Media Engineering and Technology Faculty
German University in Cairo

Feature Extraction for Navigation using Prosthetic Vision

Bachelor Thesis

Author:	Youssef El Khayat
Supervisors:	Ḋr.Seif El Dawlatly
Submission Date:	26 May 2019

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This is to certify that:

(i) the thesis comprises only my original work toward the Bachelor Degree

(ii) due acknowlegement has been made in the text to all other material used

Youssef El Khayat
26 May 2019

Acknowledgments

My sincere gratitude and thanks to my family and friends for believing in me and always motivating me to accomplish more. I would like to send my deep thanks to Dr. Seif ELdawlatly for the opportunity to work on this project and for his guidance and supervision. Finally, I would like to send my deep thanks to all my colleagues for taking part in the experiment and volunteering to be a part of it.

Abstract

As the field of prosthetic vision is starting to grow, In our study we are trying to simulate the concept of prosthetic vision in an attempt to be able to understand it more. We have done this simulation in virtual reality so people can try it and understand more how a prosthetic vision user sees through a virtual reality experience that should make them live the experience as closest as much to the reality. In our study we focus on how people will be able to navigate in a prosthetic vision environment, measure their ability to avoid obstacles and sometimes see if they recognize what kind of obstacle are they seeing. As well as applying some image enhancement techniques and testing how it will make the user experience different.

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Chapter 1

Introduction

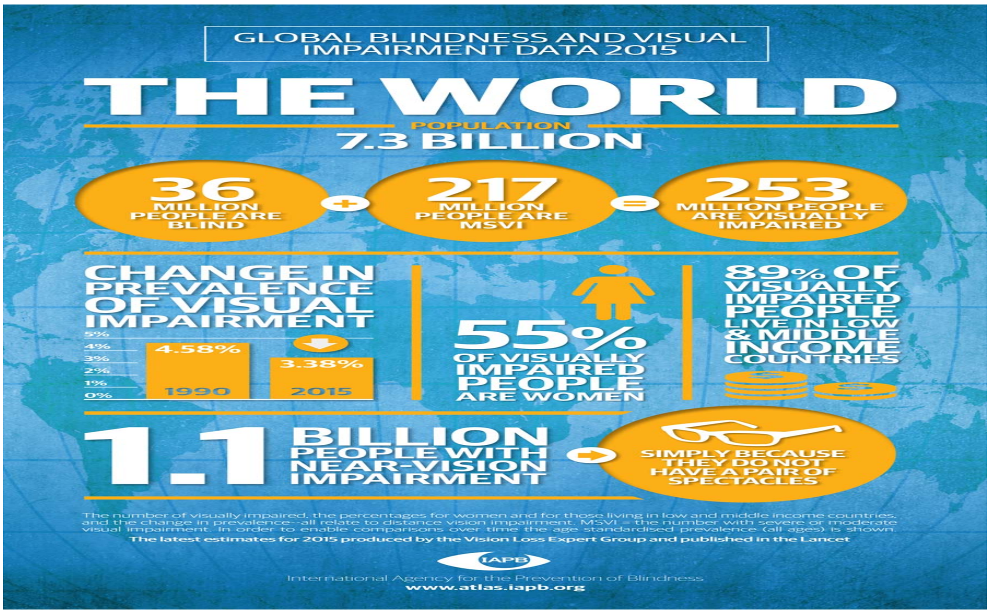

Figure 1.1: blindness statistics [4]

1.1 Motivation

Blindness is one of the most common handicaps that faces the human race from the old ages till today.It is a complete nightmare.It prevents the blind person from living the full life experience.The person cannot see the faces of the loved ones.Crossing the streets and navigating are very risky and problematic aspects.The huge problem is that it makes the person very dependent on others and limits the person's freedom.Most of us view blindness as mere problem that is really not so common however numbers and statistics emphasize that blindness affects myriads of lives around us on across the globe.As shown

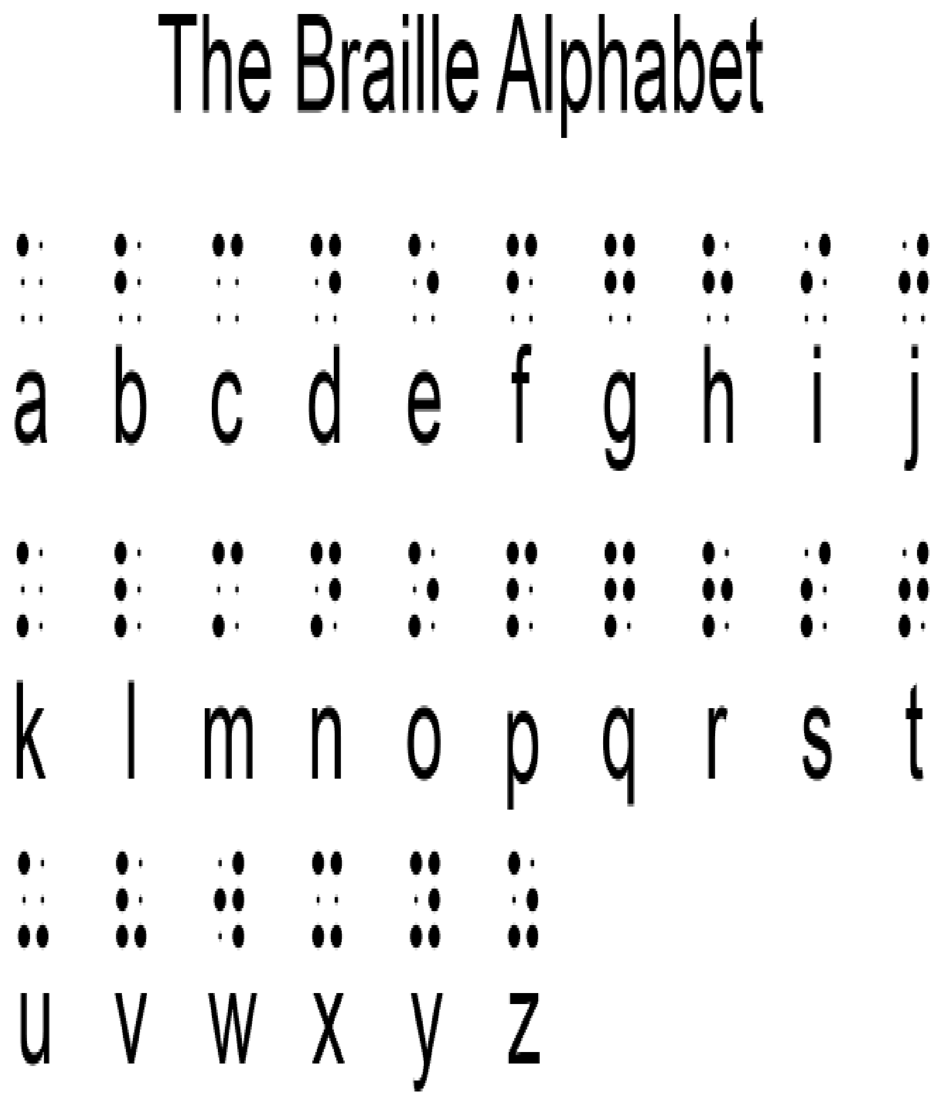

Figure 1.2: Braille alphabets [5]

in figure(1.1) we have about 36 million blind person around the world.Another 217 person with moderate or severe visual impairment.So we are talking about 253 million people are visually impaired.That is a huge number and means there is a big problem that needs to be solved to end the suffering of more than 250 million person.From the very beginning,scientist tried to solve this problem and help end the suffering of blind people [4].The tried to help them live a nearly normal life.The braille alphabet was introduced to help blind people read documents.The idea was introduced by Louis Braille in the 19th century.As shown in figure(1.2) the Braille characters are represented by 2 rows of dots each containing 3 dots so we have a total of 6 dots.This one braille cell can correspond to a number,letter or even a complete word we have possible 64 permutations using one or more of the dots.All these attempts to improve the blind person's life failed to give them any sort of vision it all dependents on other senses like touching in the Braille method.Here comes the magic of our topic prosthetic vision.Finally there is something that gives blind people a sense of vision.[2]

1.2 Objectives

In our project we will simulate the prosthetic vision in virtual reality.We used some image processing techniques to transform images to their prosthetic vision version.first of all we transform the image to gray scale.Also change the image to be 16*16 pixels.we do some sort of dropout and remove randomly a percentage of the image details to similar to the real prosthetic vision images.we tried to examine the ability of people to navigate in virtual reality environment first when we used the normal prosthetic vision image processing techniques.After that we tried to test the navigation of people and the obstacle recognition after applying some enhancement image processing techniques.At the end we compared the results to see how the ability to navigate and recognize obstacles will change before and after applying the image processing techniques.

Chapter 2

Background

2.1 History of prosthetic vision

Many people or losing sight due to accidents , injuries or they are born blind (due to retinal degenerative diseases such as retinitis pigmentosa (RP) and age-related macular degeneration (AMD)).As technology tries to improve our lives and solve tough problems, it is trying to help people with such problems to regain vision. the whole idea is so simple we just substitute the parts of the retina which are destroyed by some manufactured chips and pieces.In other words,we switch our natural human visual system with an artificial similar one. The idea is simple prosthetic vision receives the image from outside translate it to electrical signal to the brain to read it and convert it to an image. How did all of this started? The idea of restoring vision with electrical signals was first introduced in the 18th century by Franklin, Cavallo and LeRoy. LeRoy started an experiment by passing electrical signals through the eyes of a blind man this produced visual sensations of light.[15] In 1929 a German neurosurgeon called Foerster got a visual neural response from electrical signals stimulation of his visual cortex when his patient saw a spot of light during this process. This was just the start.

2.2 Medical background

Figure 2.1 shows the human vision pathway. Blindness occurs when there is a damage or failure in any part of this system. There were many approaches to fix any of the failures in any of these parts of the system such as cell re-growth using stem cells and another way was using semi-conductor photo detector array. Yet implanting the prosthetic vision technique was the one with the best results. The visual prosthesis simply bypass the damaged part in the human vision system and give the image to the rest of the working parts in the human vision system. Of course it does not create the perfect image as it normally looks, it returns a sort of spots or pixels the are seen during the electrical simulation the visual cortex (shown in purple in the figure). It can help people with navigation ,face detection or reading characters in texts. Working on the building the prosthetic vision requires engineers for working on the hardware part need to collaborate with people from the medical field with surgical background to get the work done.

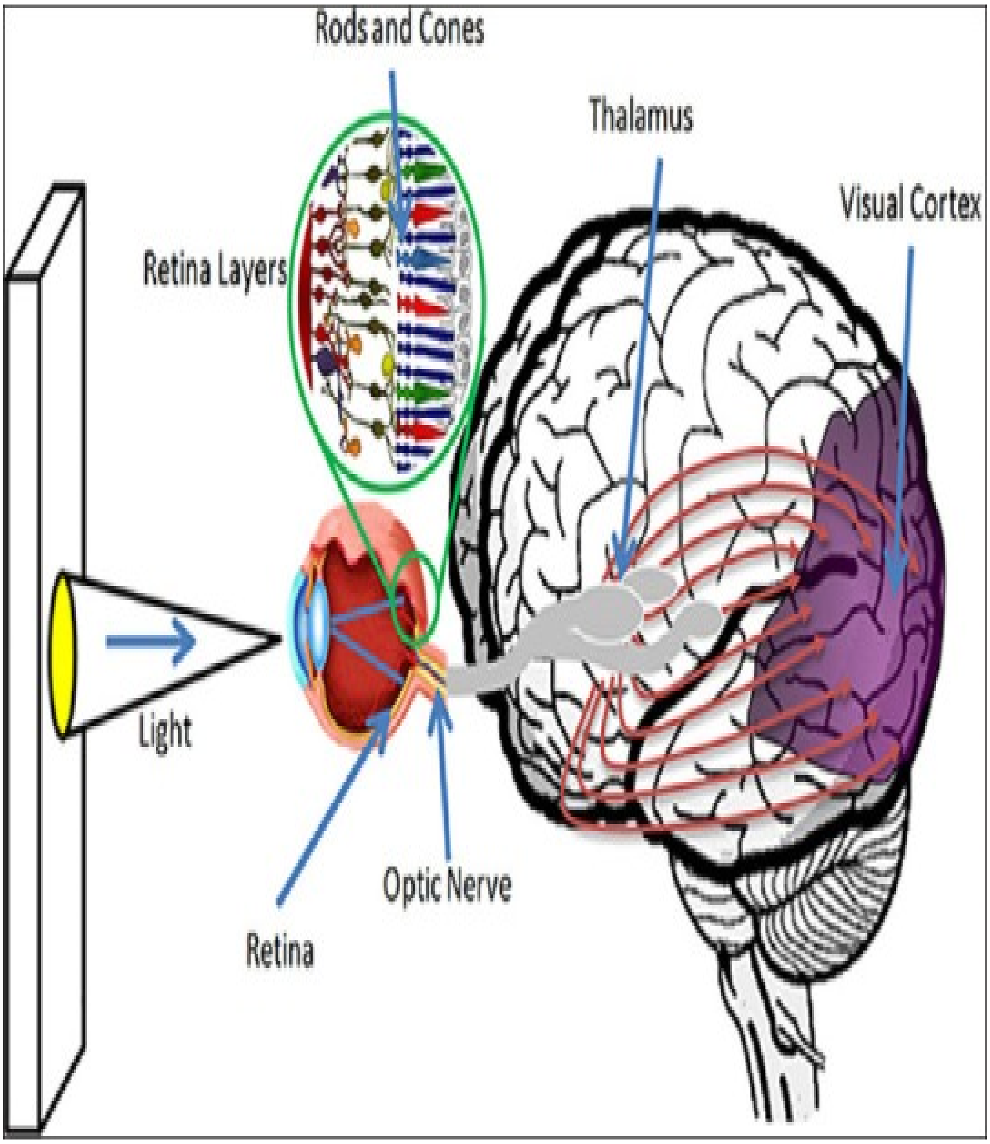

Figure 2.1: visual path system [14]

