# An E-Learning Platform for Hearing Impaired Children

MMK Rowel#, ADAI Gunasekara, GAI Uwanthika and DB Wijesinghe

*Faculty of Computing, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka*

#rowelmindula@gmail.com

**Abstract –** E-learning, also known as electronic learning, is a method of disseminating knowledge with the separation of teachers and students. Hearing loss and hearing impairment are common examples of disabilities that affect people. E-learning is found to be an effective method for hearing impaired children for their education as it gives them the ability to do their education at home without having to go anywhere else. Although the concept of e-learning gives a full idea of the opportunities it can offer, it has some shortcomings that need to be considered. For children who are learning letters and numbers, this online learning method would not be as effective as it would be for the older generation. Therefore, children under the age of five should have a proper solution to learn letters and numbers, even in times of crisis. The main objective of this research is to discuss the need for a proposed solution for hearing impaired children. The proposed e-learning platform will support both Sinhala and English languages. Therefore, children can get an education in the language of their choice. This platform will teach the children step-by-step how to write letters, in both Sinhala and English as well as numbers. The system uses machine learning with Support Vector Clustering (SVC) to identify the letters and numbers they provide. This algorithm is constructed by SVM (Support Vector Machine). In addition, the system will provide simple questionnaires and activities for them to complete, while doing their studies through the platform. The aim of this paper is to make e-learning more effective and efficient for hearing impaired children.

*Keywords***:** *hearing impaired children, e-learning, distance education, crisis situation, education, deaf children*

## I. INTRODUCTION

Every citizen on this earth has the right to education. Every child has the right to learn and attend school no matter where they live or how wealthy or poor their families are. The same condition applies to hearing impaired children. However, children with hearing impairment face significantly different barriers and challenges to learning. Some of the main barriers to learning for hearing impaired children are societal attitudes, lack of access to basic services and crisis situations such as public health issues, political issues, and environmental crises. As a result of these barriers, hearing impaired children are confined to their homes and their education gets disrupted. Therefore, people have started using the latest technologies to prevent these kinds of barriers.

The rise of technology has been a great opportunity for education and as a new implementation, distance education also known as e-learning was introduced. E-learning is considered as an important factor as the younger generation feeds upon technology during their difficult times. E-learning entails physical separation of students and teachers. At the same time, the students and the teachers have the capability to interact with each other online as well as offline. Video conferencing has become one of the most popular types of distance education. Video conferencing is the most common way for students to interact directly with their teachers during live lessons (Daniel, 2020). This technology has become a great support to students with disabilities as they are capable of doing their studies at home without going anywhere. Some of the students with disabilities are reluctant to attend traditional classrooms to do their studies due to their sociological differences. Hence, distance education or e- learning can be supportive for students like them (Tomaino et al., 2020).

According to the world health organization, there are 466 million individuals with disabling

hearing loss and from that 34 million are known to be children ("Deafness and hearing loss," n.d.). The ability of hearing-impaired children to receive education and access to it has become one of the most establishing and challenging discussions in the history of deaf people (Hashim et al., 2018). For many years, sign language was primarily used to distribute education to hearing impaired children. Sign language is also used by deaf people to communicate with others. It is considered as one of the most emerging research fields in the research history. Figure 1 and figure 2 show samples of sign language using both hands and only one hand (Vinoth and Nirmala, 2017).
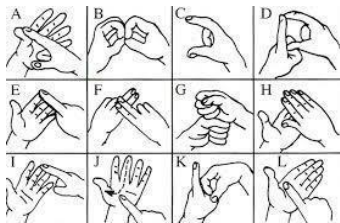


Figure 1. Two hand sign language Source: Deaf Students Higher Education System Using E- Learning
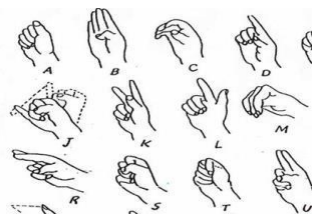


Figure 2. Single hand

Source: Deaf Students Higher Education System Using E- Learning

E-learning is known as a modern method that can be used for education. It does not require physical representation of children in a classroom. It can be considered as a great opportunity to do education remotely anywhere in the world.

