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Adaptive Auditory Feedback Mechanism of Visual Impaired

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ABSTRACT

There is a lot of work done in HCI research area, due to this auditory interface develops for visually impaired people that assist them to work with desktop environment easily. To enhance better design, designer faces many challenges to develop auditory feedback system. This study purposed an new method named as adaptive auditory feedback system, which is continuous switching of speech-based feedback system (i.e. sound, music) to non-speech-based feedback system (i.e. spearcone) according to user state of interaction. As a visually impaired person who frequently access desktop system does not need continuous instructions. Experiment done on sixteen visually impaired people and result shows that adaptive auditory feedback system is efficient then only one particular method (speech-based or non-speech-based). User can choose any type of instruction according to need and want that improve usability experience. Result and discussion shows highest satisfaction level of visually impaired people regarding adaptive auditory feedback. In future, same type of adaptive auditory feedback system may implement on mobile applications rather than desktop environment.

Key words: Visually Impaired People, Desktop Environment, Adaptive Auditory Feedback, Speech Only Feedback, Non-Speech Feedback.

1. INTRODUCTION

Computer operated applications have greatly affected life of visually impaired persons. There are different types of visually impaired such as night blindness, loss of basic vision, blurred vision, high light sensitivity, and generalized haze [1]. Not only visually able person uses computer application, but visually impaired people can also do their daily tasks, such as accessing information, operating different applications, and communicating with other devices. Studies shows that desktop interaction enhanced by using auditory interface. According to WHO, almost 1.3 billion people face vision problems, in them 36 million people are completely blind, and almost 188.5 million persons suffer from minor visual complications. Auditory feedback is more reliable to access information, in case of blind people using desktop environment [2].

Auditory feedback helps visually impaired people to work in desktop environment. Some of magnification software like MAGic1used to provide auditory feedback while using desktop applications. Web Anywhere, Talkback5, 3 Voiceover, and JAWS are some assistive technologies facilities visually impaired people to interact with desktop and accessing information through desktop applications [3].

These hear-able interfaces essentially rely upon either discourse based or non-discourse interfaces for help. Discourse put together interfaces are based with respect to human discourse, which can be handled, recorded, played, or integrated by a desktop. In general, auditory interface divided into two types, non-speech-based feedback mechanism or speech-based interface. Speech based auditory feedback interface allow users to play, process, synthesized and record information through human spoken words.

Non-speech based auditory feedback such as music, Spearcons also used to create interactivity between desktop applications and visually impairedpersons. Speech based feedback that repeated several time cause irritations for visually impaired person but in comparison of speech-based feedback non-speech based auditory feedback is more convenient and pleasant. Only drawback of non-speech based auditory feedback it provides less information of deficient to provide complete instruction to visually impaired people [4]. Non speech auditory icons such as Spearcons [5], require less training and give effective learning results then earcons. When speeds of speech exceedupto 50-60%, it is difficult to recognised, new spearcons are produced. In addition, every phrase generates a new spearcon that is easy to identify [6].

The general aim of paper is to give assistance to visually impaired persons using adaptive auditory feedback [7] to enhance performance of doing work and better understanding for action awareness using desktop for visually impaired people. In this regard, purposed methodology comprises on speech only or non-speech based auditory feedback. Auditory feedback shifts from speech only to non-speech according to user state. Experimental verification strengthens by using desktop applications to assist visually impaired people. Adaptive auditory mechanism helps visually impaired people to work on desktop environment by combing both speech-only based or non-speech-based feedback by eliminating the shortcoming faces in both types to increase features effectiveness.

In case of visually impaired people, hearing is basic source of getting information. Aim of research is to provide a better assistance using both approaches speech only and non-speech-based feedback to reduce irritation while using desktop applications. Adaptive auditory feedback provides better action awareness, task performance to visually impaired people to maximize user satisfaction level.

Rest of paper organized as section II explain literature review. Section III describes methodologyadapted to comfort visually impaired people. Section IV explains the experimental verification of adaptive auditory feedback system. Lastly, conclusion and future work depicts in section V.

