Smart Glasses: Digital Assistance in Industry

Trupti Sutar and Savita Pawar

Abstract New media developments have revolutionized the behavior of people in an unprecedented technique in the latest decades. Mobile phones have created an always online mentality. However, what is next? Recent developments underline the increase of a technology known as "Wearable devices." Augmented reality smart glasses (ARSG) such as Microsoft HoloLens and Google Glass are very good examples of these technology. It provides huge potential for innovation for firms and manufacturing industries. ARSG is becoming very common and important technology that promotes shop floor operators to fulfill industry 4.0 requirements. Augmented reality is currently an interesting and hot research topic in manufacturing industries. The main goal of this research paper is to improve the use of smart glasses for operator training with augmented reality. It will assist to increase effectiveness and shorter learning times for the individual operator. ARSG products available in the market are very expensive. It will help to find an affordable solution for the industries. It provides new methods for reducing the efforts of the operators working online. It mainly focuses on minimizing disadvantages of the existing products.

Keywords Augmented reality smart glasses (ARSG) · Industrial operator support · Smart factory

1 Introduction

The growth of new communication and IT has had a huge effect on how individuals communicate with each other and how companies interact with clients. Because of mobile phones such as smartphones and tablets, consumers are always and everywhere online [1]. But what is next? A review of the recent innovations by leading

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S. N. Merchant et al. (eds.), *Advances in Signal and Data Processing*,
Lecture Notes in Electrical Engineering 703,
https://doi.org/10.1007/978-981-15-8391-9_13

technology firms like Microsoft, Google, and Facebook shows that what we call ARSG could be the next development in media technology. These smart glasses are wearable devices that meld in the field of view of the customers real and virtual data. Recent marketing and academic projections indicate that intelligent glasses in media evolution are likely to be the next "major thing" [2].

Microsoft HoloLens, Google Glass, and Everywhere are three examples of commercially announced intelligent glasses. We define smart glasses as "Wearable Augmented Reality (AR) Systems" that are worn like regular glasses and combine the user's field of perspective with virtual data with physical information smart glasses are distinguished from other smartphone and wearable devices in different ways. Most significantly, they merge digital and physical data while being carried, rather than merely providing a virtual reality. Existing wearables, such as smart watches or virtual reality glasses, are not built from any parts of augmented reality. For example, many AR techniques are stationary, mirrors or AR screens. Furthermore, AR applications that can be used on smartphones or tablets must be managed proactively by the user, while intelligent glasses function separately and can be regulated by speech instructions [3].

The fourth industrial revolution is here, requiring a basic shift in attitude to intelligent factories using fresh techniques and manufacturing philosophies to notice brief product life cycles and extreme mass customization in a cost-effective manner [4, 5]. The smart factory concept is designed to enable flexible and self-conforming manufacturing processes with products and machines that function smartly and autonomously using concepts such as the Internet of things and cyber-physical systems [6]. This fundamental change in policy and a new manufacturing form will change the conditions for the operators working in the workshop, as the work activities of the operators will no longer be static and predetermined, but will be dynamic and constantly changing [7, 8]. This will position the operator's flexibility and adaptability with heavy demands. Operators need to be equipped with effective technology to promote optimal decision making and intervention to satisfy these requirements effectively.

Augmented reality smart glasses (ARSG) have been recognized in the latest years as a strong technology that supports plant operators performing multiple duties such as installation, maintenance, quality control, and handling of materials. While working on a line operator is bounded by timeline, he has to complete the task within time. If he misses any required task or steps the entire work he has done will come for rework and this rework costs much higher. To avoid such kind of instances, operator must be equipped with the device that is continuously guiding him about the next step. This task is done by a device called augmented reality smart glasses (ARSG).

ARSG is fundamentally a hand-to-hand transparent screen that integrates a miniature portable computer that adds virtual data to what the user sees [9]. ARSGs are hands-free devices with eye-level data correct where it is required, making them a perfect user interface for an industrial operator. Using ARSG for operators enables the precise data required to be automatically provided at the correct location and moment to manage a particular situation or job assignment in an ideal manner. In the latest years, ARSG's clear advantages have made technology interest grow quickly, and its growth is presently driven by several industries, such as games, sports, and tourism. ARSG shipments are expected to explode in the years to come.

