produce interpretable findings, PCA was chosen as the best approach for this research. It provides a thorough technique for evaluating eye tracking data and has tremendous promise for understanding the underlying structure of participants' gaze behavior in connection to commercial ad decision-making. Dimensionality Reduction: One of the most significant benefits of PCA is its ability to reduce the dimensionality of eye tracking data while maintaining the most critical information.

Eye tracking data is frequently made up of a large number of variables (for example, gaze coordinates, fixations, and saccades) gathered from several people and stimuli. By converting the original variables into a new collection of uncorrelated variables known as principal components, PCA helps to escape the curse of dimensionality. These components capture the greatest amount of variance in the data, providing for a more compact representation of the information [78].

PCA determines the most influential characteristics or patterns within the eye tracking data. Researchers can discover which components contribute the most to the total variance in the data by ranking the main components based on their associated eigenvalues. These components provide the underlying structure and collect the critical information that differentiates various eye tracking patterns and behaviors. These indicators, such as conspicuous regions of visual focus or gaze patterns linked with engagement, can give useful insights about the strengths and flaws of ads.

PCA allows for excellent display of eye tracking data in lower-dimensional domains. Researchers can display complicated eye tracking patterns in two or three dimensions by projecting the data onto a smaller number of major components. This visualization assists in comprehending the links between various data points, detecting clusters or groups with similar eye tracking behavior, and visually evaluating the distribution of participants' gaze data. Such visual representations aid in the interpretation of findings and the successful communication of outcomes to stakeholders [80].

Interpretability: Because the main components are linear combinations of the original variables, PCA produces interpretable output. This interpretability enables researchers to identify and comprehend the contributions of various eye tracking parameters to total data variation.

2.8 Related Works

Eye tracking technology has been extensively applied in various fields to explore decision-making processes. Several noteworthy research studies have delved into how eye movements and visual attention patterns can provide valuable insights into consumer decision-making.

1. Madlenak et al.,2023 [81], in this study eye-tracking analysis was used to assess the impact of outdoor advertising on consumer behavior as cars traversed specified routes in Ilina, Slovakia. The research combined questionnaire surveys with A/B testing to investigate both conscious and subconscious influences of outdoor advertising on consumer decisions.

   The findings have significant implications for businesses offering outdoor advertising spaces and those utilizing outdoor advertising as part of their marketing strategies.

2. Mancini et al., 2022 [82], the research focused on how users perceive in-game advertising (IGA) and introduced a specialized eye-tracking research protocol designed to accurately measure visual attention directed towards key elements of the game viewing experience.

   The results revealed that ads within the game view (IGAs) captured 3.49% of users' visual attention, the chat section drew 10.68% of users' visual attention (even more than the streamer's face, known as a potent attentional driver), animated ad formats garnered more visual attention (1.46%) than static formats (1.12%), and, in some cases, visual attention induced by commercials was higher in "Goal" scenarios (0.69%) than in "No-Goal" sequences (0.51%).

3. Hamelin et al.,2022 [3], the authors measured participants' reactions to 14 real estate advertisements using facial detection and eye-tracking analysis. These commercials were recommended by a creative advertising agency for a real estate campaign targeting both males and females. Twenty participants, interested in home buying, were involved. Eye-tracking revealed insights into advertisement effectiveness and cue saliency, affecting emotional responses. Data envelopment analysis (DEA) assessed the attention, engagement, and delight generated by the ads. The study identified commercials that maximized positive emotional reactions for each gender, uncovering significant differences in ad effectiveness between males and females.

4. Peker et al., 2021 [83], the research conducted a study to investigate the impact of various components of online banner ads on consumers' visual attention. Eye-tracking was utilized, with 34 participants, including 18 males and 16 females. They were exposed to eight web banner ads containing brand, discount rate, and image elements. The findings highlighted the image component's appeal and the significance of banner section placement, with central sections viewed first. Higher discount rates made the discount section more attractive, and participants' familiarity with the brand influenced their focus.

5. Kuo et al.,2021 [84], conducted two case studies to provide guidance for investigating eye tracking applications in design concept validations. In the first case study, product qualities were analyzed using cognitive-affective emotion theory. The second case study examined product qualities in terms of perceived usefulness and emotional quality. The study involved 105 participants who evaluated product graphics while their eye movements were recorded.

The results indicated that eye movements could predict perceived product qualities in rating tests. Additionally, experienced users exhibited longer mean focus durations compared to new users and tended to form their perceptions of the product based on multiple components. This research offers valuable insights for incorporating eye tracking into design concept validation processes.

6. Deng and Gu,2021 [85], conducted an eye-tracking experiment to explore information acquisition during online shopping in browsing and searching contexts. The study demonstrated that a selected computer product received more eye fixations, and participants with cross-product-attribute eye movements completed tasks faster. Attribute-oriented displays garnered more eye movements, positively impacting website engagement. These findings recommend attribute-oriented information presentation for browsing-oriented customers.

7. Pfeiffer et al.,2020 [86], The study implemented two eye-tracking experiments applied in front of grocery store aisles. The first experiment was conducted in immersive virtual reality, while the second was carried out in physical reality, specifically in a real supermarket. The decision to implement a virtual reality survey was motivated by the increasing interest in leveraging virtual shopping environments as a retail channel.

The results demonstrated that support vector machines could classify search motivations in virtual reality with 80% accuracy and in physical reality with 85% accuracy. Notably, their models achieved 70% prediction accuracy after just 15 seconds in virtual reality and 75% in physical reality, suggesting that eye movements enable the early discovery of shopping motivations during the search process. The use of an ensemble technique significantly improved prediction accuracy to over 90%.

8. Rojas et al.,2020 [87], the study focused on utilizing eye-tracking technology to understand customer preferences among young individuals. The study involved 28 participants aged 7 to 12 years. Participants went through two separate phases. In the first phase, they viewed a collection of stimuli in an eight-position configuration called Alternative Forced Choice for decision-making. In the second phase, they were asked to freely examine the stimuli and select their preferred one. The sample was randomly divided into two gender-balanced groups, and non-obtrusive eye-tracking devices were used to assess visual attention.

The findings supported the use of visual attention measures as an implicit tool for analyzing children's decision-making and preferences. The study revealed that design features of stimuli influenced eye movement and liking/disliking decisions. Notably, the results indicated gender differences in fixation patterns and visit times based on stimulus size.

9. Cuesta et al.,2018 [88], conducted a study using a combination of eye-tracking, facial expression analysis, and galvanic skin reaction (GSR) to explore the impact of music in advertising. Nineteen university women participated and viewed a perfume TV commercial, with nine watching the version with music and ten watching the silent version. Researchers recorded visual areas of interest, fixation time, facial expressions, and GSR, and participants completed questionnaires before and after. The results showed that the music version elicited higher GSR levels, indicating increased arousal. Facial expressions related to "enjoyment" and "engagement" were more pronounced in the music

version, which also resulted in more positive valence. However, there were no differences in the evaluation of the "attention" variable based on facial expressions. Exposure to the music version improved certain product attributes, like "power."

10. Hwang and Lee,2017 [89], investigated how mobile consumers' visual behavior affects their buying intent for items shown on a mobile shopping screen.

The results revealed that goal-oriented customers paid more attention to product information regions in order to achieve their buying objectives. Their visual attention to two areas of interest, such as product information and consumer comments, affected their buying intention positively. Recreational shoppers, on the other hand, tend to focus on the marketing area, which favorably impacts their buying intention.

The findings help to comprehend mobile customers' visual activities and purchase intents via the lens of mindset theory.

Table 2.3: Summary of Related work

	Research Title	Author	Year	Problem	Results	Accuracy	Method
1	Investigating the Effect of Outdoor Advertising on Consumer Decisions: An Eye-Tracking and A/B Testing Study of Car Drivers' Perception	Madlenak et al. [81]	2023	To investigate the effect of outdoor advertising on consumer decisions.	Outdoor advertising can have a significant impact on consumer decisions, especially when it is placed in strategic locations and designed to be visually appealing.	86%	Eye-tracking and A/B testing were used to assess the effectiveness of different outdoor advertising campaigns.
2	Esports and Visual Attention: Evaluating In-Game Advertising through Eye-Tracking during the Game Viewing Experience	Mancini et al. [82]	2022	To evaluate the effectivenes s of in-game advertising through eye-tracking during the game viewing experience.	In-game advertising can be effective at capturing the attention of gamers, but its effectiveness depends on a number of factors, such as the placement of the ad, the type of ad, and the game itself.	80%	Eye-tracking was used to measure the amount of time gamers spent looking at different in-game ads.
3	Forecasting advertisement effectiveness: Neuroscience and data envelopment analysis	Hamelin et al. [3]	2022	To develop a model for forecasting advertiseme nt effectivenes s using neuroscienc e and data envelopmen t analysis.	A model that combines neuroscience data and data envelopment analysis can be used to forecast advertisement effectiveness more accurately.	75%	Neuroscience data and data envelopment analysis were used to develop a model for forecasting advertisement effectiveness.
4	The effects of the content elements of online banner ads on visual attention: evidence from an-eye-tracking study	Peker et al. [83]	2021	To examine the effects of the content elements of online	The content elements of online banner ads, such as the colors, images, and text, can	80%	Eye-tracking was used to measure the amount of time users spent looking at different online banner ads.

				banner ads on visual attention.	have a significant impact on visual attention.		
5	Investigating the relationship between users' eye movements and perceived product attributes in design concept evaluation	Kuo et al. [84]	2021	To investigate the relationship between users' eye movements and perceived product attributes in design concept evaluation.	Users' eye movements can be used to infer their perceived product attributes.	85%	Eye-tracking was used to measure the amount of time users spent looking at different design concepts.
6	Information acquisition, emotion experience and behaviour intention during online shopping: an eye-tracking study	Deng et al. [85]	2021	To investigate the relationship between information acquisition, emotion experience, and behavior intention during online shopping.	Information acquisition, emotion experience, and behavior intention are all important factors in online shopping.	90%	Eye-tracking was used to measure the amount of time users spent looking at different product pages. Users were also asked to rate their emotion experience and behavior intention.
7	Eye-tracking-based classification of information search behavior using machine learning: evidence from experiments in physical shops and virtual reality shopping environments	Pfeiffer et al. [86]	2020	To develop eye tracking-based classification of information search behavior using machine learning.	Eye tracking data can be used to classify information search behavior with high accuracy.	90%	Eye tracking data was collected from participants while they were searching for information in physical shops and virtual reality shopping environments. Machine learning algorithms were used to develop a model that could classify information search behavior based on eye tracking data.

8	Recognizing decision-making using eye movement: a case study with children	Rojas et al. [87]	2020	To investigate the use of eye tracking to recognize decision-making in children.	Eye tracking can be used to recognize decision-making in children with high accuracy.	71%	Eye tracking data was collected from children while they were making decisions in a variety of tasks. Machine learning algorithms were used to develop a model that could predict whether or not a child was making a decision based on their eye tracking data.
9	A case study in neuromarketing: Analysis of the influence of music on advertising effectivenes through eye-tracking, facial emotion and GSR	Cuesta et al. [88]	2018	To investigate the influence of music on advertising effectiveness through eye-tracking, facial emotion, and GSR.	Music can have a significant impact on advertising effectiveness, depending on the type of music and the target audience.	75%	Eye tracking, facial emotion, and GSR data were collected from participants while they were exposed to different advertising campaigns with and without music.
10	Using eye tracking to explore consumers' visual behavior according to their shopping motivation in mobile environments	Hwang et al. [89]	2017	To explore consumers' visual behavior according to their shopping motivation in mobile environments.	Consumers' visual behavior in mobile environments is influenced by their shopping motivation.	80%	Eye tracking data was collected from consumers while they were shopping on mobile devices.