E-learning is known as a method of education that is based on student-student interaction (SSI), student-content interaction (SCI) and finally the most common relationship, student-instructor interaction (SII) (Gunesekera et al., 2019). However, this method requires several electronic devices such as laptops or smartphones or tablets and Wi-Fi. Those who are unable to afford to find such devices will have to face some difficulties to find a solution (Sokolova, 2018). Many people nowadays benefit from e-learning, including differently abled people. This method can only adversely affect anyone's life if they are not familiar with the newest technologies (Vinoth and Nirmala, 2017). Hence, it is important to keep people informed about the latest technologies and upcoming trends.

Differently abled children require more attention than other children. A typical online classroom for them would not be as effective as it would be for hearing children when it comes to learning letters and numbers. A structured environment is highly required for hearing impaired children to succeed in their education. Some of the researchers who are in the field of e-learning have found several methods and techniques that can be used to overcome the above-mentioned barriers. The issues they faced when developing those systems and the advantages of the techniques and the methods they used will be discussed in this study.

The main purpose of this study is to introduce a method for hearing impaired children to do their education even in times of crisis. A method to learn numbers and letters in both English and Sinhala languages will be introduced in this research.

The significance of this research is that this study is based on e-learning platforms for hearing impaired children. The idea of e-learning platforms for children with disabilities is an emerging trend in the field of e-learning. Therefore, this study deliberates existing e-learning platforms for hearing impaired children and the technologies and trends used by other researchers to solve existing problems. Also, this study presents the developed model that can be used to solve the existing problems. The structure of this paper is as follows. Second section of the paper describes the background of the study and section 3 includes the methodology of the study. The section 4 and section 5 include the evaluation and the conclusion of the paper.

## II. LITERATURE REVIEW

Researchers have observed various techniques and methods that can be helpful for hearing impaired children in their education. The effectiveness of e-learning for them has been observed in different perspectives by the researchers who are working in the field of e-learning. This section of the study is devoted to identifying the proposed perspectives of researchers which can later be used to analyze the technologies and the newest trends they have used. According to Saunders, Lewis and Thornhill, the literature will support the research question and objectives providing a complete justification for the research aim and objectives, gaining insights as per the outline of the research and providing important information and ideas for other research (Saunders et al., 2019). Therefore, this section is structured in accordance with the research objectives.

*A. Existing Systems*

There are many e-learning platforms currently available for hearing impaired children and the content of most of platforms is based on Math, general education, and communication. Some of the studies that were done by researchers are as follows,

Table 1. Existing studies on e-learning for Hearing Impaired Children

| Name of the Study | Participants | Areas Based On |
| --- | --- | --- |
| "A Gamified E- learning Framework for teaching Mathematics" | Deaf students | Mathematics |
| "Adaptive Learning System and an Academic Advisor Agent" | Deaf students | General Education |
| "Design an Application for the Hearing Impaired People" | Hearing Impaired People | Communicate with others |
| "Deaf Students Higher Education using E-Learning" | Deaf Students | Higher Education |
| "E-learning course based on AdAPI" | Deaf and hard of hearing participants | Computer literacy |

Table 1 covers a wide range of subjects taught to hearing impaired children and adults. The system implemented by Samaa M. Shoheib is a gamified e-learning framework that can be used to teach mathematics to hearing im paired students.

