Skill Specific Spoken Dialogues Based Personalized ATM Design to Maximize Effective Interaction for Visually Impaired Persona

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Abstract. Making machines for visually impaired persons is very challenging because they do not receive any useful information through SIGHT. The perception of background activities can be a good supportive mechanism for visually impaired users. In this work we focus on ATMs and propose a new ATM design, i.e., skill specific spoken dialogues based ATM (3s ATM). The personalized ATM design fulfills the requirements of visually impaired people while provisioning services for normal users also. Our proposed ATM is designed to assimilate into conventional ATMs and enable the effective interaction of visually impaired users with the machine. We first analyze the conventional ATM system through heuristics index to simulate its standardized design. For peer evaluation, visually impaired participants carry out the task analysis for simulated systems, i.e., both conventional ATM and 3s ATM. We found that 3s ATM design achieves 47% higher learnablility and 76% better usability than conventional ATMs. Thus we can achieve the machine compliance by overlooking the barriers and needs of the visually impaired persons in design stage.

Keywords: Usability, task evaluation, heuristics index, HCI, 3s ATM.

1 Introduction

Human Computer Interaction (HCI) deal how human interaction become more easy and effective with the help of different human factors (e.g. psychological methods, soft skills) to complex machines. Since, as long as the complexities of machines are exceeded from human ability, applications of human factors become inevitable for designing machine interfaces, to expedite interaction, besides the provision cognitive relief. To implement software's interaction within machine's interface, that is easy to learn and use, but difficult to build. HCI plays important role to make human lives more comfortable, making machines more usable and effective for normal user. However, the role of HCI is more demanding for designing machine interface, which are equally helpful to use for special peoples indeed. According to WHO 285 million

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people are visually impaired worldwide, 39 million are blind and 246 have low vision in 2012. Hence, public systems like "Automated Teller Machine" (ATM) should preferably be designed to make them also useful by the blind user. Visual sense is a BLESSING indeed, user is able to perceive information at a very high speed as compared to other senses. Since, visual sense is able to precede information at one million bits per second. However, on the other hand visual impairment is a DISEASE which referred as the limitation of activities that can be performed with the help of visual sense e.g. blindness. Blindness refers to visual impairment ranging from legal blindness to total blindness. Visual impairment is a disability of severe reduction in vision. It is severe or sometime complete loss of vision. A person whose corrected visual acuity is less than three, they are considered as visually impaired. A visual impaired person can see light but unable to see shapes. Visual impairment has a deep impact on cognitive development of a person. It reduces the ability of person to perform any task. The perception level of blind and partial sighted person is different. The visual input of visual impaired persons is limited and incorrect and the processing speed to process visual input is also very slow. Visual impaired person have to rely more on their memory and other senses that is why these senses become strong. Visual impaired person face difficulty to perform special task since they developed their own strategies to learn/copy and become proficient to fulfill their requirements with the help of self-developed strategies. Human have different senses and they play a vital role to retrieve information from the environment, most important sense that we used to get information is SIGHT. Peoples who are visually impaired have to depend more on their other SENSES to obtain information. Thus, designing machine's interface for almost, 285 million visually impaired peoples as important as for normal user, to support them while interacting with such a sophisticated world of technology. Since, Graphical User Interface (GUI) has made it possible that visual impaired user can use it but they are unable to use them efficiently as required [3]. Growth in GUI development is getting fast with the advent of time. In the earlier days, command line interfaces were used to interact with system but these interfaces are difficult to use, need expertise, boring and missing the element of user friendliness. While, progress in the interfaces development for visual impaired users is very slow, like, provision of ATM services to visually impaired users. In the earlier designs of ATM history speech driven automatic teller machine provide more natural interaction between user and ATM interface [5].Since, Icon based interface are also introduced in these days as an alternative of speech recognition through, MENUS require accessing the interface of ATM [8], [6]. However, unfortunately visually impaired peoples are barren from such a sophisticated technology. Innovations in HCI and spoken language dialogues give a new direction to this discipline for designing suitable specific dialogue system to reveal ATM services, having full support to interact with visual impaired effectively.

