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Abstract – A website design that allows visually impaired and blind users to access and shop without any assistance. The system gives voice instruction to users and an input is requested from the user. The user is required to hover over the entire page using the cursor to access different voice messages for various fields. The user provides input using the keyboard keys thus taking the process forward.

The website is developed using ASP.NET with its database stored in SQL server. The website also provides recommendation based on customer selection using collaborative filtering algorithm. It is a process of filtering information or patterns using techniques involving collaboration of data gathered from different agents and data sources [1].

In this paper effectiveness and efficiency of the developed website is also calculated based on the usability study conducted with three evaluation methods tested by 4 blind individuals in which the entire system is divided into 5 tasks.

Keywords – *Visually Impaired User, Blind User, E-commerce Website, Visually Impaired Friendly, Human Computer Interaction, Recommendation System, Collaborative Filtering Algorithm, Usability Study, Information System.*

I. INTRODUCTION

According to the World Health Organization (WHO) there are around 1.3 billion people in the world that are visually impaired out of which 36 million are blind [2]. Since most websites are not visually impaired friendly a lot of these people need constant assistance while shopping online. In 2016, the government of India took initiative to make 100 government websites visually impaired friendly but none of them achieved the goal successfully. In India, none of the non-government websites are accessible to the visually impaired people. All these circumstances affect the autonomy of a visually impaired individual. The shortness

of tool such as audio features, detailed description and linear navigation forces a visually impaired person to take assistance from someone and makes it significantly difficult for them to shop online. This is the most frequent reason that they do not prefer to shop online.

It has appeared as a salient need for all kinds of groups in society to have proper access to the World Wide Web. Therefore, it is important to make the World Wide Web accessible for every person despite of his or her capabilities, social status, purchasing power, etc. One potential community that can be discriminated with regards to accessing the web is visually impaired due to strong trend of web sites and applications towards visual utilization.

Our society includes a group of people who does not have proper vision or people who are blind. In recent years there has been great emphasis on the need for making web approachable to visually impaired people. It resulted in generating a significant enforcement on web content providers.

In recent years' tech giants like Apple, Microsoft, Facebook, Google have attempted to make their products and services more accessible for people with disabilities. Examples of which are map navigation, screen-reading technology that describes content on a device and tools that share detailed descriptions of photos [3].

Other e-commerce businesses like Amazon, Flipkart, Alibaba among others are also actively trying to make technology inclusive for everybody regardless of their disability. But have fallen short while developing e-commerce website accessible using desktops and computers that has keyboard/ braille navigation for the sake of the linear flow of the system.

This work is concentrated on an accessible E-commerce website that helps a visually impaired or a blind person to shop and order products online, the paper focuses on different tools, techniques and methods used by developers' in recent years, problems faced by visually impaired in prevailing technology, solution for the same.

Visual Studio software is used for development since it makes parallel programming simpler. It also provides

extensive variety of browser support. SQL server offers better tool support, integration support. It has better speed than MySQL and is compatible with Visual Studio. Java Script provides a responsive web design and has major libraries and frameworks. ASP.NET has a built in authentication to keep applications secured, uses early binding to improve performance, provides simplicity in code, language independent, it also makes the deployment easier.

Section II focuses on the literature survey. Section III focuses on the methods and algorithm used in the website including the design used, method used and the algorithm used. Section IV compares this website with some of the other related websites. Section V describes the future scope. Section VI is conclusion.

II. LITERATURE SURVEY

This section talks about previous studies conducted in the same field and their outcomes.

Borodin, Bigham, Dausch and Ramakrishnan conducted a study in 2010 [4], focused on how visually challenged users use websites to gain the information available. It was found that people use screen readers but this method is not reliable due to links and hyperlinks interruption of the feedback, it was concluded that the screen readers must avoid links and must notify it separately.

Lazar, Allen, Kleinman and Malarkey conducted a research in the year 2007 [5], to identify things that make the visually impaired user frustrated while using screen readers, discovering that layout caused problem for the screen reader and was found that layout must be simple to avoid this.

In 2006, Farnandes, Carvalho, Almeida, Simoes conducted a study [6], to find a technique that can be used in screen reader to support accessibility. It was concluded that before starting the screen reader, the website layout must be transcoded to something that is simpler. For this it must fetch the semantics from the structure of the website, so that the system is able to get the information from inside the website.

