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Empowering Communications Challenged users using Development Kits

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***Abstract*—**The rapid pace of technological advancement and its consequential widening digital divide has resulted in the marginalization of the disabled especially the communication challenged. The dearth of suitable technologies for the development of assistive technologies has served to further marginalize the communications challenged user population and widen this chasm even further. Given the varying levels of disability there and its associated requirement for customized solution based. This paper explains the use of a Software Development Kits (SDK) for the bridging of this communications divide through the use of industry poplar communications SDKs towards identification of requirements for communications challenged users as well as identification of appropriate frameworks for future development initiatives.

***Keywords*—**Assistive Technology, Communication, Disability, Marginalization, Software Development Kit, Waveform and Wideband

I. Introduction

THE recent technological advances have transpired into faster data transfer, larger data volumes and cheaper data transfer capabilities [1]. This in turn is spurning the rapid deployment of digital technologies especially in the field of communications.

Despite these advances in the digital arena a majority of these advances have not trickled down to disabled persons, in particular developments in telecommunications have failed to include the disabled [2], leading to a further widening of the digital divide from the perspective of the disabled and even more so from those that face communication challenges.

Despite the availability of numerous studies into the prevalence, causes, and effects of physical, mental, learning and communication disabilities (e.g.: the Sri Lankan Ministry of Social Welfare 2003 census into disabilities and the Christopher and Dana Reeve Paralysis Foundation 2009 census into spinal cord injuries) there are insufficient studies conducted with regard to the provision and success of ICT solutions aimed at social inclusion for the disabled, especially via communications.This paper attempts to address shortcomings associated with the provision of accessible communication technologies for the disabled by firstly extrapolating from vertically targeted studies and censuses in a holistic manner. Firstly this paper intends to chart the use of emerging technologies that could be adapted for provision of communication assistive technologies for the disabled.

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Next this paper will ascertain the demographics of those affected by disabilities based previous census. This is followed by a discussion of the applicable assistive technologies. Section three discusses justifications for the purposed approach. The manner of the execution of the research, case studies and its results will be detailed in sections four and five respectively.

II. Target User Base

Numerous studies (British Department of Health (2001), Weerasinghe et al, (2007) and the Dana Reeve Paralysis Foundation (2009)) have revealed that there is a high prevalence of disabilities in our population. People with disabilities find inclusion into society difficult especially owing to their communication disabilities [3].

It has been proven that the use of computers and the Internet can not only enrich the lives of people with disabilities but can also enhance independence and facilitate a new channel of communication through which users could gain access to information, social interaction, cultural activities, employment opportunities, and even access to consumer goods [3], [4]. However, regrettably only 23.9% of the persons suffering from disabilities even in the United States are likely to have access to computers when compared to non-disabled persons [4]. This divide widens to further for internet accessibility which is only reported as 9.9%. Add to this the rapid pace of technological advancement has reduced accessibility to telecommunications for disabled people, thus depriving them of their basic right for communication [5].

A. Use of Assistive Technologies

The varying nature of disabilities requires customized solutions [6]. Some who suffer from communications disabilities excel at expressing their views via keyboard whilst some benefit from the use of visual symbols and related commercial software such as Makaton or Widgit's Rebus which translates text to symbols and vice versa [3]. The use of symbols in the facilitation of communication in present societal context are readily apparent [7]. Samples of such symbols are given Figure 1 below:

Fig. 1 Common symbols used for communication in present society

Symbols as given above could be used as an alternative and augmentative communication system as well as for enabling access to information, promoting of reading and writing and therein enhancing independence and self advocacy [7].

Speech recognition and synthesis too has documented benefits in certain contexts especially in its use with the disabled [8]. The particular format of speech recognition used is critical when used in the context as an assistive communication tool for disabled. The use of single words, short phrases or sounds for speech recognition by users who have difficulties producing intelligent speech had enabled speech recognition to be used as an effective assistive tool in contrast to the use of speech recognition when used with continuous speech [9].

