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Social Network Framework for Deaf and Blind People based on Cloud Computing

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Abstract—**Most of the governments and civil society organizations work hardly to promote the disabled people especially blind and deaf persons to join the normal community and practice the regular daily life activities. Indeed, Information Technology with its modern methodologies such as mobile and Cloud computing has an impressive role in enhancing the intercommunication among the people with different disabilities and normal pupils from one side and among the disabled people themselves who have the same or different impairments. However, a few numbers of suggested systems are quite limited for the Arabic Region. Additionally, according to our knowledge, there is no proposed system for connecting the blind and deaf people within direct Arabic language-based conversations. In this paper, we propose a comprehensive framework constructed upon three main modern technologies: mobile devices, Cloud resources and social networks to provide a seamless communication between the blind and deaf people especially for those living in the Arabic countries. Moreover, it is designed to facilitate the communication with normal people through various directions by using recent methodologies such as time-of-flight camera and social networks. The main modules and components of the suggested framework and its possible scenarios are fully analyzed and described.**

Keywords—**Cloud, Mobile Devices, Social Networks and Blind/Dead people**

I. Introduction

LACK of awareness of the blind/deaf needs could lead to discrimination in a single community. It could also leave many talented blind/deaf people out of productive members of society. In addition, it could have a substantial effect on the educational performance of children. Furthermore, children with hearing loss and deafness, specifically in developing countries, hardly receive any education. Moreover, adults with hearing loss suffer from a much higher unemployment rate [1].

As recently reported by the World Health Organization, 285 million people around the world are visually impaired (39 million are blind and 246 have low vision) [2]. About 80% of all visual impairment around the world could be cured or avoided [2]. However, this is unachievable due to fact that 90% of the 285 million visually impaired people live in developing countries. It is also reported that, 360 million of the worldwide population have disabling hearing loss [1]. In addition, "current production of hearing aids meets less than 10% of global need" [1].

In Egypt, as an example of the developing countries, about 6% of the total Egyptian population is visually impaired [3] and nearly three million people in Egypt suffer from hearing impairment. Nonetheless, there is no a national project on how the government helps those people to be active members in the community. For example, according to the report in [4], the Egyptian government has provided sign language services for News Programs on Television (10 minutes to 7 hours a week). However, there are no current programs or plans to provide subtitles or captions. In addition, the government does not provide any access for Deaf people to get governmental documents in their sign language [4]. Indeed, the blind/deaf communities are still out of the government interests and future plans.

As a matter of fact, social interaction is a life-process and a crucial part of our success in life. It supports independent living, community experiences and relationships. However, social skills are learned by repeated visual observations (e.g. facial expressions, body language) that are translated to cues that help us to develop and understand concepts of social behavior. In other words, vision plays an important role in establishing and maintaining social interactions that is a great challenge for individuals who are visually impaired or blind.

To enrich the social interaction process, recent technologies such as social networking websites and mobile devices have been introduced and used in a wide scale as new means for social communication between people. These services are widely popular in Egypt – a February 2013 survey found that around 13 million out of 32.5 million online Egyptians use Facebook [5]. In addition, in January 2013, MCIT of Egypt [5] reported that the mobile subscribers are 96.11 million and 10.08 million of these subscribers are accessing the Internet through their mobile phones. Meanwhile, there are no real interests or efforts for helping disabled people to get benefit of these technologies to develop their social skills. The main goal of our work in this paper is to introduce a new framework that may help to shorten the distance between the blind/deaf people and the normal life. In other words, the proposed solution should support a seamless communication between blind, deaf and normal people from one side, and facilitate the interconnection between the blind/deaf and daily-based activities from the other side.

In this research paper, we propose an integrated framework to provide a Mobile-Cloud system to help blind and deaf people to gain better social skills for a more successful life. The main goals of the system are:

- Seamless communication between blind and deaf people. This includes ways to (a) detect the face to tell the blind about the identity of the conversation partner, (b) detect emotion to tell the blind about his feelings, and (c) detect sign language and convert it to Arabic speech if it exists.