2 Problem Statement

The gap between user skills to machine design has challenged the effectiveness of its usability, even for normal person like ATM. ATM has already several barriers including literacy level, awareness, accessibility, multi interfaces and visual impairment. Despite normal user, visual impaired persons unable to handle such terrible multi screens. While, visual impairment is more specific barrier for visually impaired ATM users. This is mostly a variant that depends on individual's SKILLS and different LEVEL of impairment. The differences between individuals include traits, facts of personality, aptitude, skill specificity and performance. Since, language diversity, vision, color recognition, listening strength are also a variant forms of specificity that may vary person to person. A different individual uses different strategies in order to complete same task [7]. The thing need to be focus is to identify universally correct set of interface FEATURES and to design skill specific spoken dialogues for INTERACTION of personalized ATM. Our research problem related to the questions that: (1) How 3s personalized ATM design useful for visual impaired persona? , and (2) How 3s dialogues based technology influence machine usability to its effectiveness?

3 Literature Review

Spoken language dialogue systems as present development in the field of HCI gave new hopes and expectations. Methods introduced by Gudivada et al are used to separate images from text, these methods gives good result but require more processing power [2]. Use of 3D sounds are also very popular which provide audio cues, the main advantage of this approach is that sound come from one direction. These approaches require user to wear headphones in order to present specialized sound. A solution proposed by Yu et al, to access internet by navigation on web, representation of information and accessing graphical information [12]. Visual, audio and hepatic technology used to develop multimodal interface. A model is proposed by McKiel et al that generate audio on mouse position. This system looks perfect but it is unable to tell the position of the pointer on precise objects [13]. Some issues of visual impaired persons are raised by Goble et al that, visual impaired persons don't know what kind of information is given on page, what is the length of page, how to move forward and how to access tables and frames [14]. Speech reorganization is used to identify/match a word, phrase or sentence with the help of finite set of possibilities. Method proposed by Edwards et al for the first time in which blind/visual impaired user can access computer with the help of derived feature of GUI and peripheral devices [15]. Later on the projects by Edwards et al and Petrie et al were launched, the goal behind these projects are to give complete access of windows system by different methods [16],[20]. An interface is proposed by Mynatt et al, in which tree structure is being used through sound, this interface used a specialized tactile hardware in order to keep objects [17]. Researchers done a great job on the development of GUI's and focuses on different factors discussed above to optimize and fulfill the requirements for almost visually impaired user so far. However, visually impaired were not paying attention, exclusively for ATMs. Although ATM systems used in these days are sophisticated and user friendly but are unable to meet the requirement of visual impaired persons, conveniently. The main reason behind them is that the FEATURES essential for visual impaired persons are missing in their graphical user interface.

4 Proposed Framework

Our study is composed of three major phases, first DESIGN of 3s personalized ATM system, second DEVELOPMENT of simulators to be used as test bed for data collection and finally the ANALYSIS of 3s ATM system with conventional ATM system on well-known principles of HCI. Figure 1 exhibit further steps of framework:

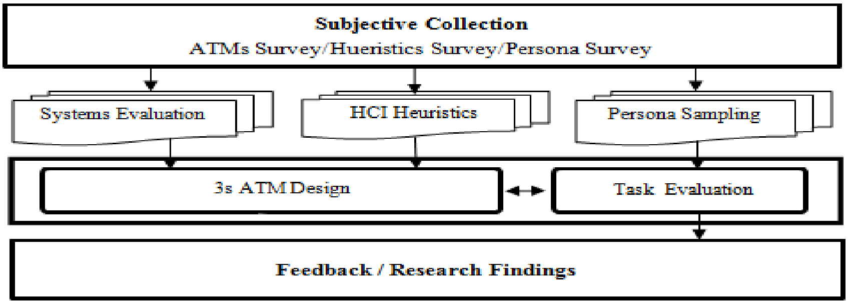

Fig. 1. Study Framework

4.1 Subjective Collection

We have focused four techniques for subjective collection i.e. (1) ATMs SURVEY to simulate the conventional ATM system and subsequently design and simulation of 3s ATM (2) LITERATURE REVIEW for the designing of HCI heuristics index, required for the evaluation of conventional ATM design (3) PERSONA SAMPLING for the representation of visually impaired, and finally (4) TASK EVALUATION to populate the log files with tasks results of participants for ensuing research findings.