There are many ARSG producers and a broad variety of products available on the market, but very few manufacturing businesses have embraced ARSG [4] despite this general availability. This may seem surprising at first glance given the obvious benefits of using ARSG on store floors, but at least two main reasons can be identified for this lack of adoption. First, the products of today are mainly sold either as goods of the general customer or as professional office products. Second, with big variations in design, technology, and functionality, the products are extremely varied. This wide variety of products makes it both complex and time-consuming for a manufacturing business to define the ideal product for its distinctive shop floor context, creating a threshold for ARSG adoption. The aim of this research is to remove this limit and promote the industry's inexpensive and easy-to-access solution, which clearly costs less than the products already on the market. The potential of new business models for innovative apps occurs in relation to enhancing the efficiency of current functions.

Knowledge on the motivations of prospective customers is required to create effective intelligent glasses and apps. Consequently, the study findings are discussed and expanded in Sect. 2 and thus give readers an overview of promising approaches. Section 3 explains the methodology used to design intelligent lenses. Section 4 provides results and discussion. By incorporating intelligent glasses, the objective is to make readers think about fresh and innovative business ideas. We finish the paper in Sect. 5. The discussion given also stimulates thoughts for studies on leadership that is academically essential.

2 Related Work

Smart glass performance can encourage ongoing research into past research and technology adoption models. A study was carried out to analyze the smart glass design factor [10].

2.1 Smart Glasses

Smart glass users can see the display irrespective of the user's position. They provide technology and data opportunities for users. Smart glasses allow individuals to do things like connecting to the Internet, sending messages, taking photos and videos, discovering locations, and running mobile apps. Companies continue to operate on virtual reality and enhanced reality to alter visual information. The main fields of use of smart glasses are medical, schooling, leisure, sports, and commerce [11].

This article provides guidance on smart glass assessment parameters, which will help the sector to choose from among the products accessible. Authors comment only on the product comparison they do not provide any technical data. But the nice thing

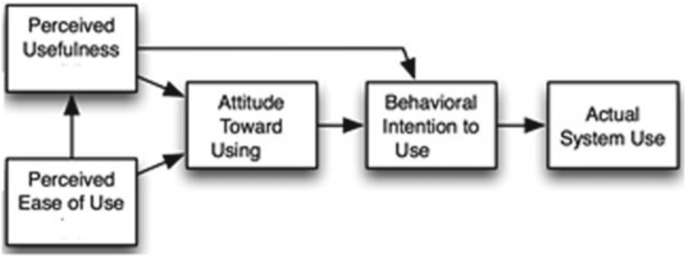

Fig. 1 Technology acceptance model (TAM)

about the document is that writers are exploring the future smart glass expansions [4].

2.2 Technology Acceptance Model

The technology acceptance model (TAM), with its roots in data systems, is a commonly cited and extended framework to explain the intentions and behaviors of potential customers in adopting particular technologies. Research on technology acceptance, particularly TAM, appears to be a helpful starting point for exploring the basic mechanisms of smart glass adoption. In particular, different researchers have implemented modified TAM models on wearable techniques. For example, for studying accepting smart watches, Kim and Shin used a revised TAM [12]. The technology acceptance model (TAM) provides an effective solution that predicts the implementation of new technology [13] (Fig. 1).

2.3 Usability

Usability is the capacity with fulfillment to communicate efficiently with data systems for par-specific purposes. The goal of interaction issues with human computers is to create more usable systems. Volker Paelke proposes a fresh strategy to the use of vibrant information content that automatically adapts to the individual operator and their learning progress in order to improve effectiveness and shorter learning times. In this paper, Buti Al Delail and Chan Yeob Yeun introduce the original experience with this scheme, which has already been used effectively by several hundred customers without prior installation assignment experience [14].

2.4 Interaction Methods

There are various elements, such as vision-based and not vision-based approaches, gesture-based and not gesture-based approaches. An alternative element divides approaches to communication into three classes that are less handheld, touch and touch.