- Social network that can help blind and normal people to communicate with each other. Such network could help blind people to (a) detect certain objects or identify Arabic text, (b) use a social website to communicate with their friends while protecting their privacy, and (c) find and contact the nearest friend in case of critical situations.

The rest of this paper is organized as follows. The related work is discussed in Section 2. Section 3 presents the proposed framework and its involved modules. Section 4 describes the seamless communication between blind and deaf persons. Section 5 demonstrates the roles of social networks for connecting a disabled person to reality. Section 6 shows the possible challenges that may encounter the framework implementation. Finally, Section 6 concludes the presented solution and highlights the future work.

II. Related work

In this section, we will introduce all related research according to three main bases or technologies that may assist the blinds to have a normal life with regular activities which are: social network, mobile device and Cloud infrastructure. The social network is proposed as an electronic hand that would guide them to the right position or decision. The mobile device is the portable eye that might describe and recognize the objects or people who are naturally invisible for them. Finally, the Cloud infrastructure is the co-brain for processing the captured photos and associated data.

There are several innovative trials to build a particular social network for disabled people in general and for the blind community in particular such as [www.disabilinet.com, www.disabledcommunity.net, audioboo.fm/about/social_blind, and theblinduniverse.com] in which some special features have been added to facilitate the interaction and communication among the involved subscribers including the audio and media contents. These networks may give the disabled and blind people what they wish to connect them with their peers or friends; However, they may lead to (1) isolating the blind people from the normal world, (2) increasing the feeling by their hindrance, consequently fallen in more sociological and depression problems. On the other side, to the best of our knowledge, the popular social networks such as Facebook and Twitter do not provide any particular features for the blind/deaf people for attracting them to their community or helping them to easily participate in regular life with its different activities (e.g. searching jobs) as well as bringing them in a direct relationship with several parties including near friends and families members.

Some previous solutions have been accomplished for helping blinds to recognize the surroundings and figure out the objects they interact with such as the VizWiz [6] and VizWiz Social systems [7]. The VizWiz backbone is mainly based on two important concepts: crowdsourcing [8] and Mobile-Q&A [9] [10]. In the VizWiz system, the blind recruit a number of employees (i.e. crowdsourcing) to answer the audio questions related to a photo taken by their mobiles (i.e. Mobile Q&A). The suggested VizWiz system gives them the full confidence that they are basically depending on their selves rather than asking for help from friends or family members through the traditional social networks (i.e. friendsourcing) [8]. However, it is not a free service and does not support any automated process for recognizing the captured photos that clarity degree basically depends on the mobile model that the blind regularly use. At the same time, it is difficult for blinds to correctly target their mobiles' camera in order to capture clear and easily recognizable pictures.

The VizWiz Social is a free application installed on iPhone and has three separated distinguished features: (1) accessing the original VizWiz with no cost, (2) automated object or photo recognition, and (3) social-based application. The study run over this application in [7] demonstrated that most of the involved blinds, who have involved in a survey sample, preferred to access the original paid VizWiz instead of the new two features added to VizWiz social. This is due to the some technical challenges in the automated object recognition such as the picture obscurity and the inaccurate results received. Regarding the social-based feature, there is a delay (approaches to an average of a full day) in the answers the blind users obtain due to the unavailability of the trusted friends or family members. Additionally, the blinds have anxious feeling about their privacy and independence when sharing their data and photos online.

The work in [11] [12] presented a hybrid system of special camera glasses connected to a mobile device through Bluetooth technology in order to transfer the captured images to a Cloud platform to speed up the matching and recognition processing time and obtaining accurate results in which the blind society can depend. Also, the work in [13] introduced the possibility of combining social networks with Cloud environment through analyzing the taken photos from blinds phones by either Clouds, or friends subscribed in social networks who are sharing the same geographical locations in order to obtain quick and accurate answers.