4.2 System Evaluation via Heuristics Index

In this stage of our research, as just stated, significant HCI heuristics for 3s ATM design are constituted trough the literature survey for heuristic evaluation of conventional ATM. To rate the significance of heuristics, recommended by HCI experts, we have designed a checklist of HCI heuristics index demonstrated in Table 1, which is intended to design for system evaluation. The system evaluation based on screens and interaction designs of ATM systems, collected through the field survey of two sampled banks, HBL and MCB in December 2013, within the region of Gujrat, Pakistan. This step further constituted of two phases. First, is the 'Interface Analysis' and second, is the 'Interaction Analysis'. The problems found, while ATM systems evaluation were in large. However, due of space limitations some of the sampled issues, concerning interaction and interface design are illustrated in Figure2 and Figure3.

Issues Concerning Interaction Design: (1) Familiarity, Structure, Learnability, Predictability: MCB -ATM process is very obvious, machine interaction starts as long as user insert ATM card, following card validation, machine request for PIN, user follow PIN request, after verifying PIN, machine display option menu to precede transaction. However, HBL machine's behavior is quite different, since after validating card machine display language selection dialogue first, then request for PIN, user follows the request by passing PIN user wait for option menu to display like MCB-ATM experience, thus, time out and card ejected. Since, meanwhile machine is waiting for user action to push ACCEPT button for displaying option menu. Consequently, because of this disparity user perceives machine is out of order.

Table 1. Checklist heuristics index

Interface Com-ponents Focused by Experts to Support :	HCI Heuristics Index	Authors								References
		Constantine	Nielson	Dix et al	Norman	Lauessen	Preece et al	Shneiderman	Treu et al	
Content Cognition	Predictability			✓						[6]
	Learnability			✓		✓	✓			[6],[10],[9]
	Consistency		✓					✓		[1],[11]
	Memorability					✓	✓	✓		[10],[9],[8]
	Familiarity			✓						[6]
Handling Information	Recognition		✓							[1]
	Synthesizability			✓						[6]
	Generalizability			✓						[6]
	Visibility	✓	✓		✓					[11],[1],[18]
	Simplicity	✓			✓					[11],[18]
	Subsitutivity			✓						[6]
	Feedback	✓						✓		[11],[8]
	Error indication		✓							[1]
	Standardizibility		✓		✓					[1],[18]
	Responsiveness			✓						[6]
	Safety						✓			[9]
Handling User Interaction	Recoverability		✓	✓				✓		[1],[6],[8]
	Robustness			✓						[6]
	Flexibility		✓	✓						[1],[6]
	User control	✓	✓					✓		[11],[1],[8]
	Customizability			✓						[6]
	Satisfaction					✓				[10]
	Help		✓							[1]
Machine Performance	Effectiveness						✓			[9]
	Efficiency					✓	✓			[10],[9]
	Effort								✓	[4]
	Error Prevention		✓		✓			✓		[1],[8],[18]
Dialogue Design	Universality							✓		[11]
	Aesthetic		✓							[1]
	Conformance		✓		✓					[1],[18]
	Structure	✓								[11]

(2) Visibility, Conformance, Flexibility and Feedback: While, interactions through MCB ATM as long as user request balance inquiry, after accessing database, machine displayed concerning amount over the screen and offer user for getting receipt. User accepts this by passing yes eventually machine generates slip. However, on the other hand HBL ATM process is quite different which may cause users in trouble if slips tray become empty, Since visibility of balance amount become a serious issue if it will not be displayed over the screen unlike MCB.