The culmination of the above evidence dictates in the development of assistive communication technologies for the disabled and learning and speech challenged users should include speech recognition, speech synthesis and symbolic communication at the very least. Each with a limited function and vocabulary set and customized as per each disabled users situation and requirements may warrant.

However, whilst there is an abundance of empirical research on the benefits in the use of symbols for communication (e.g.: studies conducted by Widget 2000 and 2004) there is a serious dearth of such research in the sphere of speech recognition and speech synthesis. This paper focuses on the use of symbol, speech recognition and speech synthesis for the development of assistive technologies.

III. Proposed Method

The research herein aims to ascertain the suitability of a comprehensively structured, modular, layered and reusable Assistive Technologies Development Framework based approach towards the provision of above assistive technologies.

The use of a Software Development Kit (SDK) development model provisions better development process, simplification, cost reduction and better re-use of process, platforms and data whilst the widespread use of SDKs by solution developing communities enables in the creation of a defacto standard and thereby wider usage [10]. Test teams using the SDK approach to development have achieved exponential performance when compared to other development methodologies [10].

Given the above it is clear that the SDK model provision greater reusability, flexibility and adaptability. This is of paramount importance in situations such as in providing customized development for the disabled wherein each disabled user is provided customised and specific application to suit his/her needs. Therefore, this paper will explore the benefits of using SDK based development model for the development of assistive technologies.

IV. Methodology

The study conducted initially with the participation of 22 volunteers who are staff members of Commonwealth Rehabilitation Services Australia. These volunteers were augmented with 110 other disabled volunteer from Paraquad as well as those who subscribed via the internet.

The foundations for the research methodology were based on the benefits of participatory research methods demonstrated by the Disabled learners' experiences of e-learning (LExDis) study by the University of Southampton [11]. LExDis was conducted in order to increase the understanding of issues and interactions by disabled students for accessible e-learning, assistive technologies and learning support and emphasizes on the use of "participatory" research, which focuses on the voice of the disabled students as both consultants and partners and not just as research subjects.

Whilst LExDis is considered as providing robust guidelines on effective research methodologies for disabled and communications challenged this method required the active participation of the end users in specifying what their requirements .

A. Sample Population Based Research

Here a smaller sample from the above population was selected and research parameters were obtained through a survey conducted amongst the sample population as well as direct personal interviews with each participant.

Based on the key functionality required all popular SKDs were evaluated for their capabilities towards matching these requirements and three were selected. Each selected SDK resulted in the development of an Assistive Application containing components of that SDK and features the capturing of the original entered text/captured voice and synthesized voice/translated text as raw WAV or text files, in separate files named in a numerically and chronologically ordered manner for subsequent analysis.

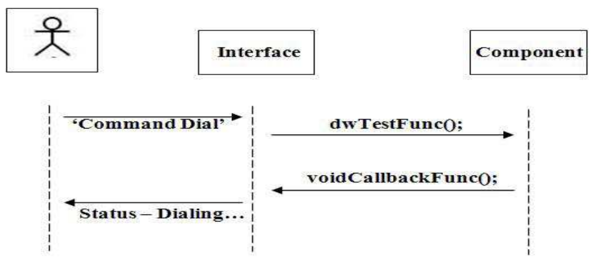

Fig. 2 Test sequence diagram

The above sample population was randomly divided into three groups and each member of the sample population received a binary file that comprised of these three executables and were encouraged to utilize each Assistive Application for a minimum of thirty (30) minutes a day for One Hundred and Eighty (180) days. User enrollment based optimization was not incorporated in order to ascertain user independent performance.