CHAPTER THREE

PROPOSE D METHODOLOGY

3.1 Overview

This chapter presents a comprehensive methodology for extracting valuable insights from participant-generated data, specifically eye tracking data. Our methodology consists of four stages: data collection, pre-processing, processing, and Points of Interest.

In the data collection stage, we collect eye tracking data from participants as they interact with a stimulus. In the pre-processing stage, we clean and prepare the data for analysis. In the processing stage, we focus on the areas of interest in the ads by grouping the eye tracking data into regions and identifying the regions with the highest concentration of eye tracking data. In the Points of Interest stage, The dimensionality reduction feature is used in the PCA algorithm to find out which points of interest are the most attractive and thus the most powerful area in the ad.

The following diagram Figure (3.1) depicts the sequence of steps in our methodology.

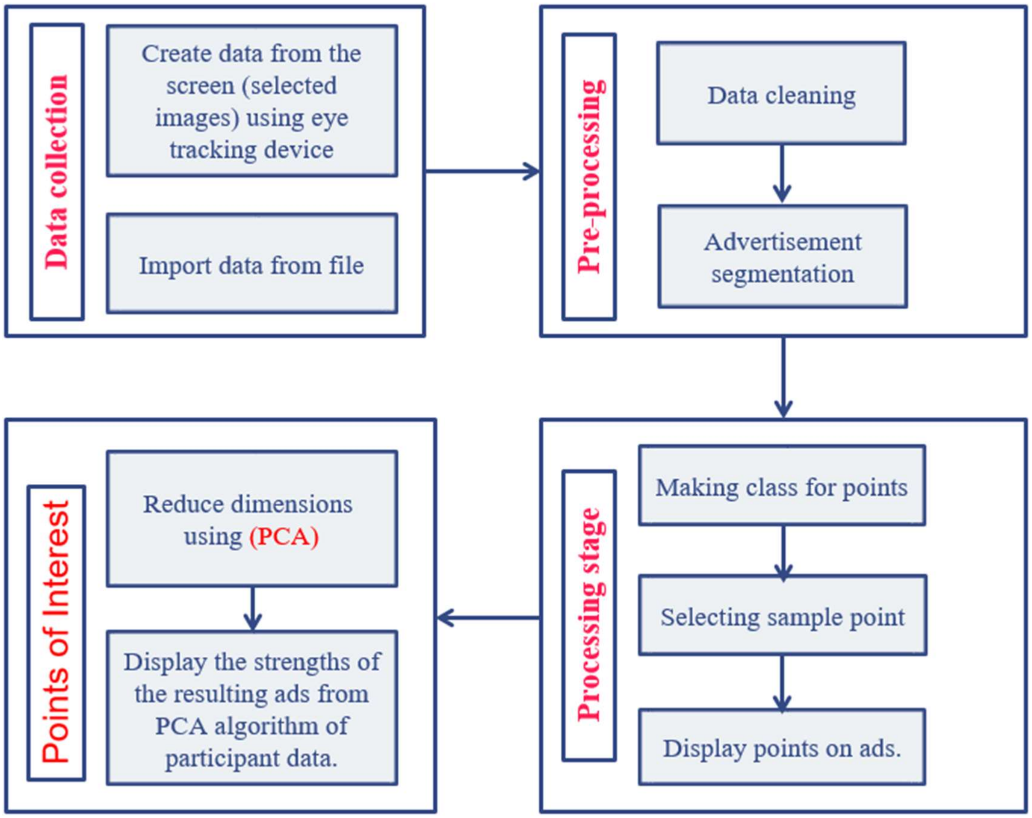

Figure 3.1 Proposed method diagram

The main fourth component of research methodology will be explained in details, respectively.

3.2 Data Collection

The initial step in this stage was the selection of images to be presented to the participants. This was done in collaboration with the Media and Government Communication Department of Karbala Governorate. The goal of this collaboration was to ensure that the selected images were meaningful, representative, and aligned with the objectives of the study.

A formal request was sent to the Media and Government Communication Department, outlining the purpose of the image selection task.

Three indicative images were selected to be shown to the participants, and eye tracking points were taken for them using the Tobii EyeX device. The first image, Figure (3.2), focusing on the uses and importance of water, is a powerful reminder of the essential role that water plays in our lives. Figure (3.3) shows three regions (7, 15, and 24) of interest imposed on this image. It was used to assess participants' understanding of the different ways in which water is used and its importance to human society.

Figure 3.2 instructive image about uses water

Figure 3.3 Imposed regions in Image No.1

The second image Figure (3.4) is an advertisement for a drinking water bottling company. It provides a contrast to the first image as it focuses on the commercialization of water. Figure (3.5) shows three regions (1, 17, and 18) of interest imposed on this image. It was used to assess participants' awareness of the different brands of bottled water available and their perceptions of the different marketing messages used by these companies.

Figure 3.4 Image about water ad.

Figure 3.5 Imposed regions in Image No.2

The third image, Figure (3.6), raises awareness of the importance of rationalizing electricity consumption. Figure (3.7) shows three regions (20, 24, and 25) of interest imposed on this image, which were used to assess participants' attention.

Figure 3.6 Instructive image about importance of rationalizing electricity

Figure 3.7 imposed regions in Image No.3

To ensure data accuracy and consistency, participants were furnished with comprehensive instructions prior to the commencement of data point collection. These instructions served as a guide for participants, underscoring the importance of adhering to the provided guidelines. These guidelines, carefully crafted, played a pivotal role in maintaining the integrity and reliability of the dataset.

3.2.1 Participant Instructions and Scenario

1. Clearly instruct participants regarding the task, gaze behavior, and any specific requirements.

Participants should be given clear instructions about the task they are to perform, the specific gaze behaviors that are of interest to the researcher, and any specific requirements that they must follow. For example, maintaining a stable and natural gaze. It is also important to ensure that participants understand the purpose of the study and how their data will be used.

2. Educate participants about blinking, head movements, or gaze drift, and provide guidance on minimizing these artifacts during data collection.

Blinking, head movements, and gaze drift are all natural eye movements that can occur during eye-tracking experiments. It is important that participants be instructed to try to blink as infrequently as possible, to keep their heads still, and to focus their gaze on the center of the screen.

3. Create a comfortable and controlled environment with minimal distractions to reduce noise introduced by external factors.

A comfortable and controlled environment is essential for collecting high-quality eye-tracking data. Participants should be seated in a comfortable chair in a well-lit room with minimal distractions. The eye tracker should be properly calibrated and positioned so that it has a clear view of the participant's eyes.

4. Monitor participant behavior during data collection and intervene if any issues arise that may compromise the quality of the eye-tracking data.

It is important to monitor participant behavior during data collection to ensure that they are following the instructions and that the eye tracker is working properly. If any issues arise, such as if the participant is blinking excessively or moving their head too much, the researcher should intervene to correct the problem.

3.2.2 Entity Relationship Database Eye Tracker (ERD ET)

The database structure is a key component of any database application. This section describes the database structure for the application, which is shown in Figure (3.9). The database consists of five tables.

1- Participants Table: This table contains individual participant information, including id, name, age, and address.

2- Eye_data Table: Stores the eye tracking data collected during the image presentation phase.

Contains id, eye_x (the x coordinate of the tracking point), eye_y (the y coordinate of the tracking point), timer (a timer that ends in 60 seconds), timestamp (the time to the moment of taking the point depends on the time of the computer), Participants_id (an indicator indicating the participant's number)

3- Noisy_data Table: Retains the eye-tracking points that were identified as noise and subsequently removed from the dataset.

Contains id, eye_x (the x coordinate of the tracking point), eye_y (the y coordinate of the tracking point), timer (a timer that ends in 60 seconds), timestamp (the time to the moment of taking the point depends on the time of the computer), Participants_id (an indicator indicating the participant's number)

4- Clean_data Table: Holds the cleaned eye tracking data after the noise reduction process.

Contains id, eye_x (the x coordinate of the tracking point), eye_y (the y coordinate of the tracking point), timer (a timer that ends in 60 seconds), timestamp (The time to the moment of taking the point depends on the time of the computer), Participants_id (an indicator indicating the participant's number)

5- SquarePointCounts Table: Records the frequency of the most commonly occurring points for each participant, correlated with their respective regions of interest.

Contains id, x (the x most frequent y-coordinate of the participant), y (The most frequent y-coordinate of the participant), count (repetition Points Counter), image_name, Participants_id (an indicator indicating the participant's number).

This meticulous process and the employment of the Tobii EyeX device lay the groundwork for obtaining meaningful insights into participant gaze behavior, facilitating subsequent data refinement and analysis phases.

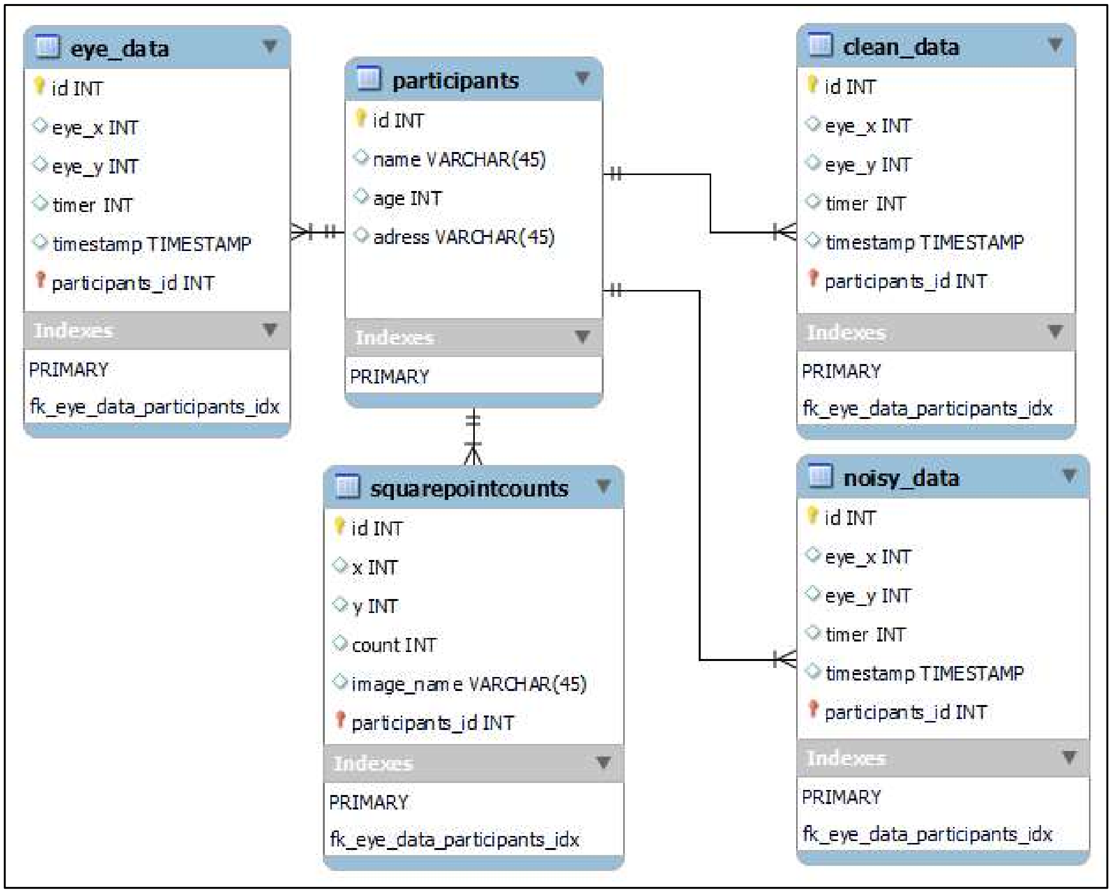

Figure 3.8 Entity Relationship Database of suggesting model

After we have completed selecting the images, the device used, designing the database, and giving directions to the participants, it moves to the user interface. Participants were required to provide personal details, including their full name, age, and residential address, through a user-friendly interface, as illustrated in Figure (3.10), This information is for categorizing participants accurately.

