



Sign Language e-Learning system for hearing-impaired community of Pakistan

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Abstract An increasing number of ratios in illness and injuries has lead to increase in the number of disabled people at the early age of birth. In this work we presented a web based e-learning system that is completely concerned with the sign language. In Pakistan, there is a scarcity of sign language resources available to assist deaf children in strengthening the language skills necessary for academic advancement. Thus, e-Learning for hearing impaired people is an application developed not only for deaf children but also for normal people to communicate with the deaf people. It is a web based application focusing on sign language of Pakistan which allows non-vocal information exchange. The purpose of this research work is twofold. First is to provide an e-learning system for educating sign language to deaf/hard-of-hearing people of Pakistan. Secondly, to develop a text translation system to translate English into its equivalent Pakistani sign language gestures in order to overcome communication barriers. The system also contains feedback for improving the quality of

application by taking suggestions from normal and disable people. The proposed application is distributed in modular client server entities; the framework is specially designed for parents to edify their children the indispensable communication skills. We believe that proper communication lays the foundation for accelerated learning and reduced frustration.

Keywords Impaired · Deaf · Pakistan Sign Language · e-learning · Disable

1 Introduction

In relatively short time frame, developing web based tools has gone from an esoteric curiosity to an essential skill set. Rapidly increasing numbers of users and their ever demanding needs make the development of online applications as one of the most promising fields in software engineering and human computer interaction (HCI) [18]. Applications have been developed in wide variety of domains to serve diverse range of users. The use of computer technology for language instruction has expanded rapidly. To serve in this context, we present an idea of an e-Learning application for delivering sign language instruction and thereby enhance learning of deaf community of Pakistan. Communication is the method of conveying messages, opinions and ideas between two or more persons and language is a medium to accomplish this. Communication falls into two categories: Verbal/Vocal communication and Non-verbal/non-vocal communication. Verbal communication uses syntax, well-defined grammatical structures and vocabulary to outline sentence semantics. This form of communication is used by unimpaired people. Non-verbal communication mainly

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comprises of hand gestures to deliver messages and is typically used by impaired group of people. Concept of non-vocal communication is strongly related to the notion of Sign Language. Sign language is a language that uses body movements, hand gestures, expressions and specific mouth actions instead of sound to communicate [10].

No one form of sign language is universal. It differs from country to country or even according to the regions. Some of the developed sign languages are Japanese Sign Language (JSL) [19], Arabic sign language (ArSL) [9], Australian sign language (Auslan) [9], Indian Sign Language (ISL) [15], Pakistan Sign Language (PSL) [16] and many more. Since each region has its own sign language, so a single gesture can carry a different meaning in different parts of the world and similarly a same word can be depicted using different gestures.

Figure 1a and b demonstrates the difference between alphabetical representation of PSL and ArSL and Fig. 1c is the depiction of word women in different sign languages.

Pakistan's demographic distribution is surrounded by a remarkable number of deaf people. As according to the statistical data taken from [8], approximately 3.3 million of Pakistani people are afflicted by some kind of physical disorders out of which 0.24 million (specifically belonging to age group from 5 to 29 years) are hearing-impaired. This contributes to almost 7.4% of an overall handicapped

community thereby giving rise to the significance of Pakistan Sign Language.

PSL is a visual gestural language having its own vocabulary and syntax like any other language. It uses manual communication and body sign language to convey meaning as opposed to acoustically conveying sound patterns. PSL combines hand shapes, orientation and movement of the hands, arms or body, and facial expression to fluidly express a speaker's thoughts. Signing is not only used by the deaf, it is also used by people who can hear, but cannot physically speak.

Sign language has emerged as the result of interaction of (PSL) with Urdu. In Sign Urdu, the signs are put together as they are Urdu words in Urdu grammatical structure. Figure 2 is a demonstration example of Urdu and sign Urdu.