According to the author, Gamified is an approach to accelerate the experience curve of teaching, learning, and thinking in education. Simply, gamification is an application of game planning elements and game principles in non-game contexts. The general contents of the implemented system were, content, Arabic sign language avatar, quality standards, learner support as well as characteristics, and gamification components. The content of this study contains the course syllabus, structure, quantity, depth, and activities. The learner support includes grading, feedback, and guidance. Grading and feedback are given in using score and instant feedback. These are included in the gamification components. Special guidance is provided using the Arabic sign language avatar.

Gamification components that were used in this study were, points and performance graphs, challenges, badges and achievements, leader modes, levels, time-based activities, stories, and characters as well as freedom to fail (Shohieb, 2019).

The main objective of the adaptive learning system proposed by (Hammami et al., 2017) was to monitor the student's achievement in the learning program and instruct them to do better. They proposed this system to overcome the difficulties hearing impaired learners face. According to the researchers, some of the challenges hearing impaired people face are, difficulties in writing and reading online and being compared with other normal students, grammatical errors they make when writing, and not having tutors who are willing to educate them without any hesitations as most of the tutors find it difficult to teach hearing-impaired students. For the above-mentioned problems, the authors proposed a solution based on a set of defined skills that would help hearing-impaired children to enhance their knowledge in writing and reading. These skills were specified as DSLO's ("Deaf

Students Learning Outcomes") (Hammami et al., 2017).

Matjaž Debevc and others have created an e-learning environment that is adapted for people with hearing disabilities. In this study, the utility and educational effectiveness of the e-learning curriculum was evaluated using an inventory and adapted education index system that measures software usage. The researchers have used sign language videos to teach hearing-impaired students to make the system more effective for them (Debevc et al., 2014).

A design and implementation of an application for hearing impaired people have been studied by ChoulWoo Kim and the others. They have designed this application for the smooth communication and easy life of hearing-impaired people. For this, sign language, voice to text translation features were included. In addition, a vibration alarm was added for the safety of the people. In this application, eight functions were implemented including, sign in, sign up, sign language search, voice translation, vibration alarm, SOS, substitute order, and welfare facility guide. This application was designed to ask for the minimum personal information from the users (Kim et al., 2017).

*B. Approached Techniques*

This section contains the technologies and the approaches used by the above-mentioned authors to implement the systems they proposed.

Table 2. Technologies used in Proposed Systems

| | |
|---|---|
| "Adaptive Learning System and an Academic Advisor Agent" | N-tiers, Multi-Layer architecture, Multi agent system, Model View Controller pattern maintenance |
| "Design an Application for the Hearing Impaired People" | Sign Language, Voice to text translation |
| "Deaf Students Higher Education using E- Learning" | Cloud Computing, Big Data, Video Streaming, Text |
| "E-learning course based on AdAPI" | Video Streaming (sign language and subtitles), Animations |

According to Samaa M. Shoheib, Gamified is an approach to accelerate the experience curve of teaching, learning, and thinking in education. Simply, gamification is an application of game-planning elements and game principles in non-game contexts (Shohieb, 2019). This is known as a game-based method. Hence the goals of the system are presented to users as games. According to the researchers, a study was conducted to determine the effectiveness of this method by applying a gamification plugin to a learning management system. The results show that the gamification method has better effects than the traditional education system. Hence, the researchers used an avatar that supports Arabic sign language to support hearing-impaired children with their education.

Adaptive learning system which was proposed by (Hammami et al., 2017) and others used N-tier, multi-layer architecture, model view controller pattern maintenance, and the multi-agent system as techniques to implement the system (Hammami et al., 2017).

C. Effectiveness of E-learning for hearing impaired children during Crisis Situations

With the development of the world, distance education also known as e-learning has started growing rapidly all around the world. It has also become the major solution to provide education to the younger generation in difficult times. The effectiveness of e-learning cannot be analyzed just by comparing it with the traditional education system as both the systems have many advantages as well as disadvantages. Especially in times of crisis.