Zajicek, Powell, Reeves in 1998 [7], developed a web accessing tool that lets visually impaired user to operate the system. It resulted to the development of BrookesTalk system that uses keyboard shortcuts to let the user operate it. To use this system user must be familiar either with the Braille keyboard or the normal keyboard.

In 2009, Anasuya and Katti [8][9], studied to compare the methods used in speech recognition. It identifies four types of speech recognition which are Isolated Words, Connected Words, Continuous Speech and Spontaneous Speech.

In 2014, Md Abdullah Al Imran[10], studied Amazon: Information Systems, Business Strategies and eCRM and found that the information system of this tech giant doesn't focus on visually impaired or blind users. Although amazon has made efforts and made the mobile version of their website that can be accessed using mobile devices and supports other amazon devices like Fire TV, Fire tablet, and

Kindle e-reader [11]. But amazon hasn't taken efforts to incorporate keyboard or braille for simpler liner navigation.

S Bhuvaneswaran, A K Subramani and M. Prabhu conducted a study in June 2015[12], conducted a customer satisfaction study in Chennai City by conduction a survey and data was collected from respondents through scheduled containing questions. In the study conducted none of the participants contributing to the study were visually impaired or blind. Flipkart also supports visually impaired users with the help of their mobile application and does not have any technology to incorporate it in the desktop version.

Alibaba, the e-commerce giant has plans to launch Smart Touch [13], an affordable silicon sheet that goes on the top of the smartphone screens while would contain 3 buttons for functions like "Go back", "Confirm" and "Return to home page". Alibaba has plans to launch this by the end of the year. Even though Alibaba has incorporated the sense that helps visually impaired people the most it has not developed anything for the desktop version yet [13].

Amazon lets the visually impaired users to "Subscribe and save" a list of products they need regularly so that the customers can directly check out each time making it very simple to make complete the purchase [14].

TABLE I. TYPE OF CUSTOMERS FOLLOWING COMPANIES SUPPORT

COMPANY NAME/ TYPE OF USER	SIGHTED	BLIND
AMAZON	Considered	Not Considered
FLIPKART	Considered	Not Considered
ALIBABA	Considered	Not Considered
AUDIMART	Considered	Considered

Table I shows tech giant companies that have e-commerce website for their business and the type of customer they support in the desktop version of the website and the development efforts by us that considers sighted, blind and anyone in between.

The recommendation algorithm used by Amazon, Flipkart, Alibaba and Audimart websites is "item based collaborative filtering" which suggests customers to buy more products based on the products that are already added to the cart or previous purchases. This recommendation algorithm is of high efficiency and helps upscale the sales. Through the research and communication with visually impaired people it is found that the constant recommendations from ecommerce sites fill up quite a lot of page and increase chances of confusion. Multiple product recommendation makes it difficult for visually impaired people to complete their order and linearly navigate through the page.

III. PROPOSED METHOD

A. Front End and Back End

The website is accessed by two entities namely, Admin and User. Admin can login with their valid login credentials in order to access the application. Admin can add products to the website, and he/she can also manage products by adding new, updating existing category details and can also delete categories and products. Admin can view registered

user's contact and delivery related details. Admin can also view all the details regarding the confirmed order. The admin side of the system is developed using SQL server and C#.