2.3 How does prosthetic vision works

Figure 2.2 shows briefly the steps of how prosthetic vision is created.First step is related to the design of the hardware and the circuits of our system.The next step is focusing on building the processing units to read the signals coming from the hardware.Finally the biological and medical side of the idea.[14]

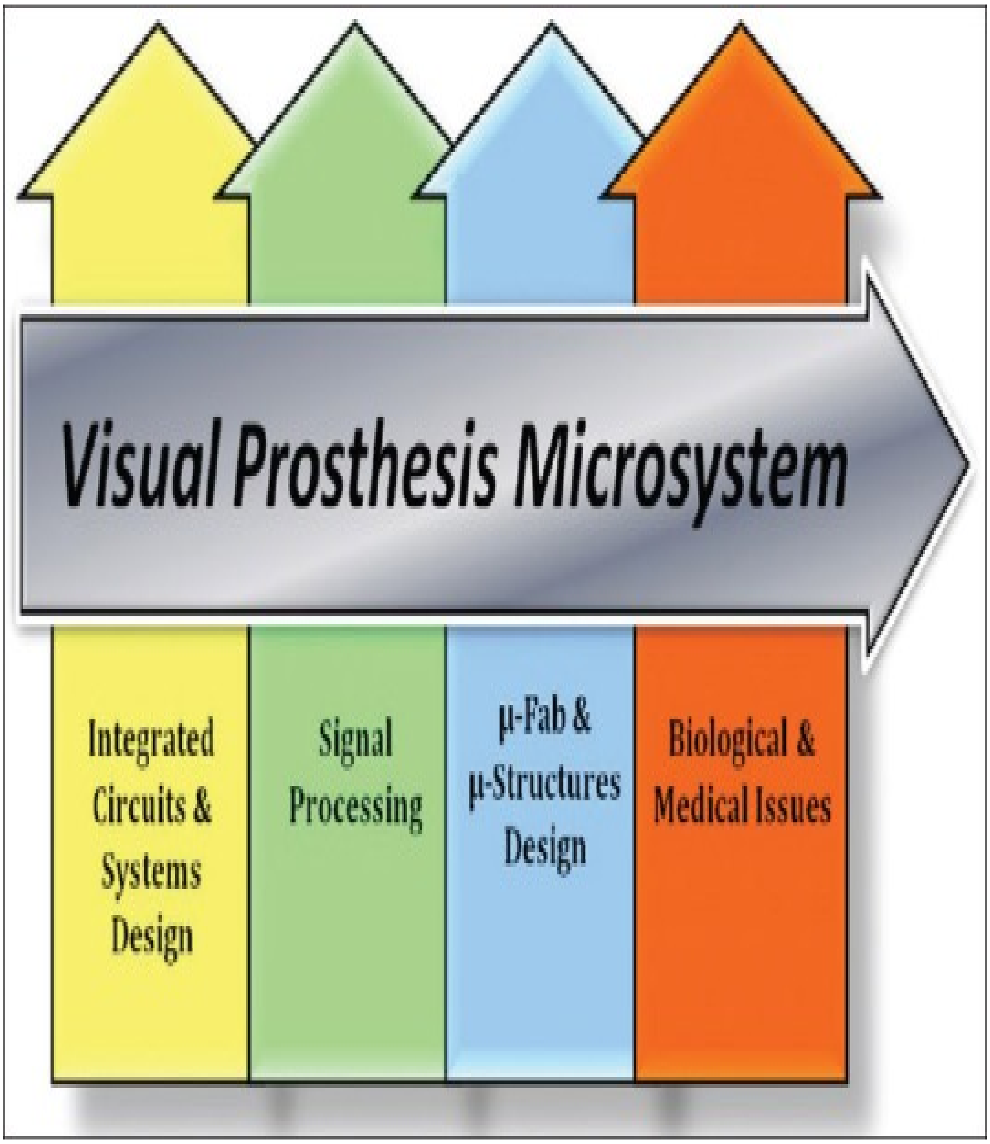

Figure 2.2: prosthetic vision steps [14]

Here is how the system of the visual prosthesis is designed.A video camera is used to record images of the outside world for the patient that has sight problem.The camera is worn by the patient by attaching it to glasses.The recorded images is processed with some algorithm to extract only the important features that will be beneficial and exclude the rest of the data.This is to reduce the transmitted data to the implanted part.The implanted part receives the data and an embedded processor sends the data of the image to the stimulation back-end which is the part responsible for generating electrical pluses.These pluses are transmitted to the target tissues a flexible cable that transmits them in a sort of electrode array.Figure 2.3 representing this design operation.

Different types of cameras have been used for image and video capture, e.g. photodiode arrays, charge-coupled devices(CCDs) and complementary metal-oxide semiconductor(CMOS) cameras.[10]Some of these cameras can be shown in figure 2.5. The power is transferred to the external part through batteries .While the implanted part receives energy through wireless connection.The implanted part is usually small as much as possible this to avoid circuit complexity and to lower the energy consumption as possible.After the image is recorded or detected the needed image processing techniques are done such as zooming, contrast or brightness configuration to pass the image to the brain in the most beneficial way.The input data must be minimized as possible to follow any system restrictions or limitations such as wireless bandwidth.So the resolution and color information must be lowered.[17]

In image processing,in general,pixels are usually in the shape of small squares sitting by each other and forming a continuous picture. Each electrode in prosthetic vision represents a pixel in the real image. Users of the prosthetic vision see something like a matrix of dots of light.So if we would like to do a simulation of what a patient who uses prosthetic vision sees we should represent pixels in a round or circular form rather than their normal square representation.The quality of vision restored using a visual prosthesis is highly dependent on the resolution of the image delivered to the visual system of the subject.This resolution is indeed defined by the number of stimulation sites on the target tissue.Simulations of prosthetic vision suggest that 6001000 electrodes will be required to restore visual function to a level that would allow for reading,independent mobility and facial recognition in retinal prostheses.Figure 2.4 shows some of the different grayscale levels[8]

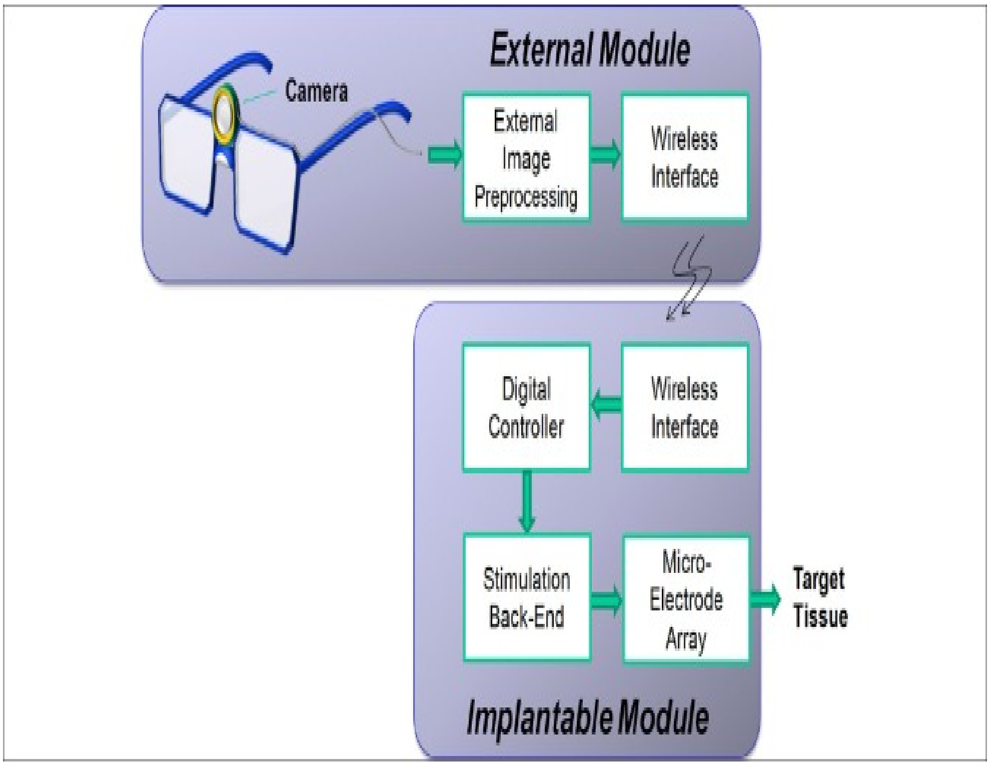

Figure 2.3: External part of prosthetic vision [17]

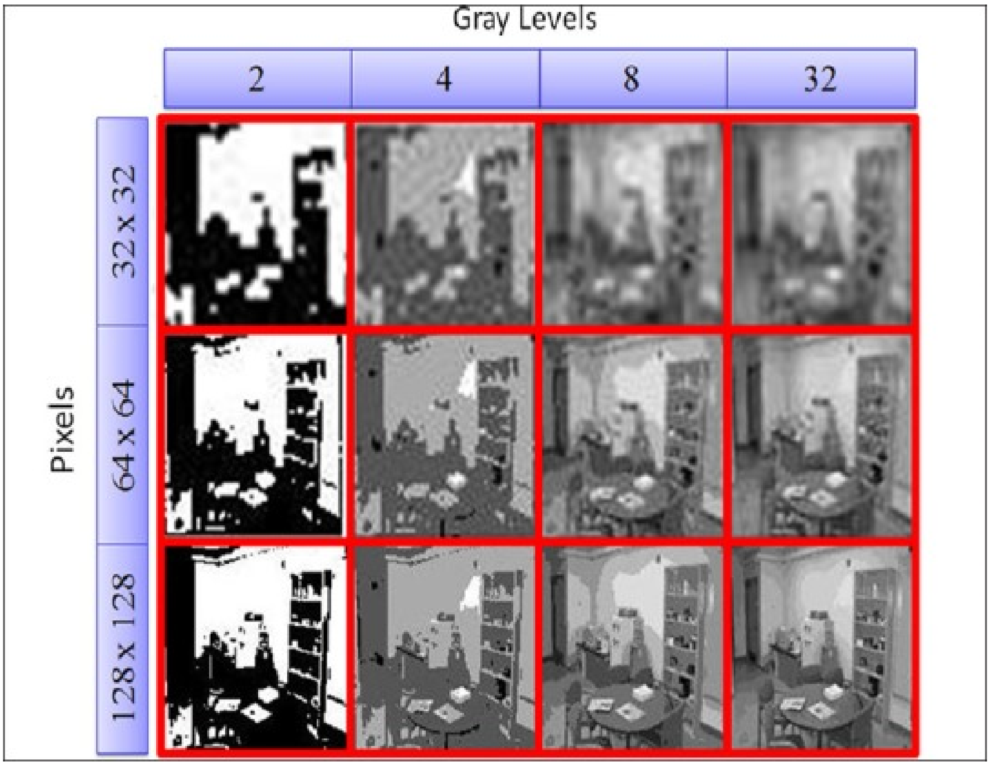

Figure 2.4: different grayscale levels [18]

It is important to keep the size small in hardware used as we discussed above also it is important to avoid any wires to prevent any possible infection. Thats why we use some wireless operation for sending data and power to the biomedical part from the external device. The approach used to do this is through two coils. The first one is called the primary winding which is the transmitting coil. The other coil is the secondary winding and is the receiver coil. The primary coil is being placed outside the human body in the external of our prosthetic vision system. The receiving coil is placed inside the body. The same equivalent resonant frequency must be provided for both parts. In order to receive the data there is a data demodulator circuit and a power regulator to receive the power all of these are included in the wireless interface.figure 2.6 shows what we have described. [12] The capacitive link approach is sometimes preferable over the inductive approach.One of the advantages that favourite the capacitive link approach over the inductive link is that the capacitive link has a high pass feature which is preferable in prosthetic vision to improve the quality of images.[20] [19] Also when designing wireless interfaces, the amount of absorbed radio frequency (RF) energy has to be evaluated and compared with the human safety levels as it can damage the tissues if it results in a higher temperature than the tissue can tolerate.[9]

Prosthetic vision is like any other implanted system (microstimulator) it needs to get data and the setup from an external part.There is an embeded controller in the implanted microsystem.The controller job is to generate the data and manage the implant operation.A stimulation back-end receives the data that the controller outputs and then