According to the authors, the distance education system is the most effective and efficient way to handle education in crisis situations. During crisis situations people are stuck at home unable to go anywhere. There are times when people are not able to get the essential products for themselves. In such situations, advanced technology is needed in order to sustain the situation. As a result, distance education was developed to address all barriers that affect the education sector in a country.

According to Oliveira, in a crisis, schools and institutions are closed to prevent external damages. Hence there won't be a place for students to do their studies. In the distance education system, no specific space is required for students (Oliveira et al., 2018). Students can do their education at home. In the traditional education system, the teacher may have to teach the same subject to different classes at different times but with the distance education system the teacher or the tutor can conduct only one session (video) and can ask students to join that at the same time. It is much easier than teaching the same lesson at different times.

According to "The rise of online learning during the COVID- 19 pandemic", distance learning requires 40-60% less time to learn than in the traditional learning system ("The rise of online learning during the COVID-19 pandemic | World Economic Forum," n.d.). The main reason for that is that students have enough time to self-study and clarify the queries on their own. According to the authors, the effectiveness of distance education varies among age groups. Since young children require more attention, they require physical activities as well as in depth guidelines.

## III. METHODOLOGY

### A. Data Gathering

To gather the required data for the development of the system were done using data collection protocols such as interviews, questionnaires, and documentary reviews. The main purpose of this system is to deliver an effective learning method for hearing impaired children that can be used to do their education even in their difficult times.

### B. Data Analysis

Data required for the implementation of the system were analyzed using charts and diagrams. In the analysis process, problems and difficulties faced by hearing-impaired children were identified. This helped the authors to discover the need for a new learning method for hearing impaired children in times of crisis.

### C. Approach

Main users of this system are hearing impaired children and lecturers or teachers of hearing-impaired children. There are two types of inputs for the system. They are basic information such as the name, the date of birth etc. of both users and uploaded course materials by the teachers.

### D. Technology Adapted

To gather user inputs through sign-in and registration modules, the system has been implemented using HTML, CSS, JavaScript, and firebase. These technologies were used by considering the functional and non-functional requirements of the system. It is important to develop a system that satisfies the requirements of the users.

The proposed e-learning platform for hearing impaired children is a web-based system. Non-functional requirements such as availability, security, learnability, and usability were mainly considered when developing the system. To develop the frontend of the system, Html, CSS, and JavaScript were used with visual studio code. To develop the backend of the system, machine learning, python, Jupyter notebook, and firebase were used. Since the main goal of this system is to teach hearing-impaired children how to write letters and numbers, machine learning was used to recognize the handwritten text and digits.

### E. Proposed Design

The architecture of the system was broken down into four main components and they are, software architecture, database, modular architectures as well the interfaces of the system.
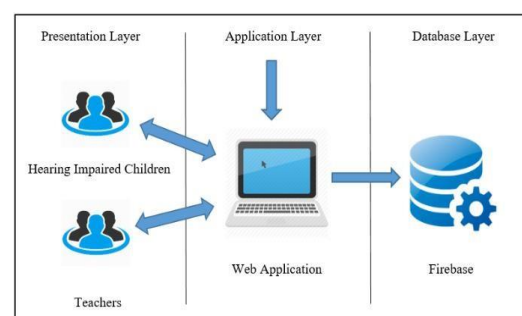
1. *Overall System Architecture*



Figure 3. Overall System Architecture

Presentation Layer - This shows information about the system and the web application. It is a user-friendly layer and is the front part of the system. In this layer, user interfaces of the system are largely considered. User interfaces of this system are eye-catching and graphical.

Application Layer - The application layer consists of the web application. The application layer presents the functional logic that shows the basic functionalities of a web-based system. It is an abstracted layer that connects to the other two layers as it acts as the central part of the entire system. This presentation layer performs a detailed configuration of the system.

Database Layer - The database layer consists of databases, tables, records, etc. It has database servers that can be used to store all the required information. This layer is independent of the application layer and the presentation layer. This storage will be used to ensure the efficiency of all operations related to the database of the e-learning platform.

