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Future Scenarios of Smart Glasses for Visual Impaired Persons in Malaysia: A STEEPV-Based Foresight Study

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Abstract

Visual impairment affects millions of people worldwide, yet the potential of smart glasses as an assistive technology remains largely unexplored in the Malaysian context. This study examines the future drivers and scenarios of smart glasses for persons with visual impairment in Malaysia, and assesses the technology readiness of potential users. Employing an exploratory research design, the study applied STEEPV (Social, Technological, Environmental, Economic, Political, and Values) analysis to identify key drivers, followed by impact-uncertainty analysis and scenario building. A descriptive questionnaire was distributed to 384 potential users or their caregivers in the Kuala Lumpur area, yielding 251 valid responses (response rate: 65.36%). From the STEEPV analysis, 10 key drivers were identified and ranked by mean impact and uncertainty scores. Two drivers emerged as having the highest combined impact and uncertainty: Social and Interpersonal Dynamics (impact mean = 4.67; uncertainty mean = 3.35) and Technological Evolution and Adoption (impact mean = 4.56; uncertainty mean = 3.26). These two drivers were used to construct four future scenarios over a 10- to 20-year horizon: (1) “Develop New Social Channels for Interaction,” (2) “Mismatch Between Technology and User Needs,” (3) “Privacy and Security Issues,” and (4) “Stagnation in Society and Technology.” Technology Readiness Index (TRI) analysis revealed an overall TRI score of 3.69 (High), with Innovativeness (mean = 4.33) and Optimism (mean = 4.14) as the dominant positive attributes. The most probable future scenario is the development of new social channels for interaction, driven by high technology adoption and positive user attitudes. These findings provide evidence-based guidance for smart glasses developers, healthcare providers, and policymakers seeking to promote inclusive assistive technology in Malaysia.

1. Introduction

Smart glasses are wearable computing devices that integrate the display capabilities of a microcomputer or mobile phone into a glasses frame. The key enabling technologies of smart glasses include augmented reality (AR) or mixed reality (MR) functions, the Internet of Things (IoT), and artificial intelligence (AI). These technologies allow users to interact with digital and physical environments simultaneously and are expected to redefine how people engage with the world (Nsflow, 2023). Despite growing global interest, the adoption of smart glasses as assistive technology for persons with visual impairment remains underexplored, particularly in developing countries such as Malaysia.

Smart glasses provide functionality comparable to smartphones, including navigation, social media, photography, and communication. When powered by AI, they have the potential to transform the lives of persons with disabilities by enabling them to overcome barriers that were previously insurmountable (Bloom Healthcare, 2023). For example, Microsoft's Seeing AI application uses artificial intelligence to describe people, text, currency, colours, and objects, converting visual information into audio descriptions for users with visual impairment. Such applications demonstrate the profound impact that smart glasses technology can have on daily independence and quality of life.

Globally, at least 2.2 billion people live with near or distance visual impairment (World Health Organization, 2023). In Malaysia, persons with visual impairment represent approximately 1.2% of the population, yet they continue to face significant barriers to independence, social participation, and employment. Existing assistive technologies — such as white canes, screen readers, and Braille devices — are limited in their ability to support real-time environmental interaction. Smart glasses, with their capacity to overlay digital information onto the physical world, represent a promising next generation of assistive technology. However, the extent to which smart glasses are accepted, understood, and likely to be adopted in Malaysia has not been comprehensively investigated.

Despite the potential of smart glasses, their development and widespread adoption for visual impairment face several critical challenges. These include technical limitations, high costs, privacy and data security concerns, social acceptance, ergonomic design, and regulatory compliance (Adamska, 2023). Furthermore, there is a notable scarcity of research on smart glasses specifically designed for or studied in the context of visually impaired users (Lee et al., 2020). This research gap is particularly significant in the Malaysian context, where the intersection of disability, technology readiness, and future planning has not been examined through a structured foresight framework.

To the best of the authors' knowledge, this is the first study to apply STEEPV (Social, Technological, Environmental, Economic, Political, and Values) analysis combined with scenario building and the Technology Readiness Index (TRI) to examine smart glasses for persons with visual impairment in Malaysia. Prior studies have examined smart glasses from engineering and design perspectives (Lee et al., 2020; Mukhiddinov & Cho, 2021), but none have employed a structured foresight methodology to map future scenarios in a Malaysian context. This study therefore makes three key contributions: (1) it identifies the dominant external drivers shaping the future of smart glasses for visual impairment through STEEPV analysis; (2) it constructs evidence-based future scenarios using impact-uncertainty analysis; and (3) it assesses technology readiness among potential users using the TRI framework. The findings are intended to support smart glasses developers, healthcare providers, and policymakers in making informed decisions about the future deployment of this assistive technology in Malaysia.

The objectives of this study are: (1) to identify the key issues and challenges of smart glasses for persons with visual impairment in Malaysia; (2) to identify the key external drivers shaping the future of smart glasses through STEEPV analysis; (3) to construct future scenarios of smart glasses for visual impairment over the next 10 to 20 years; and (4) to assess the technology readiness of potential users using the Technology Readiness Index (TRI).

The unit of analysis in this study is the caregiver or family member of a person with visual impairment, rather than the visually impaired individual directly. This approach was adopted because persons with visual impairment may face difficulties participating in self-administered written surveys. Caregivers and family members, who are closely familiar with the daily experiences and assistive technology needs of visually impaired individuals, served as proxy respondents. This proxy methodology is consistent with established practices in disability research (Boynton, 2004) and is explicitly acknowledged as a limitation of the study. The perspectives captured therefore reflect caregiver assessments of smart glasses' potential benefits and challenges, which may differ from the direct experiences of visually impaired users themselves.