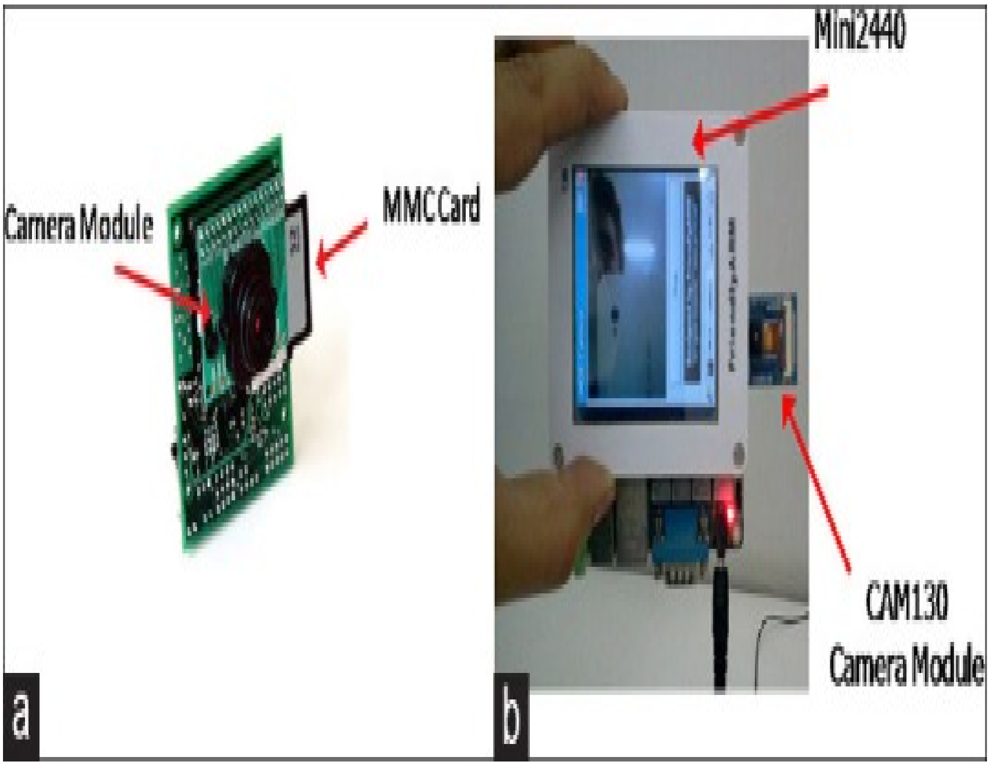

Figure 2.5: Prosthetic vision cameras [18]

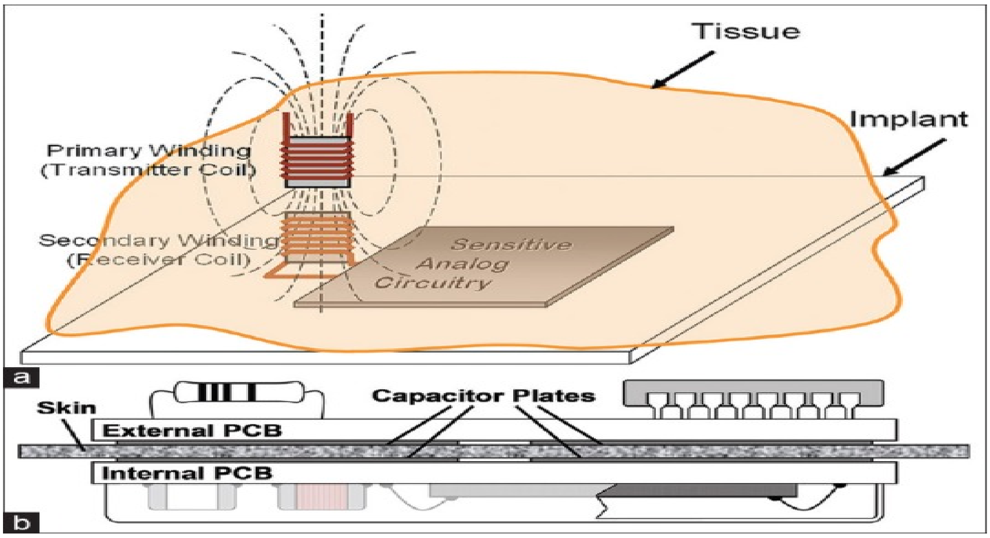

Figure 2.6: a-Inductive coupling b-Capacitive coupling approach[19]

pass them to their correct tissues according to their pulses.The microstimulator gets the order from the controller to produce electrical pluses with varying amplitudes and pulse widths in respond to the data coming from external module.Regarding the design of the controller it must be with small dimentions as it will be implanted inside the human body.It must consume as less power as possible.[16]

2.4 Types of prosthetic vision

The problem of sight loss affects millions of people around the world even though many of them can solve their problem by surgical methods or medications.A huge amount of people can as they suffer from damage in the eye retina or the optic nerve.For such cases they can only use visual prosthesis. The idea of prosthetic vision (also known as visual prosthesis) is built upon the idea of the connection between the electrical stimulation of any part of our visual system and the resulting image. To make it clear, prosthetic vision makes a blind person see through activating neural cells in the patients visual system electrically. There are myriads of ways to build a visual prosthesis system, yet they all share some common things. First we have to get the information from the outside world and pass it in to our system and then translate it to the patients brain. So to do the first step and get the image of the outside desired view that the patient is watching prosthetic vision uses one or two cameras to capture the scene. The prosthetic vision system consist of two main parts the outer part and the inner part. The outer part contains the transmitted, power supply and the processing unit. While the inside part contains the electrodes that are implemented inside the patients body. It could be connected for example to the eye or optic nerve or any part in the human visual system. One of the types of the visual prosthesis is called retinal prosthesis and it is the most used type so far.Yet also other types are there and it is used to treat other visual problems.The European union approved in 2011 the usage of a retinal prosthesis system called Incs Argus II to help in curing a disease called RP (retinitis pigmentosa) that leads in some cases to blindness. Starting from that date other retinal prosthesis systems got their approvals to treat patients with retinal problems. Until now everything seems perfect and there is not even a single drawback for our system. Here is the biggest challenge we live in a world full of colors and details. Unfortunately the visual prosthesis system provides only gray scale images meaning that images has no colors only black and white scenes with high contrast edges and some spots of light. The image is not a high resolution so the patient cant see too much of the details in the photo. But still the outcome of the image is useful as it can help the patient recognize the surrounding environment and helps a lot in navigation.[7]

One of the other problems that is decelerating the process of developing prosthetic vision systems, is what is called electrode to tissue issue. The microelectrode must be placed near the cells it targets. In order to do so the microelectrode needs to have a very accurate design so that is not big or too tiny. If the microelectrode is so big, this will result in interaction between the microelectrode and numerous other neurons. On the other hand when the design of microelectrode results in a tiny size, it makes to small it may not be able to interact with close and needed neurons. Also on the long term the microelectrodes gets a kind of corrosion. In other words, even the highest biocompatible biomaterials causes some suffering for the body and causes biological response. So it is one of the top priorities in the future to understand better the interaction between the built device and the inner body. Lets talk about the first time of prosthetic vision

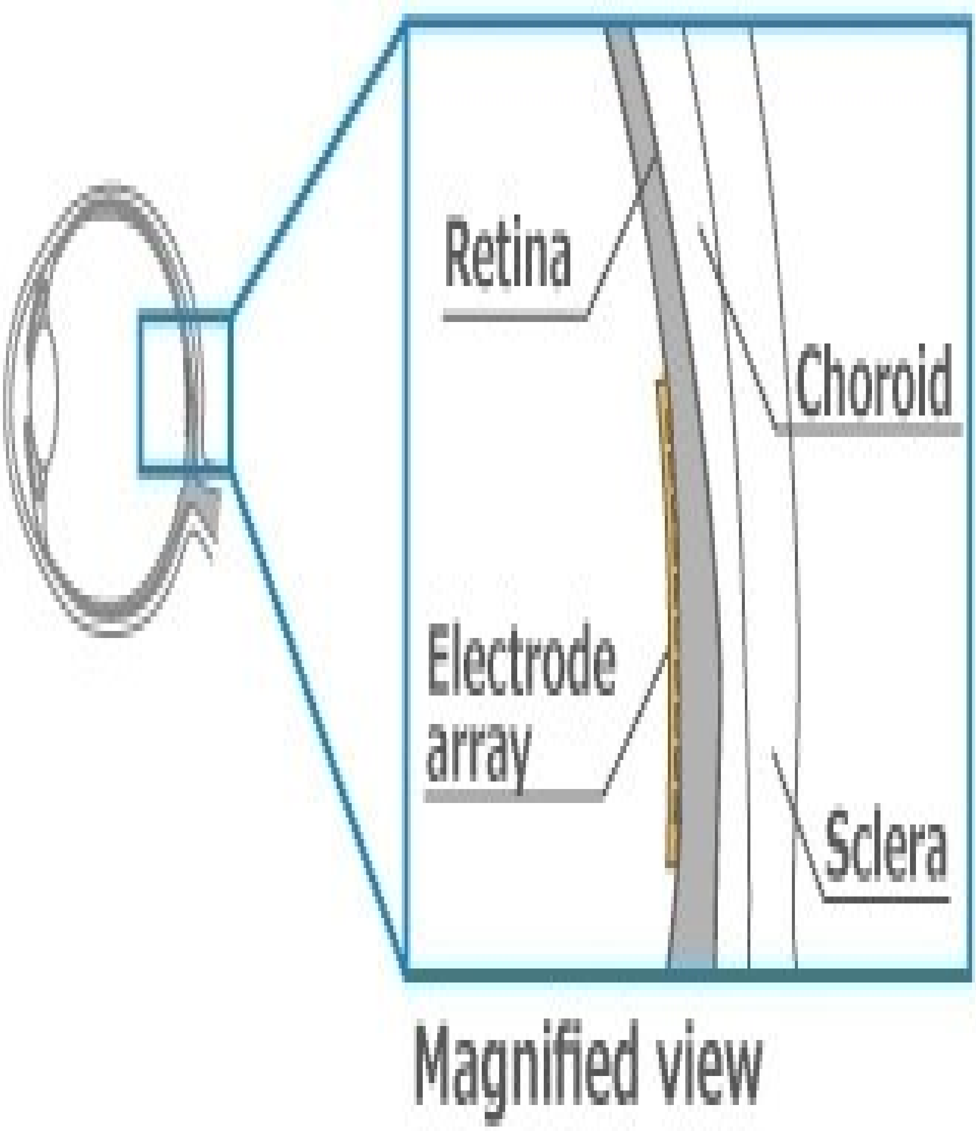

Figure 2.7: retinal implant Epiretinal Implant[7]

retinal implant. In the human visual system, the retina is the first place that can generate electrical signals. In the retinal implant method, we stimulate the retina with electrodes. The retinal implant method is also known as artificial retina. There are many ways for how to do the artificial retina yet there are three main techniques. Epiretinal Implant is the first option (figure2.7). Here the retina is simulated from the surface. The multi electrode is placed on the top of retina. The hard part and most challenging is placing the electrodes to fit the planar array on the curve of the eye and keeping all electrodes in equal distance to the retina. Subretinal Implant is the second type of retinal implant also shown in figure 2.8.Here opposite to the epiretinal method instead of implanting the electrode on top of the retina, we just position the electrode beneath the retina.The core idea here is to build a chip that does the job of a photoreceptor.Then we implant it in the body replacing the destroyed photoreceptor.The eye movement is used for analyzing the scene.To fix the electrode array we use intraocular pressure.The biggest drawback here is that the surgery is really complicated and after the operation a power supply is needed.[7] Suprachoroidal

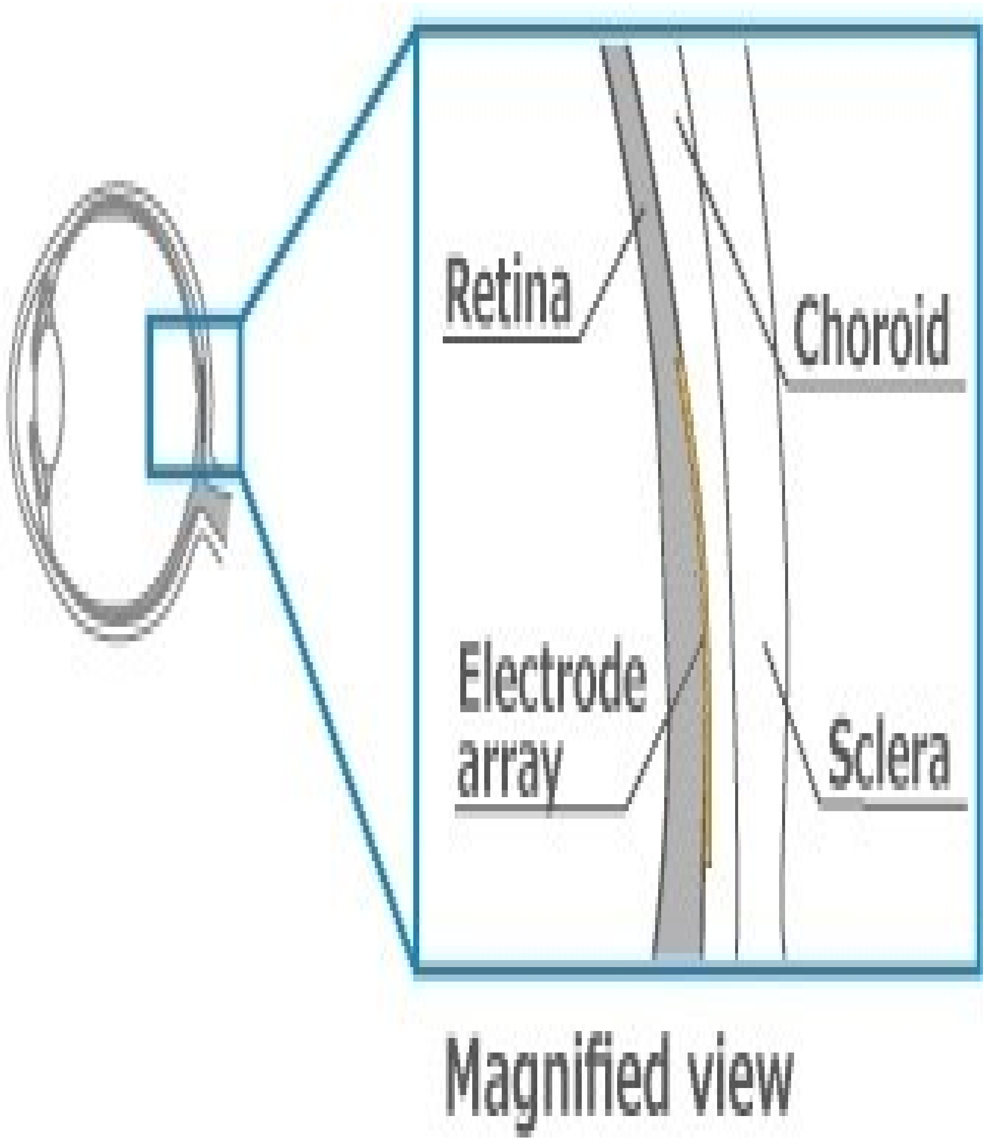

Figure 2.8: retinal implant Subretinal Implant[7]