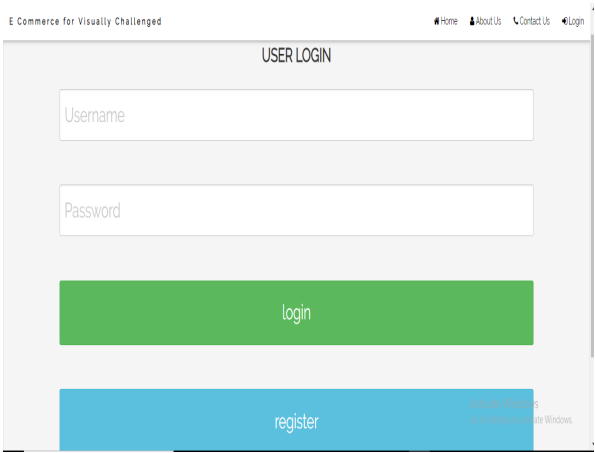


Fig 1. Screenshot of the login page

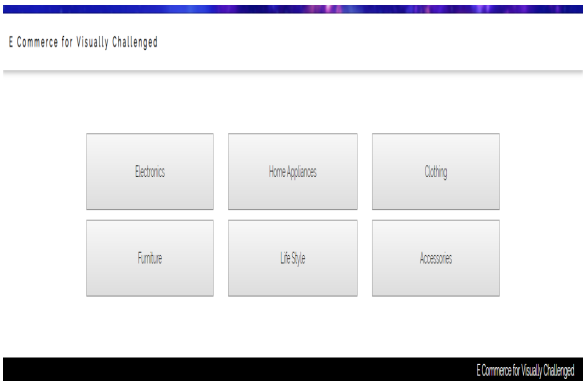


Fig 2. Screenshot of the category page

Considering a blind person, this e-commerce web site has been built for their feasibility so they can order products with ease. Registration and login page consists a system generated voice which helps user to register using input text fields. As the new customer hovers over the screen tabs a voice input is generated. The user input all required information for registration. On successful creation of id and password, user can now access the website. To Login, the user hovers over the page, when the user hover over 'user name' tab, the system generates a voice output saying 'please enter user name', thus prompting the user to type the user name and then the password. After successful login, website reads out the different categories; for example the voice output says "press 1 for Electronics, 2 for Home appliances, 3 for clothing etc." and the user selects the key required to access respective category he/she wants to shop from. After selection users can simply press a keyboard key to add product to cart where they can choose to hear the recommended products. The front end of the system is developed using ASP.NET, JQuery, JavaScript and HTML.

Color blindness is one of the most common visual impairment affecting approximately one in 12 men and one in 200 women around the world [15]. To incorporate the

color blind users a high contrasting color scheme is chosen that is purple and yellow which will help them navigate through the page and distinguish the tabs from one another.

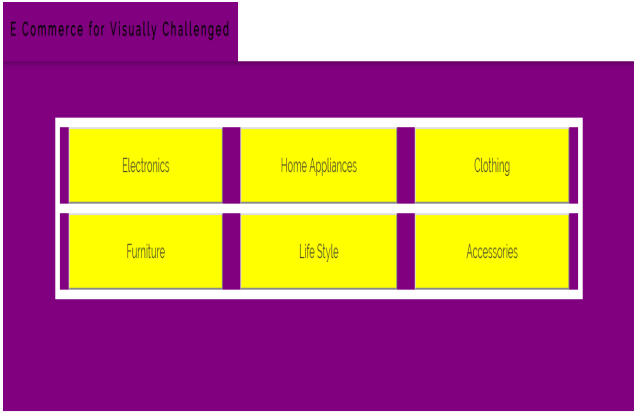


Fig 3. Screenshot of the category page for color blind users

As show in Fig.1. and Fig. 2. the website has a clean and linear flow that helps visually impaired user to access the fields faster.

Fig.3. represents the high contrast color scheme used for color blind users.

B. Recommendation Algorithm

Collaborative filtering algorithm is used for recommendation system. It is one of the most frequently used item based recommendation approach [16]. This algorithm is not based on the ratings but users buying history and is also called item based recommender and is used to build co-occurrence matrix based on the order [16] [17].

i. Flowchart of Recommendation Algorithm

Fig.4. is a flowchart that explains the working of the recommendation system based on collaborative filtering which uses co-occurrence matrix.

- (1) The recommendation algorithm starts with the products in the order database which is used to form a square matrix(p) based on occurrence of one product with others.
- (2) cart summary(q) which is used to form a matrix of order n*1.
- (3) These matrixes are used to find 'r matrix' such that $r = p * q$ where $r_1 \dots r_n$ are recommendation number of products $p_1 \dots p_n$.
- (4) Using this matrix, the product with highest recommendation number is considered.
- (5) The products are recommended based on the ascending order of recommendation number i.e. product with recommendation number as 1 is recommended first and so on.

