

# Mushir: An Arabic Edutainment Application For Deaf and Hard of Hearing Children Using Real-time Image Processing

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## Summary

Education is an essential stage of children lives. Children with special needs (deaf and hard hearing) may encounter challenges and need more assistant in their education journey. Recent technology could be utilized to improve the deaf and hard hearing children learning experience. For these reasons, this paper proposed "Mushir" an Arabic application that targets deaf and hard of hearing children from four to seven years old. "Mushir" aims to increase child knowledge and enthusiasm for learning letters, numbers, shapes, and colors in Arabic sign language. In addition, the child can examine the knowledge he achieves by playing two different games. The first game is a multiple-choices questions. The second game utilized image processing technology by applying real-time processing for the camera senses. In this game the child will be asked to open the camera and indicate a movement of his/her hand in sign language.

### Keywords:

*Real-time image processing, deaf and hard of hearing, children, Arabic Application*

## 1. Introduction

As we all know, "Education in childhood is like engraving on stone," so one of the most important things that must be considered for a child's life is education. With education, our nation will rise and evolve. Preschool education is a remarkable stage full of energy and excitement that should be considered by deaf children's parents; learning the basics at this stage might positively affect the children in advanced stages [1].

The dilemma is that education opportunities differ from child to child, especially for people with special needs (deaf and hard of hearing) because they have much fewer learning opportunities than healthy kids do, so they need more care in their education and future. Technology changed everything; since the internet started spreading, learning has become different, so we have to take advantage of it for people with special needs. Not being attentive to this part of society (children with special needs deaf and hard of hearing) caused a lack of educational applications for children with special needs in Arabic sign language. Most of the applications available focused on communication purposes or apps that educate people in sign language [2]. Therefore, to support their educational journey and encourage them to learn an educational and entertaining application is proposed.

Mushir aims to support deaf and hard of hearing children in learning basics such as letters, numbers, shapes, and colors in Arabic sign language (ARSL) using image-processing techniques to make the application more interactive. Arabic sign language (ARSL) is a full natural language that used by the deaf in Arab countries to communicate in their community. Unfamiliarity with this language increases the isolation of deaf people from society. This language has a different structure, word order, and lexicon than Arabic. The translation between ARSL and Arabic is a complete machine translation challenge because the two languages have different structures and grammars [3].

## 2. Literature Review

### 2.1 Related Studies

Technology plays an important role in our society, especially in the field of education. It is quite regrettable that children, particularly the deaf, still face many challenges in acquiring an education. Their learning methods are different as compared to hearing people. They use Sign Language (SL) rather than natural language to communicate and learn [4]. In this literature review, we are going to discuss the difficulties that deaf and hard of hearing children face and how technology can make a huge difference in educating them. In the work presented in [5], Al-Megren and Almutairi elicited the user requirements for the development of an augmented reality (AR) application that supports the literacy development of Arab children who are hearing impaired. The findings indicated that the parents and teachers preferred Arabic SL (ARSL), pictures, and videos, whereas the children struggled with ARSL and preferred fingerspelling. These preferences highlighted the importance of integrating various resources to strengthen the written Arabic and ARSL literacy of Arab children. It also showed the importance of establishing requirements elicited directly from intended users to support their learning process. The study results were used in the preliminary development of Word & Sign, an AR mobile application intended to aid

Arab children who are hearing impaired in their linguistic development.

Komal Parvez et al [4] developed a mobile application for learning basic mathematical concepts using Pakistan Sign Language (PSL), and the objective was to determine the effectiveness of the application. The study bridged the gap between the technology-based method and conventional teaching methods. The sample was 192 deaf participants aged 5–10 years. They were divided into two groups; one group learned through conventional methods (flashcards and board) and the other group through the developed mobile application. The difference in the performance of both groups was evaluated by conducting quizzes. The findings revealed that the Experimental Group (EG) participants, who were instructed by the mobile application showed higher proficiency in the quizzes as compared to the Control Group (CG). CG participants took 20 min longer than EG participants to complete the quizzes. The results showed that the quiz scores were directly affected by the mode of teaching used for participants in both groups.