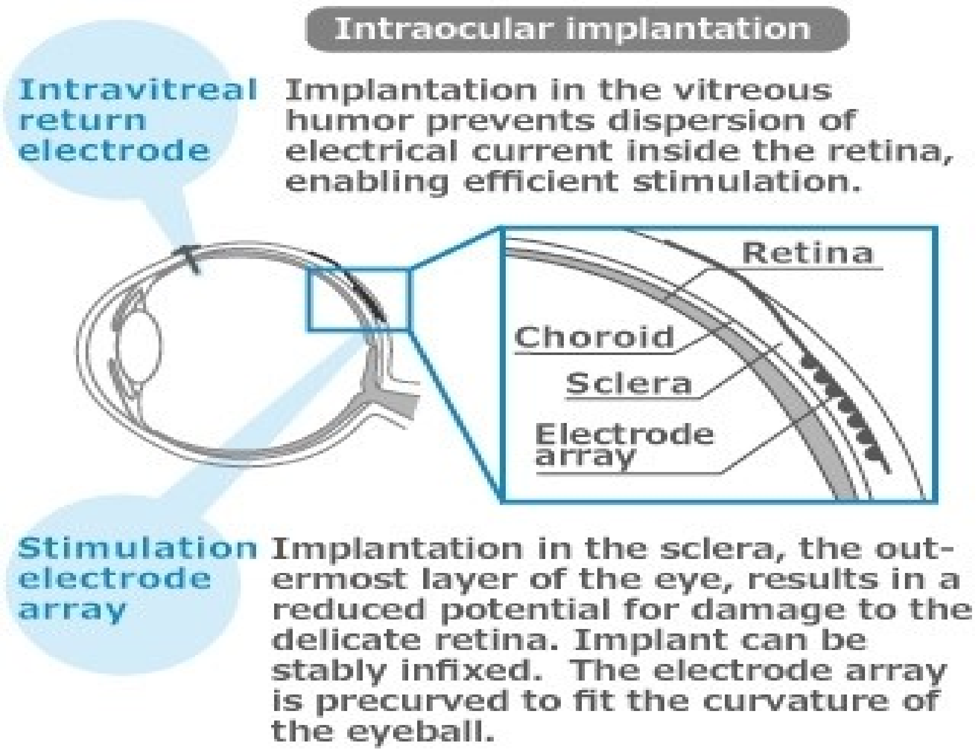

Figure 2.9: Suprachoroidal Transretinal Stimulation [7]

Transretinal Stimulation (STS) figure 2.9 is the third type of retinal implant as show in figure 2.9.This technique tries to overcome the problems in epiretinal and subretinal implants methods and it is originated from Japan.The first difference between this method and the other techniques is that the electrode array is placed in the tissue that covers the majorty of the eye from outside that is called sclera.And another electrode is placed intravitreously.The electrical stimulation gets inside through retina uses the 2 electrodes mentioned above. The best thing in STS method, is that it is safer for retina. Retinal stimulating is the most popular research topic in visual prosthesis. That is because it is easier to access by surgery than other tissues to stimulate electricity.There also a relation between the retina and the perspective of vision.So if the center of the retina is your damaged part you will be unable to see the center of the scene you are looking at.Also the peripheral retina is equivalent to the peripheral part of your view.So we can use this fact in a certain pattern to help the patients brain recognize the real image like the letter N in figure 2.10.

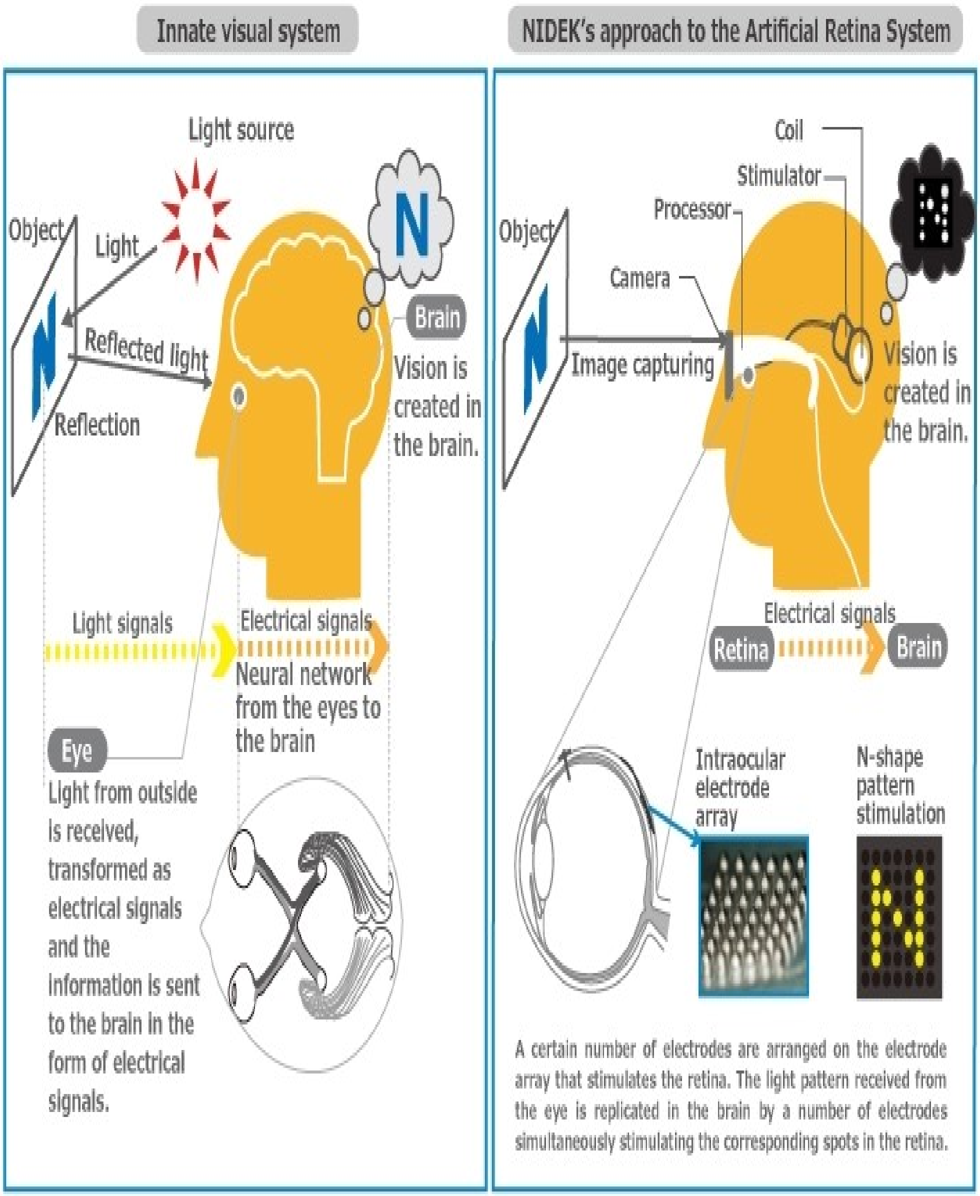

Figure 2.10: Innate visual system [7]

The second type of prosthetic vision is shown here in figure 2.11. That is called optic nerve implant. The optic nerve is built from group of nerve fibers called retinal ganglion cells. This nerve fibers escape the and they are connected with the nerve cells in the brain. The optic nerve is surrounded by the cuff electrode array that contains electrodes.

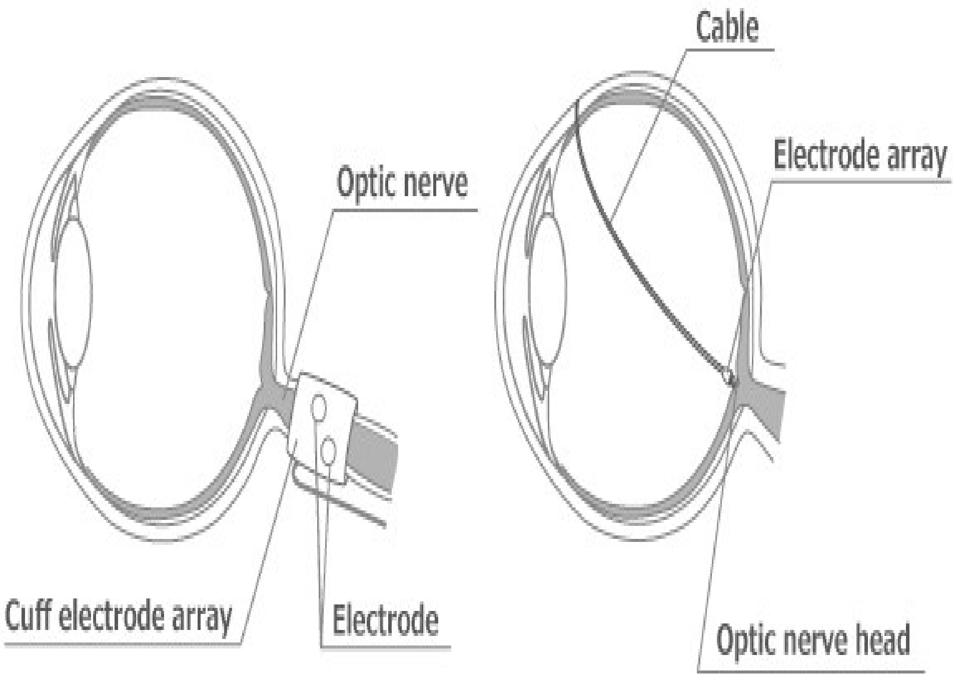

Figure 2.11: optic nerve implant [7]

Figure 2.12 shows cortical implant which is another technique for prosthetic vision. This time the electrodes are placed in the cortex inside the brain specifically the visual cortex which is responsible for the vision. This is a different approach than the other methods this time we try to reconstruct the image at the destination which is the brain rather than reconstructing the image from the beginning in the eye like the other approaches. Although the eye or nerve cells in the path way have problems. The drawback here is that placing electrodes inside the brain needs surgery which is dangerous, expensive and has also risks during and after the operation.