This system has been developed to focus and assist such impaired population of Pakistan. Lexical database/corpora

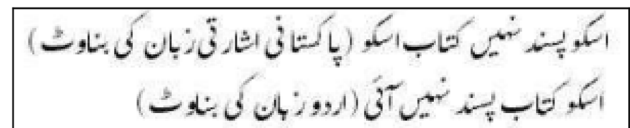
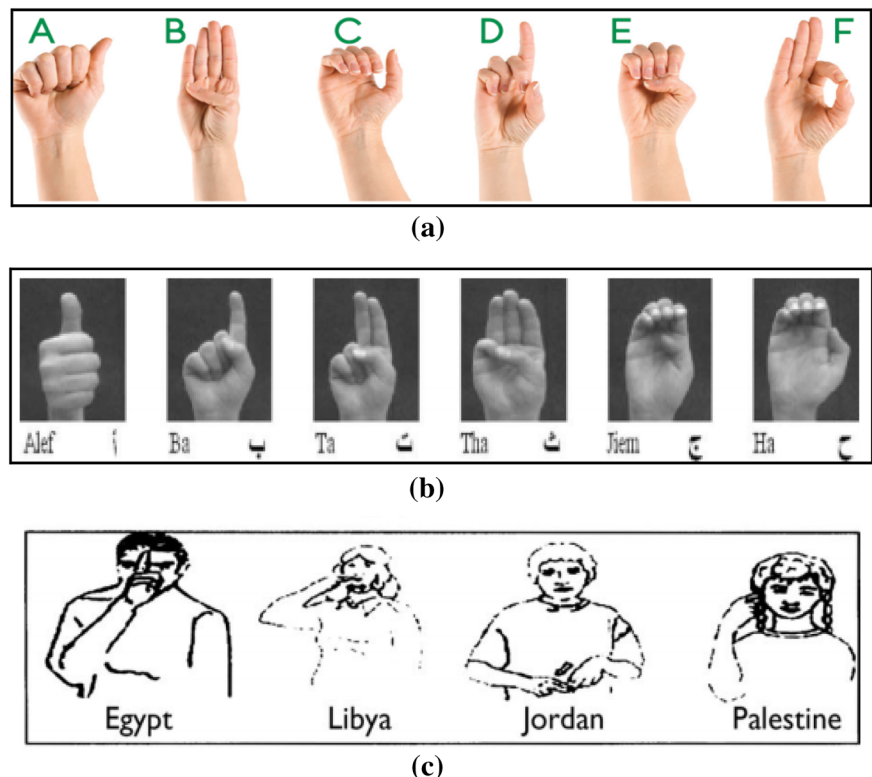


Fig. 2 Example of Urdu and sign Urdu [16]

Fig. 1 Representation of non-universal property of sign languages. **a** Pakistani sign language (PSL) [13], **b** Arabic sign language (ArSL) [5], **c** Word “woman” in Egypt, Libya, Jordan and Palestine sign languages [2]



is created to catalogue signs and hand gestures. It is used for translation of source text provided as an input in English language into its equivalent targeted PSL. The convenient and intuitive graphical user interface of this web-tool immerses the learner into a well-off educational environment where they can effectively learn sign language of Pakistan. The main motivation behind this research work is to develop an assistive and a teaching tool to understand and learn visual communication language in an efficient manner. For this Initial prototype, qualitative testing based on expert opinion and a targeted deaf group of people was performed using a Web Evaluation Framework which indicated remarkable results.

2 Related work

The exploitation of computers and modern era technology as a tool for sign language recognition has long been explored and investigated by experts in the field of software engineering. Various algorithms and techniques have been used for hand gesture detection in sign language [7]. Study in [6] has presented the design and development of a static prototype based on android platform to recognize Indonesian sign language. Sahoo et al. [15] proposed an architecture for automatic detection of Indian sign language. This system can disseminate useful information to deaf community of India. The designed system in [5] translates alphabet gestures into Arabic signs using natural hand movements. To improve system accuracy rotation invariant and scale are used as extracted features. Drigas et al. [4] developed an e-Learning system for Greek sign language to assist hearing impaired people. This learning software takes text as an input and provides Greek sign languages videos as an output thereby making interactive learning possible for the targeted users. Research in [11] discusses an e-Learning system to ameliorate learning skills of deaf pupils in Jordan typically insisting on their mathematical, reading and writing skills. Work presented in [8] demonstrated the emergence of Pakistan sign language and the use of computer vision based approaches in assisting deaf people of Pakistan.