Bouzid et al [6] aimed to examine the deaf learners' interest in using an educational game for learning the sign language notation system Signwriting. The results found indicated that, overall, the application is useful, enjoyable, and easy to use. The game can stimulate the students' interest in learning such as notations. Alnafjan et al [7] describe the design and the development of an iOS application. The application provides the chance for children with difficult hearing, ages 7-12, to learn about basic Islamic tenets like ablution (Al-Wudu), daily prayer (Salah), and supplication (Al-Adhkar) using the Arabic Sign Language (ARSL).

## 2.2 Related Applications

- SignLang : is an iOS application (iPhone and iPad) designed for all ages who want to learn about the American Manual Alphabet (AMA). It uses real-time image processing hand shape and motion trackers to recognize sign language. The application has a simple interface with two sections, and there is an option to choose the left or right hand. the training section shows all letters in the sign language at the bottom of the screen. The user can select any letter to see it as an alphabet and try to shape it with his/her hand using the camera and it shows the user the percent of matching to the letter. In the challenge section, the user will start the challenge when entering the section with a timer of one minute and they have to answer questions as possible as they can [8].
- ASL Kids : Is an application that works on IOS and Android systems provide a set of American Sign Language (ASL) dictionary to help deaf and hard of hearing children to learn and examine their knowledge. It includes fingerspelling letters where the child can see the letters and its corresponding hand sign. In addition, when a child tests his/her knowledge, a gif picture is provided for sign language movements. In addition, a multiple choice quizzes are provided. The application teaches

children signs about various subjects like family, colors, animals, etc. An audio button option is available if needed to hear how a word is pronounced to stimulate speech and hearing. [9].

- Hands on ASL : Is an application available for both iOS and Android. It aims to teach children the communication-basics using the American Sign Language alphabet interactively uses 3D hand models that can be rotated from all angles. The application targets children from the age of 4 and up. It provides quizzes of varying difficulties and allows learners to choose the level to test their knowledge. [10].
- Baby sign dictionary : Is an application works on IOS and Android systems. Edutainment is provided in a set of different options, chosen based on the child's interests such as work words, animals, daily routines, feelings and emotions, food, morals, behavior, and nature - all arranged alphabetically for quick and easy searches. Moreover, the child can see an image, replay a video tutorial for each sign, and learn sign language movement with a voice where it describes instructions on sign language movement and how to do it in detail. Furthermore, the application also comes with a fun interactive video quiz and voice button if needed. [11].
- Educational letters for deaf : Is an educational application for Android targets deaf aged 6-8 and enables them to learn the Signal alphabet in several entertainments' ways using multimedia, such as attractive colors, graphics, and shapes. It also includes simple games that enable children to understand the letters with an example. The app supports Arabic and English [12].

## 2.3 Discussion

Early childhood learning of sign language for deaf and hard of hearing children results in increasing their knowledge and improving their confidence. Mushir application will help Deaf and hard of hearing children to be able to communicate freely with everyone, learn easily in school and to be involved more in the society.

The applications reviewed above raised our knowledge and awareness of the most important features and characteristics that should considered in edutainment applications, such as attractive design and variety of displays. The reviewed applications have many features, but they also come with limitations. Some of the most common limitations are: many of these applications do not support Arabic language, lack of a reward system and they do not support image processing. In contrast, Mushir application provides all these features.

## 3. Problem Definition

Many people in the Arab world suffer from various disabilities and difficulties. In Saudi Arabia, the General Authority for Statistics stated in 2017 that people with

hearing difficulties reached 1.4% of its population [13], and this category constitutes a large proportion of sign language users. In particular, the number of Saudis aged five and over who use sign language is (27748) person. There is no doubt that children make up a large part of this group.[14]

Children with disabilities in our Arab world, specially the deaf and hard of hearing, may face some challenges in their educational journey. Like other children aged 4-7 years, they need to be prepared to enter school. They are in the stage of having some basic knowledge of letters, numbers, shapes, colors, etc.