This study makes several important contributions. From a practical standpoint, the findings provide eyewear developers and policymakers with evidence-based insights into how smart glasses can be designed and deployed more effectively for persons with visual impairment in Malaysia. The results can inform decisions related to managing device adoption, reducing operational costs, and ensuring compliance with relevant laws and regulations (GlobalData Thematic Intelligence, 2020; Yigit, 2023). From a social perspective, this study highlights the role that technology can play in improving independence, social inclusion, and quality of life for a population that is often underserved by mainstream technology development. Ultimately, this research aims to position smart glasses not merely as an assistive tool, but as an integral part of daily life for persons with visual impairment — a bridge between disability and full participation in society (Georgiou, 2023).

The remainder of this paper is structured as follows. Section 2 presents the methodology, including the research design, STEEPV analysis framework, data collection approach, and analysis techniques. Section 3 provides a literature review covering the history, trends, advantages, and challenges of smart glasses. Section 4 presents the data analysis and results, including the impact-uncertainty analysis and TRI findings. Section 5 discusses the four future scenarios and their implications. Section 6 concludes the paper with a summary of findings, practical recommendations, and directions for future research.

2. Methodology

The research methodology serves as a systematic approach that enables researchers to conduct a comprehensive study to address the research problem effectively. A well- defined research methodology enhances the efficiency and effectiveness of data collection and analysis throughout the research process.

This paper explains the purpose and implementation of the research methodology. The qualitative method employed in this study is the STEEPV analysis, which helps identify external factors that will influence future trends. STEEPV analysis considers Social, Technological, Environmental, Economic, Political, and Values factors. STEEPV is recognized as a structured tool for conducting Technology Foresight analysis (Minhas et al., 2011). The following subsections describe the research design, foresight process, and data collection method.

This study adopted exploratory research design to achieve the study's purposes. Even though technology foresight involves a wide range of activities like group discussions, scenario workshops, brainstorming, consensus building, system foresight, foresight activities, strategic intelligence, future research, or technology roadmaps. This study focuses on horizon scanning, STEEPV analysis, Impact uncertainty analysis, and scenario building.

The foresight process collects data and interprets it so that people can consider the future in new and diverse ways (Conway, 2006). The findings indicate that the selection of foresight methods has been influenced and dominated by professionals' and organizers' instinct, insight, impulsiveness, and sometimes inexperience or irresponsibility (Popper, 2008).

The foresight process, usually called strategic foresight, is used in various industries, including marketing, to foresee and prepare for future developments and obstacles. It entails a methodical approach to data collection, analysis, and interpretation to spot future trends, opportunities, and risks that could impact a company or sector (Hirvensalo, 2023). The foresight process prioritizes the future by employing 10-year-ahead long-term thinking to support strategic decision-making.

Horizon scanning is used to identify potential threats, risks, emerging issues, opportunities, and future developments by concentrating on new technologies and their impact. Horizon scanning aids in analyzing the future and identifying emergent trends and developments that will influence future policies and practices (Government Office of Science & Cabinet Office, 2013). Horizon scanning is gaining popularity among commercial organisations because it can aid in strategic planning, policymaking, risk management, and research prioritisation (William et al., 2019). In this study, horizon scanning assisted the researcher in identifying constants, changes, unexpected developments, and trends based on desk research.

The STEEPV structure is used for scanning developments in the external macro environment of smart glasses for visual impairment in Malaysia.

In this study, the population of interest is potential users of smart glasses among persons with visual impairment in Malaysia. Data collection was conducted in the Kuala Lumpur metropolitan area, which was selected because it is the most densely populated region in Malaysia and offers the greatest access to technology users and caregivers of persons with visual impairment. It is acknowledged that this geographic scope limits the generalisability of findings to the whole of Malaysia, particularly with respect to rural and less urbanised populations. This is treated as a limitation of the study. Based on World Population Review (2024), Kuala Lumpur's 2024 population is estimated at 8,815,630 people. Applying the national visual impairment prevalence rate of 1.2%, the estimated population of visually impaired persons in the Kuala Lumpur area is approximately 105,787. Following Krejcie and Morgan (1970), a minimum sample size of 384 was determined. Convenience sampling was employed due to the absence of a comprehensive sampling frame for this population (Edgar & Manz, 2017).

A descriptive questionnaire was used in this study. The questionnaire was developed based on the drivers identified through STEEPV analysis and was pilot-tested with 20 respondents prior to full distribution; minor wording adjustments were made based on feedback. Reliability was assessed using Cronbach's Alpha, with all sections yielding values above 0.70, indicating acceptable internal consistency. There were four sections in the questionnaire: Section A collected demographic information; Section B measured the importance of factors encouraging smart glasses adoption in Malaysia using a five-point Likert scale [(5) = highly impact to (1) = no impact]; Section C assessed the impact of implementing smart glasses in Malaysia [(5) = complete certainty to (1) = no certainty]; and Section D measured uncertainty related to implementation [(5) = strongly agree to (1) = strongly disagree]. The Technology Readiness Index (TRI) was incorporated into the questionnaire to assess user attitudes towards smart glasses technology.

In this study, the primary data were collected through a descriptive questionnaire derived from the STEEPV analysis results. The collected data were analysed using Microsoft Excel to generate descriptive statistics, including mean scores, frequencies, and percentages. Leading drivers were then identified based on their mean impact and uncertainty scores for further impact-uncertainty analysis. Scenario building analysis was subsequently conducted using the top two drivers identified from this analysis.

