Correcting Visual errors using Smart Glasses

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Abstract

One of the oldest problems facing humans is that of poor eyesight. Methods to correct this problem include usage of spectacles and laser surgery. These are the prevalent methods from around 1990s, first patented by Juergen, who describes their usage to improve visual acuity [1]. Even refractive surgery is common nowadays [2]. However, these methods are not the best. About 20% of the general population suffers from binocular vision, 27% of adults in their 60's, 38% for over the age of 80, and around 12% of the population has some type of problem with binocular vision. Binocular vision dysfunction can be caused by a number of factors which has a great deal of strain on the eye muscles as they constantly struggle to re-align and eliminate blurriness and double vision. It has been discussed from centuries, Ortho-optics, was introduced by physicians in the late 1800's. As physicians became more focused on eyeglasses, medication, and surgery, the benefits of ortho-optics were taught to fewer and fewer practitioners.

Currently there are smart glasses available in the market that has any applications to access information, data collection, building facades, skylights, hospitality interiors, medical interiors, healthcare, sports, to identify shapes, determine distance and objects [8]. But there are no smart glasses that provide solution for the binocular vision dysfunction. Pursuing down the line of using lenses to correct refractive errors in eyesight, we propose a new type of smart wear, that could make regular spectacles obsolete.

Problem

One of the critical problems facing human development is eyesight errors, which can have many causes, whether caused during birth or developed through aging. This problem affects multitudes of people across the world. Yet we have no solution to this problem, other than using a pair of spectacles. Approximately 75% of Americans use some form of vision correction, in combination of both eyeglasses or contact lenses [3]. This implies that the problem has a large domain. Smart glasses are commonplace in today's world, though none of them provide any vision correction.

Delving in the matter, there are currently multiple variety of smart glasses available in the market. They provide functionality from augmented reality to GPS navigation and more. These are expensive while including a host of features and connectivity with cellphones and other devices. The problem of vision impairment occurs in all age groups, some worse than the rest. The worst form of it is blindness, which cannot be fixed easily but there are advancements in this field, with the eSight 3 [4]. Another side effect of using spectacles is that one must replace the lens and frame with passage of time. While this might be easy to achieve, it is slightly expensive. These factors and more lead us to the development of a new prototype, which should correct all the vision errors and be portable across different individuals. This technology needs to be verified against different types of evaluation techniques to confirm its advantage.

Consequently, the main consequence of having poor vision is that one simply needs to spend more energy correcting the visual error than utilizing his eyes to see. This might not be clear directly, but consider when you wish to see far objects, without using a pair of binoculars. Our product should come in handy even in this situation. We intend to provide the common individual the power to see far and near objects without the need to wear custom made glasses or use binoculars. A pair of smart glasses equipped with high resolution camera should be able to achieve it. Using advanced optical zoom mechanisms, we believe that we can replace the typical eyeglasses with specialized equipment. This entails a whole new host of features to it, such as taking pictures using such a smart glass with binocular vision. The problem is that till date, there haven't been techniques that generalize this problem to an extent that we can have smart spectacles shareable between two or more people. There has been no motivation to remove the customized power rating for each eye. The idea of carrying a spectacle everywhere you go seems normal today, but it might become a thing of the past.

Further, the market for such a product is large. In America itself, we have almost 75% of the population under this spell of buying spectacles and contact lenses. This might be a vague indication of other countries' statistics. However, we can see how this product can change lives.

Related Work

Currently there are multiple products in the market. The market offers solutions such as the eyeglass spectacles and smart glasses. These two are entirely unique with respect to each other. The former corrects the vision while the latter augments it [6][7]. Vision errors can only be fixed age 18 onwards. This implies that the user needs to wear a pair of spectacles for a long time. People have got so accustomed to wearing glasses that there are special frames that are lightweight and flexible so that the users are comfortable wearing them.

As explained by Border, in his paper on see-through near-eye display glasses with a small-scale image source patented device, it is possible to display data close to the eye without affecting the focus [7]. We see that electronic devices such as the camera, coupled to visual displays mounted on the head, can be used to achieve our purpose as claimed by Deering in his patented paper.