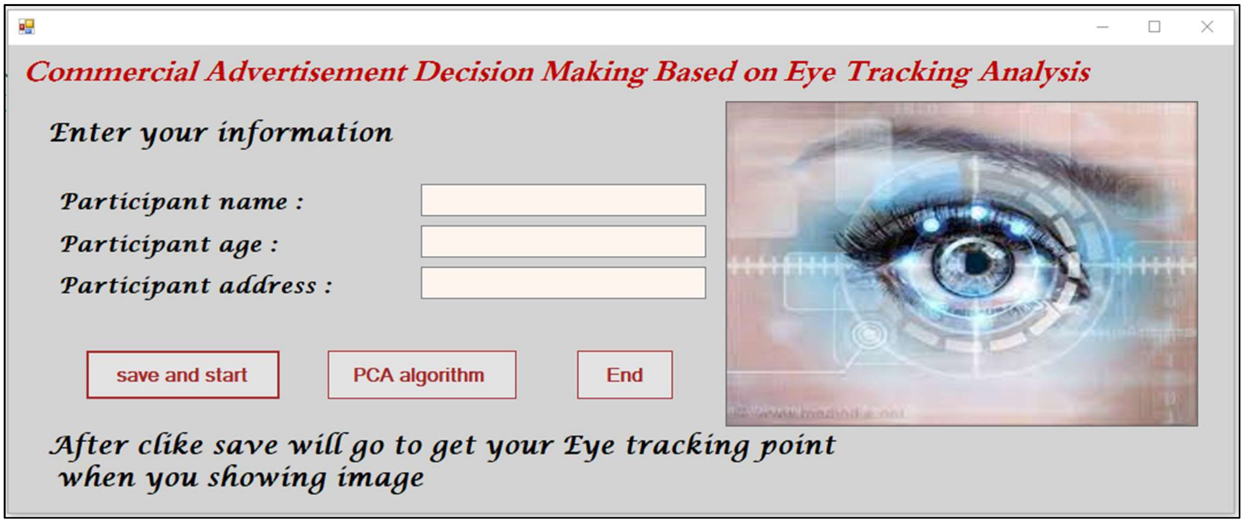

Figure 3.9 User interface to Participants entering personal details

All participant data was stored within (participants) table, as illustrated in Table (3.1). Following the completion of personal data entry, participants were shown a series of three images. Each image was displayed sequentially, with an interval of 20 seconds between transitions, resulting in a total viewing time of 60 seconds. These images were strategically chosen to serve as visual stimuli, capturing participants' attention and stimulating their visual engagement. Concurrently, the eye tracking system, an integral component of this research, was activated to monitor and record participants' gaze points throughout the image-viewing period. These gaze points were meticulously tracked and documented, creating a comprehensive dataset of each participant's visual preferences and areas of interest within the presented images. This data was methodically stored within the (eye_data) table of the research database.

Table 3.1: participants information

id	name	age	address
1	KARRAR	28	kerbala
2	Raja	45	iraq
3	Taisir	33	kerbala
4	zainab	25	kerbala
5	Ali	27	Basra
6	Ahmed	35	kerbala
7	Haydar	28	iraq
8	Hoda Mohamed	30	kerbala
9	Nadia	38	Baghdad
10	Mayameen	28	kerbala
11	Ammar	38	Babylon
12	Amira Abdel Aziz	45	Babylon
13	Mona	41	kerbala
14	Hussein	15	iraq
15	Zahraa daya	14	Basra
16	fatma	14	iraq
17	Seif El-Din Wasfi	38	iraq
18	Hani Nour	60	iraq
19	Riad Nour	49	iraq
20	Shuruq Hakim	35	kerbala

This data collection framework is not limited to real-time participant data entry; it can also use data obtained from archived sources with the potential for experiment replication.

A diverse group of 20 participants contributed to this data collection phase, encompassing a range of ages and representing both genders. This diversity in the participant pool ensures a broader perspective on viewer attention and preferences, contributing to the robustness of the study's findings. The data collection procedure, as described above, formed the foundation for the subsequent stages of data analysis and interpretation.

3.3 Data Pre-processing Stage: (Refinement of ET Data)

At this stage, our focus turns to optimizing the quality of the data collected. A critical step involves the application of a noise removal treatment to the extracted data points. The rationale behind this step is to meticulously reduce any potential inaccuracies or discrepancies in the dataset, ensuring that the subsequent analysis is based on reliable, meaningful, and dependable data. This two-part pre-processing approach streamlines the eye-tracking data, ensuring its accuracy and relevance. By seamlessly integrating noise removal and strategic data segmentation, this stage sets the foundation for the processing stage, see Figure (3.11).

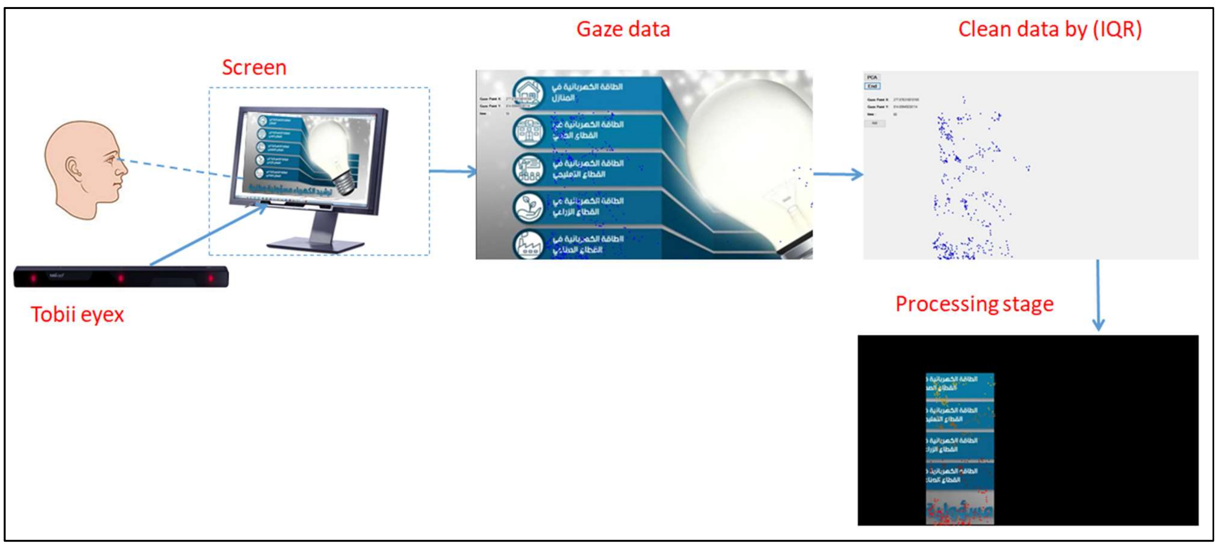

Figure 3.10The figure shows the stages of the model for one participant

3.3.1 Part One: Data Cleaning

The initial phase of data analysis, known as data cleaning, is crucial for eliminating noise from the participant's eye-tracking data. This process is essential for ensuring the accuracy and reliability of the subsequent analysis.

One common technique for data cleaning is the interquartile range (IQR) method. The IQR is a statistical measure of the spread of a dataset. It is calculated by subtracting the first quartile (Q1) from the third quartile (Q3). Any data points that fall outside of the IQR by more than 1.5 times the IQR are considered outliers and are removed from the dataset.

I also worked on exploring the z-score method, where a data point is calculated by subtracting the mean of the dataset from the data point and then dividing by the standard deviation of the dataset. Any data points with a z-score greater than 3 or less than -3 are considered outliers and are removed from the dataset.

Both the IQR and z-score methods are effective for removing noise from eye-tracking data. However, it is important to note that there is no one-size-fits-all approach to data cleaning. The best method to use will depend on the specific characteristics of the data and the research objectives.

The resultant clean data is stored within the (Clean_data) table, ensuring its readiness for subsequent analysis. Additionally, the removed noisy data finds its place within the (Noisy_data) table, providing a comprehensive view of the refined dataset. This will ensure that the clean data is readily available for subsequent analysis, and it will also provide a record of the data cleaning process.

3.3.2 Part Two: Advertisement segmentation

The second phase of data analysis, involves segmenting the presented image into regions, or boxes. This segmentation enables a focused examination of each quadrant individually, facilitating systematic data sampling. The number of boxes (N) used to segment the image depends on the complexity of the image.

For images with a high density of details, a lower value of N may be necessary to ensure that all relevant areas of the image are captured. Conversely, for images with fewer intricate details, a higher value of N Data filtering is a powerful tool that can be used to extract specific information from eye-tracking data.

region (i,j)	**Col(0)**	**Col(1)**	**Col(2)**	**Col(3)**	**Col(4)**
Row(0)	Region(1)	Region(6)	Region(11)	Region(16)	Region(21)
Row(1)	Region(2)	Region(7)	Region(12)	Region(17)	Region(22)
Row(2)	Region(3)	Region(8)	Region(13)	Region(18)	Region(23)
Row(3)	Region(4)	Region(9)	Region(14)	Region(19)	Region(24)
Row(4)	Region(5)	Region(10)	Region(15)	Region(20)	Region(25)

Figure 3.11 the segment divides the image into 25 regions

Figure (3.12) represents the proposed division of images. The regions have been numbered to be distinguished later. We will deal with the region numbers to indicate which region is most viewed.

3.4 Processing Stage: (Area of interested)

The processing stage of this research plays a pivotal role in harnessing the collected eye-tracking data, enabling us to derive insightful analyses and meaningful interpretations. This stage involves several intricately designed steps, each contributing to a comprehensive understanding of participants' visual attention patterns.

To initiate the analysis of visual attention patterns, the eye-tracking data classification process. The data is meticulously classified based on predefined image regions. This granular categorization is instrumental in knowing the nuances of participant engagement within specific areas of interest.

Subsequently, the recurrence of gaze points within these designated regions is systematically calculated. This step elucidates the frequency with which participants' gaze fixates on particular regions, providing quantifiable insights into the prominence of these areas.

Gaze points, was categorized within their respective regions, are visually overlaid onto the original image. This visual representation employs a distinctive color-coding scheme, highlighting the regions with the highest concentration of gaze points. The points are represented in red to elucidate the areas of maximum participant interest.

This approach allows for quick and intuitive interpretation of the data, facilitating a deeper understanding of which regions within the image draw the most attention from participants.

Invaluable insights generated during this stage are systematically recorded and stored for subsequent analysis. The calculated gaze points, along with their respective recurrence counts and the corresponding image identifiers, are securely stored within the 'SquarePointCounts' table. This meticulous organization of the data ensures its integrity and accessibility for future analyses.