2. LITERATURE WORK

Wafa M. Elmanna et al. purpose a easy to wear system for visually disable people to walk on road by avoiding collision with any obstacle. A hardware (GPS, music, wi-fi, FEZ microcontroller etc) and software (computer vision and multisensory data approaches) based framework implemented using GHI Electronics and .NET Gadgeteer-compatible main board. Avoidance algorithms used to achieve 96.4% accuracy and outstanding performance. Doors and walls are difficult to detect by using this framework therefore background and foreground is difficult to distinguish. Ultrasonic sensors can be used to deal with such background difficulties and increase framework accuracy [8].

Jäger and Hanjaeos [9] noticed an iterative plan measure and recommended that cooperation can be improved by giving enough number of extraordinary voices in the game. Another zone where hear-able criticism was effectively utilized is gaming. Outwardly debilitated individuals look into sound games in light of the fact that these kinds of games can animate the players' considerations. In addition, sound games are utilized for various purposes, e.g., improvement of information, portability, critical thinking abilities, and context-oriented mindfulness in visually impaired clients. Finger Dance [10] is a sound-based mood activity game which is explicitly intended for dazzle people. It gave a procedure to create computer games for dazzle clients with the assistance of tactile substitution. Some other game called Sonic-Badminton planned and created by Kim et al. [11] is a sound increased game which utilizes virtual shuttlecock with sound input.

Adrian AiordChioe at al. inventoried a voice-based input for assistive smart glass-based application for visually impaired people. Voice, touch, and mid-air gestures uses as input modalities for HMDS, VR communities, smart glass and in

all interactions techniques that are designed for visually impaired people. Research comprises on 500 papers, and 13 research prototypes to strengthen voice-based input such as Amazons Alex, Microsoft's Cortana, and Apples Siri. The core step is to integrate smart glass with voice input in smart devices that refine design for input voice command for assistive smart glass-based application. Embedded gesture and voice input in wearable devices lead to new ideas to assist visually impaired people [12].

Ghiani et al. proposed [13] area mindful historical centre assistance for the individuals with visual debilitation. The instructions has a Vocal User Interface, which misuses an installed text to-discourse (TTS) motor given by Loquendo,1 which integrates discourse for portraying craftsmanship's/segments and for provide guidance tips on the fly.

TravelMan, a portable multimodal person on foot and public vehicle course direction applications are being presented by Kainulainen et al. [14]. The framework utilizes non-discourse sound, which supplements discourse in passing on course data to the client. In tests with the application, fundamental mindfulness data in regard to four methods of public transportation, for instance sound of strolling, prepares, cable car and transports, are passed on to the client as hear-able symbols. Besides, the worldly distance data is passed on, rather than spatial distance. This is accomplished with the utilization of 'stop' in a discourse yield, which differs impressively and relies on the unpredictability of course and discuss something about the objective.

Likewise, another framework called Ontrack, planned and created by Jones et al. additionally helps clients in common route [15]. The framework passes on directional data to theclient through nondiscourse sound (i.e., music) which encourages the client reach to theobjective. The framework works so that if a client is strolling toward the objective the music playsin the two ears by means of earphones. In any case, if the bearing of the objective is on the correct side of a client the music will begin playing in the correct ear and the other way around, if the objective is on the left half of the client. In the event of a misguided course, the volume of the music played would bit by bit diminish [16].

Neveen I. Ghali at al. research the consequences of the augmented experience innovation on crippled individuals, for example, daze and outwardly disabled individuals to upgrade their PC abilities and set them up to utilize ongoing innovation in their everyday life. In this creator depicts what best devices and practices in data innovation to help incapacitated individuals, for example, hard of hearing visually impaired and visual disabled individuals in their exercises, for example, portability frameworks, PC games, availability of e-learning, electronic data framework, and wearable finger-braille interface for route of hard of hearing visually impaired [17].