From the perspective of interaction objectives, interaction methods, including spectacular smart glass frames, rings, wristbands, body surfaces, body movements, gloves and cameras, LIK-HANG, LEE and PAN, HUI, are evaluated. Their input capabilities are discussed based on the suggested touch and touchless input classification scheme [15]. In conclusion, touch input and freehand interaction are the most popular research topics in smart glass communication.

2.5 The Lying Challenges

This type of technology has many difficulties. One of the primary problems is that in which product category has intelligent glasses [16]. There are physical, mental, social, psychological, and technological issues related to the category of product difficulties. These are as illustrated in Fig. 2 and further discussed.

While companies find excellent alternatives to workflow through eyewear technology, the general public will still have to wait a little longer to reap the benefits

Fig. 2 Lying challenges for smart glasses

of mass accessibility and use. It happens that the challenge of achieving a harmonious balance between functionality and wearability at an inexpensive cost must first be overcome by companies in order to eventually attain mass market usage. High-performance smart glasses currently tend to be bulky and stand at a cost range that is not yet sufficiently (nor fashionable) convincing for daily social use. On the other hand, fashionable products need to sacrifice effectiveness to get a sleeker look and still tend to keep a higher range of prices. Furthermore, in either functionality, wearability or both, affordable parts will be lacking. In addition to this use of smart lenses, some eye illnesses will also tend to occur. Continuous use of eye-sensitive technology and finding that the brain and eye can quickly adapt and thus be affected by ongoing use [17].

More usually, there is a possibility of computer vision syndrome [18], resulting from looking close to the eye for a long time. It may possibly generate various types of cognitive dissonance and pain [19]. How the technology affects the eye is therefore an unresolved issue.

The main regulatory problem is mainly whether and how it is legal to film without knowing and accepting it, and partially how the information will be stored and who has access to it.

3 Methodology

3.1 Motivation

Wearable technology is considered as the next big thing and seems to be the most promising hi-tech in our lives. Our growing technological dependence desires further innovation. Innovation, communication channels, time, and social structures will determine the future. But if we look at Gartner's hype cycle (2018) shown in Fig. 3, wearable user interfaces are at the top of the hype but have a timeline of up to 10 years until they are widely used. According to the cycle logic, the hype around [20].

The products will be disillusioned before the products achieve wide execution.

However, most commentators think it will take less than 10 years for growth. In the next 3–5 years, there will probably be a powerful market selling some kind of intelligent glasses—probably not the Google Glass design we understand today.

3.2 System Design

The primary processor choice is guided by the device type and characteristics. As glasses should be wearable, processor should be lightweight and should have capability to process the images. Here, in this design, Raspberry Pi is used as an application processor because it works on its own operating system which is open source.