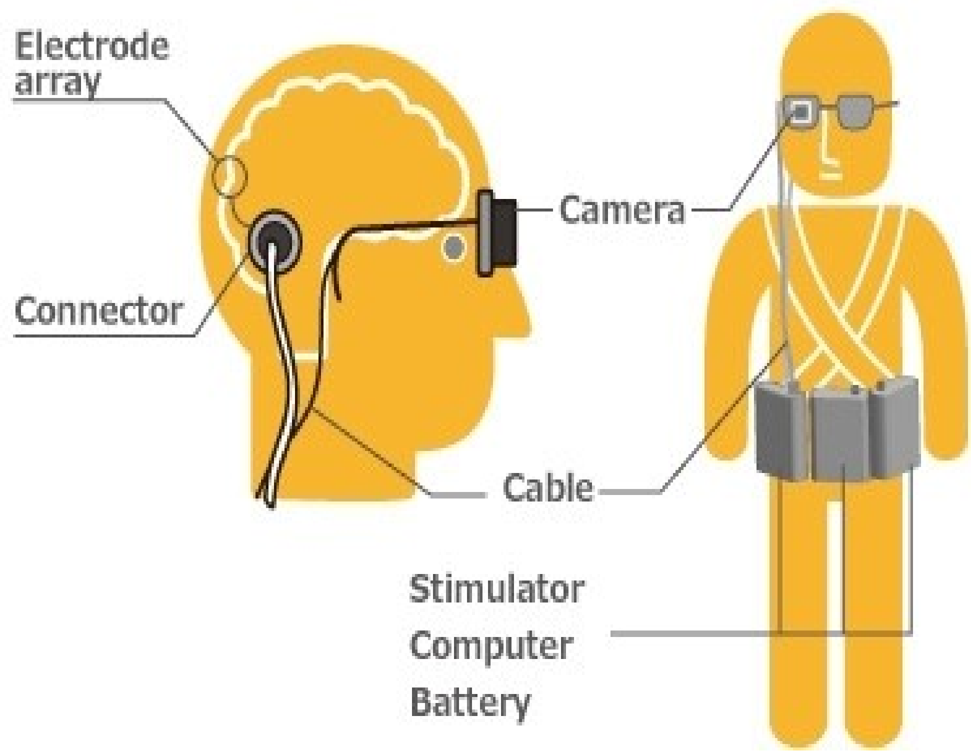

Figure 2.12: cortical implant [7]

2.5 Related work

In this experiment photos were taken by a video camera and were transformed into dots like pixels in real time. The volunteers see these transformed images using a monitor and a head mounted display.The goal of this study is examining how patients with prosthetic vision experience vision. To do so, the study used 2 image processors working in real time pixelizing the input photos so we can simulate what a prosthetic vision user will see. Also some of the images pixels were randomly chosen and removed. his was done to simulate the percentage dropout of prosthetic vision. volunteers taking part in this study were undergrad students and also some hospital employees. With visual acuity of 20/20 or better than this they joined the study. The experiment was about testing object recognition. first there is a black table facing the volunteer doing the experiment. A cup, plate, pen and a spoon were put on the table. Staying for a maximum of three minutes each one. The only hint given for the people is that they were told that these objects are very likely used in people's daily lives. They were allowed to use their head movement which also moves the camera in the process of trying to figure out what the object is. They were told to describe the object shape, appearance and size. Under one rule they are only limited for one guess per object. If you have a close to the right answer guess you are awarded one point. If you were able to guess the right object you get two points. If your guess is far from the real object you are awarded nothing. As figure 2.13 shows the camera (headset) and the monitor showing the output image. And the object tested is the cup.[11]

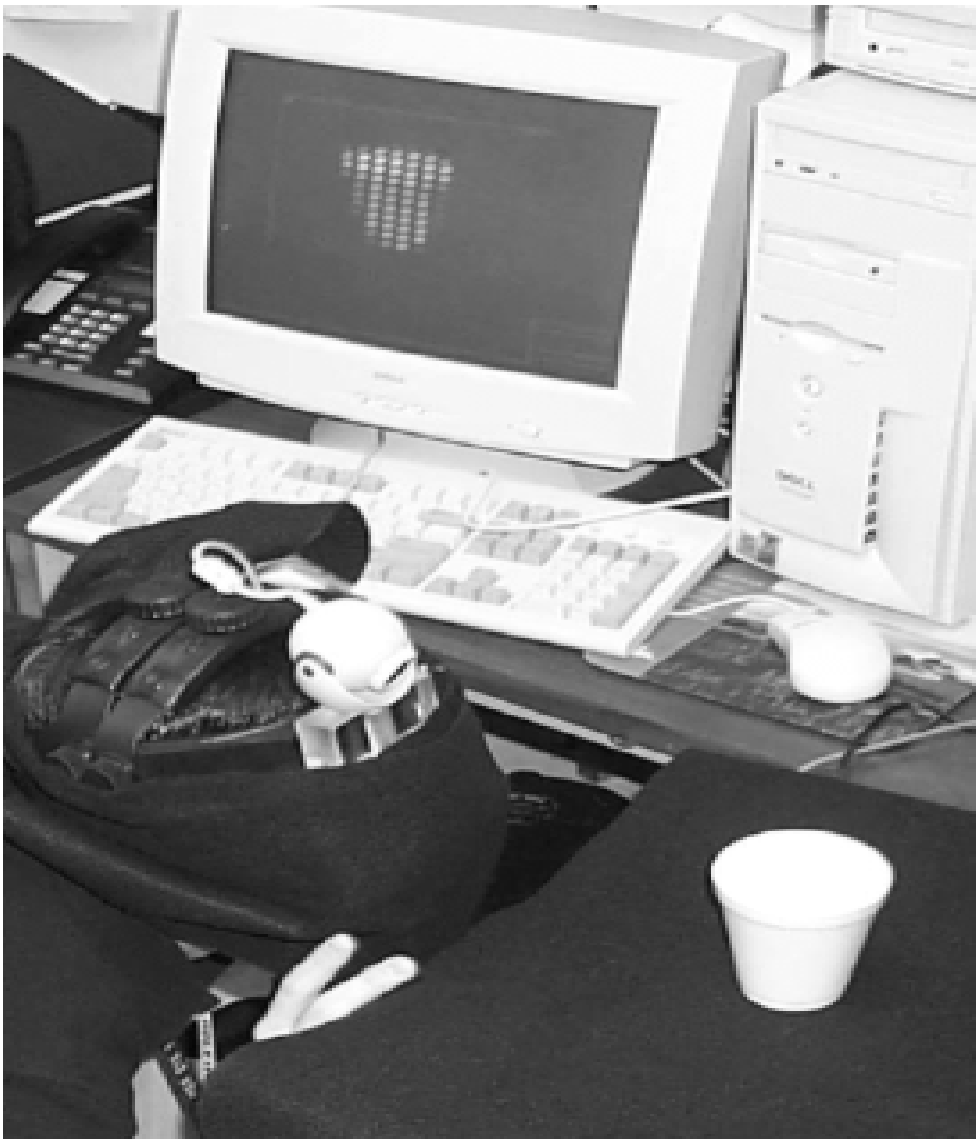

Figure 2.13: object recognition experiment [11]

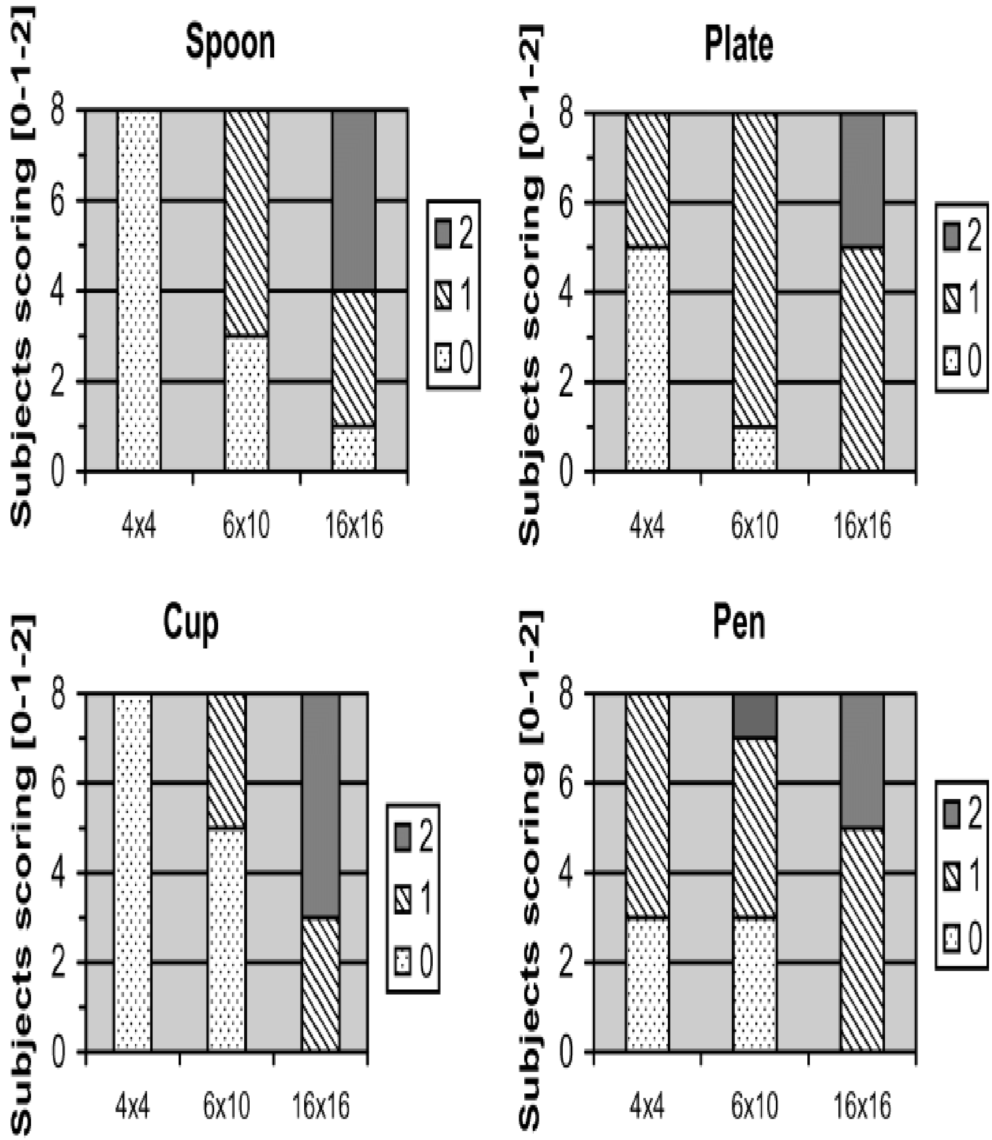

Figure 2.14: results [11]

Figure 2.14 shows the results. As we have agreed the person naming the object correctly is awarded 2 points. One point is awarded in case of giving a close description to the correct object. No points is awarded in case of inaccurate description. The 4*4 some people were able to describe the object but no one was able to name it correctly. Only in 16*16 people were able to identify the object correctly. Generally the objects with the simplest feature were much more easier to recognize rather than the objects with highly complex nature in their design. So the plate and pen were much more easily identified than the spoon and the cup[11]

Chapter 3

Methodology

3.1 Enhancement

Any image is represented digitally by an array of pixels. Each of these pixels corresponds to a gray level value. Figure 3.1 shows an example of the digital representation of an image.

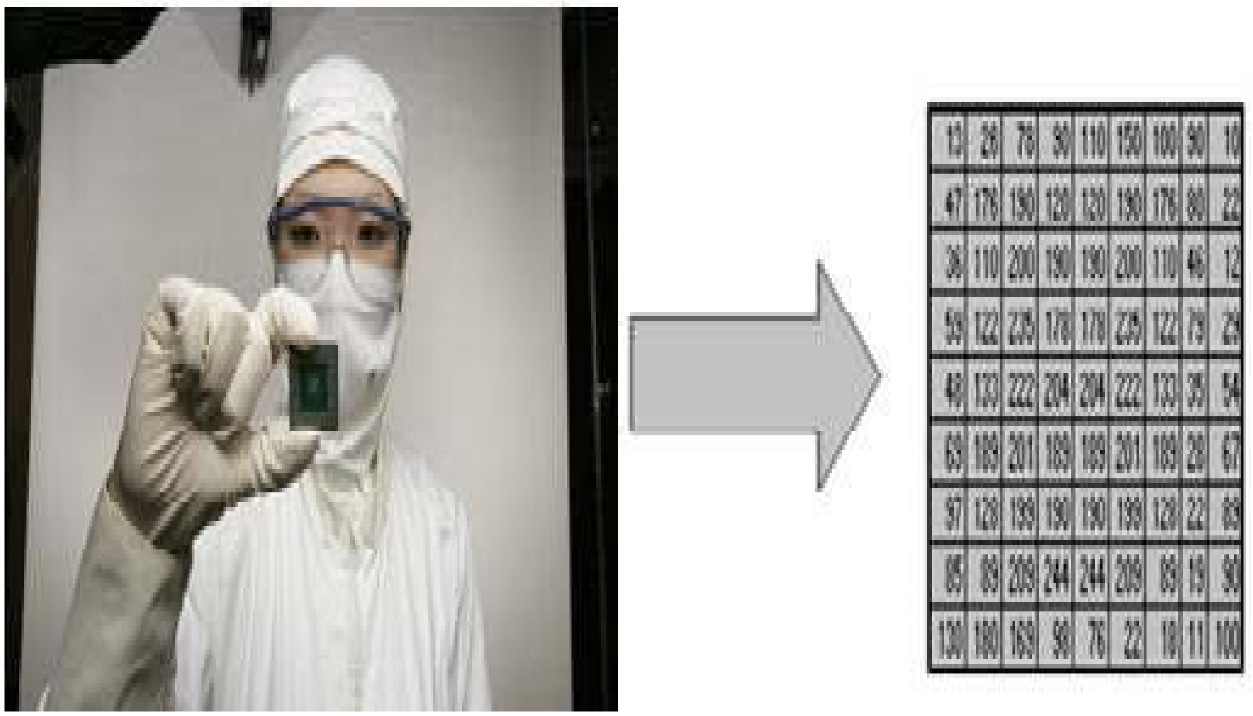

Figure 3.1: Image digital representation [13]

Generally speaking, a histogram is always used to represent a probability of certain data type. Regarding any image a histogram is a representation of the of the whole distribution of gray levels in the digital image. While viewing an image histogram we can deduce the appearance frequency of the different gray shades. In Figure 3.2 we can see an image and the histogram graph representation of it. We notice that the image contains only gray levels between 50-10. So this explains why the image has a low contrast.[13]