Sheethal at al. explains of this paper is to collect the perceptions of blind learners from school and examine which tool can be used to control the problems that blind learner may face in education. The absence of mindfulness about designing and the absence of designing devices were a portion of the key difficulties raised [18].

Wong at al. said as cell phones are getting more omnipresent, it is presently conceivable to improve the security of the telephone. We allude to this as portable biometry. The goal of this investigation is to expand the ease of use of versatile biometry for outwardly impeded clients, utilizing face as biometrics. We represent a situation of an individual catching his/her own face pictures which are as frontal as could reasonably be expected. In this paper, a sound input component is proposed to help the outwardly impeded to obtain face pictures of better quality [19].

Howard at al. explains the mechanical technology field speaks to the joining of different features of software engineering a lot. Mechanical technology-based exercises have been appeared to urge K-12 understudies to think about professions in registering and have even been embraced as a feature of centre software engineering educational program at various colleges. Sadly, for understudies with visual

hindrances, there are as yet lacking openings made accessible for instructing essential figuring ideas utilizing advanced mechanics based educational plan. In this paper, we examine the utilization of elective interface modalities to draw in understudies with visual weaknesses in mechanical technology-based programming exercises [20].

Keefer at al. describe as we known that IT had growing very fast such as cell phones. This research focused on the user interfaces of mobiles. A Framework of a voice interface for a mobile is presented. Three field with visual impaired were showed to make and enhance the framework. A formal grammar is used to explains the voice interface, and a stochastic Petri net was established to framework the complete device interaction [21].

Khan at al. present a book revision device that is altogether intended for the outwardly impeded. Rather than utilizing customary console or mouse, they can compose or alter text utilizing discourse as it were. The content can be perused to the client utilizing discourse synthesizer. The client will be told of various occasions through sound input and the client will have the option to compose text completely utilizing discourse. Diverse voice orders have been intended to associate with this device. Too, significant modes can be actuated utilizing a solitary snap on a mouse button. Since clicking both of the mouse catch may not be very hard for the outwardly impeded, we can utilize this choice for adaptability [22].

Minagawa at al. present the highlights of the framework are: 1) the utilization of multimodality, i.e., material and hear-able faculties are utilized for seeing spatial and phonetic data and 2) two-way correspondence, i.e., the framework empowers a visually impaired individual to peruse and compose a graph. This paper presents a material sound graph and an actualized model framework dependent on this hypothesis, alongside a conversation furthermore, techniques for improved portrayals [23].

Connier at al. explains could possibly know, little work has been made to use this wealth of assets to create assistive gadgets for Outwardly Impeded Individuals (celebrity). Nonetheless, we accept that SOs can both improve customary assistive capacities and offer better approaches for interfacing with the climate. In the wake of portraying spatial and non-spatial insightful capacities empowered by SOs, this article presents the SO2SEES, a framework intended to be an interface between its client and neighbouring SOs [24].

Mascetti et al. have planned a versatile application called Just Point, which identifies shades of different things for individuals with visual handicaps. The client brings up a specific thing with the assistance of a finger marker, and the application precisely distinguishes the shade of the thing and portrays it to the clients as one or the other content to discourse or with non-discourse sound. Dazzle clients demonstrated their fulfillment and confirmed its helpfulness. Another framework named Third Eye upheld with brilliant glasses contains a camera and gives a hear-ablecriticism to the visually impaired people to investigate continuous video. This framework gives here-able input to navigational directions [25].

A wearable framework proposed by Wang et al. offered navigational help to dazzle clients. The framework passes on input in type of vibration when any obstacle is faced by the outwardly disabled. This framework effectively differentiates walkable and hindrances Felds. Data with respect to the general climate is given as hear-able criticism, for example, finding a seat. There are two sorts of guides being utilized, material alleviation and intelligent guides. Material alleviation maps get a psychological outline of room yet have a few limits, for example, less measure of braille text. Then again, intelligent guides have effectively defeated the issues confronted while utilizing the material help maps [26].