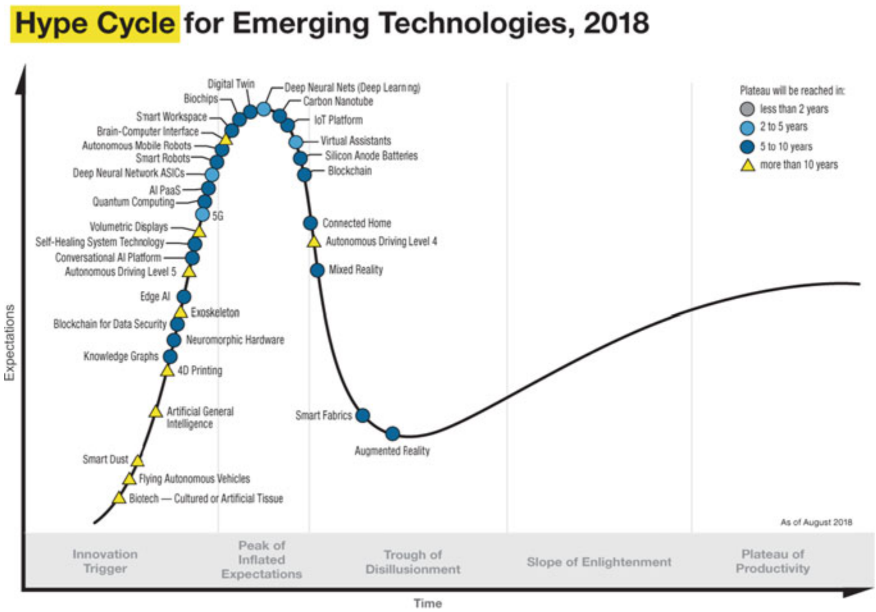

Fig. 3 Gartner's hype cycle 2018

To display the images, LCD used is of smallest size. To make the images viewable by eyes, later the images are magnified by using the convex lens and are projected by using the pentagonal prism which is semitransparent. So, it will not affect the real field of view of the operator. By assembling all these component altogether, the requirements for the wearable devices are fullfilled. How this device will look is shown in Fig. 4. This prototype can be used at left as well as right side by rotating the image and can also be useful for the prescribed eyeware user.

3.3 Working

Figure 5 shows the system block diagram. The main objective of this design is to provide assistance to the workers in the industry, i.e., it will display the work instructions at the operator's eye level. In this system, Raspberry Pi works as application processor which will drive the LCD module for display of images containing the work instructions of operator.

In this system, the interaction method for smart glasses used is push button. When user will press the key/button, the next image in the line will be displayed onto the LCD module.

The view field is a key parameter that directly affects how much information can be displayed and where it can be put. The horizontal field of view is particularly

Fig. 4 Prototype of smart glasses

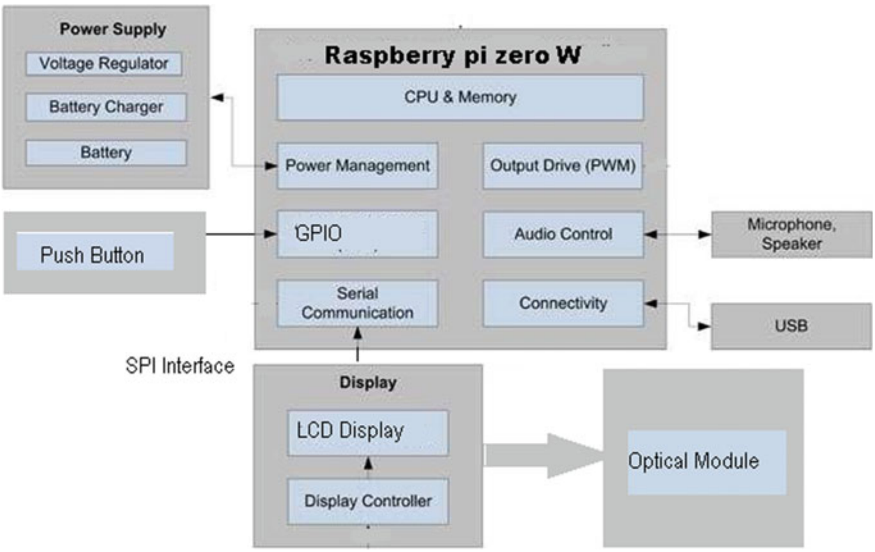

Fig. 5 Smart glasses block diagram

important because it is a wide horizontal field from the point of view, the edge of information can be displayed, keeping the sight clear to see the real world [4].