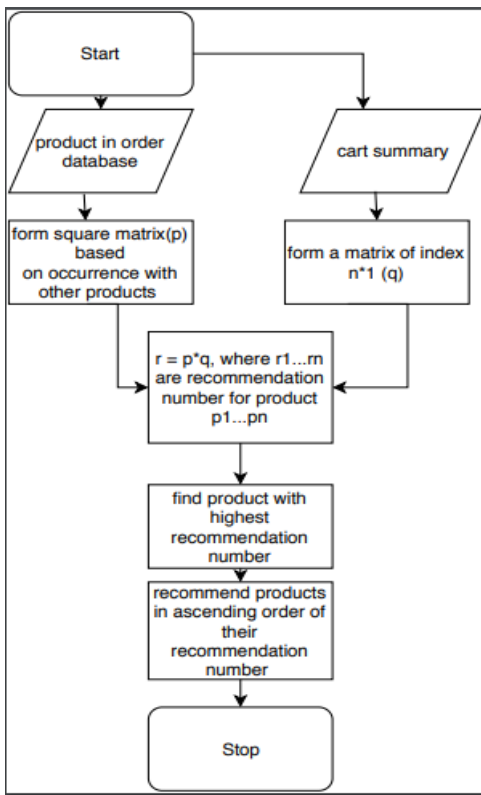


Fig 4. Flowchart for recommendation system.

IV. COMPARISON WITH OTHER RELATED WEBSITES

Currently there are no visually impaired friendly e-commerce websites, there are extensions provided to add to the browser but it only converts text-to-speech, the lack of existing modules makes it very difficult for visually impaired people to navigate through a site and be successful at making a purchase. The Audimart website considers various other factors which includes hovering over the text to convert text to speech, color contrast for partially impaired users, providing text alternative for image, using format supported by screen readers like providing summary about the data tables and avoiding use of emoticons among others. Along with the above mentioned factors the Audimart website also follows all the 11 rules given by WCAG, WCAG (Web Content Accessibility Guideline) is a W3C initiative that stands out as the most comprehensive and general approach among the several existing guidelines for making web content accessible [18].

A. Usability Study

Usability study is based on three evaluation methods Heuristic evaluation, Think Aloud and Post-Task Walkthrough.

Heuristic Evaluation is expert evaluation technique which helps to identify usability problems in the User Interface(UI). Think Aloud is evaluation method done by the user where the user goes through the tasks and talks their thoughts aloud which is recorded with user's permission. Post-task walkthrough is evaluation done by the user where the transcripts are played back to the user and reasoning for some tasks are questioned.

The usability study is conducted with 4 blind users from Mumbai, India. Based on their inputs the effectiveness and efficiency of the Audimart website is calculated.

Usability study of other e-commerce websites was not conducted because none of them supported keyboard navigation and the personas that were considered for this usability study are well versed with desktop keyboard and braille keyboard navigation along with text reader of any website.

B. Calculating efficiency and effectiveness

Based on the activity, the website is divided into 5 main tasks which are further sub-divided:

Task 1: User Registration: - where user has to enter personal details.

- 1.1: Enter Name
- 1.2: Enter E-mail Address
- 1.3: Enter Age
- 1.4: Enter Delivery address
- 1.5: Enter Contact Number
- 1.6: Enter Password
- 1.7: Click Register

Task 2: User login: - where system authenticates user's login credentials.

- 2.1: Enter User ID
- 2.2: Enter Password
- 2.3: System Verifies and Authenticates

Task 3: Select category and sub category: - based on product that user wants to purchase.

- 3.1: Select product category of desired products (e.g.: Clothing)
- 3.2: Select product sub-category of desired products (e.g.: Male or Female)

Task 4: Select product: - selection of products.

- 4.1: Select desired products

Task 5: Checkout and place order: - check the cart and confirm the order.

- 5.1: Add product to cart
- 5.2: Check the cart
- 5.3: Confirm the order
- 5.4: Check recommended products
- 5.5: Checkout

i. Calculating Effectiveness

Effectiveness can be calculated using the completion rate. Equation (1) gives the formula for calculating effectiveness [19].

$$\text{Effectiveness} = \frac{n}{t} \times 100 \% \quad (1)$$

Where, n is number of tasks successfully completed.
t is total number of tasks.

TABLE II. Task completed and effectiveness for each user

	User 1	User 2	User 3	User 4
Tasks completed	4	3	3	4
Effectiveness (%)	80	60	60	80

Total number of tasks undertaken is 5

Average effectiveness is 70%

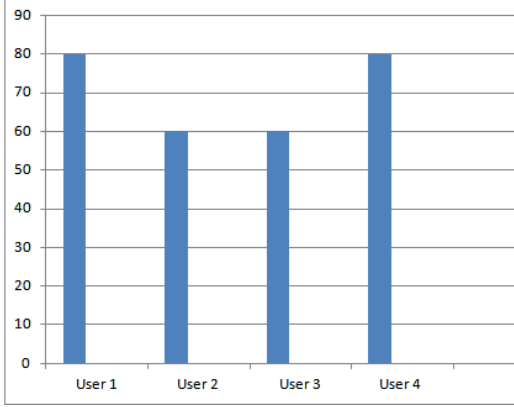


Fig 5. Graph showing Effectiveness

Table II. gives details about the number of tasks completed by each users and by substituting it in equation (1) respective effectiveness is calculated. The average effectiveness of 4 users is 70%. Fig. 5. represents effectiveness for each user in graphical format.