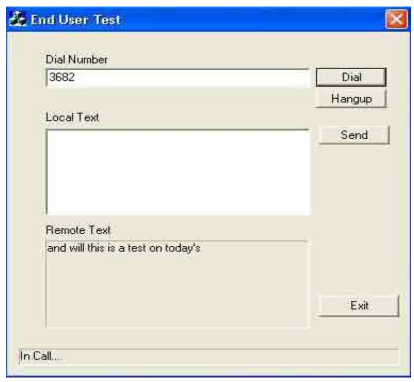

Fig. 3 End user assistive application

Each member of the sampled population was required to provide their feedback which was logged at three levels. Pre-use feedback was collected using an application based startup form that logged the user parameters, duration and purpose expected for that session. This was followed with a post use application based form that focused on the collection of the perceived satisfaction level, accuracy, error detection, difficulties and fulfilling of user parameters and objectives specified at the initiation of the session as well as meeting the criteria specified during the requirement gathering phase in the development of the assistive application. The above was further augmented through the incorporation of a local stored database comprising of mirrored raw input and output data. Feedback was also collected through the use of both end user and developer blogs.

B. Laboratory Research

Separately laboratory testing of the shortlisted SDKs was performed using a test bench approach were each SDK's core and peripheral functions were evaluated with particular attention to functionality identified as key success criteria by the above sample population and end users.

Fig. 4 Laboratory test bench application

Laboratory testing using the test bench was performed in three (03) phases. In order to test the functions two identical copies of the test bench Named Test bench A and Test bench B were executed on the same host machine as peers, with the IP addresses set to internal localhost (127.0.0.1). Here the same telephony component was featured on both peers.

During phase one (01), the test bench was utilized to perform testing on Dialing out, Displaying of Incoming Calls, Answer Capability, Dual Tone Multi Frequency Detection and Generation. Here the text '***Hello, this is a test, how are you today***' as well as a wave file that contained a clear vocal recording of this text by a Native English male speaker was transmitted by Peer A to the Peer B which displayed its output in the Edit Box titled Remote Text.

In Phase Two (02), Voice Synthesis and Recognition, was tested. In phase two the functions of the telephony component that were tested in phase one were retested. In Peer A the input into the test bench was conducted using speech recognition only whilst in Peer B the output capturing was performed by both speech recognition and speech synthesis.

Here the components that incorporated speech recognition capabilities were tested directly whilst components that lacked such facilities were augmented using the Microsoft Speech API version 5.1. All assistive applications were tested without the creation of specific user profiles. And native speech recognition capabilities were tested.

Phase Three (03) expands on the tests conducted during Phase Two (02) by testing the similar functions as well as Speech Recognition and Synthesis capabilities but induces adverse network conditions in order to ascertain the quality of jitter correction and buffering provisioned by the components. This was conducted using SIPInspector to feed RTP packets to the other SIP end point in order to create network conditions simulation losses or silences.

V. Experimental Results

The WAV file were analyzed and wave files were compared using SFS release 4.7 (version 1.7) where Waveform, Wideband and Narrowband spectrograms were obtained and compared.