The list of drivers was used to develop an Impact Uncertainty analysis. The drivers were ranked according to their importance, impact, and uncertainty. Based on the list, the top two variables with a higher level of impact and level of uncertainty have been chosen to develop a scenario analysis. Scenario analysis is developed following an impact uncertainty analysis based on average values calculated from data analysis.

Based on the impact uncertainty, the researcher identified two main drivers that have both high impact and high uncertainty. Based on the two drivers, the researcher then identified the scenario that were occur in the future.

3. Literature Review

The focus of this chapter is to identify the issues and drivers of smart glasses in Malaysia. STEEPV analysis was conducted to analyze the issues and drivers, tabulate them separately and merge them from the keyword list.

3.1 Overview of the Smart Glasses

In 1968 the first head-mounted display (HMD) system was created. Wearable smart glasses are an emerging technology that's gaining popularity in the assistive technologies industry (Georgiou, 2023). With the development of AR technology, the first generation of AR smart glasses began to be launched in 2011.

Smart glasses are wearable devices that look like regular glasses but have advanced features such as cameras, screens, speakers, microphones, and sensors (Leonard, 2023). Smart glasses can connect to the internet and perform various functions such as taking photos, making calls, browsing the web, and more. Superimposing information onto a field of view is achieved through an optical head- mounted display (OHMD) or embedded wireless glasses with transparent heads-up display (HUD) or augmented reality (AR) overlay. One of the key technology of smart glasses is virtual retinal display (VRD), which projects images or content generated by a computer, TV, or smartphone, directly onto a wearer's eye rather than a screen (Margit, 2022).

In recent years, the development of AI has become a future trend, so the smart glasses launched in recent years are more complete. Smart glasses equipped with AI have infinitely surpassed previous AR smart glasses. According to GlobalData, the smart glasses market will reach $2.3 billion by 2030.

3.2 The Trends of Smart Glasses for Visual Impairment

According to the article "Examining the Past, Present, and Future of Assistive Technology", early innovations in assistive technology include the invention of Braille in 1824 by Louis Braille, which revolutionized reading and writing for the blind. Another milestone came in 1935 with the introduction of talking books, utilizing phonograph records to provide educational and entertainment resources for the visually impaired.

The mid-20th century brought further advancements, such as the Perkins Brailler in 1951, a mechanical braille typewriter that made writing in braille more accessible. Although electronic hearing aids originated in the late 1800s, the mid-20th century saw significant improvements in miniaturization and electronics, paving the way for more sophisticated assistive devices.

In the late 20th century, technological progress included screen readers in the 1980s, such as JAWS, which enabled visually impaired users to interact with computers through text-to-speech conversion. Optical Character Recognition (OCR) technology, developed from the 1970s to the 1980s, allowed printed text to be scanned and read aloud by computers, enhancing accessibility.

According to the article "History of Assistive Technology", The 21st century introduced powerful tools like smartphones and tablets with built-in accessibility features, including screen magnification, voice control, and text- to-speech capabilities. AI-powered navigation systems have further enhanced independence by using artificial intelligence to assist visually impaired individuals in navigating their environments. Additionally, smart glasses now provide real-time information and assistance, improving interaction with surroundings. Future trends point to the potential of advanced virtual and augmented reality (VR and AR) technologies to create immersive environments that aid navigation and interaction, opening new horizons for assistive technology.

3.3 Advantages of the Smart Glasses

Smart glasses could make it easier for the visually impaired to work and live alone. In the rapidly advancing world of technology, smart glasses, such as the Meta Ray-Ban glasses, are emerging as a beacon of hope for the blind and visually impaired. These sophisticated devices, which blend the latest in augmented reality (AR) and artificial intelligence (AI), have the potential to significantly enhance the quality of life for those with blindness or visual impairments (Posner, 2024). Assistive smart glasses designed to help people with poor vision typically work by translating the wearer's surroundings into computer-synthesized speech (Georgiou, 2023).

With the new smart glasses, users with visual impairment can read books. They may also come with features such as voice recognition control for internet searches or booking services, among others (Georgiou, 2023). The latest Smart Vision Glasses use artificial intelligence (AI) and Machine Learning (ML) to function. The device uses AI to offer users a more interactive experience (Mukhiddinov & Cho, 2021).

Smart glasses can make it easier for visual impairment people to go out for a walk. Smart glasses become their eyes, providing them with information about their surroundings. Mapping software, with the help of cameras, can tell them when to stop at traffic lights and tell them when they can continue on their way. It will provide them with turn-by-turn navigation while monitoring the surroundings. It can even remind them of curb steps and provide them with better guidance when they are out and about (Bajarin, 2021). Smart glasses can guide users through unfamiliar environments with audio directions, helping them navigate obstacles and hazards (Posner, 2024).

3.4 Challenges of the Smart Glasses

While the potential of smart glasses for the visually impaired is vast, there are challenges to consider (Posner, 2024). The fact that smart glasses are a new technology, creates a lot of uncertainty about whether they will be adopted by users, as is the case with other new technologies (Rejali, Aghabayk, Esmaeli & Shiwakoti, 2023).

Smart glasses require powerful processors to handle complex tasks and deliver a smooth user experience (Yigit, 2023). Smart glasses just like most smartwatches, so it can't have many operations or usage Independence. Most of the features, they'll require being connected to your phone or your intended gadgets (Ayoadetek, 2022).

The cost of these devices can be prohibitive for many, and there are also concerns regarding privacy and data security, especially with features like facial recognition (Posner, 2024). Smart glasses are envisioned to threaten security (Boissier and Castelfranchi, 2014) as information about a person and his or her behavior may become accessible by others (Nyang, 2014).