ii. Calculating Efficiency

Efficiency uses ratio of time taken by user to complete the tasks. Equation (2) gives the formula for calculating efficiency [19].

$$\text{Efficiency} = \frac{\sum_{n=1}^N \sum_{m=1}^R \frac{n_{mn}}{t_{mn}}}{\sum_{n=1}^N \sum_{m=1}^R 1} \times 100 \% \quad (2)$$

- Where, (i)N=Total number of tasks (goals).
(ii)R=Total number of users.
(iii) n_{mn} = The result of task m by user n; if the user successfully completes the task, then $n_{mn}=1$, if not, then $n_{mn}=0$.
(iv) t_{mn} = The time spent by user n to complete task m. If the task is not successfully completed, then time is measured till the moment the user quits the task [19].

TABLE III. The value of t_{mn} for each user

(in seconds)	User 1	User 2	User 3	User 4
Task 1	115	120	125	90
Task 2	70	80	90	54
Task 3	51	60	72	55
Task 4	43	57	54	49
Task 5	50	52	52	46

TABLE IV. The value of n_{mn} for each user

	User 1	User 2	User 3	User 4
Task 1	0	1	1	1
Task 2	1	0	0	1
Task 3	1	0	0	1
Task 4	1	1	1	0
Task 5	1	1	1	1

TABLE V. Efficiency wrt tasks

(%)	Efficiency
Task 1	75
Task 2	75
Task 3	50
Task 4	75
Task 5	100

Average Efficiency is 75%

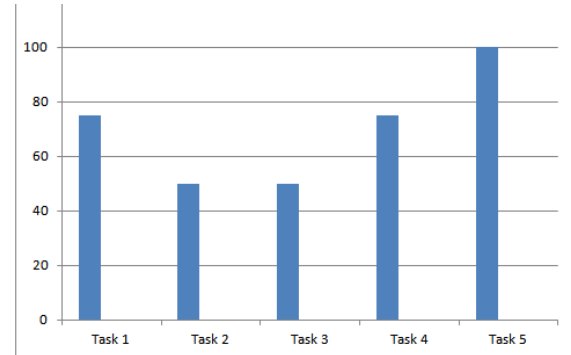


Fig 6. Graph showing efficiency

Table III. represents time taken by each user to complete all the tasks (in seconds). This table is represented in equation (2) as t_{mn} . Table IV. Represents the tasks completed by each user without any assistance. In table IV. 0 represents external assistance was required and 1 represents user completed tasks by themselves without any assistances. This table is represented in equation (2) as n_{mn} . After substituting the values from table III. And table IV. in equation (2) Efficiency for each task is calculated and the values are represented in table V.

Fig. 6. shows graphical representation of efficiencies of each tasks.

V. FUTURE SCOPE

The Audimart website is created so that it helps visually impaired and blind people to use the e-commerce websites with ease. In future with the new studies additional technologies can be integrated with the existing website which further prove to be helpful for the audience in better navigation.

In the future the website can also be converted to a mobile application which can help user navigate with the help of gestures.

With the increasing efforts by major companies like Google, Netflix, Uber, Apple, Samsung to incorporate accessibility, in future the technologies used in the website can also act as an extension to other e-commerce websites so that it increases target audience on a global level.

VI. CONCLUSION

This paper summarizes development of India's first e-commerce website which is visually impaired friendly.

The main motivation for development of such website is lack of availability of visually impaired friendly e-commerce website. The website has linear navigation through entire website and processes voice output to instruct users about each step and the inputs to be provided so that it

is easier for navigation and accepts the input in the form of keyboard commands, apart from this it also uses appropriate color contrast to help visually impaired users and the recommendation system uses collaborative filtering algorithm that recommends the products based on what user has purchased and what is usually bought together with the purchased item by previous users. The website also has separate admin login where admin can manage products and users and perform analysis based on that information. The paper also calculates effectiveness and efficiency of the website.

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