Processing stage thus concludes with the identification of the region that most captivates participants within the image. Through the systematic segmentation of data, precise calculation of point recurrence, and impactful visual representation, this understanding serves as a foundation for subsequent analytical endeavors, empowering the research with comprehensive insights into the intricacies of visual attention patterns.

3.5 Points of Interest Stage:

The pivotal phase aimed at the systematic identification of points of interest within the eye-tracking data. It facilitated through particularly the Principal Component Analysis (PCA) algorithm. This stage leverages the extensive dataset stored within the 'SquarePointCounts' table, a reservoir of participant gaze behavior and engagement patterns.

At the core of this stage lies the objective of transforming raw data into insightful categories, unveiling the salient regions that captivate participants' attention. To achieve this, the collected data reflecting participants' visual engagement undergoes a rigorous classification process by the PCA algorithm, renowned for its ability to unravel latent connections and concealed patterns within datasets.

The PCA algorithm methodically dissects the dataset, grouping together points with similar characteristics and behaviors. By identifying clusters of frequently visited points, it reveals hidden insights into participants' attention during their interaction with the presented images.

3.5.1 Displaying the Strengths of the Resulting advertisement

The outcomes of the PCA algorithm are then translated into a visually intuitive representation. putting the identified points onto the original image, employing a distinct color scheme. Specifically, the color red symbolizes points of the highest recurrence, illuminating the regions that garnered the most attention from participants. This visualization serves as an effective tool for instantly directing attention to the most prominent points of interest.

Research methodology employs a systematic, multi-stage process to unveil the intricacies of consumer behavior and decision-making through comprehensive eye-tracking analysis.

Through these methodological stages, research offers a nuanced and comprehensive understanding of consumer behavior. It intricately captures visual attention patterns, decision-making processes, and key points of interest that shape participants' interactions with the presented images. This comprehensive methodology serves as a potent tool for refining marketing strategies, enhancing user experiences, and designing products aligned with genuine consumer preferences and behaviors.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

In this chapter, showing a comprehensive overview of the outcomes derived from our study. The primary objective was to shed light on how viewers engage with advertisements. Discuss the key findings related to viewer attention and their implications for advertising effectiveness.

The data collected through the eye-tracking process has been meticulously analyzed, and the results offer valuable insights into the complex interplay between visual stimuli and viewer responses.

The chapter unfolds as follows: In Section 4.2, Result Outcomes of Model Experiments, provide a concise summary of the main outcomes of study. It offers readers an immediate glimpse into the overarching trends that emerged from the data.

Section 4.3, Data Statistical Analysis, delves into the data analysis techniques and statistical methods employed, presenting both raw data and any significant statistical findings.

Following this, in Section 4.4, The Eye-Tracking Framework for Enhanced Advertising, highlighting its relevance in shaping the research process and interpretation of results.

Overall, this chapter offers a foundation for understanding the insights obtained from our eye-tracking study and sets the stage for a comprehensive exploration and interpretation of these findings.

4.2 Experiments outcome of Result

In this section, delve deeper into the outcomes of comprehensive eye-tracking study, which provides invaluable insights into the impact of visual stimuli within advertisements on viewer attention. The results are thoughtfully organized into multiple key subsections, each illuminating different facets.

The figure (4.1) shows the variation in the number of tracking points per participant that affects the results in Image No. 1. This variation can be attributed to a number of factors, including:

1. The participant's attention span: Some participants may have had a shorter attention span than others and may have therefore looked away from the image more frequently.
2. The participant's interest in the image: Participants who were more interested in the image may have spent more time looking at it and therefore accumulated more tracking points.
3. The participant's familiarity with the image: Participants who were more familiar with the image may have been able to identify the areas of interest more quickly and may have therefore spent less time looking at the image overall.
4. The participant's fatigue: Participants who were more fatigued may have had difficulty focusing on the image and may have therefore accumulated fewer tracking points overall.

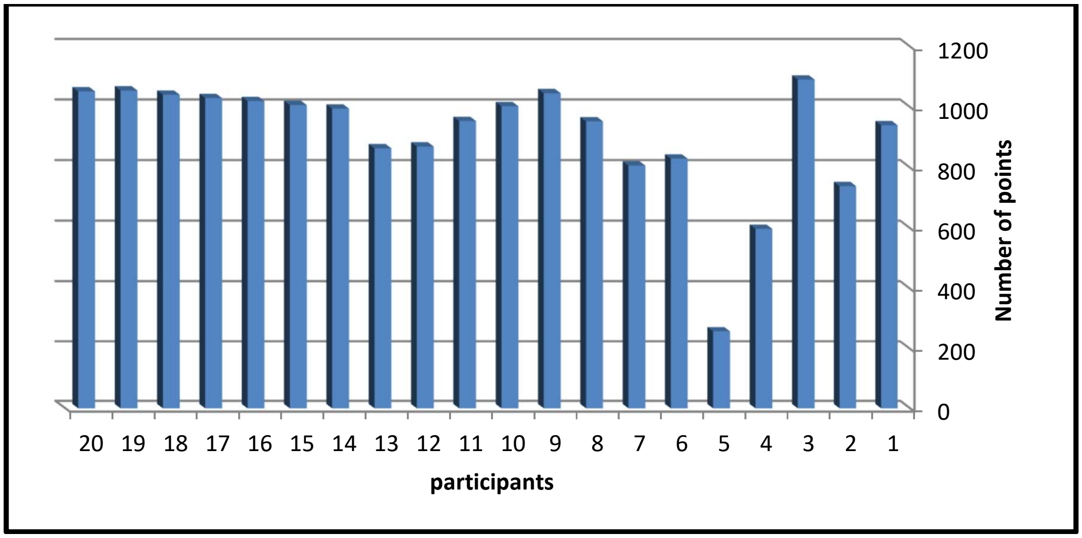

Figure 4.1 the total tracking points for each participant to Image No.1

The figure (4.2) shows the number of tracking points per participant that affects the results in Image No. 2.

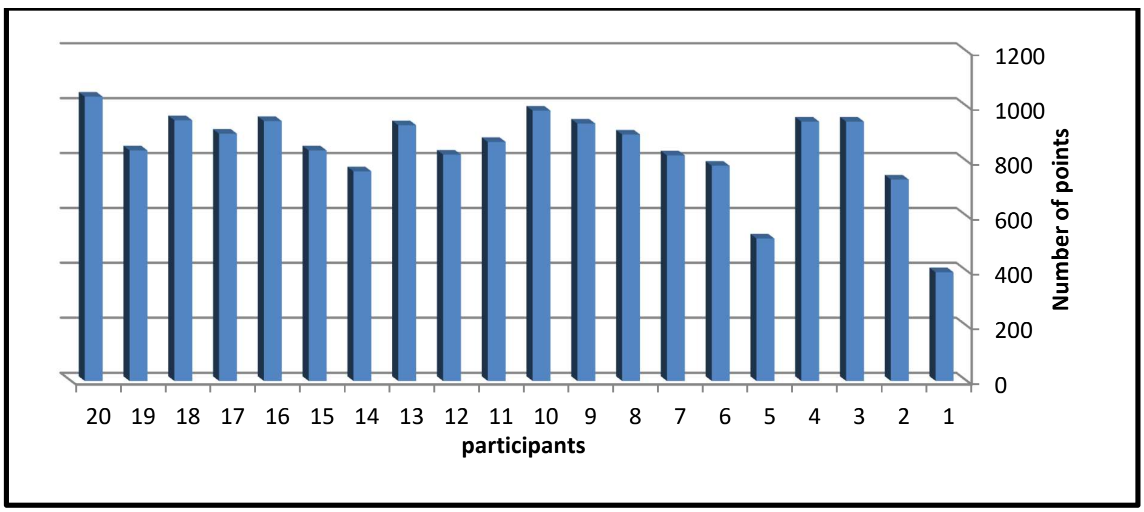

Figure 4.2 the total tracking points for each participant to Image No.2

The figure (4.3) represents the quantity of tracking points for each participant in Image No. 3.

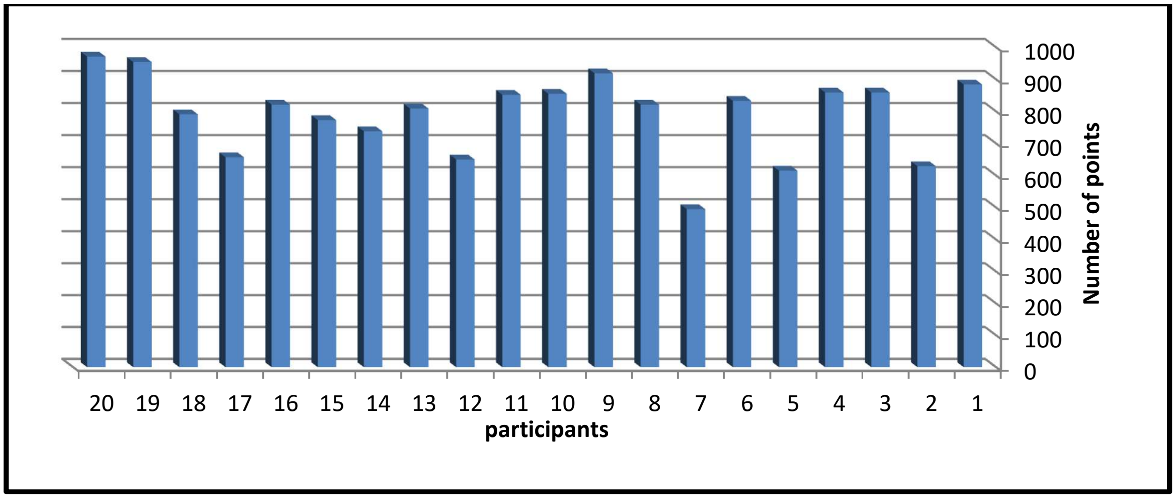

Figure 4.3 the total tracking points for each participant to Image No.3

These tracking points hold the key to uncovering which regions of the advertisements garnered the most attention across participant group. Such insights can significantly inform advertising strategies, helping to pinpoint the precise areas where viewers' gaze is naturally drawn. With this knowledge in hand, advertisers can tailor their content to optimize viewer engagement.

The study delves deeper into the tracking points by categorizing them across 25 distinct regions. By doing so, gain a more granular understanding of viewer attention dynamics. This breakdown allows to identify specific regions within advertisements that have consistently captured viewer interest.

By examining the total tracking points and the distribution across regions, can derive meaningful conclusions about viewer attention patterns and their implications for advertising design and strategy.

4.2.1 Tracking Points by Region

To gain a comprehensive understanding of viewer attention within the advertisements, divided each image into 25 distinct regions of interest (ROIs). These ROIs were carefully designed to capture specific visual elements or content within the ads. Analysis of tracking points across these regions revealed fascinating patterns.