3.5 STEEPV Analysis

A study of smart glasses for visual impairment reveals a variety of key drivers, including technological, economic, consumer, environmental, regulatory, service quality, social, health, workforce, and modernization aspects. These drivers are intricately linked through emerging trends, issues, challenges, and their respective frequencies. Table 1 shows that technological drivers are the most numerous.

3.5.1 Social Driver

There are several key factors that influence consumer adaptation and behavior of smart glasses. The visual experience of smart glasses is very important because the unique design can attract customers (Tamer, 2023). The market acceptability of smart glasses is very high due to their ability to meet customer needs and preferences, as well as their creativity and practicality (Greenwald, 2024). However, the expensive price of smart glasses will become a consideration for consumers (Adamska, 2023).

The emergence of smart glasses will change social and interpersonal dynamics. Smart glasses can become a social platform and change people's social style (GlobalData Thematic Intelligence, 2020). It also provides a better social environment, which allows people to better maintain social relationships (Tamer, 2023).

Health and safety issues with smart glasses include a range of critical issues affecting personal and public well-being (GlobalData Thematic Intelligence, 2020). Smart glasses security challenges are critical because security and privacy can be compromised (Focus point, 2023). Smart glasses can raise the standard of care and are critical to delivering high-quality care and improving patient outcomes. In addition, smart glasses can effectively aid telemedicine and remote consultation, especially in underserved areas, but they also bring new security and medical challenges (GlobalData Thematic Intelligence, 2023).

Smart glasses are an advanced digital technology (I&T Today, 2024). Businesses can also use smart glasses to increase productivity and achieve higher efficiency and output with fewer resources (Qin, 2021). Through reaching worldwide audiences, providing cutting-edge goods and services, and staying competitive in an increasingly digital economy, this digital revolution opens up new markets for enterprises (GlobalData Thematic Intelligence, 2020). As a result, job roles and skill requirements across industries will also change, emphasizes Demand for a digitally skilled workforce.

3.5.2 Technological Driver

Smart glasses incorporate the latest augmented reality (AR) and artificial intelligence (AI) technologies, which will have the opportunity to improve the quality of life for blind and visually impaired people. Through the integration of these two technologies, new accessibility can be achieved. Smart glasses will also become a new auxiliary tool (Posner, 2024).

The rapid evolution and adoption of technology are transforming various aspects of our daily lives and business operations. Smart glasses are equipped with many of the most advanced technologies, such as Artificial intelligence (AI), Augmented reality (AR) or mixed reality (MR) functions, 5G and so on (Nsflow, 2023). These technologies will bring huge changes to various industries. But smart glasses also have some challenges and problems, such as lack of technology, and smart glasses are also more easily broken (Ayoadetek, 2022).

Today's smart glasses are equipped with the latest technology, such as Seeing AI uses artificial intelligence to describe the world around the user, providing audio descriptions of objects, people, and text (Whitney, 2023). Google's Live Transcribe app uses artificial intelligence to transcribe speech in real-time, allowing people who are deaf or hard of hearing to participate in conversations (Goode, 2019). Wheelmap uses artificial intelligence to crowdsource accessibility information for public spaces, enabling people with disabilities to plan their routes in advance (Mobasheri, Deister, & Dieterich, 2017). Smart Glasses as a Virtual Screen has the most potential to penetrate the consumer market (Greenwald, 2024). Many smart glasses are now equipped with virtual AI assistants like Alexa, Amazon, and Siri that enable you to do speech commands if you need assistance or answers to queries (I&T Today, 2024).

3.5.3 Economics Driver

Smart glasses will have many economic impacts. As a leading technology, its future market value will be huge. This is because smart glasses can open up a new market and lead economic development around the world (GlobalData Thematic Intelligence, 2020). Then there are the problems and challenges that come with it, which is the marginalization of low-income communities (Tamer, 2023). High-tech products may attract a wave of purchases, but low-income groups may not be able to afford the high prices (Qin, 2021).

3.5.4 Environmental Driver

Smart glasses can also improve energy efficiency and minimize energy consumption in various environments. By integrating advanced sensors and real-time data analytics, smart glasses enable users to monitor and optimize energy usage in real time (Gen, 2023）. Therefore, smart glasses not only improve users' work efficiency and convenience, but also play a vital role in promoting environmental sustainability.

3.5.5 Political Driver

The adoption of smart glasses brings forth a range of regulatory and compliance issues that need careful consideration. Privacy concerns are paramount, as these devices can capture and transmit personal data, raising potential risks of misuse or unauthorized surveillance (Hildebrandt, 2014). Laws such as The Communications & Multimedia Act 1998 and cyber violence provisions in the Penal Code are crucial for addressing these challenges, ensuring that the use of smart glasses complies with civil rights and privacy standards (Wassom 2014). The establishment of effective regulations and policies is necessary to strike a balance between innovation and the defence of individual rights and public safety (Yigit, 2023).

3.5.6 Value Driver

Smart glasses are poised to significantly impact the modernization of various sectors and shape future trends. By increasing the digital integration of business processes, they enhance operational efficiency and open up new markets on a global scale (GlobalData Thematic Intelligence, 2020). Smart glasses provide novel learning opportunities that boost student engagement and productivity in the classroom (Mukhiddinov & Cho, 2021). These gadgets make life easier by offering greater convenience, security, and safety; in the medical field, they raise accessibility and standards through telemedicine and remote consultations (GlobalData Thematic Intelligence, 2023).

In conclusion, smart glasses are poised to significantly influence modernization across various sectors, enhancing digital integration, operational efficiency, and global market reach. Through telemedicine and remote consultations, they provide fresh learning possibilities, enhance everyday comfort, safety, and security, and raise healthcare standards. As smart glasses develop further, they will surely become increasingly important in determining how society and technology develop in the future.