Neither of the previous work is considered as a complete solution for the blind community. VizWiz [6] [7] does not support full automated answers and imposes a charge of the Q&A service. The VizWiz Social [7] [14] fails to address the accuracy and the users' privacy while the remaining stated work [11] [12] [13] are only focused on the navigation problem. Moreover, neither of the described work discusses how the taken photos and sent data are proceed and stored. Furthermore, none of the explained work in this section is suitable for the Arabian region as English is the main language within all those applications/solutions. Additionally, the blinds are the main focus of the study of the listed work and nothing is there about deaf people and their own needs and language. Last but not the least, the interactions emotions and feelings of both the blinds and their peers (e.g. friends) have been neglected and should be studied properly due its gorgeous impact in improving the interconnectivity among them. By including these two features, the blinds would be able to feel like normal ones.

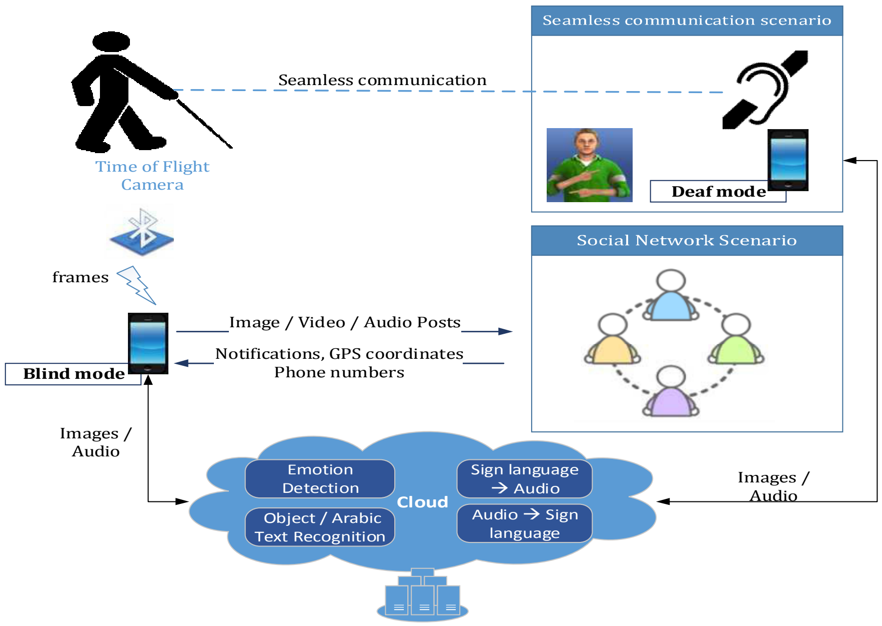

Figure 1. SoNetDBlue General Framework

III. THE PROPOSED FRAMEWORKE

The blind and visually impaired people, especially in Arabic countries, have limited opportunities for social interaction compared to those without visual impairments. At the same time, there is no much attention by assistive technology researchers for this topic. In this paper, we present SoNetDBlue (**So**cial **Net**work for **D**eaf and **Bl**ind **u**s**e**rs) framework that tries to help those people to improve their social life.

SoNetDBlue proposes a mobile-Cloud framework shown in Figure 1. In which a speech interface on the mobile is used to take commands in Arabic language from the user while visual data is captured by camera modules integrated into sunglasses and fed to the mobile device through the Bluetooth technology. Bluetooth has been chosen here due to its proven effectiveness and popularity. Machine instances in the Cloud are utilized for running complex and time-consuming tasks that cannot be achieved on the mobile device with its limited CPU power and memory capacity.