Other devices include but not limited to,

- Hammacher Schlemmer The Hands-Free Binoculars
- Ocutech SightScope Flip
- Vuzix 300-Smart Glasses
- Moviero BT-200 Smart glasses
- Level
- Sony Smart Eyeglasses
- Sony Smart Eyeglass Attach

<u>Below we provide a brief discussion of some of the existing products</u>

Vuzix 300-Smart Glasses

Vuzix 800-smart glasses are hand's free glasses an android based wearable computer that has GPS and head tracking helps to access information, data collection that operates on android and iOS. The pre-installed apps that is been stored in the memory helps to track timed events, connects to phone and manage the calendar. The wireless connectivity helps to find the direction and angle of your current view.

Moviero BT-200 Smart Glasses

Moverio BT-200 smart glasses feature binocular, see-through lenses. In weighs 88 grams, the BT-200. It is implemented with a camera, gyroscopic sensor, accelerometer, compass, GPS functions, and more onboard. wherein computer-generated text and graphics are superimposed on a person's real-world view. It runs on the Android 4.0 operating system that provides developer support to participate in application development.

Level

It's a fitness tracking smart glass which looks like a normal glass in which the sensors are embedded and keeps track on steps, distance, calories burnt and active time with the help of smartphone app.

Recon Jet

It is designed for cyclist implemented with 1ghz dual-core ARM cortex-A9 processor, HD camera, gyroscope, accelerometer, magnetometer, altimeter, GPS receiver and thermometer which delivers detailed ride statistics directly to the eyes.

Sony Smart Eyeglasses

This smart glass has a transparent lens which includes gyroscope, accelerometer, built-in camera and ambient light sensor that superimposes information onto the wearer's natural field of view. Applications can access the sensor data from the accelerometer, gyroscope, electronic compass, brightness sensor and microphone, and take pictures and videos from the built-in camera via a compatible smartphone, where the apps are running.

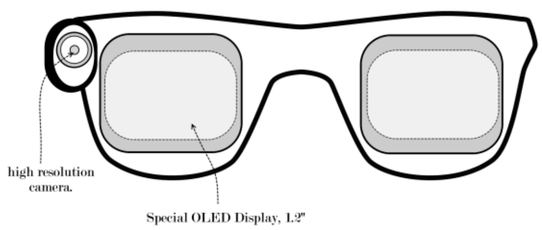
Ocutech's SightScope

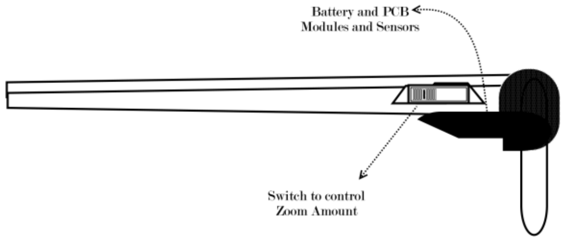
Ocutech's innovative SightScope, a Galilean telescope design, will help you see as much as twice as far away and its novel, completely adjustable binocular design, provides the widest field of view possible

Metric	Devices
Connectivity	Vuzix 300-Smart Glasses, Moviero BT-200 Smart glasses, Level, Sony Smart Eyeglasses, Sony Smart Eyeglass Attach
Vision correction	Google's Cyborg, eSight 3, SharpEyes LLC
Digital Zooming	None
Binocular Vision	SiteScope, Hammacher Schlemmer

Proposed Solution

We propose a pair of smart glasses with the unique capability to correct vision errors. We describe a basic structure for the prototype and the components used in creating this product. We also discuss the important characteristics to be featured in the product.