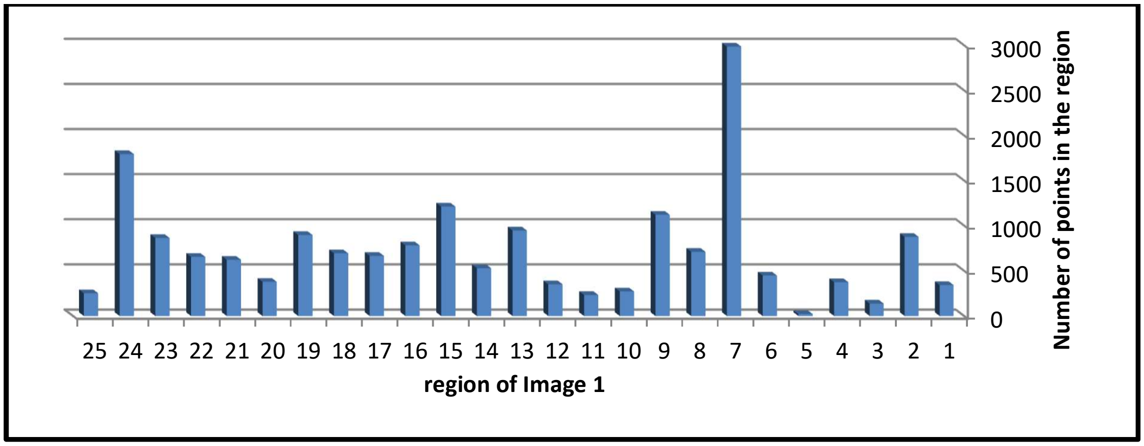

Figure 4.4 Distribution of Tracking Points by ROI for Image No.1

Figure (4.4) illustrates the distribution of tracking points across these ROIs Image No.1, showcasing how viewer attention was distributed throughout the advertisements. The findings paint a vivid picture of which regions commanded the most visual attention from our participants. Several key observations emerged:

Region (7) The Center of Advertising Strength Remarkably, ROI 7 emerged as the epicenter of attention. Participants collectively directed a significant portion of their gaze toward this region. This suggests that ROI 7 contained elements that strongly engaged viewers, making it a pivotal area of focus.

It garnered the most tracking points, indicating that it was the highest attention peak. Understanding what elements contributed to this heightened attention in ROI 7 is a crucial aspect of our analysis.

On the contrary, region (5) attracted the least attention from participants. This region had the fewest tracking points, indicating its relatively lower impact on viewer engagement.

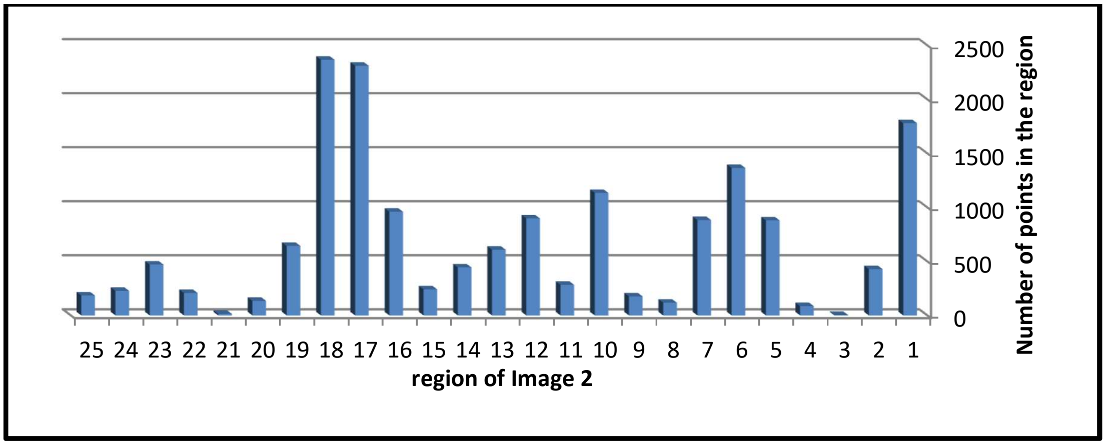

Figure 4.5 Distribution of Tracking Points by ROI for Image No.2

In figure (4.5) Image No. 2, region 18 claimed the highest number of tracking points, signifying its significant impact on viewer attention. In contrast, region 3 received the lowest tracking points, indicating a relatively lower level of engagement.

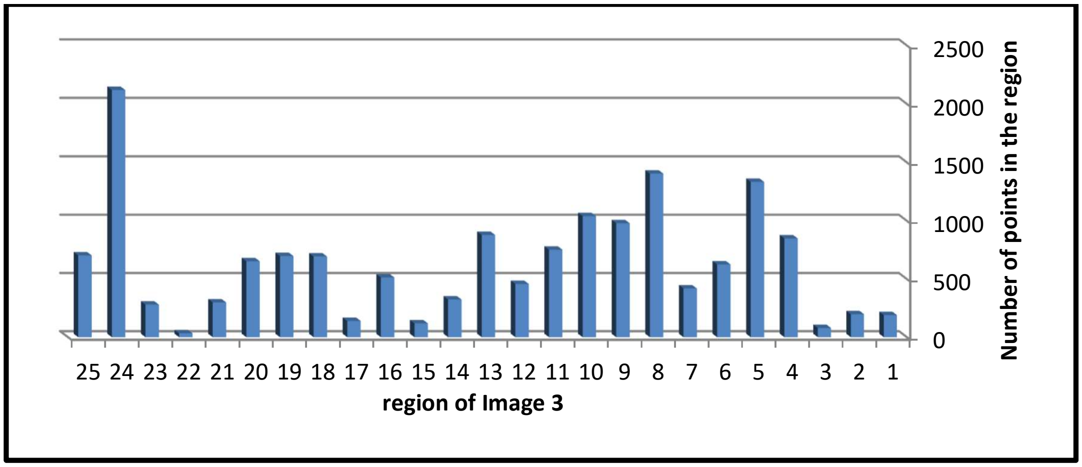

Figure 4.6 Distribution of Tracking Points by ROI for Image No.3

Moving on to figure (4.6) Image No. 3, region 24 stood out by amassing the highest number of tracking points, suggesting its substantial role in capturing viewer interest. Conversely, region 22 received the lowest tracking points, portraying a diminished impact on viewer engagement.

These observations collectively illustrate the dynamic nature of viewer attention across the three images, emphasizing the critical role played by specific regions in captivating and maintaining viewers' focus. Meticulous analysis, grounded in eye-tracking data, provides valuable insights into the intricate relationship between visual stimuli and viewer engagement, a fundamental aspect of our scientific research.

4.2.2 Individual Variations in Viewer Attention

In our comprehensive analysis of viewer attention patterns, it is imperative to recognize the existence of individual differences among participants. While overarching findings provide a holistic view of viewer attention across the entire participant group, it is equally vital to consider the nuanced responses exhibited by each individual.

To elucidate these individual variations, attention to Figure (4.7) In Image No.1, observe a fascinating interplay of viewer attention. This visual representation serves as a testament to the uniqueness of each participant's gaze patterns, underscoring the prevalence of individual preferences and the rich tapestry of variations inherent in human responses to advertising stimuli. This inherent diversity acts as a compelling reminder of the nuanced landscape of advertising effectiveness, where the interplay of individual reactions assumes a pivotal role.

Intriguingly, within this mosaic of gaze patterns, regions 7 and 24 emerge as conspicuous focal points, capturing the attention of a substantial majority of participants. These regions evidently possess a distinct allure, consistently drawing participants' gazes.

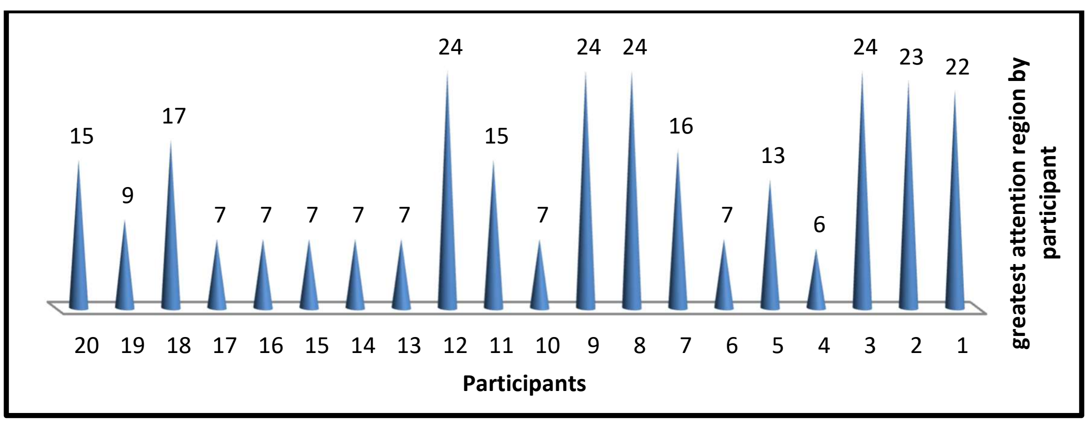

Figure 4.7 Most Viewed Regions by Participant for Image No.1

However, it's essential to note that a significant portion of participants chart different trajectories, directing their focus toward an array of other regions dispersed across the visual landscape. This multifaceted response underscores the dynamic and multifarious nature of how participants engage with and respond to advertising content, reaffirming that one size does not fit all in the realm of advertising effectiveness.

Moving on to figure (4.8) Image No.2, we uncover yet another layer of individual variation in viewer attention. Here, region 17 emerges as the primary center of focus for a notable segment of participants. This region is marked by its high concentration of tracking points.

Nonetheless, as with any diverse audience, we observe a range of responses. Some participants chart their unique gaze trajectories, directing their attention towards different regions within the image. This diversity in gaze patterns reaffirms the intricate interplay between individual preferences and advertising stimuli.

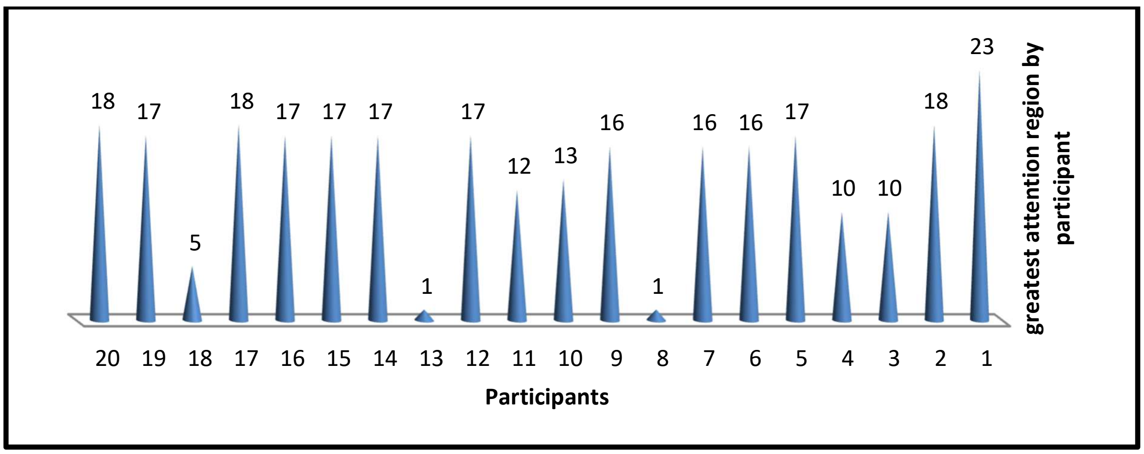

Figure 4.8 Most Viewed Regions by Participant for Image No.2

Finally, Figure (4.9) Image No.3 and provides a captivating glimpse into participant-specific gaze patterns. In this context, Regions 8 and 5 emerge as significant areas of interest for several participants. These regions, characterized by their notable tracking point density, effectively engage the visual attention of specific individuals.