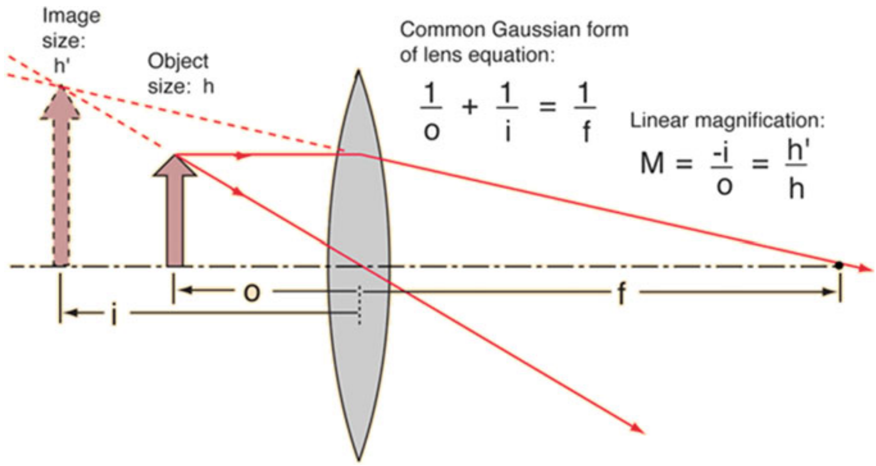

Fig. 6 Virtual image formation using positive lens

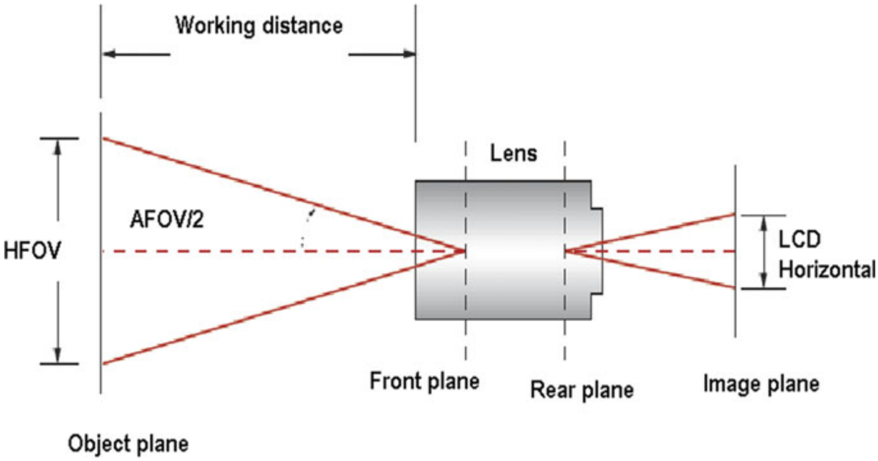

Fig. 7 Relationship between HFOV, working distance (WD), and display size

3.4 Block Diagram of the Smart Glasses

Human vision field is nearly 180° horizontal, but the present ARSG is far from that. We think that the ARSG is at least 30° (landscape) in a realistic, acceptable field of perspective.

We can calculate the object distance by using the lens equation to create a virtual image with convex lens. In order to match the illustration, if an object distance smaller than the focal length is entered, the image is an enlarged virtual image on the same side of the lens as the object, giving the image a negative distance. It is possible to use the lens equation to calculate the distance.

Figure 6 shows how the favorable lens forms the virtual image. A virtual image creates the place where the main ray routes cross when projected backward from their routes beyond the lens. While a virtual image does not form a visible screen projection, it is not "imaginary," i.e., it has a definite location and magnitude and can be "seen" or pictured by the eye, camera, or other optical device

Magnification Equation

The equation of the lens expresses the quantitative relation between the distance of the object ($d0$), the distance of the image (di), and focal length (f). The equation reads as follows:

$$\frac{1}{f} = \frac{1}{d0} + \frac{1}{di} \quad (1)$$

The equation of magnification relates the percentage of image range and object size to the ratio of image height (hi) and object height ($h0$). The equation for magnification is as follows:

$$M = \frac{hi}{h0} = -\frac{di}{d0} \quad (2)$$

These two equations are used to produce data about image range and image height.

Figure 7 shows the relationship between horizontal field of view (HFOV), working distance (WD), and display size. Using this relationship, we can calculate the field

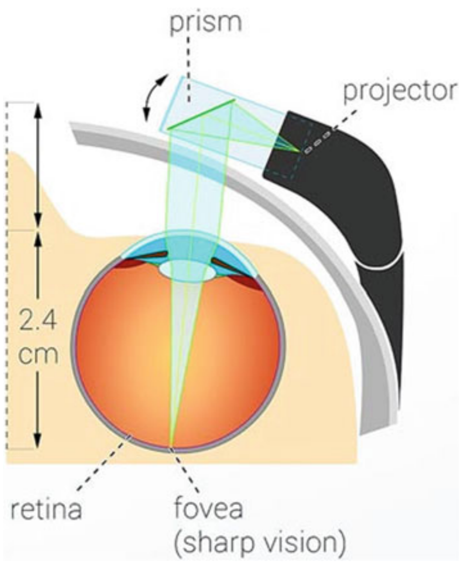

Fig. 8 Smart glasses prism and retina (eye)

of view of the above design of smart glasses.