The proposed framework is based on a collaboration model between everyday mobile devices, and the computational power provided by the Cloud infrastructure. All required complex algorithms will run in the Cloud while the thin client on the mobile device is used to capture images or audio signals and send them to the Cloud for further processing. The proposed framework is based on three major subsystems:

- ***Integrated Camera***: We consider here the time-of-flight camera, a new technology used in real-time three-dimensional imaging. This technology has produced promising results in many fields including face recognition [15], gesture recognition [16], and real time motion capture [17]. These cameras provide real-time depth information about pixels of a captured image and the camera modules are made available by manufacturers at decreasing prices with the advances in the underlying technology. Currently available time-of-flight cameras provide ranges of about 10 meters and high frame rates of about 100 frames/second making them even more attractive for dealing with dynamic environments with fast moving objects.

  As opposed to using the camera of the mobile device, the time-of-flight camera module will be integrated into glasses to be worn by blind users (an eye-level placement) that will help them to easily capture context-relevant pictures

- ***Mobile Application***: We are planning to support iOS and Android mobile platforms due to their great popularity, support for multi-tasking and accessibility features. Android and iOS based devices come with integrated speech recognition and text-to-speech engines that will facilitate the design of an easy-to-use interface for disabled people. The application supports two basic functionality modes: blind and deaf. More details about these modes will be provided in the following sections.

- ***Cloud Infrastructure***: The suggested framework is built upon the computational power of Cloud to overcome the shortage of available resources on mobile devices. The Cloud is settled to accomplish computationally-intensive algorithms including emotion detection, object and Arabic text recognition, and the conversion from Arabic language to sign language and vice versa.

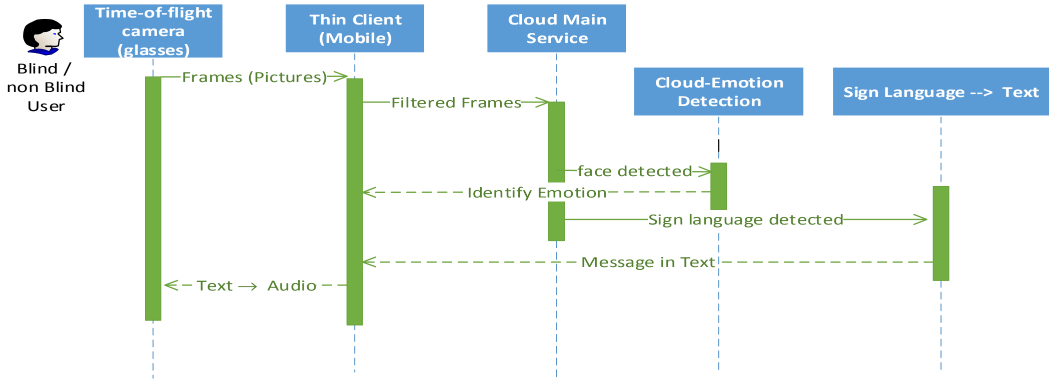

Figure 2. Sequence Diagram of Blind Mode – Seamless Communication Scenario

Our initial prototype is deployed on a private Cloud built using the OpenStack [1] Cloud operating system upon the infrastructure of the Suez Canal University, Egypt. OpenStack is open source software designed to provision and manage large networks of virtual machines, creating a redundant and scalable Cloud computing platform. It gives you the software, control panels, and APIs required orchestrating a Cloud, including running instances, managing networks, and controlling access through users and projects. OpenStack APIs are compatible with Amazon EC2 and Amazon S3 [2] and thus client applications written for OpenStack can be used with Amazon Web Services with minimal porting effort. [12]

This degree of compatibility will help us to port our final work to a commercial Cloud (e.g. Amazon EC2) to determine the overall cost expected by our system and to compare the system efficiency and reliability over different Cloud platforms.

SoNetDBlue focuses mainly on two basic scenarios: seamless communication with deaf people and social network for blind users. In the following sections, we are going to deliberate the two scenarios in detail and discuss the major challenges expected during the implementation of the system.

IV. SEAMLESS COMMUNICATION

In this section, we will concentrate on the first objective of the SoNetDBlue framework that is to provide an independent communication between blind and deaf people as depicted in the top portion of Figure 1. To achieve this objective, the thin client on the mobile phone should be configured to one of two available modes: blind and deaf modes. The thin client behavior is automatically adapted according to the selected mode. In the rest of this section, the functionalities of each mode are explained in more details.