2. *Modular Architecture*

The overall modular architecture of the e-learning platform is shown using figures. The modules of the system are mentioned below with related interfaces.

Language Selection Module - The system is designed for both English and Sinhala Languages. Users can go further by selecting the language they prefer.

Login/Signup - There are two categories of users in the system. They are hearing impaired children and teachers. Both the categories of users can log in or create a new account in the system.

User Profile - Every user will have their own user profile. The details which were entered by the user will be displayed in their user profiles. Details such as name, age, and courses they follow on the platform.

Course Selection - There will be several course materials for hearing impaired students access. They can choose to follow any of the included courses on the system.

Letters and Numbers Identification - This module includes an algorithm to identify the handwritten texts and digits entered by the users. This module includes the SVC (Support

Vector Clustering) algorithm. This is constructed by SVM (Support Vector Machine). SVM can be used for classification, regression, and for other tasks (Zhou et al., 2018). The recognition of handwritten digits is done as the flow chart mentioned below (Zhou et al., 2018).
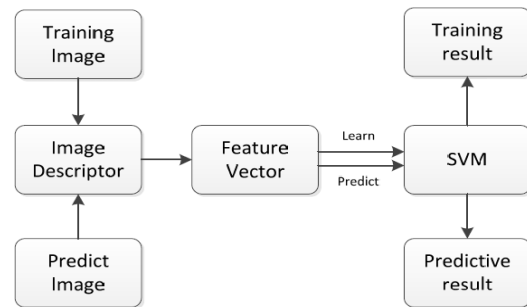


Figure 4. Flow Chart of Digit Recognition
Source: Study on Handwritten Digit
Recognition using Support vector machine.

SVC uses a kernel function to map data points from data space to high dimensional feature space. Using the support vector domain description algorithm, the kernel's feature space algorithm finds the smallest range that covers the image of the results. When this range is remapped into data space, it creates a series of contours that surround the data points. The SVC then interprets such contours as cluster borders and links the points covered by each contour to the same cluster (Ben-Hur, 2008).

Home Page - The home page contains the available courses for hearing impaired children. For teachers, the home page will include the option where the platform lets teachers add their own courses to the system.

Feedback - Users can send their feedback on the course material they follow or regarding the system. They will be given a section to add their comments on the platform. For this, a feedback form will be provided.

The developed e-learning platform for hearing impaired children is based on colorful themes and colors because children require eye-catching interfaces. Figure 5 shows the home page of the platform and figure 6 shows the course selection interface of the system. Figure 7 is the signup interface for children.

Figure 5. Home Page of the System



Figure 6. Course Selection Interface



Figure 7. Sign Up Interface

## IV. RESULTS AND DISCUSSION

Hearing-impaired children need an effective solution to continue their education in times of crisis. A typical online classroom where teachers talk, and students listen would not be effective for them at all. Therefore, an e-learning platform was proposed to be used as an alternative that hearing-impaired children can use to learn letters and numbers with proper guidelines. This allows children to draw letters and numbers on their own.

To recognize the digits and letters written by children, machine learning is used. For this, a dataset consisting of 100 images per digit was used. This data set was split into two sets. 20% were used for the training process of the dataset and 80% were used for testing. The following figure shows the accuracy of the digit recognition algorithm.

```
In [32]:  #calculate accuracy
          from sklearn import metrics

In [33]:  prediction = classifier.predict(test_x)
          print("Accuracy = ",metrics.accuracy_score(prediction, test_y))

          Accuracy =  0.98
```