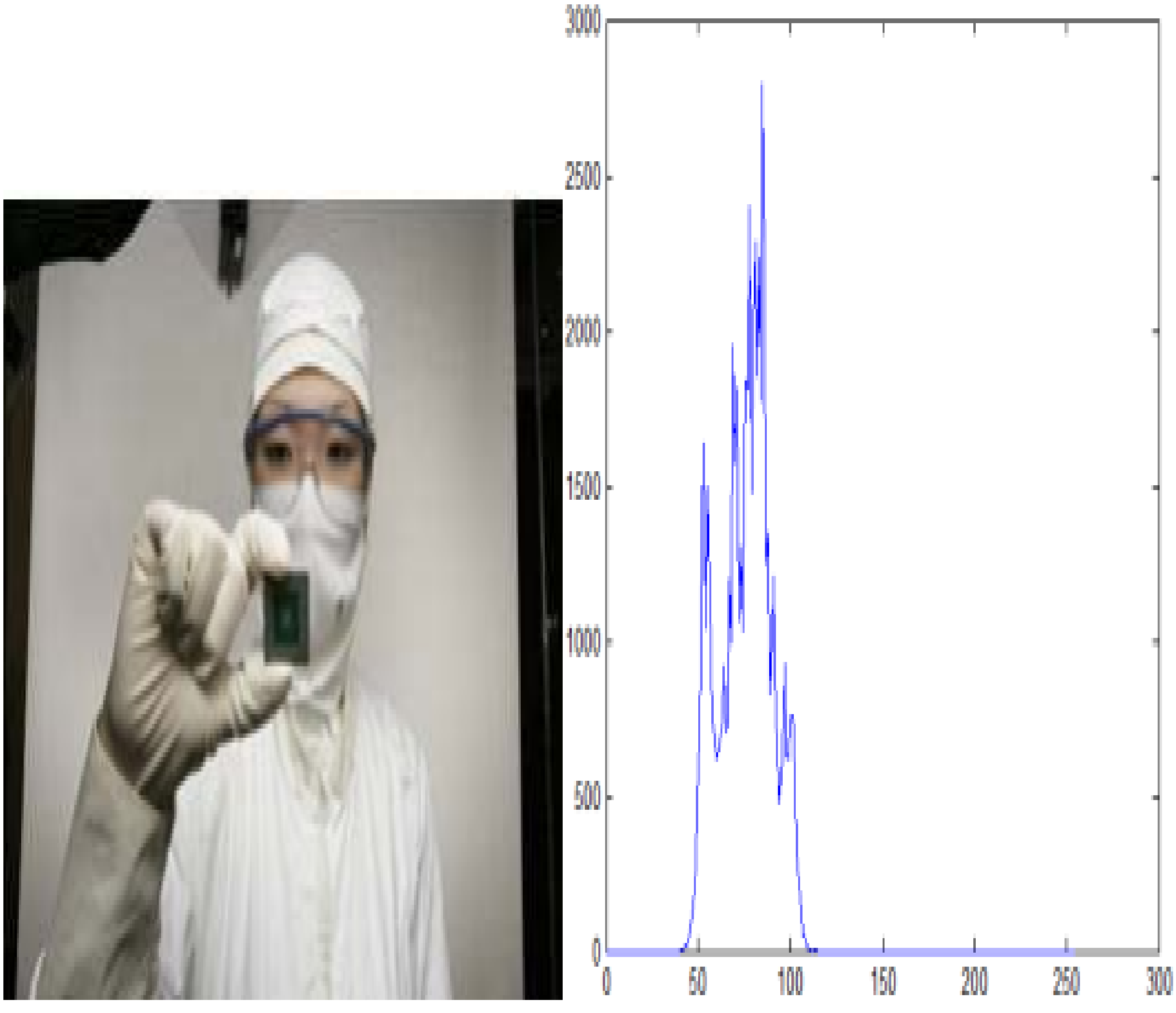

Figure 3.2: Image digital representation [13]

A good image histogram representation is which covers all the possible gray levels making the image has a high contrast and its details can be easily seen. So we can improve the image using something called the histogram equalization algorithm. The histogram equalization algorithm basically increases the image contrast. when the contrast figures of the image are very close, histogram equalization can be used. What we mean by an image that contains close contrast values is like for example a image containing the background and the foreground very dim or both the background and foreground vivid. These case means the photo contains close contrast values. The histogram equalization simply increases the image contrast by splitting the intensity value all over the total values. In figure 3.3 we can observe how the histogram of the image have changed and how the image has higher contrast than it was in figure 3.2 after applying histogram equalization algorithm on it.

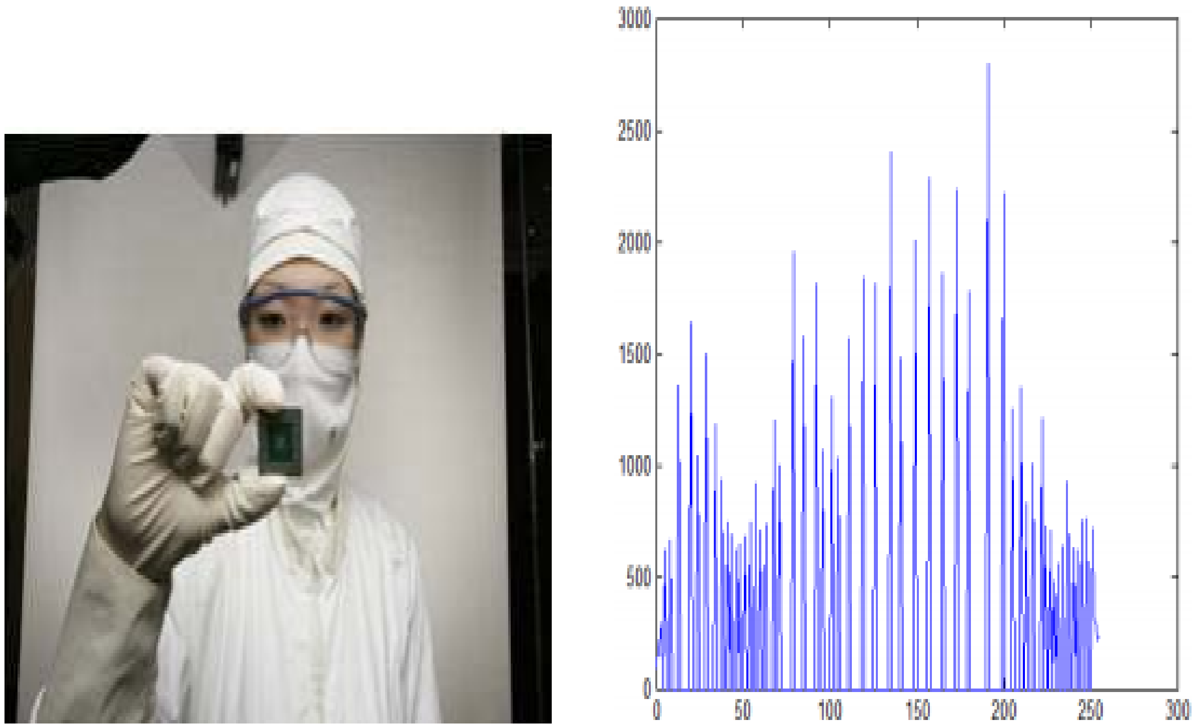

Figure 3.3: Image digital representation after applying histogram equalization [13]

Here in our project we used histogram equalization as our enhancement tool. So we let people try navigating in the virtual reality environment first without applying histogram equalization algorithm on the the photos previewed in the virtual reality environment. And another time letting people navigate in the Virtual reality environment but after we have applied histogram equalization algorithm on the photos found in the virtual reality environment and we test if there will be any differences in the results.

3.2 Image processing

To change the image to resemble what a prosthetic vision users see, of course we needed to apply some image processing techniques to translate any image into the prosthetic vision view. First a prosthetic vision image must be 16*16 pixels. And the pixels are counter to the normal state they are not squared but they are circled. To achieve this outcome a python algorithm was created to help reach this desired output successfully. First the python algorithm reads the desired image that we want to change as an input. Applying on certain pre-defined function in python we re-size the image to be 16*16 pixels and save it as a new image. Following this step we change the image to be grayscale using a created that changes the colors in the read image from colorful to be grayscaled. Now our image is complete it only lacks the drop out value. So we create the mask that will be put on our image to give it the drop out look. First unlike any image we need our image to have circled pixels and not squared pixels like any other photo. The output should be 16 rows and 16 columns of white circles. In order to reach the circular view of the pixels we color some of its surrounding pixels with black color doing this with process with correct pattern and choosing the right pixels to turn it black will give the white pixel it's circular shape successfully. Also an algorithm was designed to color some of these circled white pixels into black. This is to give us the desired drop out value. We just give the algorithm the percentage of drop out we want to create and the algorithm turns black the number of pixels that corresponds to this percentage.

3.3 Virtual Reality

3.3.1 Problematic Approach

Now we have reached the last and the most important phase which is displaying our images in the virtual reality environment. The first idea to try was about the following. The virtual reality scene will be of normal colors and we change the scene to prosthetic vision in the run-time by run-time we mean that it happens on the spot. Here is a deeper explanation of how this plan was going to be implemented. First of all, we are using virtual reality platform called unity. The unity is platform that can be used to design a virtual reality environment. A virtual reality Environment first contains what is called the player prefab. The player from its name is the object that represents the person who will be wearing the virtual reality headset. The player prefab contains an object called the camera. We set the camera in the direction we want the person who wears the virtual reality headset to see in the initial state when just put on the headset. In order to make the player see the image as prosthetic vision the idea was the following. We first created a mask that is equivalent to a prosthetic vision view. The mask contains 256 circles 16 rows and 16 columns. A percentage of the these circles are chosen randomly and get colored in black. This is done in order to block the vision and represent the dropout percentage. The dropout means the percentage of data in the image that is lost and represented in the prosthetic vision. So a 30 percent dropout percentage means there is a 30 percent data lost from the images. These data are randomly lost not in any certain pattern. So you get to see only 70 percent of the real image and 30 percent of the image details is lost. Figure 3.4 shows the prosthetic vision mask. So now the mask is ready. In the next step the we added the mask to the unity platform. Our goal was to make it move with the player head so whenever he moves his head the mask goes with him. This is to ensure that the player sees prosthetic vision view. In the unity platform we cannot place an image alone in the environment. It must be attached to any object. So I created a an object of type cube in the environment.

The image cannot be left alone in the virtual reality environment for a very simple reason. It violates one of the prosthetic vision requirements. One of the aspects that makes prosthetic vision scene is that it only contains single color in each pixels. This was not going to happen if we left the mask to move freely while the player's head is moving. So I had to find out another path to help us reach our desired goal. The goal of ensuring and guaranteeing that the player will always see 100 percent of the time the pixels containing only one single color as the normal prosthetic vision views. So as we cannot add an image alone in the environment without getting it attached to an object in the environment, I attached the mask to the newly created cube and the size of the cube is decreased in the Z axis to make it so thin to have no different thickness from the normal mask. In order to make the mask moves with the player movement we put it in the object called follow head. from the name follow head means it follows the head of the player wherever it moves. So this guarantees that the player will always see the prosthetic vision image in any direction the player moves his head. Now when the player looks through the mask he will see nothing. The player will only see the face of the cube that the mask is attached on. We want the player to see the virtual reality scene. So I added another layer or an image exactly on the back of the mask. Precisely this image is between the cube and the mask. This image contains a screenshot of the place on the virtual reality scene where the player is looking. I created a another object of type camera and placed it behind the mask. The job of this camera was to capture the screenshot of where the head of the player is looking. The screenshot immediately is saved to a known directory. At the same time a python code is running in parallel. The task of the this python algorithm is to read the saved screenshot from the directory. First thing change it to grayscale. Second thing re-size it to be 16*16 pixels. After that write this image in the same directory or in another words, overwrite the image. Consequently, the unity platform will read this overwritten image in the run-time and update the current image so the player will see the new correct image. So the output of this whole process is, a 16*16 image that is grayscale. The content of the image is a screenshot of what the player is looking to. After attaching the image behind the mask, we have met all the requirements of a prosthetic vision view after solving the single color problem. Unfortunately, This approach didn't succeed. It caused a very huge lag and the program was not running smoothly. This due to the fact that the process of running unity platform with the python code running and at the same time capturing a screenshot and reading and updating an image according to the player head movement. While this on the virtual reality headset you can see nothing. Because the process takes so much time to produce the output and then it has to run again to be updated when the player moves. So we had to look for another approach.

3.3.2 The Working Approach

So our goal from this approach is to avoid the problem of having more than one color behind the pixel. As well as finding another solution that does not cause this terrible delay and lag that was caused by the screenshot solution. The idea is simple. First we will get the image of any obstacle. Lets say in our scene we want to put an obstacle for example a chair. we take the image of the chair read in our python algorithm to change the image and re-size it to be 16*16. The next step also using the python algorithm we change the new re-sized image to be a grayscale image. The following step we apply the histogram equalization to the image doing some enhancements and making the image look better with an improved quality. Now the image is ready only missing the drop out so figure 3.5 shows an image of a chair 16*16, grayscaled and enhanced with histogram equalization. Figure 3.6 shows the image of the original chair before applying any image processing techniques.

Now our image is ready we only need to add the dropout. But first as we have agreed we can't put the image on its own in the Unity platform. We have to attach it any game object in the virtual reality environment. So I created a new object of type cube and we attach the image to it so now the image can be displayed. Now the image is almost ready it only needs the drop out. We have already created the drop out mask that we have shown in figure 3.4. So will add to the mask on the cube so it will overlap the image we had put giving us the image of a prosthetic vision with the dropout. Figure 3.6 shows us the image of the chair after applying the dropout transformed fully into prosthetic vision.