The sequence diagram shown in Figure 2 concludes the flow of actions in case of the blind mode:

1) The time-of-flight camera integrated in the sunglass records a video for the conversation's partner (deaf user) and sends it to the thin client resident on the mobile device through a Bluetooth connection.
2) Depending on the CPU power of the mobile device, the thin client may decide to apply a preprocessing stage to filter the captured frames and to extract the key ones while the other frames will be regenerated on the Cloud. This step will reduce the amount of data transferred on the network and thus reduce the overall cost of the service.
3) The thin client submits the filtered frames to a machine instance on the Cloud responsible for running, controlling and synchronizing the required processing.
4) On the Cloud, a scientific workflow management system (e.g. SWIMS [18]) is used to process received frames in parallel over available computational nodes. Various algorithms, explained below, are applied to notify the blind user about the current feelings of the conversation's partner and a translation of his sign language into Arabic text that is sent back to the thin client.
5) The received text is converted into speech using the text-to-speech engine assimilated in the mobile device.

In our work, we focus on facial expression recognition as a key index of human emotion based on the six basic emotion-specified facial expression (i.e. happiness, sadness, fear, disgust, surprise and anger) defined by Ekman [19]. Based on our architecture requirements (i.e. accuracy and response time), we will consider and evaluate the work by Mase and Pentland on advanced face detection and recognition using relatively low computational power [20] and the algorithm that classifies face emotions through eye and lip features using particle swarm optimization [21].

[1] http://www.openstack.org/
[2] http://aws.amazon.com/ec2

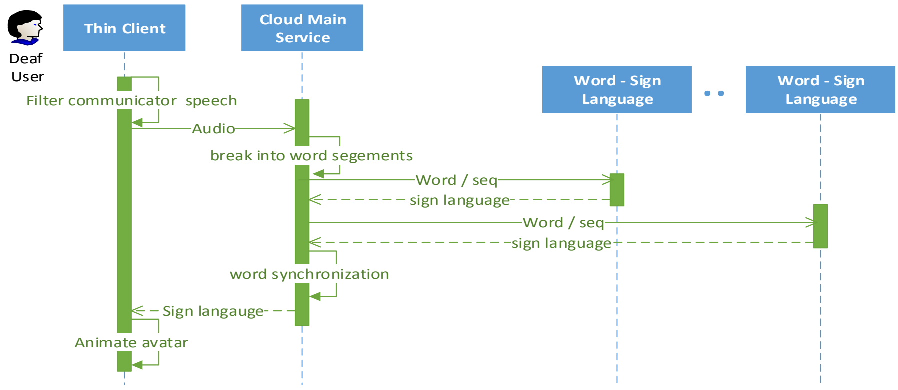

Figure 3. Sequence Diagram of Deaf Mode – Seamless Communication Scenario.

For the Arabic Sign Language (ArSL) recognition, we concentrate on testing two algorithms that achieve real time translation of dynamic gestures. The first algorithm involves two stages for automatic translation of dynamic gestures into the ArSL; in the first stage, it recognizes the group of the gesturer and the second stage interprets the gestures within the groups based on spatial domain analysis and hidden markov model [22]. The second interesting algorithm is a vision-based automatic sign language recognition system for Arabic letters with no need for any additional hardware such as gloves or sensors. The algorithm uses predefined Haar classifiers to track and detect the hand's position, then it detects the skin color, transforms the images into frequency domain, and finally uses a simple classification technique (K nearest neighbor); this algorithm achieved up to 90.55 % recognition accuracy at real time [23].

The deaf users should configure their mobile devices to the deaf mode in which the thin client records the Arabic speech and filters it to extract the signal of the conversation's partner (blind), and submits it to the Cloud for processing as illustrated in Figure 3:

1) The speech is translated into Arabic text and segmented into separated words.
2) Each word is translated into its equivalent sign language in parallel on different available computational nodes to speed up the total response time. The outcome of this step is an animation sequence that represents the sign language of the word under processing.
3) Accumulated results of step 2 are synchronized and sent back to be displayed on the thin client through a digital avatar as shown in Figure 1.