Figure 8. Accuracy of Digit Recognition

For the digit recognition 1000 images were used. In this system, the SVC (Support Vector Clustering) algorithm was used to fit the model and to calculate the accuracy. The purpose of this method is to divide the data into groups according to specific criteria and to organize data in a more meaningful way. The following figure shows one of the results taken from the system.
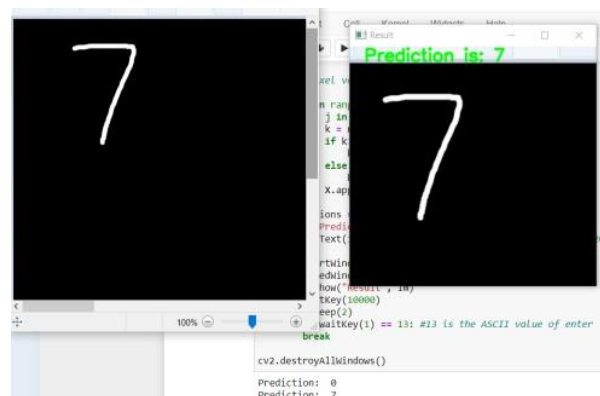


Figure 9. Prediction of Handwritten Digits

## V. CONCLUSION AND FUTURE WORK

The main purpose of this research is to suggest a better solution for hearing impaired children to do their education in crises such as public health issues, political issues, and environmental crises. Learning letters and numbers has been a difficult task for children in times of crisis. Some of the existing e-learning platforms are not cost-effective and not as efficient as traditional education. To overcome those difficulties, we were able to develop an e-learning platform that teaches hearing-impaired children to learn and write letters and numbers step by step.

This article suggests a web-based e-learning platform that includes several course materials

that teach students how to write letters and numbers. This system will be further developed for other differently-abled children and will include more course material for other age groups.

In addition, this method of learning can be presented to a group of hearing-impaired children and obtain feedback. Based on the feedback obtained, the system can be further developed to make it more effective for children.

This platform can be very useful for children who struggle with learning letters and numbers in times of crisis. Some parents find it difficult to persuade their kids to sit in one place and study, especially when they're at home. Children seek entertaining activities. Hence, this platform will help not only children but also parents regarding the education of their children.

From the research and surveys which were carried out, we can conclude that using proper technologies during appropriate situations can enhance the education system of a country even in times of crisis.

## REFERENCES

Ben-Hur, A., 2008. Support vector clustering. Scholarpedia 3, 5187. https://doi.org/10.4249/scholarpedia.5187

Daniel, 2020. What Is Distance Learning? And Why Is It So Important? ViewSonic Libr. URL https://www.viewsonic.com/library/education/what-is- distance-learning-and-why-is-it-so-important/ (accessed 4.4.21).

Deafness and hearing loss [WWW Document], n.d. URL https://www.who.int/news-room/fact- sheets/detail/deafness-and-hearing-loss (accessed 3.12.21).

Debevc, M., Stjepanovič, Z., Holzinger, A., 2014. Development and evaluation of an e-learning course for deaf and hard of hearing based on the advanced Adapted Pedagogical I ndex method. Interact. Learn. Environ. 22, 35–50. https://doi.org/10.1080/10494820.2011.641673

Gunesekera, A.I., Bao, Y., Kibelloh, M., 2019. The role of usability on e-learning user interactions and satisfaction: a literature review. J. Syst. Inf. Technol. 21, 368–394. https://doi.org/10.1108/JSIT-02-2019-0024

Hammami, S., Saeed, F., Mathkour, H., Arafah, M., 2017. Continuous Improvement of Deaf Student Learning Outcomes based on an Adaptive Learning System and an Academic Advisor Agent. Comput. Hum. Behav. 92. https://doi.org/10.1016/j.chb.2017.07.006

Hashim, N., Mohd Satar, N., Mukhtar, M., 2018. A review of e- learning models for deaf and hearing impaired people. J. Eng. Appl. Sci. 13, 9029–9037. https://doi.org/10.3923/jeasci.2018.9029.9037

Kim, C., Kim, D., Lee, H., Park, H., Kwon, G., Park, E., Lim, H., 2017. Design and Implementation of Application for the Hearing Impaired People. MATEC Web Conf. 125, 04007. https://doi.org/10.1051/matecconf/201712504007

Oliveira, M., Penedo, A., Pereira, V., 2018. Distance education: advantages and disadvantages of the point of view of education and society. Dialogia 139–152. https://doi.org/10.5585/dialogia.N29.7661

Saunders, M., Lewis, P., Thornhill, A., Bristow, A., 2019 . "Research Methods for Business Students" Chapter 4: Understanding research philosophy and approaches to theory development. pp. 128–171.