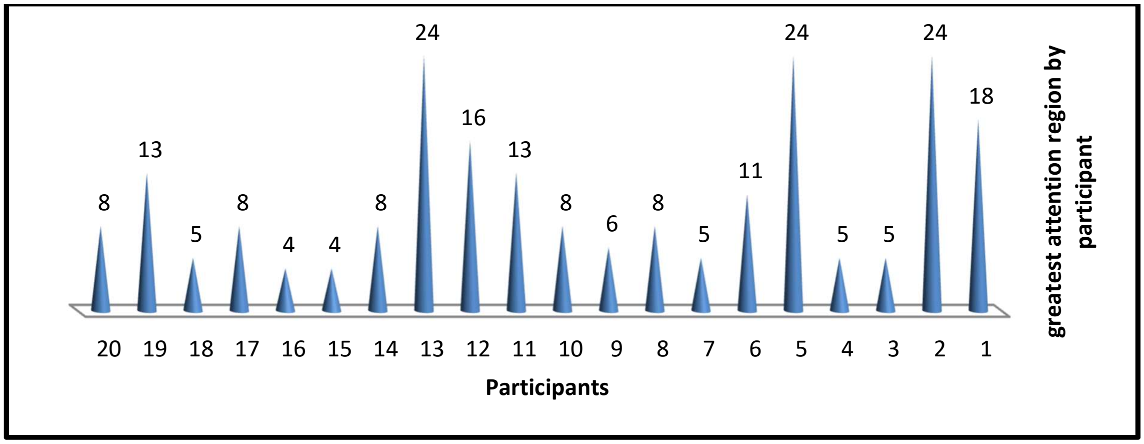

Figure 4.9 Most Viewed Regions by Participant for Image No.3

As expected, viewer responses exhibit a fascinating spectrum of variation. Many participants opt for distinct areas of focus within the image, illustrating the multifaceted nature of individual engagement with advertising content.

The above tables, table 1 for image 1, table 2 for image 2, and table 3 for image 3, present an in-depth breakdown of tracking points by region across all participants. The column represents the 25 regions of the image, the row represents the number of participants (number of tracking points per region). The last row contains the sum of points for all participants in each region. This data provides a comprehensive and detailed understanding of gaze patterns and preferences within the study. This comprehensive data help shed light on the intricate patterns and variations in participants' gaze behavior during the study.

4.3 Data Statistical Analysis

In this section, we will analyze the data obtained from the eye-tracking study, focusing on the percentage of attention each region received and the percentage of participants who watched each part of the advertisement. The study aims to determine the strength of advertisement reach by comparing the observed data with predefined areas of interest, which are determined by the advertiser's objectives.

In Figure (4.10), delve into the viewer engagement aspect. It is revealed that a substantial majority of participants, constituting 95%, have directed their attention toward these identified regions (7, 13, 17, 18). This observation underscores the significance of these regions in capturing participants interest. The equation applied here aids in quantifying viewer engagement and underscores the significance of these regions in the advertisement.

Region Frequency = Number of participants who viewed the region /20 (4.1)

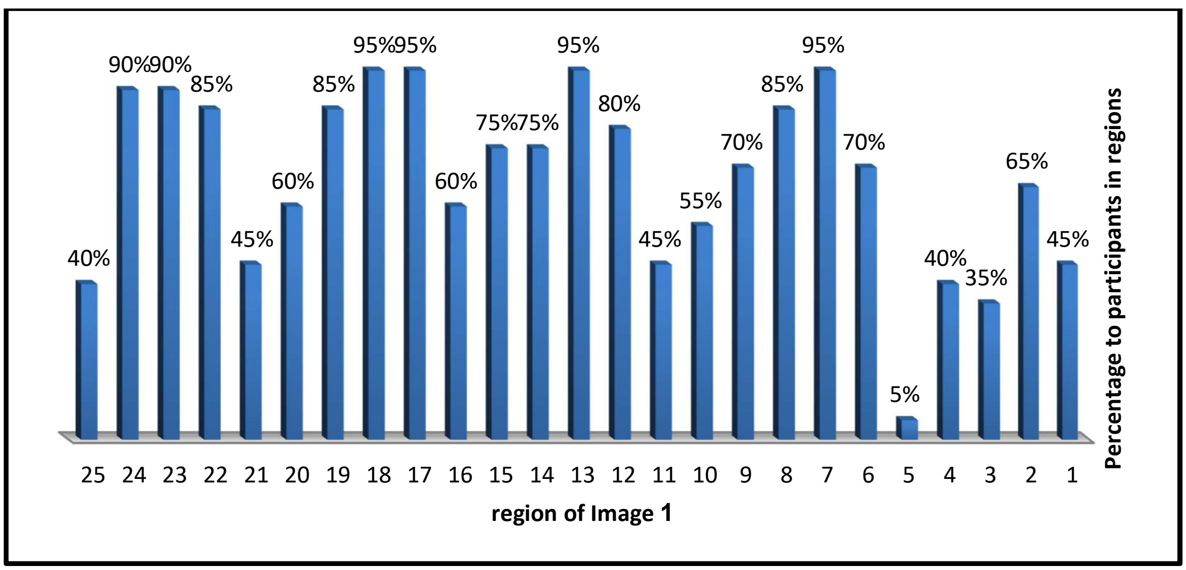

Figure 4.10 Percentage to num of participants for each region to Image No.1

Figure (4.11) provides a comprehensive overview of viewer attention distribution in Image No.1. Notably, it is observed that regions (7, 13, 17, 18) comprise for each one 6% of the total image, exhibiting higher prominence compared to other regions. The equation below was used.

Percentage for each region= Region Frequency /sum (Regions Frequency) (4.2)

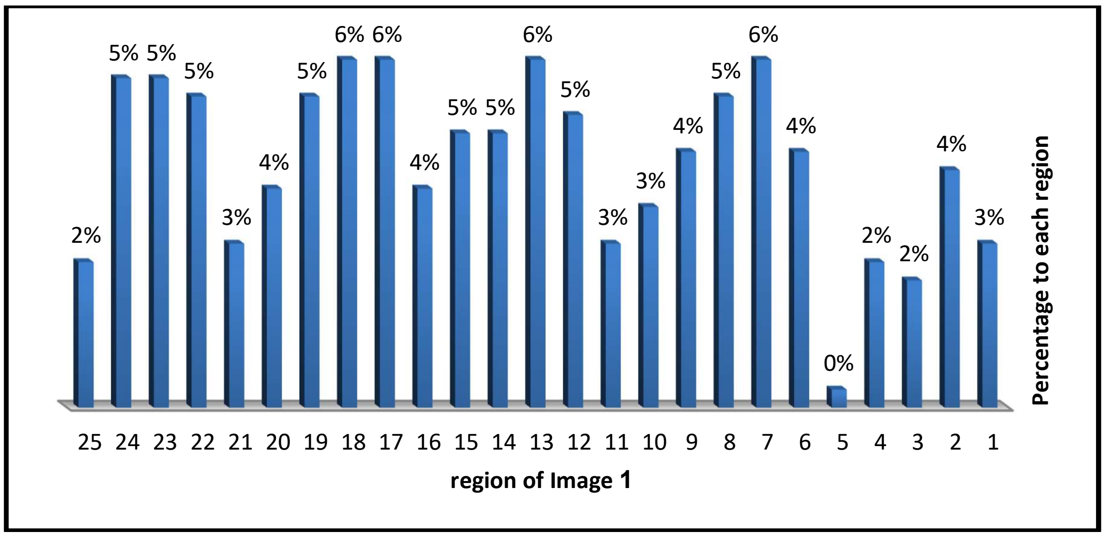

Figure 4.11 Percentage for each region to Image No.1

The figure (4.12) shows the most viewed regions to Image No.1 after applying the PCA algorithm.

Figure 4.12 Output region after PCA to Image No.1

Figure (4.13) further illuminates the viewer engagement dynamics. It highlights that 95% of participants have observed region 18, while regions (7, 13, 17, and 12) have garnered the attention of 90% of participants. These findings underscore the resonance of these regions among viewers, reiterating their pivotal role in the advertisement's effectiveness.

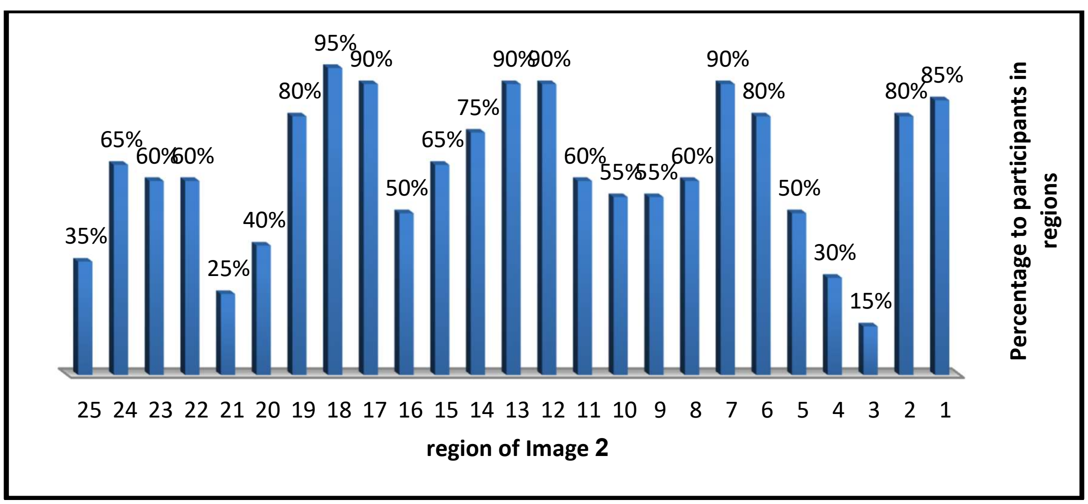

Figure 4.13 Percentage to num of participants for each region to Image No.2

Turning to Image No. 2, Figure (4.14) underscores the prominence of areas (7, 13, 17, 18, 12, 1), which represent for each one 6% of the total image area. This surpasses that of other regions within the image, indicating their notable visual presence.

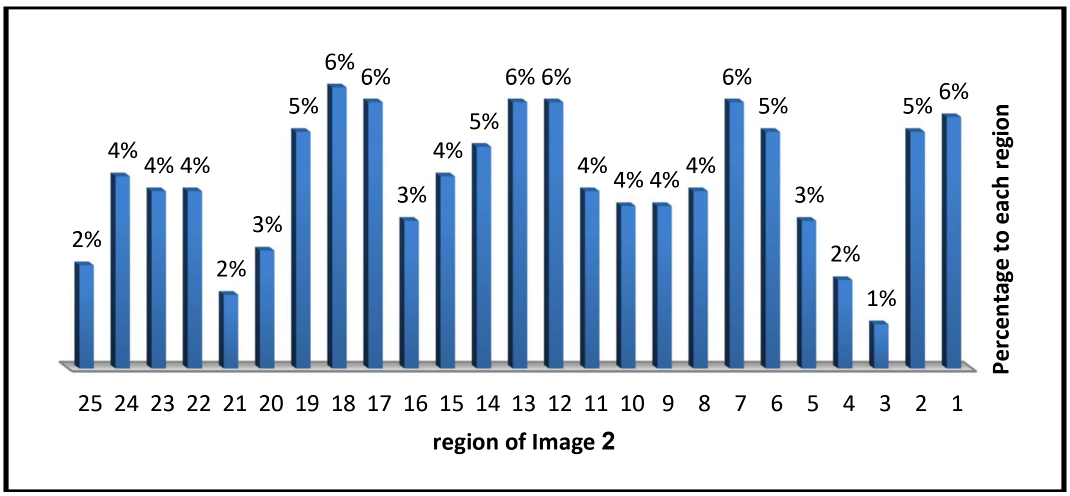

Figure 4.14 Percentage for each region to Image No.2

Following the PCA method, the most popular areas of Image No. 2 are displayed in Figure (4.15).