$$f = \left(\frac{h * \mathrm{WD}}{\mathrm{HFOV}}\right) \tag{3}$$

In Eq. 3, h is the horizontal dimensions (horizontal pixels multiplied by the pixel size) and f is the focal length of the lens.

The above discussion is all about lens calculation for the magnification of image and field of view. Now, the question is how the magnified image is presented at the eye level using prism? It is summarized below.

Here, Fig. 8 demonstrates how the retina picture is focused by the prism (Fovea = point of sharp visual picture). The layer appears in the bottom correct corner or in the center of the visual field depending on how you wear the smart glasses. When the smart glasses are high on the nose, you need to turn your eye up to see the picture sharply so that you can virtually see through underneath. You can also position it straight in front of the pupil because the prism is semitransparent. You have the sharp layer right in front of your eyes in that case.

4 Results and Discussion

Smart glass design features consist of five variables, stand-alone device, interaction, field of perspective, cost and screen resolution. Various intelligent glasses are prepared for launch and some are already on the market. Here, we can make a comparison table consisting of the above five factors for the betterment of the smart glasses design explained in this paper (Table 1).

Discussions:

Table 1 Comparison with the available products in the market

Alternative	Stand-alone device	FOV (in degrees)	Interaction	Display resolution	Price (rupees)
1	Yes	65	Voice recognition and touchpad	640 × 360	42,000
2	Yes	12	Hand gestures	1024 × 768	42,000
3	No	65	Voice recognition and touchpad	1024 × 768	42,000
4	No	65	Hand gestures	1024 × 768	42,000
5	Yes	65	Hand gestures	1024 × 768	69,000
Smart glass design	Yes	28	Key	160 × 80	10,000

Fig. 9 Experiences of participants in terms of points out of 10

Some of the key observations are also noted with the help of few participants. A series of task is carried out to access their benefits both with and without use of smart glasses. In the design of the smart glasses, display is small and rectangle within central point of field of view, expectations from people is that they get more benefit from the use of smart glasses. Two people with same characteristics, e.g., age, gender, profession, visual field, sight loss condition may have different experience when using a smart glass.

Here, Fig. 9 is plot drawn from the feedback given by participants. There is no single predictor as to why a person may or may not benefit from the smart glasses. There are so many factors (age, sight loss condition, vision level, visual field, environmental light levels, and various smart glass methods) that it is hard to identify the future profile of a prospective glass recipient.

5 Conclusion

This study aims to take the manufacturing industry one step closer to the adoption of ARSG on the shop floor by providing them with a low cost and easily available solution. It is very much obvious that these smart glasses are very cost effective and applications-oriented. By using these smart glasses for the operator working on a production line or in a maintenance section, mistakes can be minimized rather I would say eliminated. As there are some pros and cons of the design, it has very much scope for the future development. Some future scope points for this design are listed down.

A. **Extending the field of view**: Without a doubt, the field of perspective is one of ARSG's most difficult problems. The natural human field of perspective is almost horizontally 18°, but this design's field of perspective is 28°.
B. **Making the glasses wearable**: Current ARSG is actually wearable, but for extended periods it cannot be worn. There is still a scope to reduce the size and weight.
C. **Improving interaction method**: In industrial shop floor applications, communication with ARSG must be hands-free, as the user must use his/her hands to perform job duties. Using speech commands is the most common way of implementing hands-free communication. However, there are significant noises

from machinery and transportation in the industrial shop floor. In the presence of sound, voice recognition becomes an important task and with high certainty the program needs to implement distinctive features to reduce noise and accept the correct instructions. Apparently, in the context of ARSG, this challenge is not being considered and this is an important topic for further research.

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