Brock et al. given an ease-of-use correlation of two guides made out of a multi-contact screen with yield as sound criticism. They utilized 24 outwardly hindered members for the investigation. Various errands were completed by the outwardly impeded in the client study, i.e., strolling in the labyrinth, finding a seat in the room and strolling in a

jam-packed spot without catching individuals [27]. The outcomes obviously demonstrated that change of braille with hear-able material cooperation expands proficiency, viability, and fulfilment of the client. At long last, they recommended that intuitive guides with hear-able material criticism were exceptionally helpful for improving guide investigation for daze individuals [28].

Vazquez-Alvarez et al. planned a metropolitan sound nursery which supports covering sound milestones. Representative earcons were utilized, i.e., creature sounds which addressed actual tourist spots. They completed a trial in which an account of a creature sound, i.e., goose, cricket, songbird, frog and owl addressed five distinct tourist spots in the climates. Results from the trial demonstrated that it furnishes the client with extraordinary feeling of submersion and delight and can be utilized in the region of cell phones to address close by environmental factors of the clients. The ear cons utilized by VazquezAlvarez et al. were planned dependent on the past investigation of Stahl and McGookin [29].

3. METHODOLOGY

According to current situation visually impaired is creating a gap between computer users. The visually impaired are suffered a lot in this case. So, this research is an attempt to find out the way in between. A user must be familiar with text and voice search in these scenarios By keeping them in the view a mixed solution is proposed in which if a user is visually impaired, he can switch his interface of desktop into according situation [30-32].

Objective of purposed approach is to develop an adaptive auditory feedback tool for visually impaired people for desktop assistance according to user states of using desktop application. The purposed adaptive auditory feedback tool carried out by using consistent shifting of both speech-only and non-speech auditory feedback. This can be done by switching from one auditory method to another according to work done on desktop.

Purposed Adaptive Auditory Feedback Tool is used switch instruction according to user state, or desire. User can select desired type of instructions either speech based, or non-speech based according to need and want. Purpose system attains highest usability because of easy-to-use interface and switching type of instructions.

Research conducted on the base of user state. Usually there are two types of visually impaired users' familiar users (Engage) that use desktop application regularly and other is unfamiliar user (Active) that interact with system rarely or new user. When a user is unfamiliar or new to system it needed more detail to interact system that provided in form of speech-only auditory feedback.

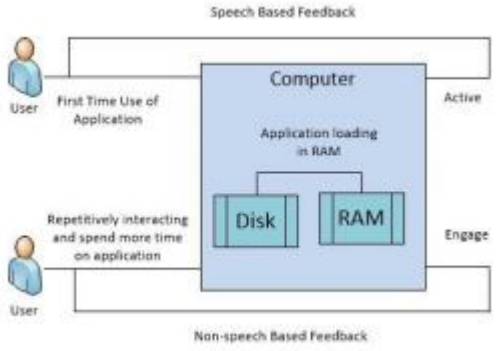


Figure 1: Feedback According to User State

Speech-only auditory feedback is defined as the instruction given in synthesized speech format to visually impaired people. But in other case when user regularly use desktop applications it knows much minor things that cases irritation when speech-only auditory feedback is used. To avoid unconvinced non-Speech based auditory feedback is used to assist visually impaired people.

Non-Speech based auditory feedback defines as non-speech instruction given to visually impaired people to enhance their interaction experience in desktop environment. A new technique, Adaptive auditory feedback that is combination of both Speech-only and non-Speech based auditory feedback used. Adaptive auditory feedback implemented purely on base of user state i.e. familiar or unfamiliar user. Interface of purposed tool is inherited with Windows10 Operating system.

Figure 2: Purposed Interface Home Screen

Purposed tool works on Windows 10, it is an extended form of JAWS interface that operated only speech-based instructions for visually impaired people. Here is the first interface that opens when user start its PC after clicking mouse on the screen two times the home page of adaptive auditory feedback tool open. After clicking on home screen one-time next interface open that have two options either speech-based instructions or non speech based instruction. Use can choose between both and them and can switch between these two types of instruction by sampling double clicking on the Windows screen double time.