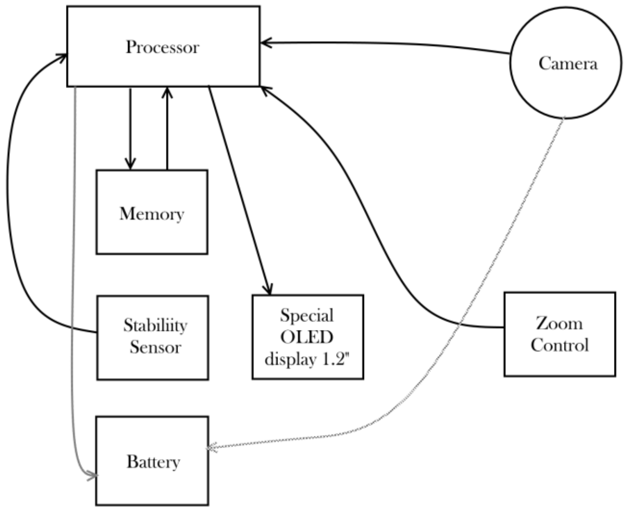


Primarily, the device must be equipped with a good quality camera, on the eyeglasses frame. This camera can capture image and video feed to be sent to the onboard processor. This processor processes the image and displays it on the included screen. This screen should be of high resolution and transparent. The onboard circuits must be capable of processing large amounts of data. This can be achieved by including a high-quality graphics processor on board. The image data acquired by the camera is stored on disk temporarily for post processing. This allows for the image to be transferred over to connected devices. However, this is not the main application of this device. Mainly, we need the device to focus automatically and be capable of displaying a view which the user desires.

This device can be developed in a portable format as well, such that the camera and the display can be attached to existing eyeglass frames. This allows for a wider market and greater portability.

As explained by other such initiatives, we are required to acquire the following components:

Component	**Component description**	**Links**
Camera & Processor	Compact module including the processor and camera.	*OV12895-C61A-Z* http://www.ovt.com/sensors/OV12895
Memory	Can be external or internal	Chipset memory – Built-in or cheap to buy.
Micro circular LCD	Circular displays such as these can be used.	https://goo.gl/J7uhR2 below $15 to buy
Spectacle Frame	Light polymer based	https://goo.gl/I7Wil7



The device can be setup as shown in the picture. The CMOS sensor or the image sensor send data over to the processor, which in turn processes the image. This processed image is in RGB format. This processed image can then be stored or displayed. This process should not take more than a few nanoseconds. The stability sensor is required to allow the processor to make sure there is no errors while image recording or capture.

The components described in the table above describes some of the main components to develop this device. The first component is the Omni Vision component OV12895, which is equipped with a processor, image sensor, and programmable controls. These include major settings for image recording and capture, such as exposure, cropping, frame rate etc. With the camera sensor at 12MP, the image quality is not sacrificed. This component is capable of 1080p HD images up to 4k.

A SanDisk memory card can be used to provide additional functionality.

We propose that micro circular LCD be used for mapping the image output onto it. This display provides feedback and also a view to the user. The high-resolution camera needs to be updated to include the zoom features. By controlling the sensor data, we can mimic a digital zoom.

Both these components claim to consume very low power. These components are available in the market at relatively low cost.

Following the camera, along the tube, one can attach a lens. This lens can be moved by very small increments or decrements to simulate an optical zoom [9]. The lens apex can adjust depending on the tube extension to provide a clear picture when the zoom function is applied.

Evaluation Methodology

In evaluating our solution, we want to think about the main aspect of whether we can reduce the cost and size to an extent where everyone is comfortable using this product. Also, how to improve image quality while in motion? How to achieve lag-free streaming from input to output? We evaluate the product by choosing Sony Smart Glasses as a baseline. Though our functionality is not supported by Sony, the build, build quality, structure, and appearance all match our product.

We choose a quantitative evaluation method. We propose that our metrics be:

1. Vision Correction
2. Binocular Vision
3. Performance
4. Accuracy
5. Portability
6. Auto focus

1. Vision Correction

How much of vision error can be corrected by our device? What are the upper and lower thresholds for the same? Can it overcome complete blindness or partial blindness?