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Table 1 *Table of driver to merged issues, and challenges*

STEEPV	Key Driver	Merged trends, issues and challenges	Frequency
S	Consumer Adaptation and Behavior	• Visual experience • Daily life • Market acceptance • Ergonomic design • Public Perception • High budget	6
S	Social and Interpersonal Dynamics	• Social relationships • Communication way • Social style • Conversational platforms	4
S	Health and Safety Concerns	• Security challenges • Health issues • Cybersecurity • Improve medical standards • Telemedicine and remote consultation	5
S	Workforce and Employment Impact	• Improving productivity • Increase digital integration of business process • New market	3
T	Service and Interaction Quality	• Accessibility	1
T	Technological Evolution and Adoption	• Artificial intelligence (AI) • Augmented reality (AR) or mixed reality (MR) functions, Internet of Things (IoT), and artificial intelligence (AI). • Seeing AI • Google's Live Transcribe • Wheelmap • VR • Voice assistant • Easily broken • Lack of technology • Display Technology • Performance and Processing Power • Connectivity • Virtual retinal display (VRD) • Microdisplays • Custom silicon • 5G	16
E	Economic Impacts and Efficiency	• Marginalizing low-income communities. • Buying wave • Market value • Digital Divide • Global economic • New Market	6
E	Environmental Considerations	• Energy Efficiency	1

4. Data Analysis and Results

This section presents the results of data collection from 225 respondents. The impact-uncertainty analysis was conducted using Microsoft Excel.

The sample size for this study was 384. A total of 251 questionnaires were collected, resulting in a respondent rate of 65.36% among those willing to participate in this research study.

Table 2 *Mean of drivers impact-uncertainty analysis*

Code	Drivers	Mean	
		Impact	Uncertainty
D1	Consumer adaptation and behavior	4.23	2.63
D2	Social and interpersonal dynamics	4.67	3.35
D3	Health and safety concerns	4.2	2.75
D4	Workforce and employment impact	4.15	2.77
D5	Service and Interaction Quality	4.1	2.8
D6	Technological Evolution and Adoption	4.56	3.26
D7	Economic Impacts and Efficiency	4.07	2.82
D8	Environmental Considerations	3.74	3.01
D9	Regulatory and Compliance Issues	4.49	3.06
D10	Modernization and Future Outlook	4.56	2.63

This section presents the demographic analysis of the respondents, with data collected using a questionnaire as the research instrument. Part A of the questionnaire gathered demographic information, including gender, age, relationship with visual impairment, familiarity with smart glasses for visual impairment, and perceived benefits of using smart glasses. A total of 251 people with visual impairment participated in the analysis, and the data was analyzed using frequency and percentage measures.

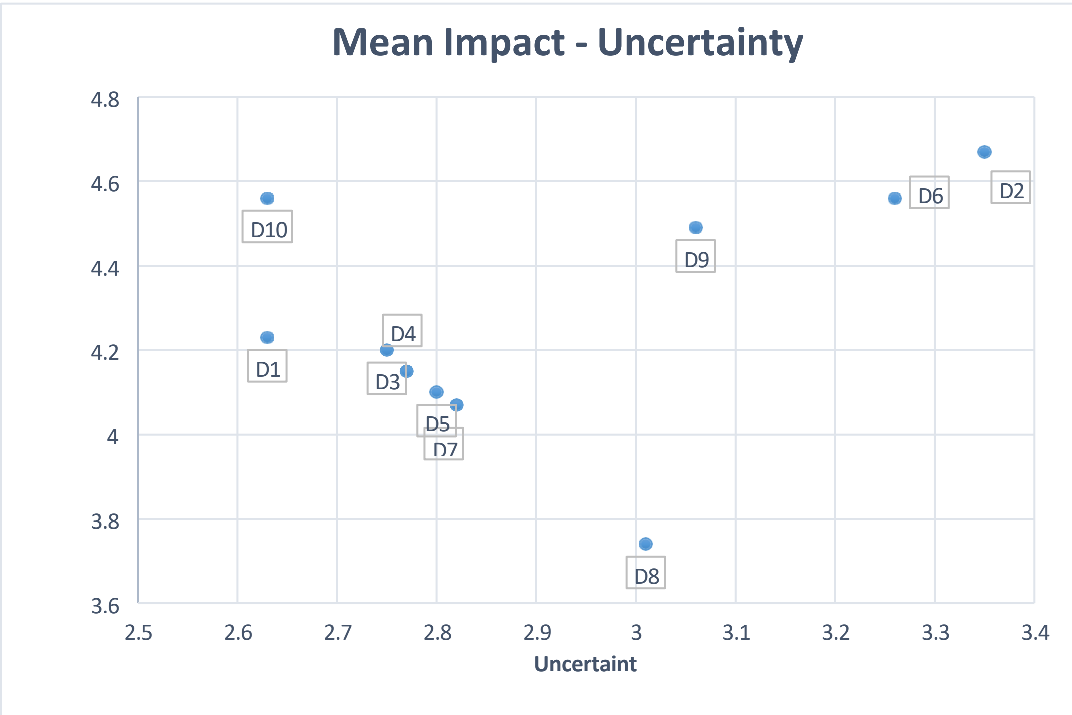

Fig. 1 *Mean of drivers impact-uncertainty analysis*

Table 2 indicates the comparison of mean value between the level of impact and level of uncertainty. All data are used to construct impact and uncertainty analysis as shown in Fig. 1. the main objective of the analysis is to determine the highest outcome in term of impact and uncertainty. Based on the Fig, 1, it is found that D2 (4.67, 3.35) and D6 (4.56, 3.26) which have been highlighted with red colour circle in the Fig. 1. The decision of the top two drivers was made based on the highest mean scores of impacts and uncertainty. D2 and D6 represent the

"Social and interpersonal dynamics" and "Technological Evolution and Adoption" respectively. These two key drivers will used to generate the scenario-building analysis.