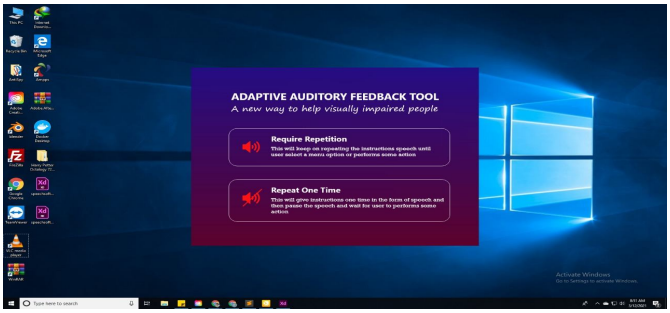


Figure 3: Purposed Interface 2

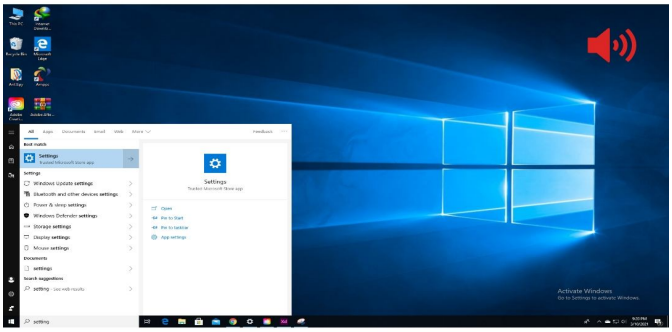


Figure 4: Purposed Interface 3

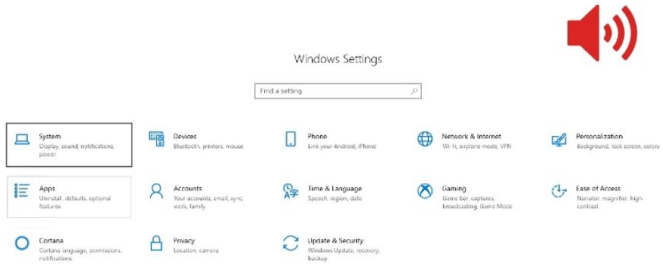


Figure 5: Purposed Interface 4

Usability evaluation performs to test the effectiveness of adaptive auditory feedback in desktop environment. User satisfaction, effectiveness, and efficiency to performing different tasks measured through ANOVA test and a complete review-based survey conduct to attain satisfaction from user side.

A.Data collection and Analysis:

Sixteen visually impaired people are selected for study that consists of 12 males and 4 females. Participants that took part in research study belong to special education department situated in okara. Age ranges from 14-18 years with mean value of 21.5. All the participants have at least 1 year experience of computer usage and habitual to doing task in desktop environment frequently. Selected visually impaired people are completely blind and know the objective of research. All of these are highly trained as the done many of task at computer and highly skilled teacher are there to assist these students.

Table 1: Participants of Research

Demographics Data	**Types**	**Frequency**	**Percentage**
Gender	Females (4)	4	16
	Males (12)	12	84
Age	18	4	25
	17	5	33
	16	2	12
	15	3	19
	14	2	12

Before collecting data, a survey is conducted to gain assurance and opinion of visually impaired people about purposed tool. Visually impaired people show their likeness, dislikes, satisfaction, and dissatisfaction in conducted survey. Survey conducted orally as visually impaired people unable to fill form.

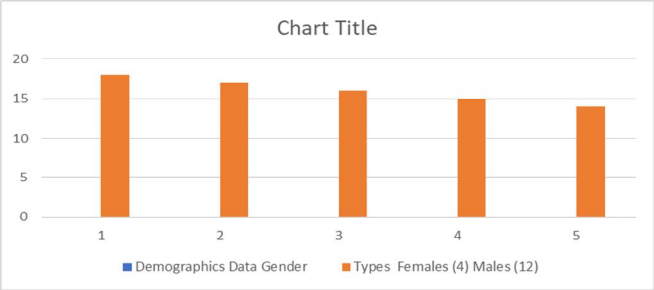


Figure 6: Graphical Representation

Complete task knowledge shared with participants through training session and all the activities related to research are recorded. Training sessions consist on filling a form such as insert father name, user name etc. All the necessary interaction strategies explained to participants so they can get familiar to desktop application better. A table use to represent the complete details (age, gender) about selected participants in study.