Both e-Learning systems and sign recognition systems have been realized by researchers of different countries/regions and are practiced by the deaf people for communication in public places with their hearing counterparts and for accessing/communicating with latest epoch gadgets.

Since Sign languages possess non-universal property, so there is a huge need to focus on Pakistani sign language which has gained a very little research attention by researchers. It is immensely important to incorporate Computer-assisted instruction (CAI) tools in existing

educational systems designed for such community. In Pakistan different welfare organizations like Sir Syed Deaf Association (SDA) [14], Rawalpindi, Anjuman Behbood-e-Samat-e-Atfal (ABSA) [1], Karachi, National Institute of Special Education (NISE), Islamabad, Pakistan Association of Deaf (PAD) [12], Karachi and few more are providing trainings and education to deaf community using different tools and electronic mediums. This trend is still evolving. In this paper we present an idea for translating English alphabets and words to PSL that can be used to eliminate communication gap and build up sign language proficiency in deaf and unimpaired people.

3 Significance of developing e-learning for hearing impaired people of Pakistan

Widespread use of information technology has made web tools and applications as a vital source to disseminate information and valuable contents to vast variety of users no matter whether they are fit or having any physical ailment.

The World Wide Web Consortium (W3C) characterizes accessibility on the Web as a trait by which “individuals suffering from physical disabilities (such as speech, visual and hearing impairments, neurological disorders etc.) can comprehend, explore and perceive the web and can make their contributions to the web [3].

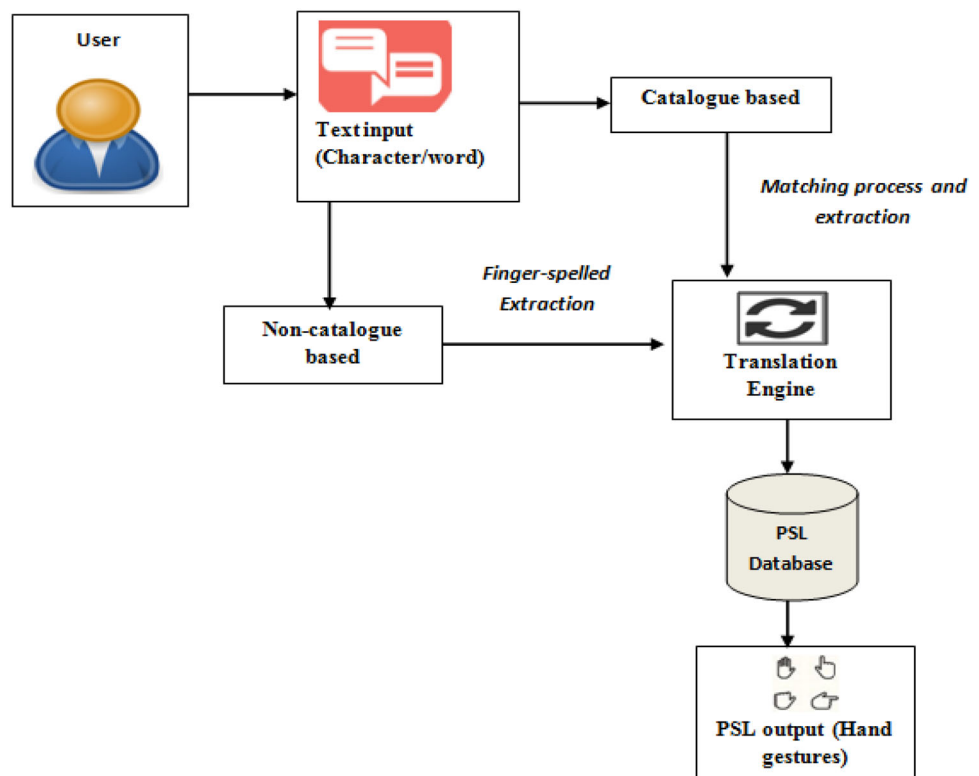
The proposed e-learning web tool in this research work is a simple and platform independent resource for hearing impaired community of Pakistan which can be conducive and convenient for people with hearing impairments belonging to different age groups, parents, and instructors. The role of this web based learning app is threefold; i-e to aid parents to understand and conceptualize PSL which is mandatory for communication with children, to provide teachers/instructors a medium to convey instructions and to allow children/adults to grasp language and reasoning skills thereby abolishing communication obstructions.