Several research projects have made efforts in translating English text into sign language [24]. However, research work focusing on Arabic language is quite limited. An early work in the field of ArSL translation shows a poor consideration of the deaf community in the Arabic world, for example, the system build by Mohandes wrongly assumes that ArSL depends on the Arabic language and shares the same structure and grammar [25]. A more powerful work has been presented in [26]; in this work the authors considered the ArSL's unique linguistic characteristics (e.g. its own grammar, structure, and idioms) and provided a full working prototype, ArSL translation system, for helping Arabic deaf community to access published Arabic text. Another interesting work that we have to consider is the translation tool introduced in [27] as a part of a full chat system for deaf people; it provides two different modes for translating from ArSL to Arabic language and vice versa; it is based on a word to word translation, and if a word does not exist in the system's database, a letter by letter translation is encountered.

An important question that may jump to the mind is how can blind and deaf people initiate communication while the blind cannot see the deaf and the latter cannot hear the blind one? For sure the one with vision capability (the deaf) should start his program that broadcasts an audio message. This message will notify the blind to initialize his application and to target his eyes to the deaf person to be able to capture his signs.

V. SOCIAL NETWORK

The second major objective of the SoNetDBlue architecture is to connect deaf and blind people with their cycle of friends (with or without disabilities) anywhere and at any time. This will help them to integrate in the community and to gain better social skills for a more successful life. To hit this goal, SoNetDBlue framework embraces a social site connecting blind and deaf users with their cycle of friends including people with or without disabilities. Figure 4 presents a use case to show the various activities that can be accomplished in this scenario:

- **Post text / audio messages:** users can post messages either in text or audio. Text messages can be entered in ArSL using a special keyboard as the one designed for the chat system presented in [27]. The received message can be also translated into one of the available format (i.e. audio, text or sign language). The camera module integrated in the blind users' sun glasses or the mobile's camera can be exploited to capture an image or a video to be attached with the posted message.

- **Find/call nearest friends:** SoNetDBlue users can utilize the thin client installed on their mobile devices to locate their nearest friends, using the GPS module installed on the mobile device, and to contact them either through calls or SMS messages. This can be very helpful for disabled people, especially in case of emergency situations.
- **Identify objects / Arabic text:** The goal here is to help blind users to identify the class of objects (e.g. car, building) in front of them. In addition, the algorithm should search for a textual note in the image to give a more descriptive explanation about the detected object (e.g. a building of Suez Canal University). According to the evaluation in [28], the Lehigh Omnidirectional Tracking System [29] is one of the best algorithms for object detection in video streams. For detecting textual notes, we have to evaluate existing Arabic optical character recognition and natural language processing algorithms to select the best of them while considering that the textual notes may contain bilingual sentences (e.g. Arabic / English) and different number system (i.e. Arabic and Indian numbers).