All the participants are well known about the research aim and objective and research conducted by considering all ethical values. To perform the adaptive auditory feedback research, an admission form-based application installed on twenty-five desktop computers. These selected computers supported windows10 operating system, 8 GB RAM and hp core i5 version. Headphones and all initial credentials are provided to visually impaired people and complete session was recorded to check behaviour of participants.

B. Sampling:

The selected participants were brought to lab that contained homogenous devices for everyone which were improvised for the visually impaired people. Participants were given three separate tasks to perform i.e. Speech only, non-speech only and adaptive auditory feedback. Non-speech-based material includes Music, environmental and Spearcons based sounds. While speech based include human voices. First of all, participants were given an introductory session, familiarized them with the lab and research intentions. This made them comfortable and familiar to lab environment.

Participants were given online form to perform. This form consists of different information such as participant's name, Father Name, Age and CNIC. Experiments were conducted in 3 days. The interface was designed to detect the user state, first users were given the Active state which had the responses in speech only mode. For consistent user, engaged state was used which consisted of non-speech only items. Each respondent attempted each experiment 3 times.

Table 2: Participant's State

Task	**Total Participates**	**Total Times**
Active State	3	3
Engaged State	13	3

First time the task consisted of speech only feedback, secondly with no speech and lastly with adaptive auditory feedback. Before the experiment, participants opened the task that's already explained to them in orientation session and listen to the audio. While recording the responses, there were three types of feedbacks already mentioned above, speech only, non-speech only and adaptive auditory feedback only. At the end of these sessions, oral questionnaire was provided to the participants. The questionnaire consisted of 3 kinds of impression measures: Like and Dislike, Satisfactory and Unsatisfactory, Interesting and boring.

C. Usability Evaluation:

Satisfaction, efficiency, and effectiveness are core three parameters to compute the usability. To measure satisfaction and performance of active user ISO rule 9241-11used. Effectiveness can be defined as value of goals that achieved through a particular task and measurement of derived results.

$$\text{Effectivness} = \frac{\text{No of completed task}}{\text{Total undertaken task}} \text{ X } 100\%$$

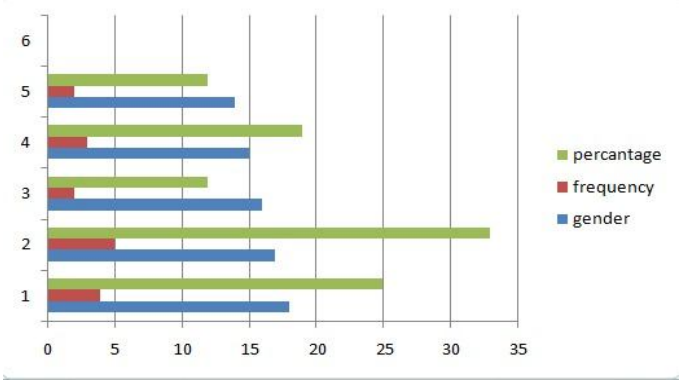
Efficiency can be defined as resources that necessary to achieve a particular goal. Resources include money, mental effort, and time. Efficiency derived as:

$$\text{Efficiency} = \frac{\sum_{j=1}^{R} \sum_{i=1}^{N} \frac{nij}{tij}}{N \text{ X } R}$$

N is number of tasks that have to performed, R is number of users that participated in experiment, n_{ij} is number of j user that perform i task, t_{ij} is time took by j user that perform i task. Many of techniques such as SUMI, PSSUQ, CSUQ, SUS, ASQ, and CUSI use to achieve usability evaluation. In our research we use, survey based on ASQ quessionnare approach used to collect data from users.

