
Team Kick

# nDVisual

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# Problem Definition

## Real world relevance and Precision

The selected theme for this project is Achieving Universal Primary Education for Everyone and thus we have decided to tackle the issue of accessibility for visually impaired students who may possibly feel discouraged when facing the challenge of navigating new school or college premises. However, we also believe that we can develop a flexible application which gives the student added utility by implementing specially designed tools such as planner and diary, email checker, timetable reader and an e-book/notes reader.

Although many resources are available nowadays to provide help for these particular students, mostly the help of learning assistants and guide dogs, we can provide an alternative approach to developing new methods of integrating these students by using a combination of existing technologies such as speech detection and computer vision. Such solution may provide moral benefits for the student as it will promote independence and self-sustainability as well as develop a strong confidence in oneself as the student will attend schools and colleges normally with other students.

## Resolving the problem

Approaching this problem is no easy task, as we are required to analyze basic aspects of everyday navigation and needs in detail. Aspects which we take for granted, example, opening doors or finding empty chairs, are all cause for possible issues for these particular students especially in a new environment where they might feel lost and at a disadvantage. We also believe that orientation does not solely rely on the knowledge of your surroundings, but also on the people present in your every day school life. Getting to know your classmates and lecturers easily helps developing new acquaintances as well as developing confidence and familiarity in your day-to-day school life.

Thus, developing object detection and face detection functionalities is a direct approach to tackling a part of this problem. Although specially designed software may exist to partly handle this problem, we aim to create a specifically designed application which allows the student to achieve both navigation and facial comprehension in a classroom environment with the use of just 2 functionalities from an entire project.

## Facing challenges

### *Object/ Face Detection*

When developing functionalities which rely on computer vision, there a number of factors which determine the detection accuracy and reliability. The most common factor is light itself. Light can cause inaccuracies when detecting colours and sometimes even faces due to changing the shade and tone of the colour. By implementing certain settings such as colour range and extensive face

training, we have improved the reliability and accuracy of the detection functionalities by a considerable amount.

### *Distance Detection*

Distance to an object is an important factor to be considered when navigating a classroom and thus it is important for us to have an application which is aware of approaching obstacles. Although the most accurate way of calculating distance is by having a static camera, in our case, we cannot assume so, as the student is constantly being on the move when navigating the class. Therefore distance detection is based on an estimate of the size of the object relative to the size of the video screen.

### *Voice Detection*

Voice detection and recognition most of the time requires training. Although it increases reliability and accuracy, it also proves to be time consuming, therefore we have instead used grammar keywords which act as voice command options. These keywords require no training, as the application can match the user's vocal command to one of the commands listed in the grammar collection. Concerning the diary, instead of implementing voice dictation, we implemented a voice recorder which allows the user to record voice entries.

## Solution Design and Innovation

The main goal prepared by the United Nations was trying to achieve universal education for everyone, and in our solution we are tackling this problem by providing a visually impaired student with a package with which the same student will be able to independently navigate through school premises and attend lectures like other students. Recent research has shown that around 285 million people are visually impaired worldwide, and although our solution is mainly based around students and their scholastic lives, individual components found within the same solution might also be of aid for visually impaired persons of an older age.

Although navigation systems for the visually impaired are available, through research and meetings with associations that work and aid visually impaired persons, we have discovered that indoor navigational system are either inaccurate mainly due to signal strength and therefore become unusable or else tend to come at a hefty price tag. On the other hand one may argue that guide dogs or learning assistants are an alternative solution to the one we are implementing, but from our research we have also discovered that funding a guide dog or paying a learning assistant may be out of budget for a middle class family, whilst also making the student highly dependent on other persons rather than being independent.

In our solution we have combined a number of existing technologies into an application with various functionalities and commodities to the educational life of a visually impaired student. Technologies such as Text to Speech, Speech to Text and Voice Commands have always been in development, and with the ever increasing need for mobility these have become important requirements for newly released devices such as Smartphone’s, Tablet PC’s and Notebooks.

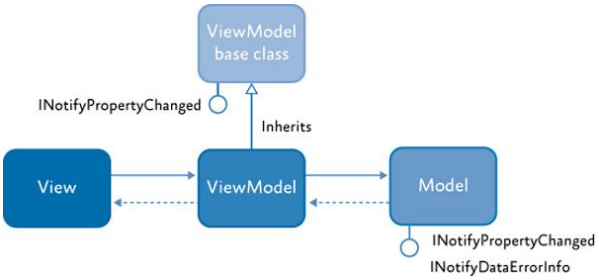
We have also made use of more advanced technologies such as Face Detection and Object Detection that even though they are not commonly developed or researched, they will surely aid and be useful in scenarios such as guiding a visually impaired person in an environment or identify important aspects such as lecturers in a classroom.

We have therefore combined these existing technologies into a single solution with different components that may be easily utilized by a visually impaired student which will enable the student to be more independent whilst also increasing confidentiality. The complete solution will be available at a reasonable price in order to enable visually impaired persons that cannot afford assistance in terms of guide dogs or learning assistants to still be able to receive their education and therefore progress in their chosen careers.

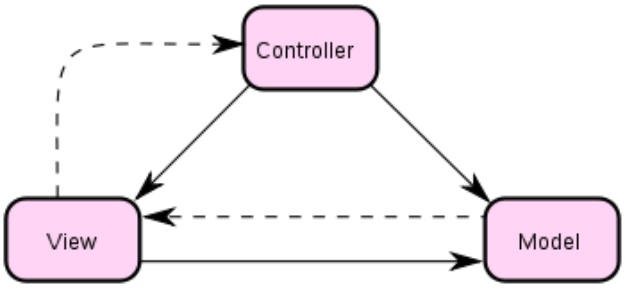
Although our application is still in the development process, recent results are very convincing and therefore we are highly encouraged to continue developing further this application in order to increase its reliability and its use in different scenarios. In our case this application will only be used indoors in a known and configured location but further improvement or development will enable the same application to be configured to different scenarios and locations.