4 Implementation

Implementation of this e-learning application has been realized by integrating front-end module with database module via a translation engine.

The overall module architecture and workflow mechanism of Sign Language e-Learning system is illustrated in Fig. 3. This system provides a convenient platform where users (hearing impaired); from novice to intelligent, can easily conceptualize and develop sound skills in Pakistan sign language. A user is allowed to type text, a character or word for translation. The characters are matched exactly

Fig. 3 Workflow mechanism of “Sign Language e-Learning system for hearing-impaired community of Pakistan”



and corresponding sign language gesture is extracted from the database and translated PSL is displayed as an output. However, words are interpreted by an application to check if the entered word is catalogue based (dictionary based) or non-catalogue based (non- dictionary based). Catalogue based words or their derivatives, via mapping, are converted into PSL whereas the characters of the words which are not directly part of a lexical database are finger spelled, much similar to how people with hearing disability communicate.

Server-side scripting is a web server technology in which a user's request is fulfilled by running a script directly on the web server to generate dynamic web pages. It is usually used to provide interactive web sites that interface to databases. This is different from client-side scripting where scripts are run by the viewing web browser, usually in JavaScript. The primary advantage to server-side scripting is the ability to highly customize the response based on the user's requirements, access rights, or queries into data stores.

Because we are dealing with web-based clients, we have used WampServer as web server that handles requests from web-browsers and then forwards them to the MySQL database. Likewise, the web server will wait for the database to respond and then pass on that response to the waiting web browsers. Figure 4 depicts interaction scenario of e-Learning application.

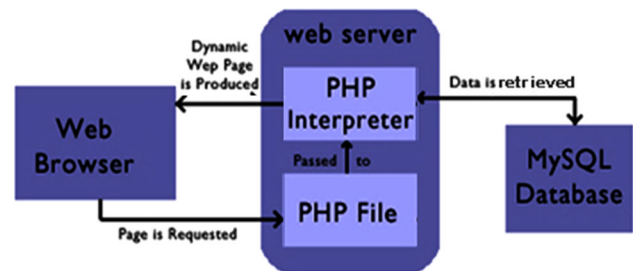


Fig. 4 Interaction diagram of e-learning application

Figure 5 demonstrates the use case diagram which is focusing on the functionalities that users and application can perform. Users are allowed to access e-Learning application in their browsers, create accounts, learn PSL and give feedbacks. The e-learning application can receive users' requests and return the PSL output and is also responsible for maintaining database of accounts.

The database schema of the e-learning application is depicted in Fig. 6. The database comprises of four major tables which are easily accessible via web server based on users' request. The discussion below is highlighting some of the significant GUI layouts.

In Fig. 7 users are allowed to enter either characters or words in English language. For example, user has entered character “A”, the e-learning application will show its corresponding PSL as shown in Fig. 8.