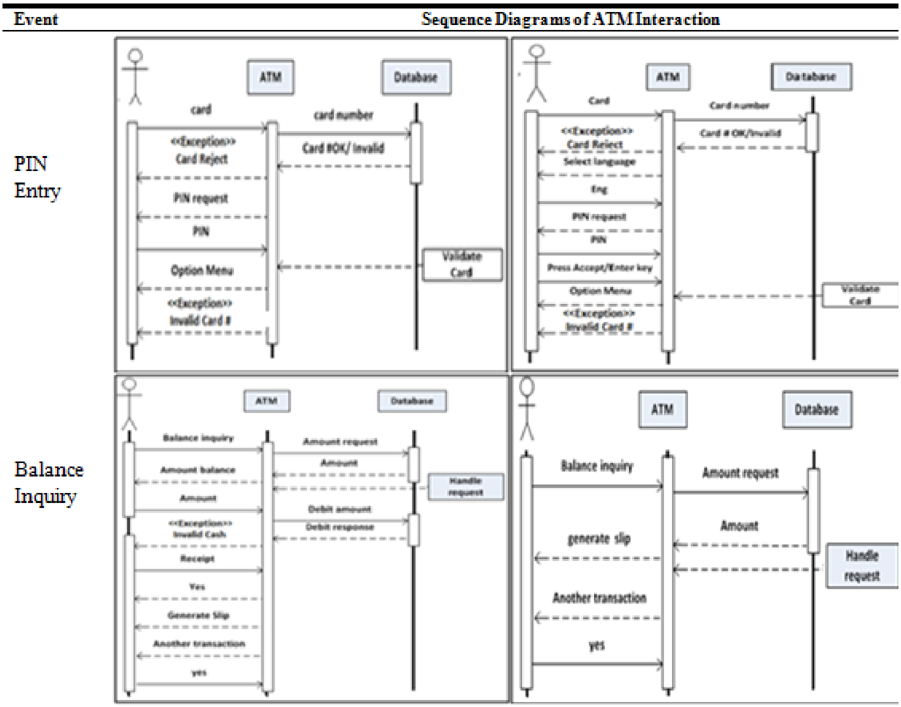

Fig. 2. Interaction Analysis

Issues Concerning Interface Design: (1) Consistency: Button's metaphore do not match with some others ATM keypad design e.g. ACCEPT for ENTER. (2) Flexibility: Other ATM does not have provision of language selection for user, like MCB while interaction. (3) Recognition: Buttons alignment problem caused user to exclusively determine the right button first, to continue. (4) Predictability: Fast cash menu option's amounts are unpredictable for user to choose from main menu.

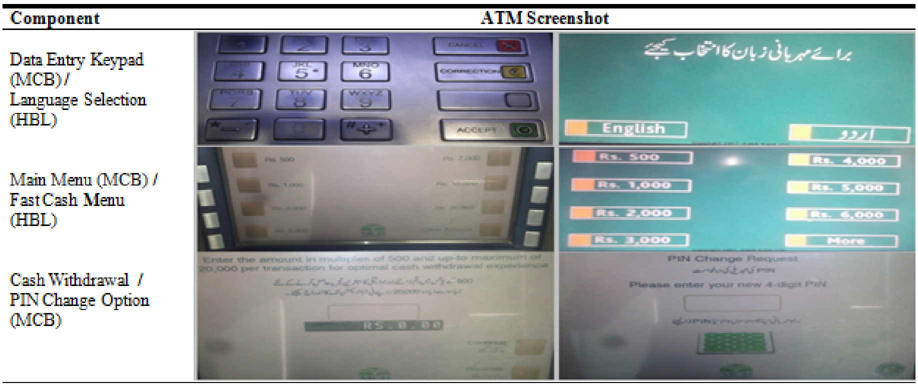

Fig. 3. Interface analysis

(5) Subsitutivity: Numerical format does not seem logical with decimal point, since it does not have to deal with floating point values. Thus, cause confusion and require more key strokes by user while passing required amount of cash. (6) Error Prevention: Unlike HBL yes/no options for error prevention are not available, since if user accidently changes his 4 digit PIN, eventually system does not have any alert to rescue user through confirmation.