## Technical Architecture and User Experience

This designed software uses two types of system architectural patterns which are Model View View Model(MVVM) and Model View Model(MVC). We had to use two different type of system architectural patterns due the fact that we used both Windows Forms and Windows Presentation Foundation (WPF) as a graphical subsystem for rendering user interface. The MVVM was used as a model for the WPF interface, as MVVM provides better tests. This is due to the fact that when in example, one has a label in the WPF interface, the developer binds events such as text to the view model and the tests are only done on the view model as the view will not have methods such as (label.text). In addition, the MVC pattern was used in Windows Forms as in MVVM, it requires the user to bind the data from the view to view model, while in MVC there is no need.




*(An image on how the MVVM patterns works)*




*(An image on how the MVC pattern works)*

For this scenario the WPF was used as it is able to create a high quality interface, making it easy to be implemented. In addition, the WPF offers a feature which makes it a more powerful structure,

it being data binding. Another advantage of the WPF is that it has an extended toolkit which has more tools which can be added to the form, such as the magnifier. EmguCV and AForge.NET both being two external libraries, were used for face and object detection. As these libraries do not work on a WPF interface, Windows Forms had to be used. For making the program more user friendly the same layout in both the WPF and Windows Forms were used. Features such as tab index where the user is not required to press on each textbox/button to type or submit a form were also included.

Two libraries owned by Microsoft such as text to speech and speechlib were used to enable interchangeable communication between the program and the user.

Regarding data storage, two database were used which consist of a local and an online database. The latter is stored on a Windows Azure platform as an SQL Azure Database. This was chosen to be the main database, which will distribute new and updated data to the local database of the client. This step was taken based on a number of reasons one of which is that if the user does not have access to internet, one can still access the software. Additionally, the database must be constantly updated with tables such as updating speech to text grammar table.

## Business Viability

### Technical

Given that our application is mostly intended for visually impaired students, we kept in mind the cost of the overall application including the equipment. Our application, which until now is developed to work on laptops, can work with minimum requirements and equipment. This means that every kind of laptop has an integrated microphone and webcam but however an external webcam is suggested since laptop webcams cannot be adjusted. Furthermore, to increase the portability of our application, it is best used on a Windows tablets. However, we may need to apply some modifications to be able to operate this application on a tablet. In order for our application to work in a reliable manner on both laptops and tablets, the user needs to buy a small webcam and a microphone to interact with the application, which still does not cost too much.

Since our application includes the features of face recognition and object detection, some limitations are included in the system. The main limitations in our system are that it can make a difference of how light or dark the room is, and how much sunlight is currently entering the room. Since these two limitations is not under our control, we researched on the internet on the average sunlight entered in a room through a window. Knowing these limitations and with the research's results, we configured our application to work around these limitations. Although our system is configured on these results, sunlight does not enter equally in every room, so small configurations needs to be done when changing the place.

## Economically

Keeping in mind that the users which are going to make use of our application are visually impaired students, they might not have enough substantial income so our priority is to keep the cost as minimal as possible. To obtain this goal, we made use of a simple webcam and microphone which can be bought inexpensively. In the future where the application will be able to work also on Windows tablets, the cost will still be kept at minimal since a webcam or a simple camera and a microphone do not cost too much. Another goal which we kept in mind to maintain the cost as low as possible is the database which is used in our application to store information and settings. In order to be cost efficient, a small amount of storage space needed by our system can be bought rather than buying the whole hosting and using a small amount of it. This way, we can keep the cost as low as possible for the users whilst efficiently using all the storage space purchased.

At present, visually impaired students who wish to navigate in a class need to make use of an assistant guide dog, which costs may rise up to around €14,000, or need to have a facilitator which will be require a monthly salary. In order to be feasible for these particular students who wish to use our product, the price will be a one-time payment and will cost less than a guide dog or a learning assistant in the long run. For the students, possible government schemes can be created where such schemes for example can provide the opportunity to have a portion of the price money funded by the government, therefore making it easier for them to acquire our product. On the other hand, users who do not have the funds to purchase our product at once or by using a monthly payment scheme, a Free Tablet initiative should be discussed with the government where people who do not have the required funds can be given a free tablet by the government as loan, where the tablet needs to be returned after the user finishes his scholastic years.

## Theoretically and Realistically

Although our system is made to be used by visually impaired students to help them familiarize themselves in a new classroom or a new school/college environment, our system can be used in multiple different scenarios. Using the same libraries and DLLs files, we can change our system to be used by cameras for security reasons by different companies. Installing our face recognition function in their security cameras' software and by giving training to the program, by capturing frontal faces of their employees, the camera will be able to recognize whether someone is an employee of the company or an intruder. If an individual is caught by the software after working hours, whether it will be an employee or intruder, different and more accurate procedures can be taken.

Another idea which our application can be changed to, is to be used for children's games. The application can be installed in a nursery school where the children would wear technical headgear consisting of a camera and microphone and play games such as getting to know each other by using the face detection functionality. On the same thought, it can also be used for educational purposes. The same headgear with object detection can be also used in primary schools where the teacher tells a student to find a red chair. After the child wears the headgear, s/he can find a red chair in the classroom with object detection and therefore children can learn the basic colours or learn the different shapes of different objects.

Also, the diary which is found in our application can be used by people who suffer from dementia. Instead of having to write everything on a normal diary, they can use our technical diary where they

can choose the particular day and record the requested entry using their voice. This will be much easier for them since they only need to press a button and record.