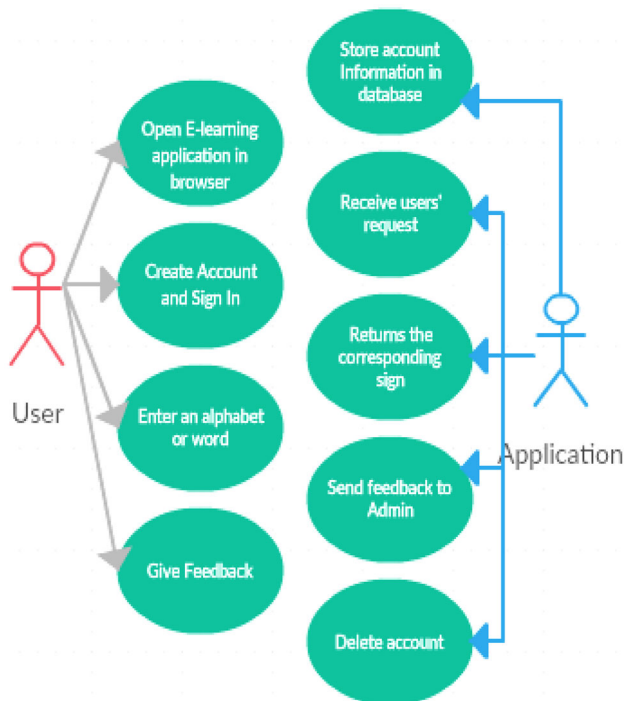


Fig. 5 Use case diagram showing user—system interaction

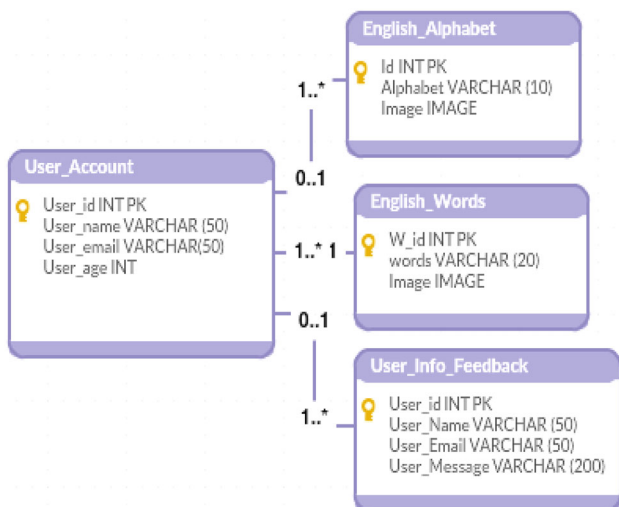


Fig. 6 Database schema of e-learning application

If the learner is looking for PSL demonstration of words then he/she can select word from the main interface and then provide the desirable word as an input. Figure 9 is depicting PSL gestures for the word “Again”.

Figure 10 is an example elucidating the translation process of non catalogue based words. If the user is searching for a person’s name i-e “SAM” then the PSL translation of finger-spelled equivalent of word “SAM” will be produced as an output by translation engine.

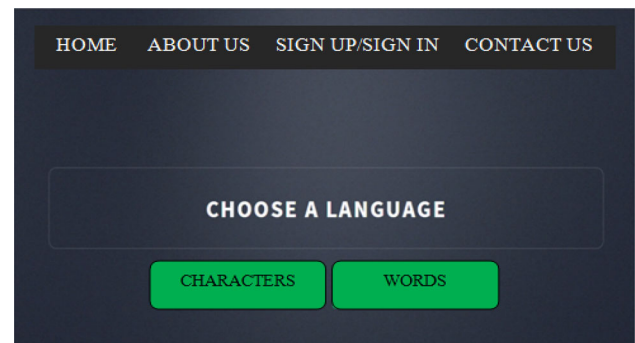


Fig. 7 GUI for text input

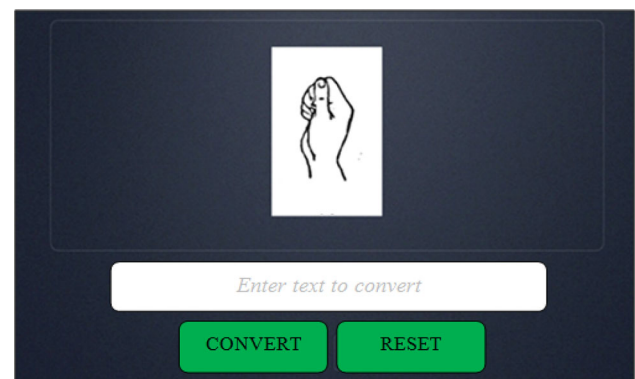


Fig. 8 PSL depiction of character “A”

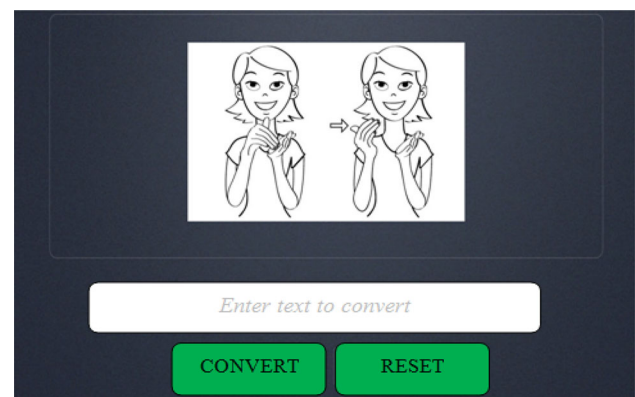


Fig. 9 PSL depiction of word “Again”