Table 3 *Statistical mean score of Technology Readiness Index (TRI)*

Attributes	Mean	Central of Tendency Level
Optimism	4.14	Very High
Innovativeness	4.33	Very High
Discomfort	2.97	Moderate
Insecurity	3.31	High
Overall TRI	**3.6875**	**High**

According to the Table 3, innovativeness has the highest mean score among the four attributes, at 4.33. Optimism follows as the second highest with a mean score of 4.14, while insecurity comes in at 3.31. Discomfort has the lowest mean score at 2.97. Overall, these four attributes demonstrate a high level of central tendency, indicating that the technology readiness of smart glasses for visual impairment is viewed favorably in Malaysia. However, smart glasses for the visually impaired also bring users a sense of insecurity.

5. Discussion, Recommendation and Conclusion

This section discusses the scenario building using the selected two drivers based on the impact-uncertainty analysis in the previous section. This chapter aims to create four distinct alternative scenarios that represent the future technology of smart glasses for visual impairment over ten years. The outcomes might be either beneficial or harmful. Impact uncertainty and scenario analysis are required to determine the top two that show high levels of impact and uncertainty to smart glasses for visual impairment. This chapter will demonstrate the four-scenario analysis in detail. Discussion on The First Research Objective.

5.1 Social and Interpersonal Dynamics

Based on the level of impact and uncertainty, the social and interpersonal dynamics is the highest selected driver. This driver was selected due to the feedback and opinion of the respondents who randomly chose smart glasses for visual impairment. This driver has a conduct mean of 4.67 and 3.35 in impact and uncertainty. Social and interpersonal dynamics play a significant role in smart glasses for visual impairment. Smart glasses can effectively improve the quality of life. Smart glasses can significantly improve the overall quality of life for people with visual impairments by improving social interaction and independence. This includes better participation in social activities and a greater sense of inclusion (Grand View Research, 2024). In addition, smart glasses can also enhance communication. According to research from Market Research Reports (2024), smart glasses can improve the ability of visually impaired people to interpret non- verbal cues, thereby improving social interactions and relationships. This can have a profound impact on their social life and overall well-being. However, privacy issues have also become the biggest challenge that smart glasses must overcome. Smart glasses users may have concerns about privacy and data security, which may affect their willingness to use smart glasses. Ensuring strong privacy measures is critical to earning user trust.

5.2 Technological Evolution and Adoption

The mean of technological evolution and adoption is the second highest mean in the level of impact and uncertainty. Which is 4.56 in level of impact and 3.26 in level of uncertainty. According to research from Grand View Research (2024), factors such as increased connectivity through the Internet of Things (IoT) and the rise of augmented reality (AR) applications are driving the market forward. The global smart glasses market size is estimated at USD 1.93 billion in 2024 and is expected to grow at a Compound Annual Growth Rate (CAGR) of 27.3% from 2025 to 2030. The market is experiencing significant growth driven by the convergence of technological advancements and the growing consumer demand for wearable technology. Furthermore, smart glasses are increasingly integrated with other technologies, such as smartphones and wearables, to provide a seamless user experience. This integration expands the potential applications and benefits of smart glasses, from navigation and communication to health monitoring and fitness tracking. However, as smart glasses become more advanced, concerns about privacy and data security are likely to increase. Regulatory frameworks will need to evolve to address these concerns, and uncertainty surrounding these regulations could impact the development and adoption of smart glasses (Market Research Reports, 2024).