4. EXPERIMENT

A prototype was designed using Adobe XD for visually impaired people including speech only mode. The experiment was conducted, and sample included 16 students of Special Education School. Sixteen visually impaired people are selected for study that consists of 12 males and 4 females. Age ranges from 14-18 years with mean value of 21.5. All the participants have at least 1 year experience of computer usage and habitual to doing task in desktop environment frequently.



Results showed that students were experienced with the computer usage. 15 minutes time was given for the performance of the tasks. 13 out of 16 students completed the task in time, while 3 students were unable to complete in time. One of the remaining students was able to complete it a few minutes later while two of the students were unable to complete it altogether.

Table 2: Task Detail

Student	Gender	Device	Start Time	End Time	Total Time	Task Completion	Relogin
1	M	PC	12:15	12:30	15	13	0
2	F	PC	12:15	12:30	15	10	0
3	M	PC	12:15	12:30	15	15	1
4	M	PC	12:15	12:30	15	12	0
5	F	PC	12:15	12:30	15	11	0
6	M	PC	12:15	12:30	15	18	1
7	M	PC	12:15	12:30	15	14	1
8	M	PC	12:15	12:30	15	12	0
9	F	PC	12:15	12:30	15	Not completed	0
10	M	PC	12:15	12:30	15	11	0
11	M	PC	12:15	12:30	15	13	0
12	M	PC	12:15	12:30	15	10	0
13	F	PC	12:15	12:30	15	8	0
14	M	PC	12:15	12:30	15	Not completed	0
15	M	PC	12:15	12:30	15	14	0
16	M	PC	12:15	12:30	15	15	0

Efficiency of anything is calculated by successful observations divided by total respondents. We calculated efficiency in two terms, in terms of overall completion and in terms of timely completion.

$$\text{Completion Effectivness} = \frac{14}{16} \text{ X } 100\%$$

Effectiveness= 87 %

$$\text{Timely Completion} = \frac{13}{16} \text{ X } 100\%$$

Effectiveness= 81 %

As expressed above, 87% of the students were able to complete the experiment. In terms of timely completion, only 81% of the respondents completed it in the given time.

Completion	Total	Successful	Effectiveness
Timely Completed	16	13	81%
Completed overall	16	14	87%

After the experiment, feedback was taken from the students. Auditory feedback tool was more efficient than other available speech only designs. Expressions used to evaluate the performance of the tool were "satisfactory and un-satisfactory, like and dislike, easy and difficult". 80% of the students liked the activity and were satisfied with adaptive auditory feedback tool. However, 70% of the students found the activity interesting. Other 30% of the students found it boring and vague.

Results showed that other speech only tools are less interesting than the adaptive auditory feedback tool designed by us. More than 80 % of the students were satisfied with the tool and found it interesting and easy as compared to other tools available. So, the data above shows that Adaptive auditory feedback tool is easier to use, enjoyable and convenient.

5. CONCLUSION

Visually impaired people are unable to view things but other medium (hearing) strengthen them to work with computer interface. Multiple interfaces such as NAVDA, JAWS etc gain popularity among visually impaired people as they provide speech-based instructions to assist while using desktop applications. This paper purposed a adaptive auditory feedback technique to improve performance of task for visually impaired people. Only-speech base or non-speech-base auditory feedback irritate user due to constant repetition of instructions. Purposed Adaptive Auditory Feedback Tool is used switch instruction according to user state, or desire. User can select desired type of instructions either speech based, or non-speech based according to need and want. Purpose system attains highest usability because of easy-to-use interface and switching type of instructions. Experiment done by sixteen highly trained visually impaired people. Results show that 80% of user satisfies with adaptive auditory feedback while using desktop application. Adaptive auditory feedback provides better action awareness, task performance to visually impaired people to maximize user satisfaction level.

In future, same type of adaptive auditory feedback system may implement on mobile applications rather than desktop environment to assist visually impaired people better because in mobile interface it is easy to switch among apps.

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