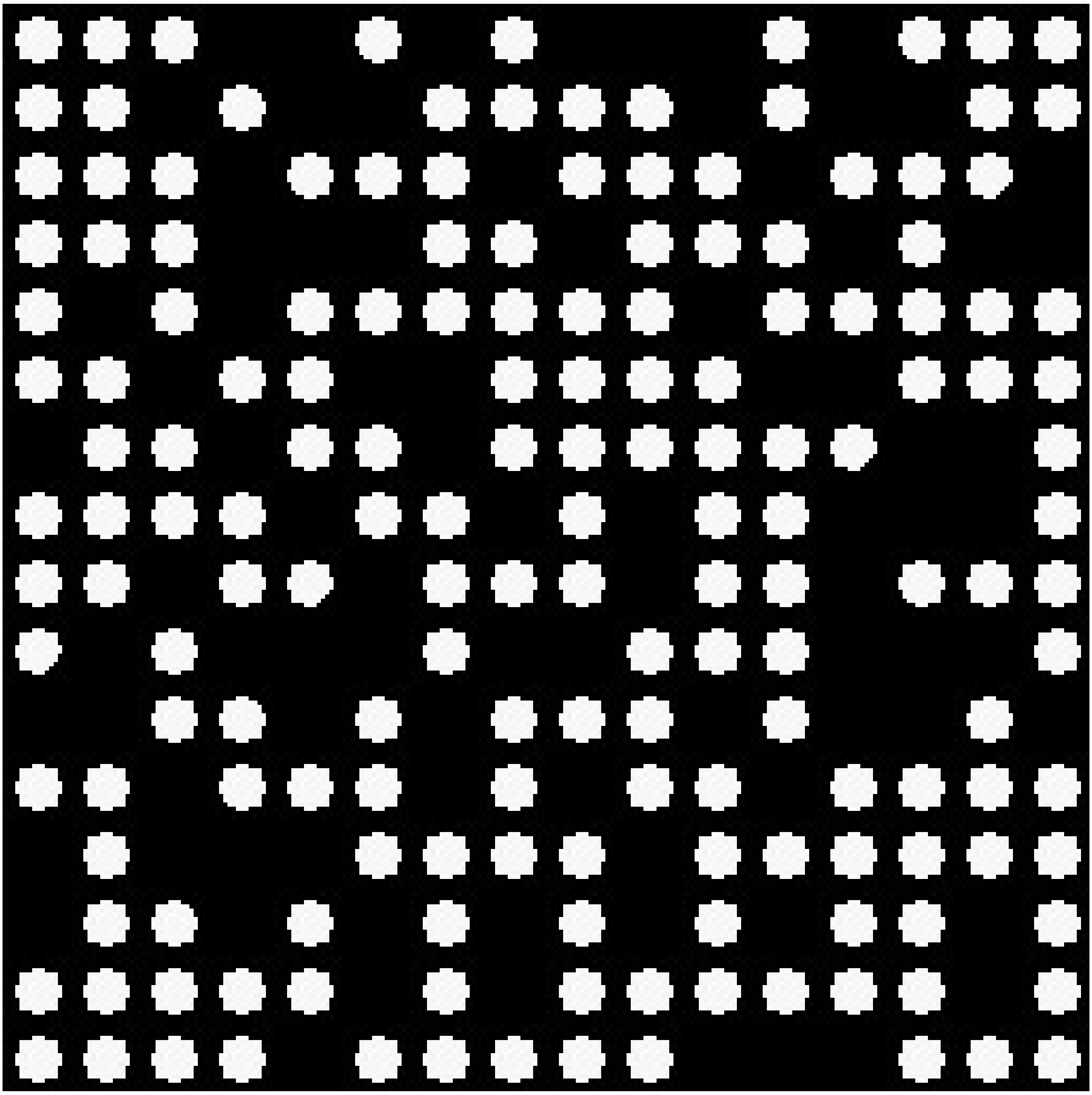

Figure 3.4: prosthetic vision mask

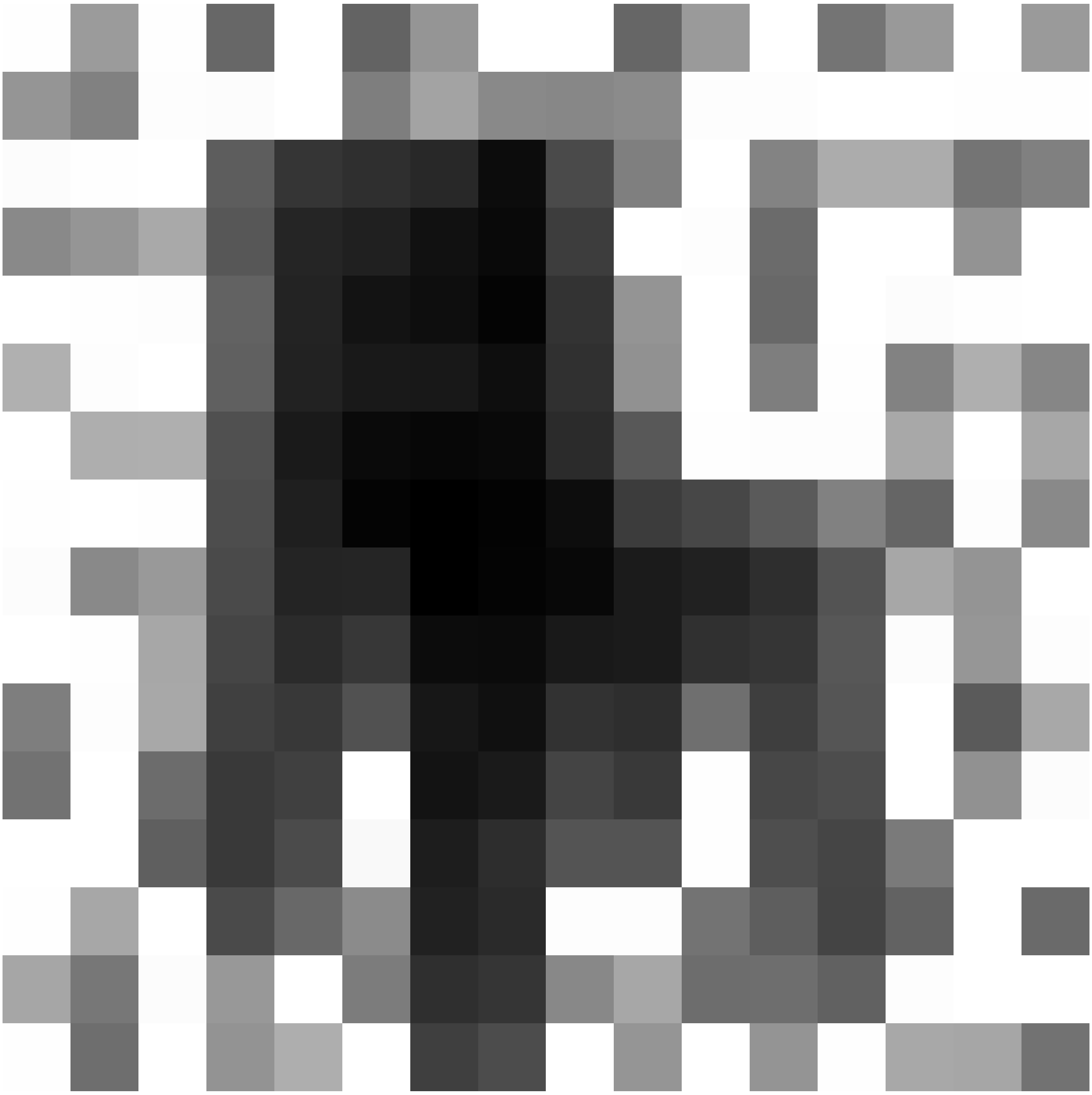

Figure 3.5: Image of a chair after applying enhancement, grayscaled and 16*16

Figure 3.6: the original photo before applying our image processing techniques [3]

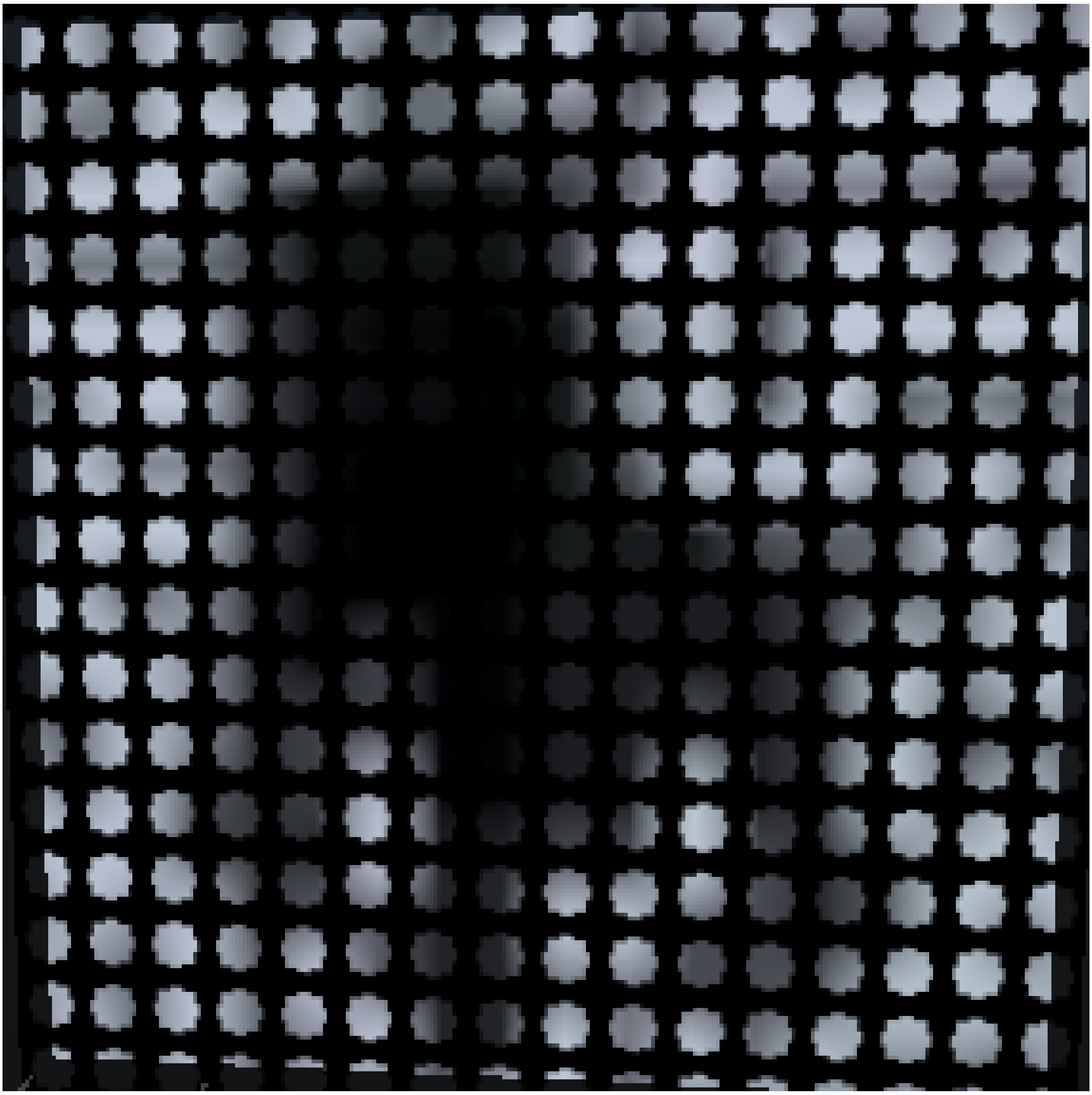

Figure 3.7: the chair image transformed into prosthetic vision [3]

Chapter 4

Results

Here we are at our testing phase. We have done our testing on 10 volunteers. The experiment is set as the following. The person wears the virtual reality headset to view the virtual reality environment we have created. The scene is about a room containing some objects that we consider as obstacles in any navigating environment. We are trying to test the ability of the person to detect the obstacle and avoid it. The first obstacle is a prosthetic vision image of a chair without any enhancement done on it and has a 30 percent drop out. All of the experiment participants were unable to recognize the chair. Even when they were told the type of this object that it is a piece of furniture they were still unable to name it. The next step was testing an image with a 20 percent dropout also with enhancement done on it and having all the prosthetic vision features from the grayscale color and the resolution of 16*16 pixels. 3 persons were successfully able to recognize the object. 7 persons were unable to name the object correctly. The last test was on a 10 percent dropout image. 6 persons successfully named the object whereas, 4 persons were not able to guess correctly. All participants agreed that simulating the prosthetic vision in virtual reality was a better choice than simulating the images on screen as in the virtual reality it is more realistic and makes the experiment very close as trying it in the real world. Specially that we were testing prosthetic vision in navigation, all participants declared that it was helpful in helping them truly understand how prosthetic vision users can navigate.The following pages shows figures with the images we have described above.