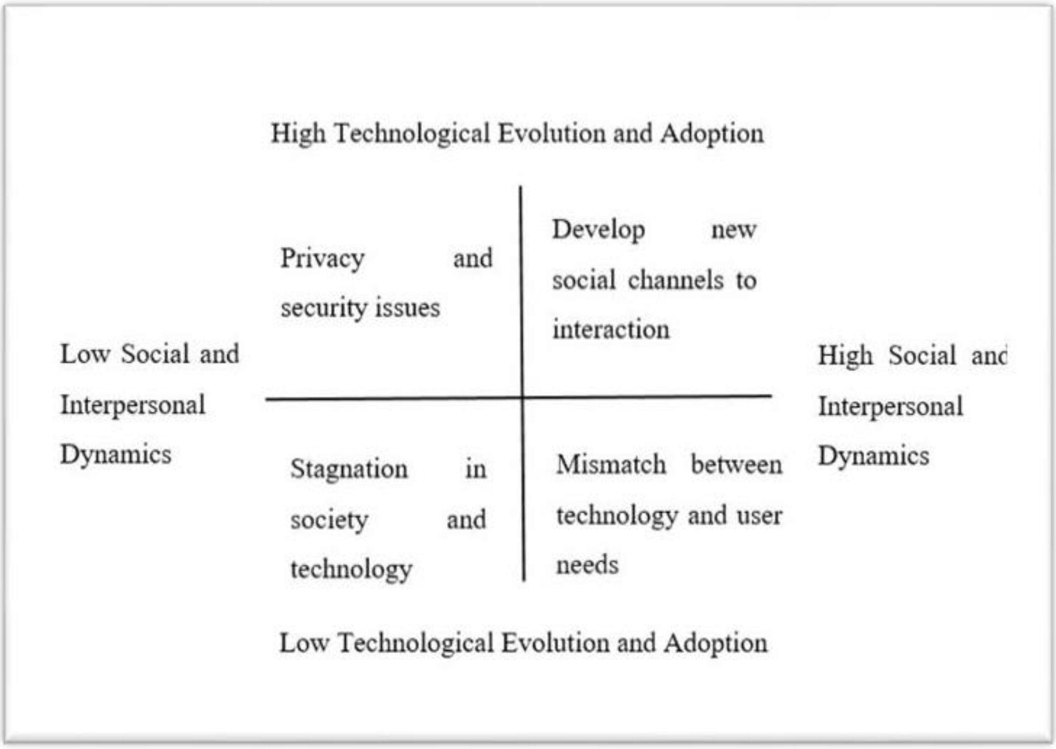

Fig. 2 *Future scenario of smart glasses for visual impairment*

Fig. 2 shows the four possible future scenarios that indicated in future, the data is getting from impact-uncertainty in chapter 4. Moreover, the four alternatives scenario were developed from two selected drivers which is "Social and Interpersonal Dynamics" and "Technological Evolution and Adoption."

5.2.1 Scenario 1 "Develop New Social Channels to Interaction"

Scenario 1 shows that smart glasses can develop a new social channel for interaction due to the high technology evolution and adoption, and social and interpersonal dynamics. Smart glasses are set to transform various aspects of daily life, enhancing social interactions and accessibility, with promising future scenarios on the horizon. One of the key benefits of smart glasses is enhanced social interaction. By integrating Augmented Reality (AR), smart glasses can overlay digital information onto the physical world, providing real-time data, translations, and even facial recognition (Caballar, 2023). This AR capability can enrich social connections, making communication more intuitive and immersive. Additionally, these devices enable virtual meetups, allowing people to connect in shared digital spaces regardless of physical distance, which could reshape socialization in an increasingly globalized world (Tugcetamer, 2023). In terms of accessibility and inclusion, smart glasses hold immense potential as assistive technology. For individuals with visual impairments, these devices offer real-time navigation assistance, object recognition, and text-to-speech functionalities, significantly improving daily life and mobility (NoorCam, 2023). Moreover, inclusive design considerations ensure that smart glasses can serve a wide range of users, bridging technological divides and making digital innovations more accessible to diverse groups (Caballar, 2023). As technology advances, we can expect smart glasses to become more mainstream, leading to widespread changes in how we interact with both digital and physical environments (Zuidhof et al., 2021).

5.2.2 Scenario 2 "Mismatch Between Technology and User Needs"

The second scenario shows that "mismatch between technology and user needs". The development and adoption of smart glasses face challenges in aligning user needs with technological capabilities, adapting to evolving social dynamics, providing essential assistive features, and navigating future innovation demands. A primary issue lies in user needs versus technology capabilities. If the technology in smart glasses evolves slowly, it may not keep up with the growing and changing needs of users. For example, users might expect advanced features like seamless AR integration or high-quality visual aids, which may not be available in lower-tech versions (Zuidhof et al., 2021). Moreover, a lack of intuitive design and user-friendly interfaces can lead to frustration and reduced adoption. Users expect smart glasses to be easy to use and integrate smoothly into their daily lives (Tugcetamer, 2023). The influence of social dynamics and expectations also plays a critical role. There are high social expectations for technology to enhance interactions and accessibility. If smart glasses fail to meet these expectations, users may

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feel dissatisfied and view the technology as outdated (Tugcetamer, 2023). For individuals with visual impairments, smart glasses need to deliver dependable assistive features, such as reliable navigation or object recognition. When the technology lags, these users may not fully benefit, impacting their independence and quality of life (Zuidhof et al., 2021). Finally , without continuous innovation, smart glasses may fail to keep pace with other rapidly advancing technologies, leading to a decline in their relevance and utility (Zuidhof et al., 2021).

5.2.3 Scenario 3 "Privacy and Security Issues"

The third scenario is that the level of technological evolution and adoption of smart glasses is high, but the level of social and interpersonal dynamics is low. In this scenario, people will worry about the "privacy and security issues" of smart glasses. Smart glasses introduce notable privacy concerns due to their potential for surveillance and recording. Equipped with cameras and microphones, these devices can discreetly capture audio and video, raising worries about covert surveillance and misuse. This raises concerns about covert surveillance and the potential for misuse (McArthur, 2023). This capability highlights the ethical dilemmas of high-tech wearable devices. Additionally, High social dynamics also bring heightened awareness and concern about privacy. Smart glasses with limited technological capabilities may not have robust privacy features, leading to potential misuse and ethical issues (Tugcetamer, 2023). Advanced smart glasses often collect a large amount of data, including location, audio and video information. This data can be used for various purposes, sometimes without the user's explicit consent. This is also a major factor in data breaches (Cybernews, 2024). Privacy and security challenges are also regulatory challenges, as governments and regulators may find it difficult to keep up with rapid technological advances, leading to gaps in legislation and enforcement (McArthur, 2023).

5.2.4 Scenario 4 "Stagnation in Society and Technology"

The last scenario shows "stagnation in society and technology"; this is the worst scenario for smart glasses for visual impairment in the future view. A stagnation of technical foundation in smart glasses development brings numerous challenges that hinder innovation, user adoption, and social acceptance. Limited innovation is a major concern, without significant technological advancements, smart glasses may lack innovative features that enhance user experience, such as advanced AR capabilities or seamless integration with other devices (Zuidhof et al., 2021). The slow evolution of technology also presents user adoption challenges, with low adoption rates as a likely outcome. Because slow evolution can result in the use of outdated hardware and software, making the devices less competitive and appealing to users. If the technology does not evolve to meet user needs and expectations, adoption rates may remain low. Users might not see the value in investing in smart glasses that do not offer significant benefits over existing devices (Smithson, 2024). The lack of a strong technical foundation can result in missed opportunities for innovation and market growth. Competitors with more advanced technology may dominate the market (Smithson, 2024).