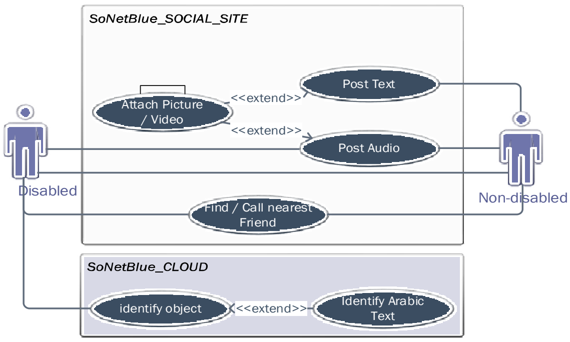

Figure 4. Use Case of the Social Network Scenario

VI. ARCHITECTURE CHALLENGES

The major challenges of the SoNetDBlue framework are fourfold: data stored on the Cloud, user's security (privacy and authentication) , Arabic language recognition, and evaluation of the proposed solution. Data stored on SoNetDBlue Cloud infrastructure is enriched with semantic annotations to determine (a) the owner of the data (user) and (b) the context in which the data has been collected [30]. This may lead to data duplications to some extent, but it will have a great impact on the response time of available Cloud services as the search scope will be limited to a certain user at a certain context. At the same time, the Cloud infrastructure will utilize advanced frameworks to manage the replication of its services [31] and expected privacy issues [32]. SoNetDBlue could be used to help a blind user to get a specific location using Global Positioning System. However, this could put the user in risk while submitting his location information to the Cloud. This information could be used by a malicious party to locate the blind user and then exploit this user for his/her own benefit. Thus, unlink-ability techniques of the user identity should be used to overcome this problem. Another aspect of privacy concern is as follows. SoNetDBlue, using Time-of-Flight camera in the blind mode, requires continuous capturing of the surroundings around the user to be sent to a dedicated website. It is crucial that the user anonymity is preserved, i.e. providing unlink-ability to the recordings. This is because these videos would disclose lots of information about the places visited by the blind user.

Another security issue is the mobile authentication. A survey in [33] reported that7jhli 40% of mobile users used to enter a password on a daily basis. In addition, 56% of these users mistype a password at least once out of ten. Users find that entering password on Mobile Internet Devices (MIDs) is more frustrating than lack of coverage, small screen size, or poor voice quality. Surely, for blind users, these limitations of using traditional password as authentication method are more frustrating. Therefore, especially for blind users, MIDs require another way for authentication such that the users' involvements are very limited or without any involvement. Furthermore, as reported in [34] after interviewing 13 blind users of smartphones, it has found that most them were not familiar with potential security threats of not using authentication methods such as a password-protected screen lock. Implicit authentication [33] [35] could be used to address these limitations. It could be used as a secondary factor for authentication to augment passwords, thus achieving a higher-assurance authentication. For blind users, this implicit authentication is very promising as they are not required to memorize how to enter a password.

The challenging bit of the ArSL is mainly concerning the accuracy of the obtained results. Comparing to the American Sign Language, the ArSL still requires more work to reach the same level of accuracy. As reported in [36], American Sign Language has achieved a word accuracy of 99.2% (users have to wear a special glove) whereas in [37] American Sign Language has accomplished an accuracy of 98%. On the other hand, the best result of the ArSL is 90.55 %, as reported in [9]. The reasons of this problem are summarized as follows [12]. ArSL, like other natural language, is an independent language which has its own structure, grammar, and idioms. In addition, it is not hand/finger spelling of the Arabic alphabet. The finger spelling is only used for places or names which that do not exist in ArSL. Furthermore, ArSL does not have a documentation system which could be utilized while building a translation corpus. Therefore, deep research should be done to address this difficulties and to fill the gap of the accuracy between the ArSL and American Sign Language. It is believed that the high accuracy of ArSL, the high adoption of the proposed SoNetDBlue solution.

VII. CONCLUSION AND FUTURE WORK

In this work, a Mobile-Cloud framework is presented to help blind and people with visual impairments to gain better social skills that are important for healthy and successful life. Moreover, the introduced framework is structured to bridge the communication gap between the blind and deaf persons, particularly in the Arabic section. Finally, we showed how several technologies and methodologies including social networks can be integrated to recognize all possible obstacles and persons to assist the blind people to feeling and visualizing the surroundings.

Our future work involves two main steps: the first one, as mentioned above, we have started to implement the suggested architecture in an OpenStack Cloud environment, we aim to complete the entire architecture implementation and its interrelated components and testing its behavior in order to meet the analyzed requirements and estimated objectives. The second step includes moving the implemented system to a commercial Cloud and practicing the expected behavior with real pupils. Also, this stage will be concluded by a real-time survey to measure the blind/deaf people satisfaction about the produced system including the performance and accuracy.

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