5 Results and discussion

The use of WebApps in vast number of domains is continuously expanding and ever demanding. The accomplishment of such applications mainly relies upon their ability to fulfill the user needs. In order to measure quality of a web based system different evaluation methods, web quality frameworks, and metrics are practiced by researchers’, experts and organizations. For the evaluation of our proposed e-learning web based system, we have

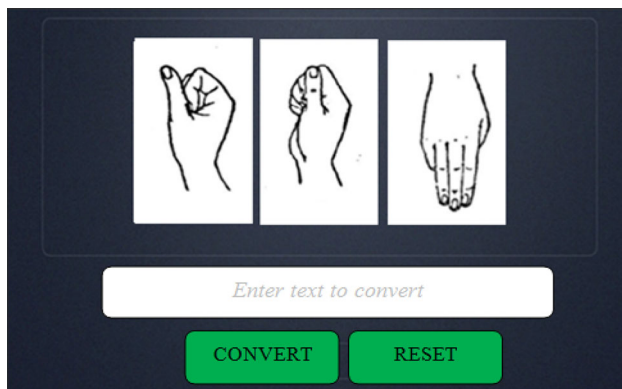


Fig. 10 Finger spelled PSL translation of name “SAM”

partially implemented web evaluation framework (WEF) proposed in [20]. WEF is depicted in Fig. 11.

WEF is a hierarchical framework based on different levels. The first level quality metrics are Aesthetics, Ease of Use, Multimedia, Rich Content and Reputation. This levels further breaks down into sub levels comprising of different quantifiable indicators. User analysis and expert’s opinion analysis techniques in cumulation with a graded response model were used to quantify above mentioned quality factors. e-learning tool efficacy was measured using

a likert-type scale. A Likert type scale consists of a series of statements. The respondents are asked to indicate whether he/she agrees or disagrees with each statement. Likert-type scales may include four to seven steps. Commonly, five options are provided. The anchors of 5-point scale for quality measurement are: “Poor, Fair, Good, Very good, excellent” [17]. A total of 32 participants’ i-e experts and Deaf/hard-of-hearing were included. Some of the participants were congenitally deaf while others were surrounded by this disorder at their infancy. Ethnicity of participants was not considered. The sample size involved 23 males and 9 females. An equal weight was allocated to each quality attribute. The total quality characteristic value was calculated using Eq. 1.

$$\text{quality characteristic value} = \left[\frac{\sum \text{respondents rated score}}{\text{total score}} \right] \times 100 \quad (1)$$

The resulting measures of quality indicators are shown in Fig. 12. Statistical data shows significantly positive results and user satisfaction with respect to different evaluation factors. Responses are having higher tendency towards positive rating of likert-scale and comparatively lesser tendency towards negative ratings.