2. Binocular Vision

How far can the device zoom in and zoom out? What is the maximum and minimum field of view? Can it be used for day to day consumer applications or can it be extended to military applications?

3. Performance

How long does it take to process the image data from the sensor and output it onto the LCD display? How many images can be processed in 1 unit of time? What is the frame rate of the processed output for different resolutions? How long can the images be processed without loss of data or breaking down?

4. Accuracy

How linear is the image collected by the camera versus the image received by the output? How accurate was the camera in capturing the user's requested frame? What is the clarity of the picture while in motion? Could parts of the image be clipped while in motion to improve overall performance?

5. Portability

How does the device compare against the baseline and other products in terms of portability? How can the components size be reduced further?

6. Auto Focus

How well does the device focus on near and distant objects? How long does it need to auto focus?

In order to quantify these metrics, starting with vision correction and binocular vison, we propose the following experimental design. First, compare the vison correction to the existing methods of user spectacles and contact lenses. If the device successfully solves the visual errors there, we can proceed to the binocular vision. The device must be able to compare accurately with each power rating as well. The human eye has auto focus capabilities, which are coupled with our device. If the device is able to perform well during testing, the human should be able to perform day to day tasks with ease. The users should be able to judge whether the object in view appear clear enough for them to recognize the objects. Initially, we may use some computer vision algorithms to further improve the vision correction techniques. Later, we can develop the parameters for user study. Further, the binocular vision can be tested by allowing the users to view very far and very near objects using the device and then comparing the results with a real binocular and also a magnifying glass. These two should be able to help the user judge whether the device can work for him or not. Standard binoculars can magnify very far objects and usually have their maximums and minimums listed on the device. Similarly, we need to find the maximum and minimum for both vision correction and binocular vision. Also, an error margin needs to be set.

Consequently, performance can be monitored by allowing the users to spend a span of few minutes on the device and then comparing their activity with the activity on the baseline. If our device is able to process large amounts of activity with adequate speeds, then we can compare it with other tools on the market. If the device fails to even perform marginally better than the counterparts, then the device needs to be speed up. Accuracy is then recorded by matching the input stream to the output stream and comparing for defective pixels or incorrect pixel values on the output side. The user can then judge whether the visual data which he perceives is close to the input or not. The margin for error has to be less than 1%. This device needs to be highly portable. We test its portability by checking its weight, dimensions and build quality with the baseline and its counterparts. This can be achieved through checking the sturdiness and compactness of the device. The device has to be within the dimensions of a standard spectacle frame. The device needs to be as light as the baseline. The device also needs to be compact enough to be carried around similar to the baseline and other spectacles.

The autofocus metric can be tested by focusing on different objects with seemingly rapid succession. This will allow us to calculate the time taken to focus various different objects. This time can be calculated for both near and far objects and also for vision correction. This value is critical to this device's success as longer it takes to focus, faster does this device lose its application.

Letter chart testing

Distance visual acuity measurement is carried out 20 meters, for the routine eye examinations. The basic regular charts reflection is 20/15 - 20/20 - 20/25 - 20/30 - 20/40 - 20/50 - 20/60 - 20/80 - 20/100 range three steps equal a change in the visual angle by factor of two. In the low vision range, accuracy on most charts drops significantly. For 20/100 - 20/200 - 20/400 each single step represents a factor of two. By the proposed solution has good accuracy it resulted in good reflection that is 20/20, 100/100, 200/200.

The subject who has problem in low vision has made to look at the letter size and reading distance to perform visual acuity to read the news print at 5"

<u>The procedure is as follows:</u>

By determining the baseline performance with the existing glasses:

Ask the patient to hold the reading material at whatever distance is in sharp focus with their existing glasses

- measure the reading distance.
- record the smallest letter size read (in M-units, 1M = newsprint) as well as the reading distance(d)

Next ask the patient to use our device. He should be able to read without adjusting any distance or setting the power rating. He should be able to use the zoom controls to comfortably focus on the text and then be able to read the same with ease. This is the general testing framework.

References

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