Figure 4.1: Image changed to grayscale with no enhancement and drop out 30 percent

Figure 4.2: original image of the bottle [1]

Figure 4.3: original image of tv [6]

Figure 4.4: Image with enhancement

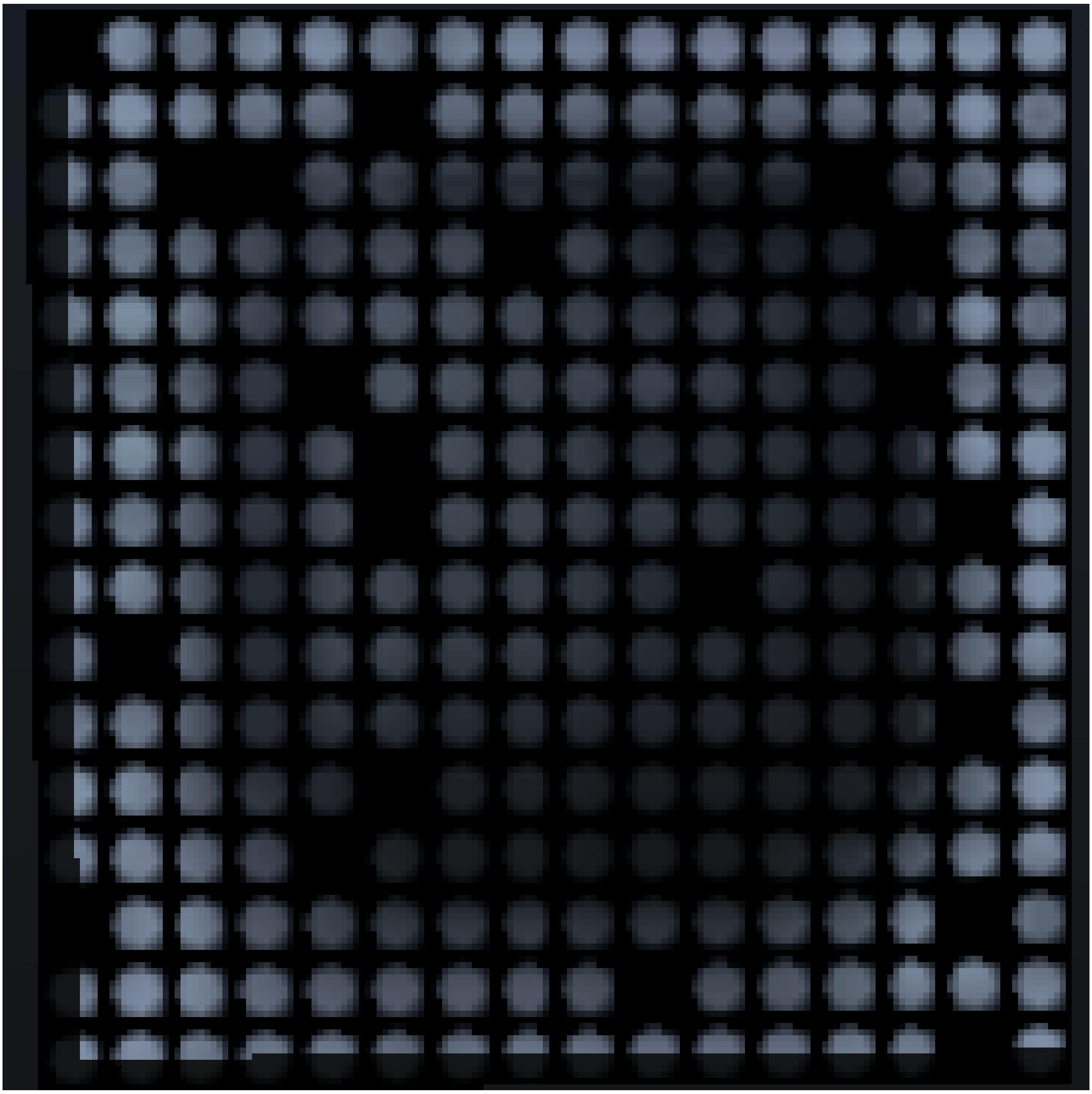

Figure 4.5: Image of television with 10 percent dropout

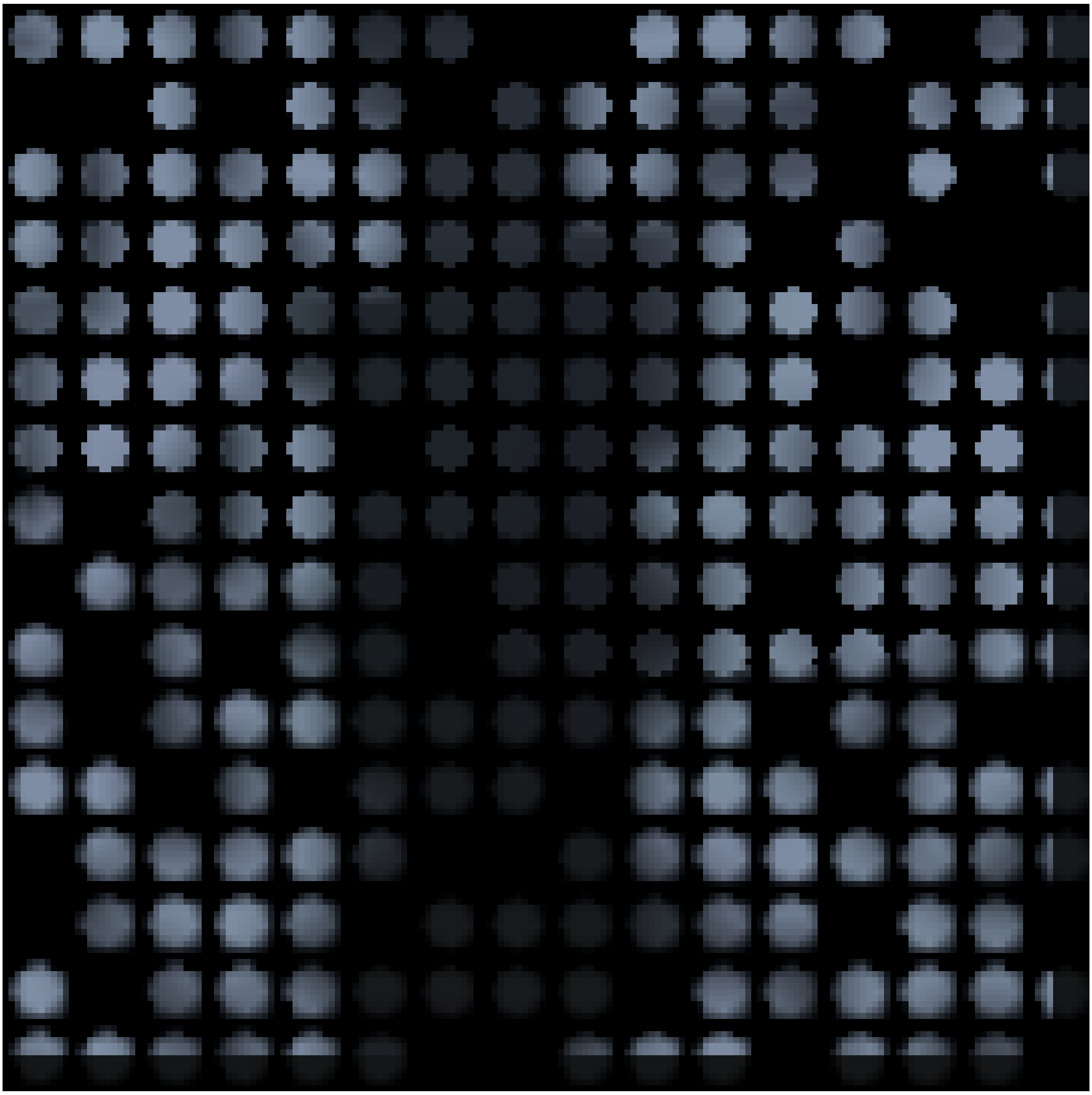

Figure 4.6: Image of a bottle with 20 percent dropout

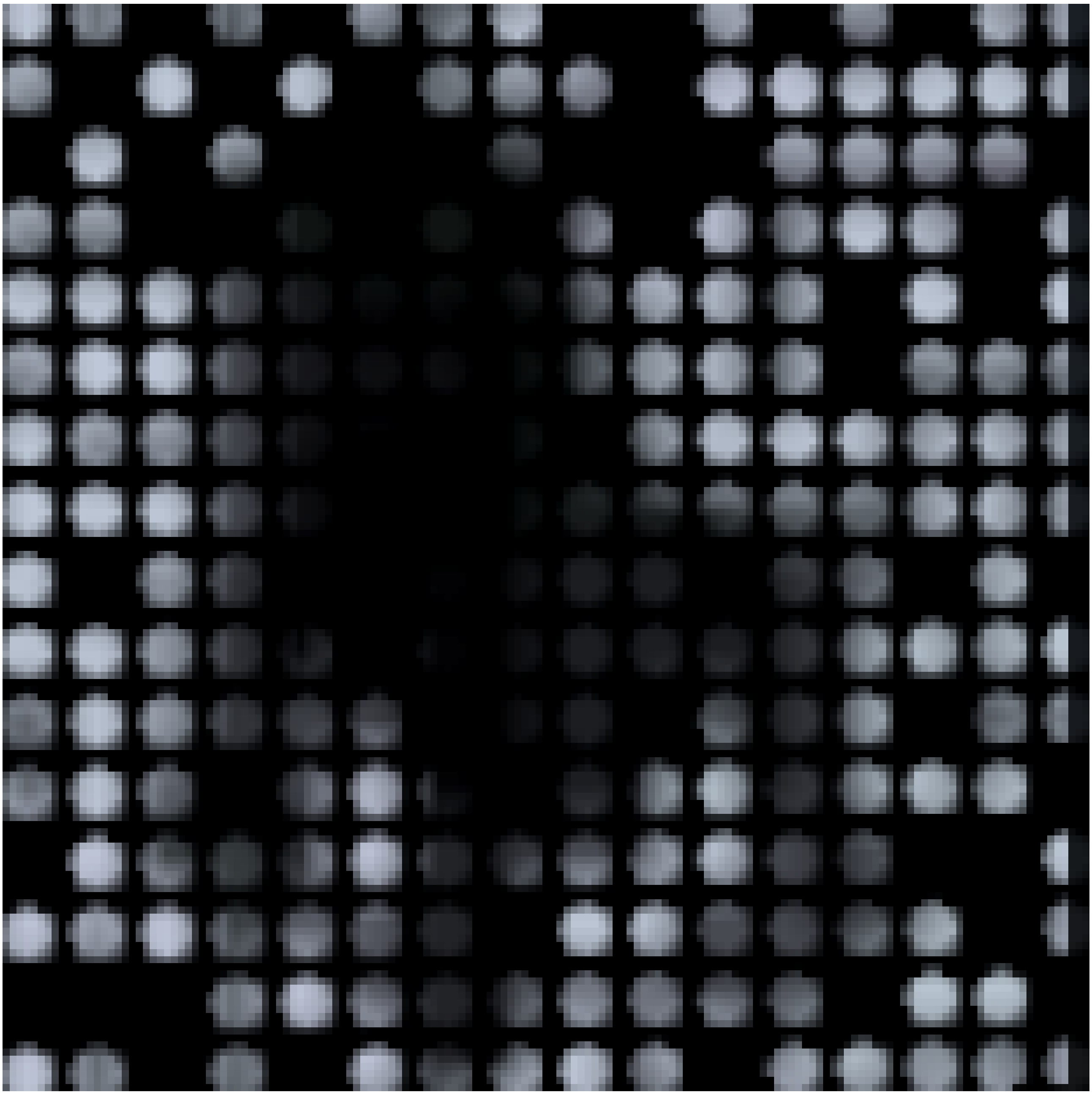

Figure 4.7: Image of the chair with 30 percent dropout

Chapter 5

Conclusion

Virtual reality helped us a lot in understanding how prosthetic vision works. It gave the opportunity for people to try navigation while they are seeing only prosthetic vision scene. Without image enhancement recognizing the type of the obstacle the person is facing during navigation was impossible. All users failed to name the obstacle they were facing without enhancement in prosthetic vision. 3o percent drop out image is also very hard to recognize yet with enhancement it was possible. 20 percent drop out image is not also easy to recognize immediately after few seconds some users were able to identify the object. The 10 percent drop out is somehow the best. As most of the image details is shown almost the majority of users were able to recognize the obstacle they were facing. These outcomes shows the huge role image enhancement played in helping people navigate through virtual reality as without image enhancement it was impossible to identify the objects. Also it emphasizes that virtual reality helped a lot the users imagine and get a true understanding of prosthetic vision rather than just seeing these images on the screen. As all the users declared they felt they lived the experience very near to reality.

Chapter 6

Future Work

The next step for this project maybe done using a camera in virtual reality. The camera will help even more in generating a more realistic prosthetic vision scene with more complex details. This will enable us to test and asses people's ability to navigate with even more accurate results. This help us measure very a higher accuracy how people will be able recognize obstacles as we can use more complicated and complex models in the virtual reality environment. People will get also a more realistic and better understanding of prosthetic vision. Using a virtual reality camera can record the outer environment and this recorded environment can be used as the virtual reality environment of the project rather than creating a fictional environment giving the user the feeling of a near to the reality experiment. Using the camera will be easier to do the screenshot approach that without having any technical, crashing and delay problems. Also we can try to use different image enhancement techniques and see if it willhelp us reach better results than the histogram equalization image enhancement technique. As well as having more number of volunteers testing the working on larger sample size will help in getting more insight.

Appendix

Appendix A

Lists

List of Figures

Bibliography

[1] bottle. https://www.cokestore.com.

[2] braille. https://www.afb.org/blindness-and-low-vision/braille/what-braille.

[3] chair. https://www.nidek-intl.com/aboutus/artificial_sight/about_artificial_sight/type.html.

[4] fig1. https://www.iapb.org/news/latest-global-blindness-vi-prevalence-figures-publi

[5] fig2. http://www.lvib.org/what-is-braille/.

[6] tv. https://www.freewechat.com.

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