Shohieb, S., 2019. A Gamified e-Learning Framework for Teaching Mathematics to Arab Deaf Students: Supporting an Acting Arabic Sign Language Avatar. Ubiquitous Learn. Int. J. 12, 55–70. https://doi.org/10.18848/1835-9795/CGP/v12i01/55-70

Sokolova, N., 2018. The Pros And Cons Of Distance Learning. https://doi.org/10.15405/epsbs.2018.12.02.157

The rise of online learning during the COVID-19 pandemic | World Economic Forum [WWW Document], n.d. URL https://www.weforum.org/agenda/2020/04/corona virus- education-global-covid19-online-digital-learning/ (accessed 10.28.20).

Tomaino, M., Greenberg, A., Kagawa, S., Doering, S., Miguel, E., 2020. An Assessment of the Feasibility and Effectiveness of Distance Learning for Students with Severe Developmental Disabilities and High Behavioral Needs. https://doi.org/10.21203/rs.3.rs-54344/v1

Vinoth, N., Nirmala, K., 2017. Deaf Students Higher Education System Using E-Learning. J. Educ. Learn. EduLearn 11, 41. https://doi.org/10.11591/edulearn.v11i1.5131

Zhou, X., Li, J., Yang, C., Hao, J., 2018. Study on Handwr itten Digit

Recognition using Support vector machine. IOP Conf. Ser. Mater. Sci. Eng. 452, 042194. https://doi.org/10.1088/1757-899X/452/4/042194

## AUTHOR BIOGRAPHIES

MMK Rowel is currently a BSc. Undergraduate at the faculty of computing, General Sir John Kotelawala Defence University. Current research is about Machine Learning based E-learning Platform for hearing impaired children that can be used to learn numbers and letters of both Sinhala and English languages.

GAI Uwanthika Received BSc(sp) in Computer Science and Technology degree from Uva Wellassa University. Currently pursuing her master's degree at University of Peradeniya. The main research interests include Bi Informatics, Deep Learning and Digital Image Processing.

Diunuge B. Wijesinghe is a lecturer at Faculty of Computing, General Sir Kotelawala Defence University. Diunuge B. Wijesinghe obtained B.Sc. Eng. (Hons.) in computer science and engineering from Faculty of Engineering, University of Moratuwa, Sri Lanka in 2015. He worked as a CEO at Nandimith Labs, Visiting Lecturer in Edith Cowan University, UCHS at Jayawardenapura Hospital, IESL College of Engineering and University of Moratuwa, Sri Lanka. His current research interests are data science, cyber security, accelerated computing, intelligent systems, and automation. Eng. Wijesinghe holds the associate membership of IESL (Institute of Engineers Sri Lanka).

Dr.Asela Gunasekara has graduated from London Metropolitan University ,UK with 1st Class Honors. He has acquired his Postgraduate Diploma and Masters degrees from University of Colombo. He was awarded a full scholarship by the People's Republic of China to follow his Doctoral studies. He was awarded as the Outstanding International Student, Academic Excellence Award and as the Honorary International Student for his outstanding performance during his Doctoral studies at Huazhong University of Science & Technology, China. His doctoral thesis is on Usability Heuristics in Human Computer Interaction. He is an active researcher in Human Computer Interaction and E-learning. He has 14 years of academic experience and at present he is the Dean of Faculty of Computing in General Sir John Kothelawala Defence University.