The educational process is witnessing a lot of progress and development. Technology and entertainment in our time are an essential part of education [15]. Children with speech and hearing disabilities lack Arabic entertainment educational programs that meet and emulate their needs [2].

Our application Mushir aims to provide suitable means of education that contribute effectively to deaf and hard of hearing children's education. Also, to develop children's capabilities and experiences and prepare them to join their school community.

The application consists of four categories the child can learn from which are: letters, numbers, shapes, and colors. Each of these categories has two sections, learn lesson and play game sections. Thus, the child learns and then tests what has been learned through an entertaining game. The child interacts with the game using image processing or by choosing the correct answer. In each of the four categories, there are stages to motivate the child to overpass these stages and complete the game. In addition, the application allows the parent to add their emails to receive periodical feedback about their child progress.

Our project's primary goal is to develop an Arabic educational entertainment application for deaf and hard of hearing preschoolers to teach them learning basics such as: letters, numbers, shapes, and colors. In a comfortable, interactive, and age-appropriate way by taking into consideration, their needs. [16].

#### **Main Objectives:**

- Help deaf and hard of hearing children to learn the basics at an early age.
- Enhance children's Sign language in a playful way, applying learning with fun strategies to raise their motivations.
- Help parents in supporting the learning of their deaf or hard of hearing children and follow their progress.
- Integrate the entertainment factor with education to improve the child's skills and ability to obtain more knowledge.

- Build a usable, user-friendly application that expanding children's perception, improving their language, enhancing their imagination.

## **4. Application Development**

This section shows how we developed the application, starting with information gathering strategies, design of the application, user interfaces, implementation and finally testing the application

### **4.1 Information Gathering**

To get a better understanding of our targeted audience, we conducted two interviews one with a special-needs education supervisor, Raed Algofily, and the other with a certified trainer in Arabic sign language Khaloofa Alshehri, who is also a deaf person. The goal was to understand deaf children's needs and utilize modern technology to satisfy these needs. Thus, improve the outcome of our project.

The interview revealed that often deaf children lack the prior knowledge about letters and numbers, if they were not enroll in kindergarten unless there are interest and initiative from their parents, and this is rare among deaf children. In addition, we wanted to know how technology can contribute to the education of deaf and hard of hearing children, and we got an interesting answer. Technology reduces burden and time due to children's need for casual learning, the technology makes it easier for parents who are not skilled in sign language to teach their children sign language as well as learning it themselves.

Besides the interviews, we have conducted a questionnaire using Google Forms, targeting the parents of deaf and hard-of-hearing children who speak Arabic in Saudi Arabia and 195 responded to our survey. The responds we received inspired us to be creative in designing Mushir to meet the children needs.

In particular, the survey results highlighted the importance of educational application in raising children cognitive level. It also indicated the parents' preference to have the educational materials presented in an entertaining way. The results also confirm the shortage of an interactive Arabic application targeting deaf children.

Finally, the questionnaire participants mentioned some features and suggestions for the application to be more attractive and motivational for the children. Some of these features are: the ease of use, interaction by adding voice feature to the application and providing the content in Arabic language. We considered those suggestions in our construction and development of the application.

### **4.2 System Design**

Mushir is designed as an educational and entertaining application that helps deaf and hard of hearing children aged

from four to seven years learning basics sign language. The application applies image-processing techniques to make the application more interactive and it is in Arabic language. As the application targets children, the design and the application interfaces are very important. The theme we have applied is “sky & clouds”, which will add flamboyance to the application and a bird character designed to guide the child throughout the application. The application consist of four categories the child can learn from which are: letters, numbers, shapes, and colors. Each of these categories has two sections, learn lesson and play game sections. Thus, the child learns and then tests what has been learned through an entertaining game. The child interacts with the game using image processing or by choosing the correct answer. In each of the four categories, there are stages to motivate the child to overpass these stages and complete the game. In addition, the application allows the parent to add their emails to receive a periodical feedback about their child progress.