Figure 4.15 Output region after PCA to Image No.2

Figure (4.16) delves into viewer attention within this context. It reveals that 85% of participants have focused on region 9, while regions (7, 13, 24) have attention 80% of participants.

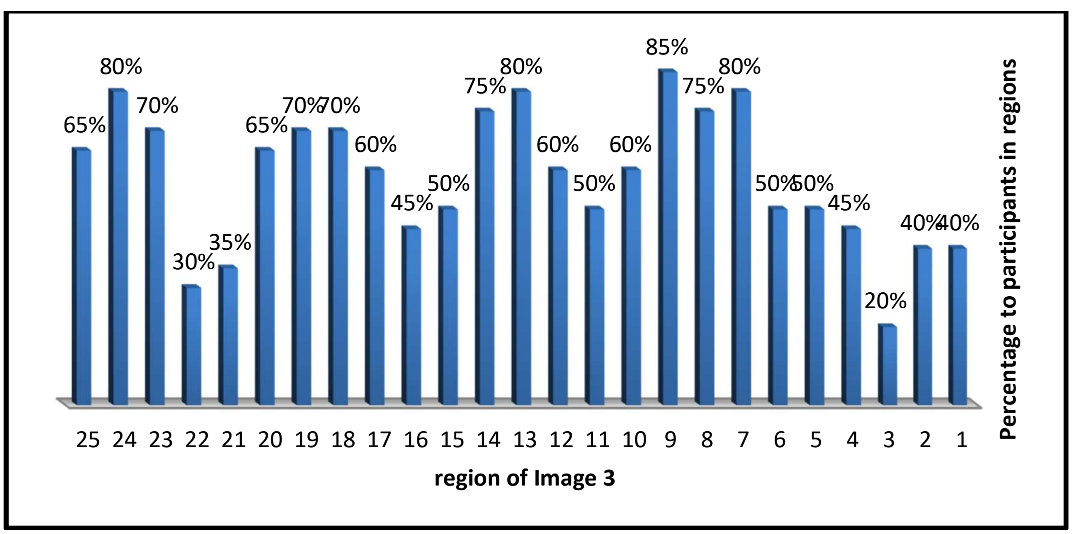

Figure 4.16 Percentage to num of participants for each region to Image No.3

In Figure (4.17) pertaining to Image No. 3, regions (7, 9, 13, 24) emerge as prominent focal points, represent for each one 6% of the total image area. This observation is indicative of their heightened visual significance relative to other regions.

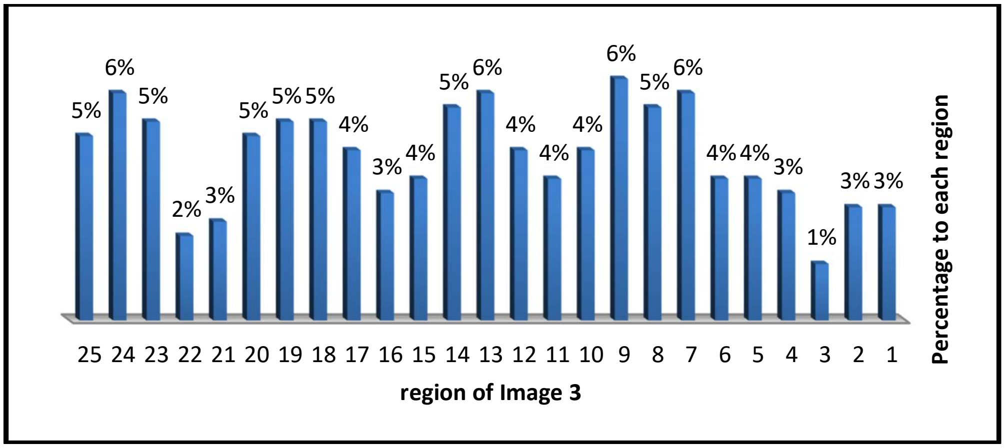

Figure 4.17 Percentage for each region to Image No.3

After the PCA technique is used, the most viewed regions of Image No. 2 are displayed in figure (4.15).

Figure 4.18 Output region after PCA to Image No.3

Table (4.1) presents the accuracy rates for each image. In Image No. 1, the accuracy rate is recorded at 87% after imposing three predefined regions. These regions, determined by the advertiser, represent crucial zones of interest that contain the message that the advertiser wants to deliver. The accuracy rate for each region was (%95,75%,90%), respectively, which represents the number of participants who viewed these regions out of a total number of 20 participants

Comparatively, Image No. 2 boasts an accuracy rate of 90%, while Image No. 3 achieves a rate of 70%. This analysis suggests that Image No. 2 is most successful in achieving the intended goals, as it garners the highest accuracy rate.

These findings emphasize the importance of aligning advertisement design with predefined areas of interest as identified by the advertiser. The accuracy rates reflect the advertisement's efficacy in reaching its intended audience, with higher rates indicating a more potent impact.

Accuracy = (sum (Number of participants points in the imposed region) /20)/3*100 (4.3)

Table 4.1: Table of Image Accuracy Based on Imposed Points and Participant Viewership

Images	**Number of participants points in the region**			**Accuracy**			**Accuracy Image**	**The imposed points**
				Region1	**Region**2	**Region**3		
Image No.1	19	15	18	95%	75%	90%	87%	3 (7,15,24)
Image No.2	17	18	19	85%	90%	95%	90%	3 (1,17,18)
Image No.3	13	16	13	65%	80%	65%	70%	3 (20,24,25)

The data analysis reveals specific regions in each image that received varying levels of attention. These findings offer insights into how well the advertisements align with the advertiser's objectives. It's evident that different regions within the images attracted distinct percentages of participants' attention.

In the context of advertising effectiveness, these results can inform advertisers about which areas of their advertisements are most successful in engaging viewers for optimizing advertising strategies and ensuring maximum reach.

This data-driven approach underscores the importance of aligning advertisement design with viewer behavior and preferences, ultimately enhancing the effectiveness of advertising campaigns.

4.4 Summary

In the field of advertising, where the visual impact of an advertisement plays a pivotal role in capturing an audience's attention and conveying the intended message. It is imperative to emphasize a viewer-centric approach. All too often, advertisers are preoccupied with coordinating colors and presenting their ideas while inadvertently neglecting the fundamental aspect of viewer engagement. This oversight can result in significant inefficiencies, with substantial effort expended on aspects that may not necessarily resonate with the target audience.

The findings derived from this study offer a clarion call to the advertising community. It underscores the importance of aligning advertising efforts with viewers' preferences and attention patterns. Rather than relying solely on intuition and subjective judgments, the results provide a data-driven framework for designing advertisements that truly captivate and involve viewers.

By meticulously analyzing the tracking points across 25 regions and the individual preferences of each participant, advertisers can gain a more profound understanding of the specific regions that command the most attention. Regions 7,13,17, and 18 from image 1, region 1,17, and 18 from image 2, and regions 7,9, and 24 from image 3, as revealed by our study, emerged as focal points that captured the gaze of a significant majority of participants. This insight into the center of advertising strength underscores the significance of optimizing these regions to ensure maximum impact.

The results promotes a viewer-centric approach to advertising design. It encourages advertisers to place paramount importance on those regions and visual elements that effectively engage viewers. Color coordination and creative ideas remain essential but should be strategically employed within the context of these attention-capturing regions.

It became necessary a shift in focus, away from merely presenting ideas and colors and toward designing advertisements that genuinely attract and involve viewers. By aligning advertising efforts with viewer attention patterns, advertisers can enhance the effectiveness of their campaigns and ultimately achieve greater success in conveying their intended messages. This research marks a pivotal step toward a more viewer-centric approach in the realm of advertising, bridging the gap between creative design and audience engagement.

CHAPTER FIVE

CONCLUSION AND FUTURE WORKS

5.1 Overview

In the field of marketing, the utilization of eye tracking analysis has emerged as a transformative tool for understanding consumer behavior and enhancing commercial advertisement strategies. This chapter shows the conclusion to what was presented in this thesis and some suggestions for future work.

5.2 Conclusion

- This study has provided valuable insights into the world of advertising by analyzing eye-tracking data to identify the strengths and weaknesses of various advertisements.
- The empirical approach employed, utilizing eye-tracking technology, underscores the scientific significance of the findings in decoding the influence of visual stimuli on viewer behavior.
- Meticulously analyzing the tracking points across 25 regions and the individual preferences of each participant, advertisers can gain a more profound understanding of the specific regions that command the most attention.
- Regions 7,13,17, and 18 from image 1, region 1,17, and 18 from image 2, and regions 7,9, and 24 from image 3, as revealed by our study, emerged as focal points that captured the gaze of a significant majority of participants.
- The results emphasize the importance of specific regions within advertisements that command heightened visual attention, varying based on content and viewer preferences.

- This research marks a pivotal step toward a more viewer-centric approach in the realm of advertising, bridging the gap between creative design and audience engagement.
- It encourages advertisers to place paramount importance on those regions and visual elements that effectively engage viewers. Color coordination and creative ideas remain essential but should be strategically employed within the context of these attention-capturing regions.
- It became necessary a shift in focus, away from merely presenting ideas and colors and toward designing advertisements that genuinely attract and involve viewers. By aligning advertising efforts with viewer attention patterns, advertisers can enhance the effectiveness of their campaigns and ultimately achieve greater success in conveying their intended messages.
- The convergence of eye-tracking analysis and commercial advertising decision-making opens a new dimension to understanding and engaging with consumers. By harnessing this technology, marketers can create more impactful advertisements, making advertising a dynamic and evolving landscape.

5.3 Future Work

The study highlights the importance of eye tracking analysis in understanding the strengths and weaknesses of advertisements. It suggests that future research could expand the application of eye tracking data to deepen our understanding of viewer behavior and emotional responses. This could contribute to the evolution of advertising strategies and enhance our comprehension of consumer behavior.

One promising direction for future research is the integration of emotional analysis alongside eye-tracking data. Tools such as sentiment analysis, facial expression recognition, and physiological measures such as heart rate variability could provide a more comprehensive understanding of viewers' emotional reactions to advertisements. This could reveal the emotional impact of specific visual elements within advertisements, offering advertisers valuable information about the emotional resonance of their content.

Another promising direction is the exploration of multi-modal approaches. Combining eye tracking with other physiological data sources, such as electroencephalogram (EEG) devices, can provide a deeper understanding of cognitive processes and emotional responses. This approach could reveal the neural signatures associated with compelling advertisements and pave the way for the development of neuro-advertising strategies.

Contextual factors, such as viewer demographics, cultural backgrounds, and viewing environments, can influence viewer responses. Investigating how these variables interact with eye-tracking data to shape advertisement performance can provide nuanced insights. Moreover, incorporating machine learning and predictive modeling techniques could help identify patterns and interactions driving viewer engagement in specific contexts.