4.3 3s ATM Design

The purpose, to device an ATM design in a way that would satisfy the requirements of visually impaired. Thus, while designing skill specific spoken dialogues based system the major issue needs to be addressed on priority basis is how to convey the verity of input by the visually impaired person and how to forward sufficient feedback that enable user to get full orientation. This scenario can only be solved with the help of sound. Since, speech (sound) is the most natural way of communication but systems that provide spoken feedback to the user they are unable to fulfill the needs and capabilities of visual impaired persons and given instructions are very difficult to understand and follow [19]. However, dialogues of 3s ATM design needs to follow skill specific features, which most likely supportive to visually impaired, while interaction, in order to modify or build spoken dialogues according to individual specification are mentioned bellow. **(1) Labels Specificity:** To initiate interaction with machine the position of its components with audible labels, user should be informed. Machine should also let user know, what type of this component is, how to interact with it. For instance at the very beginning of interaction, machine should let user know, where is card reader, and also enable user the way to insert the card. This would, likely to be useful if the interface of card reader, designed similarly to a cone for directing user, to enter card correctly. **(2) Language Specificity:** Language is the most powerful means of human computer interaction. The orientation of audio glances, speech dialogues and environmental sound should be supported with the help of user language. System should also be able to handle speech commands, hot key commands and combination of speech commands within the choice of user language. Language specific command should be supported by language specific speech dialogue dictionary which ensure that one dialogue can be expressed from more than one language. This feature most likely enable visually impaired user to control ATM system more effectively. **(3) Vision Specificity:** Low vision is far better than blindness, since, more supportive to expedite interaction. Thus fount size of screen dialogue should be adjustable by the user to support high visibility. Enabling screen magnification, will also be, highly supportive feature of 3s ATM for effective interaction of low vision user. The combination of sound and vision make a dual presentation of system that support visually and hearing impaired persons, more effectively. **(4) Color Specificity:** One of the most important features of the system is customization and configuration of GUI color for visually impaired, color blind persons having inability to discriminate between red and green. Thus, customizable GUI components may be equally supportive for sighted and color blind users by enabling them customization of color combinations through icon based manual dashboard and speech control commands panel. **(5) Speech Specificity:** Interaction of the user should be supported with the help of dialogue and this is always in the form of audio glances, speech form and environmental sound. System should able to control speech commands, hot key commands and combination of speech commands comfortably. Speech command should be supported by speech command dictionary which ensure that one command can be expressed from more than one method. Using speech synthesizer module that translates machine readable text language to artificial voice dialogues like human speech is a viable solution to seek interaction of visually impaired. This feature enable user to control system effectively and it is equally good for sighted and visually impaired users. **(6) Listening Specificity:** Listening is another subjective skill of visually impaired potential user. This specificity is associated with 3s ATM system by loudness control commands, mode of speech, audio glances, environmental sound and type of speech synthesis output. It is very essential to enable user in order to obtain, review and understand information quickly. Hearing aid is likely to be more useful particularly if the user is hearing impaired? **(7) Proficiency Specificity:** The system should be design proficiency specific and efficient to use, if user has already learned it, then to expedite interaction and chase high productivity should be supportive by the systems through short keys and smart dialogues. **(8) Tangible Specificity:** For effective input and to capitalize user effort, ATM card, key pad and ATM dashboard needed to be redesign for letting user recognize card, buttons and ATM dashboard, through his alternate senses, instead of vision, so that user can touch and feel right key while passing input to the system and right orientation of ATM card while insertion. In addition system should also acknowledge user action through audio glances and spoken dialogues. To help user, embossed dots on number keys should be placed in the design of the keys in such a way, so as not to condense legibility. However shaped and concave key tops may also be helpful in manual interaction for user's having deprived dexterity. To prevent incorrect insertion, cards should also be embossed to at least 2~3 mm, for indentation of correct orientation **(9) Safety Specificity:** The ATM environment should be fool proof to make user transaction more secure and safe. Thus, machine dashboard should be enabled with panic knob to inform security in case of emergency. However, appointment of trustworthy agents outside the cabin may also be useful to keep ATM transactions safe and sound. **(10) Biometric Specificity:** Dealing with Personal Identification Number (PIN) is an issue, for many people, since it is a source of cognitive stress, to remember, recall and enter a 4~6 digits PIN, particularly for visually impaired user. Thus, the solution of these visual and intellectual impairments may also a viable option of enabling biometric authentication in 3s ATM (e.g. fingerprint) instead of using PIN.