Mushir is an application based on real-time image processing technology, so the proposed architecture is client and server architecture. In three-tier client-server architectures, there are three main layers located on three different machines: user interface, application server, and database server. Each of these layers has specific roles and responsibilities. The first layer is the user interface, which is the layer where the users would have direct interaction with the application. The second layer is the application server which is the processing level acting as a bridge to connect the application logic with the database servers' data. The third layer is the database server the data level, has the primary responsibility of storing all the data in a database server. Since the layers separate the logical elements from the physical servers, it would be much easier to be maintained. Mushir application is based on client and server architecture to deal with storage. It requires information from an external source that works as a server, which is the image recognition API, which helps obtain sufficient information for the functionality that the application performs.

### 4.3 User Interfaces

This part presents a sample of screen shots in Mushir application to illustrate the user interface design (Fig. 1 to 10).



Fig.3. Home Page, a Nice Home Page that Contains the Category.

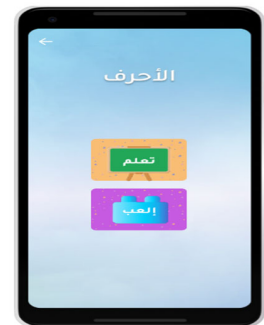


Fig.4. Select section Page, Appears after the user Choose Category.



Fig.5. Learn lesson Page, A List according to the selected category Appears for the user to Choose from.

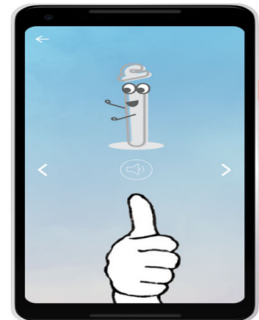


Fig.6. Lesson Page, Where the Child Learns and Understand the Necessary Skills.



Fig.7. Stages Page, a Bunch of Different Stages in the Play Game Section.

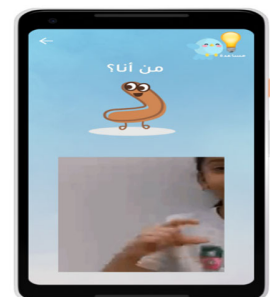


Fig.8. Play Game with "Image Processing".



Fig.9. Play Game by Choosing the Answer.



Fig.10. Child progress, Shows the Child's progress.

#### 4.4 System implementation

Implementation of Mushir developed in an Android Studio environment with Java programming language. Java was chosen since the team was familiar with the language and because it includes multiple resources to help in implementing functions. The application interfaces implemented using Figma, which is a cloud-based UI and UX design application that can be used to create websites and apps.

To run the application and ensure the functions work properly, Mushir team used an Android virtual device provided by Android Studio and Samsung mobile. Moreover, Mushir is connected to a real-time Firebase database that store users' information and category content. The Firebase Realtime Database is a cloud-hosted NoSQL database that lets you store and sync between users in real-time. Therefore, the exchange of data to and from the database is easy and fast.

In the beginning, the application starts to run the login page, so the user can log in or register if he/she does not have an account. Then the user will reach the home page, which contains four categories, and they are divided into (letters - numbers - shapes - colors), through which the child can choose. The child can choose the play section or the learning section. The child can learn from the content of the category he/she has chosen. In addition, the child can play in two different ways the question can be answered by either opening the camera then indicating the pose of his/her hand in sign language using real-time image processing technology, or through the multiple-choice answers.

#### 4.5 Image processing implementation

The implementation of Mushir application began by building an Arabic sign language detector using Python libraries and TensorFlow object detection API that is a foundation library that can be used to create Deep Learning models [16]. First, we start by cloning a real-time object detection repository from GitHub to leverage transfer learning and the training code inside of the repository. Then, we collect images using OpenCV (Open-Source Computer Vision Library) which is an open-source computer vision and machine learning software library [17]. Editing Python code was by using Jupyter Notebook, which allows us to create and share documents that contain live code [18].