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Appendix A: Tracking Points by Region and Participants for Image No. 1

25 region of Image 1	participants 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	All
1	0	0	20	0	0	0	12	18	100	3	0	0	40	70	0	46	0	33	0	0	342
2	0	0	41	0	0	116	0	172	76	81	25	0	57	16	133	50	0	20	36	52	875
3	0	0	0	0	0	0	0	0	0	3	27	0	55	15	0	3	0	0	5	30	138
4	0	0	0	0	0	1	0	0	0	0	32	0	78	1	0	57	85	0	43	77	374
5	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	22
6	8	1	24	138	0	11	25	1	71	1	0	0	26	44	0	10	2	86	0	0	448
7	37	26	213	9	2	323	21	208	137	253	29	0	329	198	253	359	214	108	89	178	2986
8	12	12	8	0	15	78	0	44	15	31	12	0	74	105	106	76	26	10	69	17	710
9	86	20	0	0	6	6	0	1	0	67	132	0	167	86	21	112	115	0	175	126	1120
10	31	3	0	0	0	0	0	1	1	9	117	0	34	19	0	5	0	0	45	7	272
11	0	0	30	122	0	18	18	0	0	0	3	0	0	0	0	1	1	39	1	0	233
12	34	36	25	32	0	16	10	0	7	19	0	2	0	26	23	79	3	11	13	15	351
13	32	111	37	1	90	14	24	1	147	71	63	0	4	7	94	99	5	10	135	1	946
14	19	52	4	8	28	0	21	0	39	11	84	13	0	0	116	5	21	0	91	17	529
15	2	21	150	7	1	0	146	0	0	212	157	4	0	158	4	12	112	0	46	179	1211
16	8	0	68	2	0	85	245	0	0	17	26	134	0	21	0	0	1	151	23	0	781
17	25	16	20	24	6	52	7	1	85	18	17	3	0	22	20	68	58	193	10	20	665
18	51	97	16	85	30	50	29	40	10	13	39	20	0	11	21	9	34	69	40	29	693
19	179	111	64	15	43	4	0	69	96	36	55	39	0	0	82	5	37	1	31	29	896
20	25	11	2	0	0	0	18	0	0	22	65	79	0	42	0	7	38	0	18	51	378
21	7	0	91	0	0	28	127	0	0	0	0	169	0	36	0	0	0	117	29	18	622
22	196	6	15	21	0	28	12	10	65	0	8	3	0	73	1	13	5	98	71	29	654
23	78	124	24	113	2	0	44	17	9	11	14	125	0	11	35	1	93	65	38	59	863
24	65	92	239	21	36	0	1	370	188	125	20	174	0	22	97	2	146	30	47	118	1793
25	45	0	0	0	0	0	47	0	0	0	7	105	0	12	1	1	34	0	0	0	252

Appendix B: Tracking Points by Region and Participants for Image No.2

participants	25 region of Image 2																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	159	18	0	0	2	192	15	0
2	4	2	0	0	0	21	155	11	5	0	6	62	67	5	0	0	95	280	7	0	0	11	2	0	0
3	89	19	0	8	145	135	63	0	0	161	0	34	26	2	29	0	88	134	10	0	0	0	0	1	0
4	89	19	0	8	145	135	63	0	0	161	0	34	26	2	29	0	88	134	10	0	0	0	0	1	0
5	35	0	0	0	18	0	8	0	58	88	6	47	17	1	4	0	207	18	4	7	0	0	0	0	0
6	0	26	1	15	19	18	30	1	3	71	95	13	0	0	25	286	111	69	0	0	0	0	0	0	0
7	1	7	0	0	106	0	15	0	0	80	32	5	62	97	33	132	3	6	87	21	0	7	42	40	45
8	277	44	0	4	28	4	54	2	14	177	0	0	2	6	33	0	0	0	75	28	3	57	0	21	68
9	11	2	0	36	93	28	1	13	46	208	88	17	3	18	29	282	55	2	0	0	5	0	0	0	0
10	159	0	0	15	0	104	15	17	23	4	16	2	180	132	7	100	0	43	50	40	0	4	47	7	19
11	101	23	0	0	73	5	53	34	1	6	10	187	2	0	1	38	155	132	19	12	0	4	7	3	4
12	118	2	0	0	0	94	61	2	0	0	0	120	29	0	0	0	345	37	6	0	0	0	9	1	0
13	310	8	0	0	0	99	33	0	0	0	1	5	45	122	14	3	6	22	110	5	0	18	52	41	37
14	174	4	2	0	0	151	2	8	0	0	2	61	31	0	0	2	273	38	0	0	0	15	0	0	0
15	0	0	0	0	0	0	0	0	0	0	24	42	26	9	0	111	251	223	74	0	1	18	51	9	0
16	175	15	0	0	0	222	90	5	3	0	0	13	21	1	0	3	244	154	0	0	0	0	0	0	0
17	45	15	0	0	0	79	83	13	1	0	0	26	28	25	4	0	82	295	94	3	1	20	44	40	2
18	96	64	0	0	166	113	73	6	21	109	1	12	3	17	14	0	129	91	15	0	0	6	13	0	0
19	17	75	0	0	87	65	53	6	1	69	0	46	33	4	19	3	131	63	39	19	5	46	5	43	10
20	79	104	1	0	0	92	31	0	0	0	2	172	7	3	0	0	39	467	26	0	0	0	7	5	0
All	**1780**	**429**	**4**	**86**	**880**	**1365**	**883**	**118**	**176**	**1134**	**283**	**898**	**608**	**444**	**241**	**960**	**2311**	**2367**	**644**	**135**	**15**	**208**	**471**	**227**	**185**

Appendix C: Tracking Points by Region and Participants for Image No.3

participants	25 regions of Image 3																								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
1	0	9	0	0	0	8	67	0	51	55	15	16	1	110	95	39	5	125	74	49	7	10	13	110	25
2	0	7	0	0	0	2	118	0	4	0	2	19	7	76	1	0	9	103	30	1	0	0	27	223	0
3	0	0	0	1	292	0	0	52	16	89	0	0	16	6	1	0	0	29	109	8	0	0	3	205	32
4	0	0	0	1	292	0	0	52	16	89	0	0	16	6	1	0	0	29	109	8	0	0	3	205	32
5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	60	0	0	0	3	546	3
6	0	0	0	12	71	93	2	5	33	112	350	13	1	1	0	82	1	0	1	6	16	0	0	27	7
7	5	2	0	15	164	11	3	0	5	137	54	10	0	0	0	51	3	0	0	1	34	0	0	0	0
8	0	0	0	62	131	18	21	252	109	178	0	1	31	18	0	0	0	0	0	0	0	0	0	0	0
9	15	0	0	0	0	180	3	6	2	9	114	19	2	26	1	147	1	1	2	97	107	0	0	47	140
10	2	94	3	178	151	0	21	205	54	132	0	0	13	2	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	26	28	36	0	0	112	416	19	0	0	29	141	0	0	0	6	28	11	0
12	23	0	0	0	0	90	26	82	0	0	88	68	0	0	0	92	35	70	9	0	57	0	2	8	0
13	34	3	0	0	0	79	0	2	17	0	58	0	12	3	2	42	4	19	11	10	48	0	14	12	12
14	0	0	0	0	0	0	21	215	92	0	0	2	80	3	0	0	20	39	59	15	0	1	24	157	10
15	0	0	9	173	4	0	21	166	109	2	0	1	30	22	0	0	1	1	25	0	0	7	73	127	2
16	36	24	50	353	10	34	24	5	197	75	12	0	1	0	0	0	0	0	0	0	0	0	0	0	0
17	28	3	0	0	0	0	5	12	37	0	1	5	42	23	2	1	0	26	54	12	0	3	48	97	38
18	47	0	0	0	176	111	3	0	0	125	59	0	0	0	12	31	6	0	0	127	0	0	3	12	79
19	0	0	17	54	42	0	22	9	13	37	0	192	202	0	3	29	26	74	14	33	30	6	26	54	71
20	0	56	0	0	0	0	36	203	189	0	0	0	9	8	1	0	0	35	33	82	0	0	13	161	145
All	**190**	**198**	**79**	**849**	**133**	**626**	**419**	**140**	**980**	**104**	**753**	**458**	**879**	**324**	**119**	**514**	**140**	**694**	**698**	**653**	**299**	**33**	**280**	**211**	**704**

Appendix D

Republic of Iraq
Ministry of Higher Education & Scientific Research
University of Kerbala
College of Computer Science & Information Technology
Division of Postgraduate studies

جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة كربلاء
كلية علوم الحاسوب وتكنولوجيا المعلومات
شعبة الدراسات العليا

العـــدد : دع / 97.
التاريخ : 3 / 5 / 2023

الى/ الاعلام والاتصال الحكومي لمحافظة كربلاء المقدسة

م/ تسهيل مهمة

جامعة كربلاء
كلية علوم الحاسوب وتكنولوجيا المعلومات
الدراسات العليا

تحية طيبة...

يرجى التفضل بتسهيل مهمة السيدة (تيسير حازم عبد المطلب) طالبة الدراسات العليا / الماجستير / قسم علوم الحاسوب في كليتنا وذلك لغرض اكمال متطلبات بحث رسالة الماجستير.

.. مع التقدير ..

أ.م.د. محسن حسن حسين
معاون العميد للشؤون العلمية والدراسات العليا
3 / 5 / 2023

صورة عنه الى //
- مكتب العميد ... للتفضل بالاطلاع مع التقدير.
- معاون العميد للشؤون العلمية والدراسات العليا ... للتفضل بالاطلاع مع التقدير.
- شعبة الدراسات العليا .. للحفظ مع الاوليات.

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الخلاصة

في مجال التسويق الديناميكي، فهم سلوك المستهلك وتحسين استراتيجيات الإعلان أمرٌ أساسي لتحقيق النجاح. تستقصي هذه الدراسة كيف يمكن لتحليل تتبع العين المساعدة في فهم تفاصيل سلوك العميل والعثور على المناطق المهمة التي تؤثر في إعداد الإعلانات التجارية.

تتضمن منهجية شاملة جمع البيانات والتمهيد والمعالجة وتحديد نقاط الاهتمام. باستخدام تقنية تتبع العين، يتم تسجيل أنماط النظر للمشاركين بدقة وحرصٍ وهم يتفاعلون مع الصور. المراحل التالية تشمل تقليل الضوضاء، وتصنيف البيانات، وحساب تكرار النقاط، وتحديد نقاط الاهتمام.

تؤكد النتائج أهمية تتبع العين في التقاط أنماط الانتباه البصري، مكشوفة المناطق التي تشد حقًا انتباه المشاركين. يُستخدم تحليل المكون الرئيسي (PCA) لتقليل الأبعاد للحصول على بيانات أدق.

تتضمن منهجية فرض ثلاث مناطق اهتمام لكل صورة. عن طريق عرض ثلاث صور لمجموعة من 20 مشاركًا، يتم حساب فعالية كل صورة.

تخضع البيانات الناتجة عن جهاز تتبع العين لعملية المعالجة، وعن طريق تحديد المنطقة التي تحتوي على أكبر عدد من النقاط وأكبر عدد من المشاهدين، يتم تحديد المنطقة التي حققت أكبر عدد من الزيارات والاهتمام.

من خلال المقارنة بين المناطق المحددة كأكثر أهمية لكل صورة والمناطق الناتجة، لوحظ أن الصورة رقم اثنان حصلت على أعلى نسبة بنسبة 90%، في حين حصلت الصورة رقم ثلاثة على 87%، وحصلت الصورة رقم واحد على النسبة الأدنى بنسبة 70%.

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قسم علوم الحاسوب

استخلاص المناطق الجذابة في الإعلانات التجارية بناءً على تحليل تتبع العين

رسالة ماجستير

مقدمة الى مجلس كلية علوم الحاسوب وتكنولوجيا المعلومات / جامعة كربلاء وهي جزء من متطلبات نيل درجة الماجستير في علوم الحاسوب

كتبت بواسطة

تيسير حازم عبد المطلب جابر

بإشراف

الأستاذ المساعد الدكتور عقيل عبد الكريم فرحان السقا

1445هـ **2024 م**