4.4 Task Evaluation

In this study, participants sampling constituted to conduct indoor laboratory test. Seven, participants were selected from student population of special education school in Gujrat. Prior task evaluation a task plan was designed, that encompasses three turns, for each turn, every participant has to pass through three task scenarios. A sum of 21 (7×3) tasks was evaluated on each simulator for each turn of participant.

The first step of this phase belongs to the SIMULATION of two ATM designs. Initial, is the simulation of conventional ATM design, developed through the analytical survey of ATM systems used by the banking sector of Pakistan and subsequent, is the simulation of 3s personalized ATM design, proposed for visually impaired persona. For peer evaluation, log base event record files are set in both simulated systems,

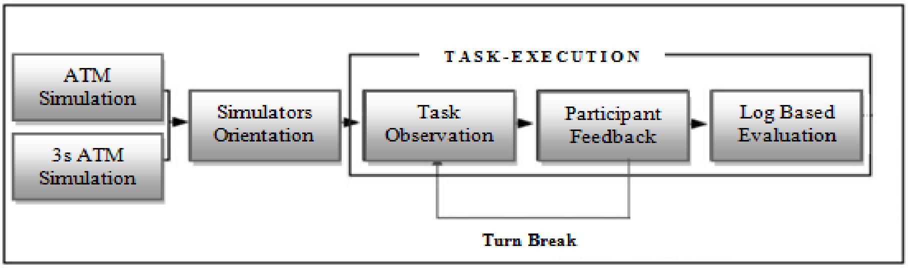

Fig. 4. Task evaluations process

to be used as test bed for visually impaired users, while navigation. Thus, before task evaluation a brief orientation about simulators to the participants was presented. Eventually, number and type of errors, meantime for task completion and task success rate were further analyzed through the task observation and navigation log files to measure the productivity of proposed system relative to the conventional system in practice, using heuristics index. Three task scenarios were designed to evaluate the in lab experiments for sampled participants representing visually impaired persona are: (1) Cash Withdrawal (2) Pin Change and (3) Balance Inquiry. Thus, after finishing, each of the three task scenarios for each of the simulated system, an interview was held during five minutes turn break for participant's feedback related to the effectiveness of system usability, concerning the execution of task scenario. To measure the productivity of both systems (i.e. ATM and 3s ATM) embedded programs of VB with Metro apps of Windows-8, simulated applications were developed to simulate ATM's realism environment in lab to evaluate each of the systems performance and support for participants, while navigation. Each participant out of the 7 is presented with simulated applications of ATM systems for a sum of 6 task scenarios i.e. 3 for each. The participants have to select the required option in given order of Table 2. This is essential that each simulation is exactly mapped out as to the realism ATM environment. However, for this study we have tried to make its conformance with real milieu, except some inevitable assumptions, for instance biometric specificity and card insertion. Since, while using simulated systems in lab, it is not possible for participants to insert ATM card therefore, we have replaced it with most relevant possible solution, which is card swipe. Once the card is swiped successfully by the participant, main menu emerges, inviting user to select interaction language first, and then, obviously prompt participant to enter their 4 digit PIN which is subsequently verified by matching algorithm of simulators. To choose required option, participant has to press the push buttons adjacent to the screen, similar to the real-life ATM. The design of push buttons for selecting option menu was really crucial, since mouse click option would not satisfy the requirements of this case study for evaluating the performance of visually impaired persona on 3s ATM design. For dual presentation embossed designed numerical keypad was acquired for data entry purpose along with audio glances, so that participant most likely recognizes the concerned keys he/she required. Last but not least, as only viable option to seek function keys in simulators, the ENTER, MINUS and PLUS keys of numerical keypad was utilized for ACCEPT, CANCEL and CORRECTION buttons respectively. Thus, this is what our simulators do.