Then we label the images by using the LabelImg package, which is a free open-source tool for graphically labeling images written in Python to draw detection boxes against the different sign language poses. After labeling the images, we split them into training and testing partitions using the Holdout method, which is randomly partitioning the data into two independent sets for training, and testing [19].

Then we generate two TensorFlow records for training and testing, then we train the deep learning model in command prompt. After the model trained, we test the trained model with the webcam called Jupyter Notebook. After the model worked properly, we change the file format from TensorFlow to TensorFlow lite which is a set of tools to help developers run TensorFlow models on mobile to allow us to link the model into Android studio and integrate it with the rest of the code [20].

#### 4.6 System evaluation and testing

We perform system testing to uncover the errors in our system and ensure that our application performs accordingly to our specification. First, we begin with the unit testing where each component in the system is tested individually. After that, we conduct the user acceptance testing in the real-world scenarios with our targeted users.

User Acceptance Testing is a phase of testing where the system is being tested by targeted end-users to determine whether the software can be accepted or not. We conducted our test on 4 Arabic deaf and hard of hearing preschool children and one parent for a child, their age ranges from 4 to 7 years old. The table below shows the User Acceptance Testing results and the given feedback.

Table 1: User Acceptance Testing

<i>Aljwharah bint Abdullaziz</i>				
<i>Task</i>	<i>Number of Errors</i>	<i>Time needed</i>	<i>User feedback</i>	<i>Completion status</i>
Signup	0	00:58:90		Pass
Login	0	00:24:13	-	Pass
Reset password	0	00:19:44	-	Pass
View account	0	00:14:58	-	Pass
Edit account	0	00:25:54	-	Pass
Select category	0	00:13:08	-	Pass
Learn lesson	0	00:55:19	-	Pass
Play simulation game	0	00:20:03	-	Pass
Open camera	0	00:09:08	-	Pass
Process gesture	0	00:23:37	-	Pass
Play match game	0	00:24:48	-	Pass
Choose answer	0	00:12:44	"الله صح علي!" "wow it is correct"	Pass
Play voice	0	00:09:05	-	Pass

View hint	0	00:01:50	"حطو الصوت والضح "nice and the voice is clear"	Pass
View progress	0	00:22:58	-	Pass
Share progress by email	0	00:40:03	"أوه شكلي فنانة بهذي اللعبة!" "Oh it seems that I am a genius of this game"	Pass
Logout	0	00:02:04	-	Pass

The test results indicates that the application functions worked as expected. The users found Mushir application very educative, enjoyable, and useful. Also, they liked play simulation game the most.

## 5. Conclusion

In this paper, we proposed Mushir an Arabic application that targets deaf and hard of hearing children from the age of four to seven years old. The application consists of four categories that enables the child to learn from: letters, numbers, shapes, and colors. Each of these categories has two sections, learn lesson and play game sections. Thus, the child learns and then tests what has been learned through an entertaining game. The child interacts with the game using image processing or by choosing the correct answer. In each of the four categories, there are stages to motivate the child to overpass these stages and complete the game. In addition, the application allows the parent to add their emails to receive periodical feedback about their child progress. We seek to be the best choice for all parents of the deaf and hard of hearing children, and that we enrich the Arabic content for pre-school applications for deaf and hard of hearing children.

## 6. Future Work

One of the challenges Mushir faced was finding people to make interview with due to COVID-19 restrictions. So it took time to find the right people. Mushir application have only four categories to learn and play games and support only a single game player. Also, its currently available only to Android users, and due to these limitations, Mushir team looking forward expanding the application to cover more categories like family, food, nature, animals etc. Also, the application will support two or more game players and will be compatible with the iOS environment.

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