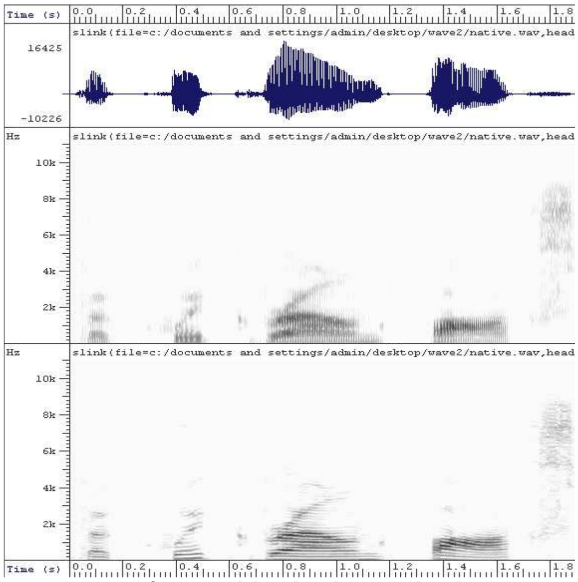

Fig. 5 Test Waveform, Wideband and Narrowband spectrograms

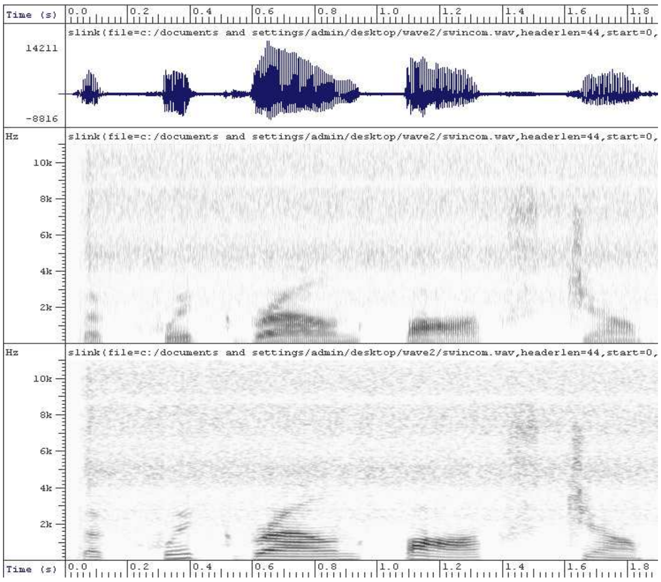

Fig. 6 Swincom Waveform, Wideband and Narrowband spectrograms

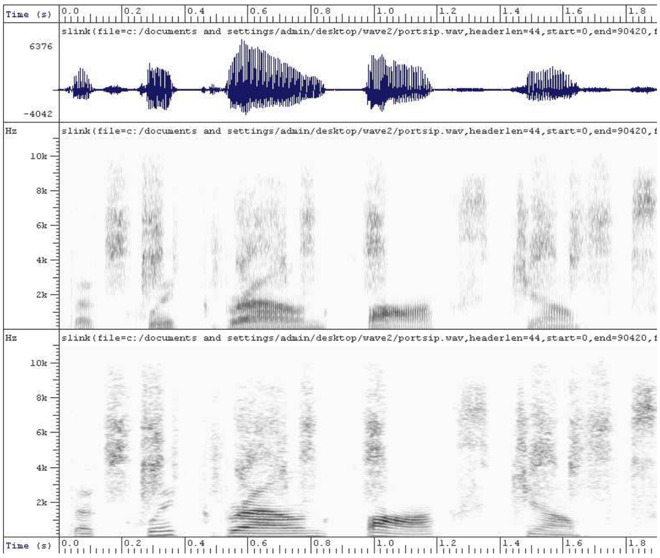
Fig. 7 PortSIP Waveform, Wideband and Narrowband spectrograms

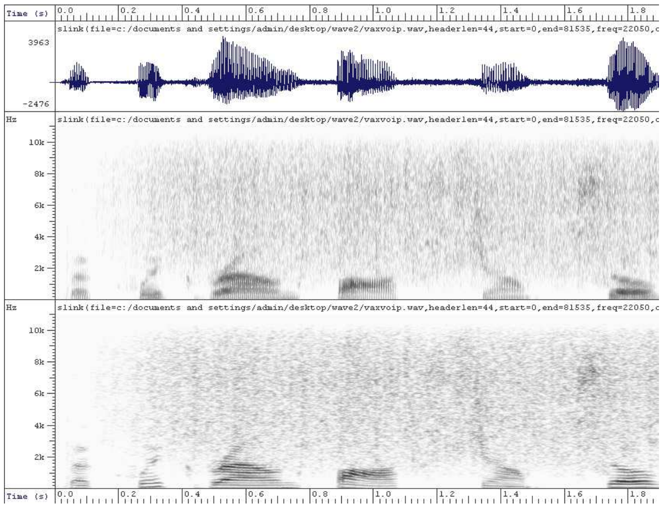
Fig. 8 VaxVOIP Waveform, Wideband and Narrowband spectrograms

Here Figure 2 represents the Waveform, Wideband and Narrowband spectrograms of the test waveform which is the captured raw wave file of the spoken text. Figure 3 shows the same waveforms and spectrograms for the generated output after it has been decoded by the end user module that uses the Swincom components.