Table 2. Task scenario

Task Description	Subtasks Involved
Cash Withdrawal Pin Change Balance Inquiry	a) Trace card insertion area, swipe card, enter pin to login, b) Choose cash withdrawal, enter amount, acknowledge amount, and transaction completion. c) Do a, and choose pin change option, enter new PIN, confirm this, finish transaction and then re-do a, with new pin and then exit. d) Do a, and choose balance inquiry, get balance also record it to the invigilator.

Table 3. Task evaluation construct of 3s ATM simulator

Turn	Task Description	Successful Tasks Sum	Total Tasks	Productivity
1	Cash Withdrawal Pin Change Balance Inquiry	3 3 4 = 10	7 7 7 = 21	47.61%
2	Cash Withdrawal Pin Change Balance Inquiry	4 3 4 = 11	7 7 7 = 21	52.38%
3	Cash Withdrawal Pin Change Balance Inquiry	5 5 6 = 16	7 7 7 = 21	76.19%
Total		37	63	

4.5 Research Findings

We have observed different barriers by the visually impaired participants while interaction with ATM simulators, since, the lack of sight, inability to read or understand instruction in English, inability to deal with numbers, inability to interact with design and affordability, for instance, inability the way card is handled, particularly with conventional ATM simulator, which was not aimed to design for visually impaired users. Since, this is very obvious reason to understand that our hypothesis become, true when, even a single participant couldn't successful to conduct any task scenario while interacting with conventional ATM design. We also observed most frequent errors on each simulator differ, which indicate that errors are more subjective to the design of ATM and less respective to the user. Since, we frequently observe same participants while conducting wrong digit errors and anagram errors particularly on the conventional ATM, than the 3s ATM design. The results of Table 3 showing that the 3s ATM simulator's productivity is 47.61% greater than the conventional ATM design, exclusively for user's doing first time interaction with the system. However, productivity rate of 3s ATM, stridently increased in 2nd and 3rd turn, to 52.38% and 76.19% respectively. First turn, productivity results reflects that how good enough 3s ATM is supportive to learn, while the productivity results of 2nd and 3rd turn, describes the effectiveness of its usability for visually impaired users. More specifically, these results really strengthen the idea of skill-specific-spoken dialogs based personalized ATM design to maximize effective interaction for visually impaired persona. The method of productivity we adapted to evaluate 3s ATM efficiency factor is:

$$\textbf{Productivity}\ \% = \textbf{Successful tasks sum/Total tasks} \times \mathbf{100}$$

5 Summary

As HCI developed, the ATM system's design should also evolve to acquire the benefits of the new innovations, especially for visually impaired persons, to make this technology equally usable as for as normal users. Through this study, this is very obvious to know that today's ATM systems totally flopped to be used for visually impaired users, since, there are not intended to design by the designers, decisively. The purpose of our study is to raise the awareness among HCI experts for the exclusive requirements and problems of visually impaired peoples into the conventional design of ATM systems. Therefore, in the first phase of our study we design heuristics index based on most significant HCI system's design and evaluation principles. Under the light of heuristics index, subsequently we analyzed the conventional ATM design disparity, which equally affect system's usability by the normal user as special users and also oversight the need/barrier of visually impaired users, indeed. In the second phase of our study, we purposed the 3s ATM to maximize effective interaction for visually impaired persona. The 3s ATM is intended to ensure compliance and assist visually impaired users through: Labels, Language, Vision, Color, Speech, Listening, Proficiency, Tangible, Safety and Biometric specificity, while interaction. In the final phase, through in lab simulated environment, we plane for the evaluation of 3s ATM design to figure out its effectiveness relative to the conventional ATM design. Furthermore, task evaluation is divided into eight steps: developing task plan, sampling participants, preparing tasks, developing simulation, briefing participants, conducting task, logging data and finally converting it into research findings. This research work is specific of its type in a developing country focusing visually impaired persons as important element of society, likely to bring them in the world of sophisticated technology of ATM, and enable them to conduct financial transaction like normal users. Since, task evaluation results reflect that 3s ATM design, constitute a significant compliance to visually impaired participants while interaction unlike to conventional ATM design. Thus, the think need to be focused by the HCI experts is, by overlooking the needs and barriers of visually impaired users, is likely to have adverse effects on taking up the services of modern technology.

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