Fig. 11 Web evaluation framework

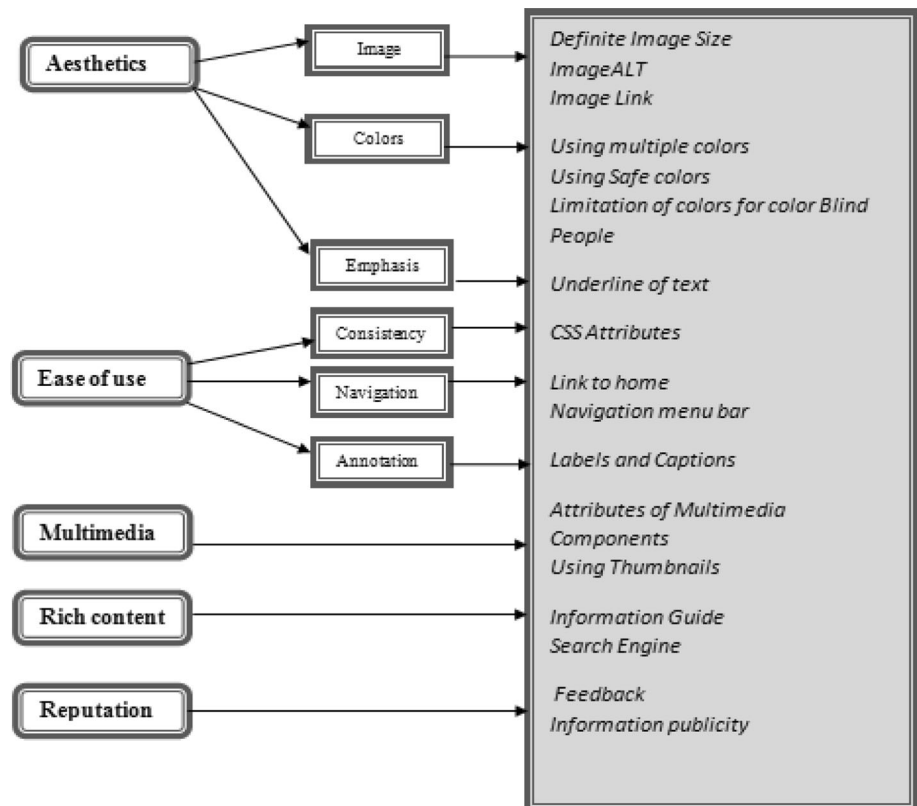
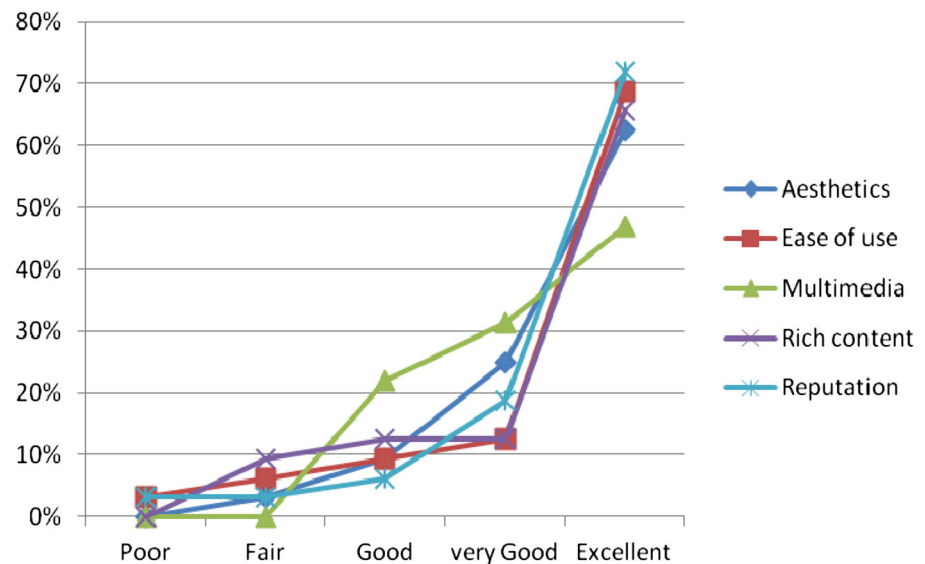


Fig. 12 Quality evaluation metrics

6 Conclusion

Sign Language of any country/region is a communication via gestures which maps words/derivatives, characters, phrases, sentences and articulations of a certain dialect to empower and enable an impaired person to talk and communicate easily. In the context of learning paradigms, e-Learning systems have become almost ubiquitous. The e-Learning application proposed in this paper is a PSL resource designed to fulfill the pedagogical needs of hearing impaired community of Pakistan. We took into account the daily challenges confronted by parents as they attempt to equip their children with the PSL tools to thrive. The system was tested via expert opinion analysis and user perception analysis using different quality indicators. Respondents' attitudes were measured and analyzed in the context of significant quality parameters and sub-parameters. The results were satisfactory with minor exceptions. The proposed e-Learning application is highly flexible for future updates. The future extension and optimization of this work will be to develop a system that can decipher English language sentences and phrases into PSL and vice versa. Furthermore, video archives and searching based on video data can also be incorporated.

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