The marked differences in voice quality are clearly evident. Figure 4 shows the same waveforms and spectrograms for the generated output after it has been decoded by the end user module that uses the PortSIP components. Here there are marginal waveform differences between the end user applications using both Swincom and PortSIP components but significant differences in the spectrograms.

Finally Figure 5 Shows the wave form and spectrograms of the output as decoded by the VaxVOIP component showing clear distortion in both the waveforms as well as spectrograms highlighting a markedly poor output quality from this end user application.

Recognized text too was captured and saved as raw Text files which were compared against the original text read by the speaker or typed in using TextDiff version 4.6. The group of applications that used Swincom and PortSIP achieved recognition of 73 percent and 61 percent respectively whilst VaxVOIP could only achieve 38 percent.

Based on the end user feedback from the group who utilized the Swincom product, suggests that under normal conditions the products featuring Swincom featured better during direct output of telephone to the Public Switched Telephone Network (PSTN). This group also used the product for the whole trial period. Whilst 52 percent were satisfied with the product the remainder suggested that improvements could be made in terms of better voice quality for the remote party and higher detection rates for the local user.

However, the group that used PortSIP enabled applications suggested that they had numerous complications when attempting to get basic words recognized and many found it irritating and all participants were not fully satisfied and requested substantial improvements. Meanwhile, of the group that used the application developed with VaxVOIP all participants stopped using the application within 3-8 days of the launch of the trial and would not utilize it for regular use and stated that they would not utilize it ever under situations that are business or mission critical as in directing field officers or for attempting dialogs with their superiors.

The collated results indicate that the sample population based test attained an overall success rate above 52% whilst the overall project attained an overall success rate of 64%.

VI. Case Studies

Based on the initial feedback from the above literature surveys as above research conducted a prototype Assistive Software Development Kit (ASDK) featuring VOIP, Speech Recognition and Synthesis, Symbolic language representation and Braille support was developed.

Utilizing the above ASDK specific Assistive Applications were developed for clinical trial by selected participants suffering from communications challenges, over a period of three (03) months. During use and post usage the participants were subjected to a brief quality evaluation test.

The collated results of the above ASDK indicate that Assistive Applications developed specifically for individual disabilities were rapidly assimilated by the participants and are adopted into the their lifestyles due to the benefits of social inclusion that it provided.

The ASDK based Assistive Applications achieved above 84 percent user satisfaction rate whilst the overall clinical trials achieved 92 percent success rate based on end user satisfaction ratings.

VII. Conclusion

The above research assessed the adaption of emerging technologies for the provision of communication assistive technologies for the disabled whilst serving as basis for research of assistive solutions for the disabled. But in light of the serious dearth in research as well as the creation of assistive technologies serves as a cornerstone in future development initiative.

The above research also indicates serious shortcoming in products available for the development of assistive technologies despite the vast market that presently awaits. Therefore, it is the recommended greater research into the development of a SDK specifically combining and integrating the advancements in ICT technologies for the development of assistive technologies. Such an SDK should ideally focus on person centered development approach towards catering for the unique individual requirements that each person and circumstance may warrant. Both Sample population and Laboratory test incorporated Telephony development kits that were not specific for assistive application development hence lack of assistive capabilities. Also there was a pronounced lack of integration between selected assistive technologies resulted in performance gaps and even further performance issues.

However, despite the above shortcomings the overall Sample population, Laboratory and clinical trials achieved success ratings exceeding 50 percent indicative of client exasperation of presently available assistive technological solutions, requirement for cost effective, customized and highly interactive assistive applications and a dramatic need for future research into this sphere.

Upon analysis of the above results it is apparent that by utilizing a SDK approach to Assistive Applications provide for a faster and more productive application that is quickly adopted by communication challenged users.

The above Assistive SDK could be further advanced through the incorporation of other leading vertical assistive technologies such as handwriting recognition, gesture recognition and eye tracking as well as through the incorporation of user enrolment based optimization and Artificial Intelligence for enhancement of Word/Gesture error rates, better human computer interaction capabilities, less end user frustration and even higher adoption rates.

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