5.3 Discussion

According to the table 3, technology readiness of smart glasses for visual impairment, the scores for innovativeness and optimism are very high. This indicates that users may be willing to explore new ways to use the technology. This openness can drive the creation of new social channels as users seek innovative ways to connect and interact. Although the scores for insecurity and discomfort are high and moderate, but the optimism score is higher than both of the insecurity and discomfort scores. This indicates that there is still a positive attitude towards the technology. Therefore, most users are still more likely to accept new opportunities, including new social channels, because they believe in the potential benefits. This once again proves that smart glasses for visual impairment are most likely to develop new social channels for interaction in the future.

5.4 Recommendations

The main purpose of this study is to determine the future trends of smart glasses in Malaysia over the next ten to fifteen years. Based on the TRI findings, users demonstrate a generally positive disposition towards smart glasses; however, the insecurity score remains relatively high (mean = 3.31), suggesting that privacy and data security concerns are a significant barrier to adoption. To address this, several recommendations are proposed. First, developers should strengthen data encryption and identity authentication mechanisms to enhance user privacy protection, and the industry should formulate security standards and certification systems to build user trust. Second, targeted public education campaigns should be developed to alleviate privacy concerns and gradually increase social acceptance. Third, researchers and developers should explore the value of smart glasses in local application contexts such as healthcare, education, and tourism, with a focus on strengthening privacy safeguards and improving human-computer interaction. Fourth, the government should strengthen regulatory frameworks, standardise usage scenarios and data handling practices, and provide a legal foundation for the safe and equitable deployment of smart glasses technology in Malaysia.

5.5 Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. First, data collection was confined to the Kuala Lumpur metropolitan area, which limits the generalisability of findings to the broader Malaysian population, particularly rural and semi-urban communities where technology access and attitudes may differ. Second, the unit of analysis was caregivers and family members of persons with visual impairment rather than visually impaired individuals themselves. While this proxy approach was adopted due to accessibility challenges in data collection, it introduces the possibility that caregiver perceptions may not fully reflect the lived experiences and technology preferences of the visually impaired. Third, convenience sampling was employed due to the absence of a comprehensive sampling frame for this population, which may introduce selection bias. Fourth, the literature review was primarily limited to sources indexed in databases such as Google Scholar and SpringerLink, and may not capture all relevant work. Fifth, as smart glasses remain an emerging and relatively unfamiliar technology in Malaysia, some respondents may have had limited prior exposure, which could affect the accuracy of their impact and uncertainty assessments.

5.6 Limitations of the Study

This study explored the future drivers and scenarios of smart glasses for persons with visual impairment in Malaysia, and assessed technology readiness among potential users. The research objectives were achieved through STEEPV analysis, impact-uncertainty analysis, scenario construction, and the Technology Readiness Index (TRI). The key findings are summarised as follows:

- From the STEEPV analysis, 10 key drivers were identified and ranked. The two drivers with the highest combined impact and uncertainty were Social and Interpersonal Dynamics (impact = 4.67; uncertainty = 3.35) and Technological Evolution and Adoption (impact = 4.56; uncertainty = 3.26). These two drivers formed the axes for scenario building.
- Four future scenarios were constructed: (i) “Develop New Social Channels for Interaction” — the most likely scenario, characterised by high technology adoption and strong social dynamics; (ii) “Mismatch Between Technology and User Needs” — where technological progress fails to align with user expectations; (iii) “Privacy and Security Issues” — where high adoption is undermined by weak privacy governance; and (iv) “Stagnation in Society and Technology” — the worst-case scenario of low adoption and slow technological progress.
- TRI analysis showed an overall technology readiness score of 3.69 (High). Innovativeness had the highest mean (4.33), followed by Optimism (4.14), Insecurity (3.31), and Discomfort (2.97). These results indicate that users hold broadly positive attitudes towards smart glasses, though concerns about insecurity must be addressed to encourage adoption.

This study advances the body of knowledge in several ways. Theoretically, it is the first application of a combined STEEPV-scenario building-TRI framework to smart glasses for visual impairment in Malaysia, providing a replicable model for technology foresight in assistive technology research. Empirically, it contributes primary data from 251 respondents on user readiness, key adoption drivers, and perceived uncertainty — data that did not previously exist for this context. Practically, the four future scenarios provide actionable guidance for developers, policymakers, and healthcare providers.

The practical implications of this study are significant. Smart glasses developers should prioritise intuitive design, robust privacy protection, and affordability to align with the needs identified by caregivers of visually impaired users. Policymakers should establish clear regulatory frameworks governing data privacy in wearable assistive devices, particularly in the context of the Communications & Multimedia Act 1998. Healthcare providers can integrate smart glasses into visual rehabilitation programmes to improve patient independence and quality of life.

Several directions for future research are identified. First, studies should be extended beyond Kuala Lumpur to include rural and semi-urban populations across Malaysia to improve the generalisability of findings. Second, longitudinal studies tracking actual smart glasses adoption over time would provide more robust evidence than this cross-sectional design. Third, future work should involve visually impaired individuals as direct respondents rather than proxy caregivers, to more accurately capture first-person user experiences. Fourth, clinical validation studies examining the functional effectiveness of specific smart glasses models in real-world assistive contexts are needed. Finally, comparative studies across Southeast Asian countries would situate Malaysia’s trajectory within a broader regional context.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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