Wear Your Size: A size recommendation web-application for online t-shirt shopping

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1. ABSTRACT

People balk from purchasing clothes online. Part of the reason lies in not knowing the size or fit. This issue is currently addressed by generous shipping and return policies. We have proposed a system: 'Wear Your Size', which can address this issue in human-computer interaction in an e-commerce environment. The proposed system incorporates image processing and object recognition to provide a personalized experience, thereby easing the apparel filtering process for the user. In this paper, we discuss how this feature is implemented and perceived by the user. To understand its impact, we have conducted an analytical and empirical evaluation of our system.

2. INTRODUCTION

The use of e-commerce websites is increasing rapidly. However, these websites need to consider several factors in order to attract users. They need to incorporate a wide range of functionalities to provide a real life shopping experience. With an ever increasing competition, companies are developing websites that not only appeal the user but enhance their online shopping experience.

Along with e-commerce websites, the purchase of online apparels is also on rise. There are several factors that influence the user's choice while online shopping. The GSI commerce survey reports that almost half of the consumers prefer shopping for fashion online. Figure 1 depicts the importance of effective filters that allow users to narrow their product selection, with 55% saying the ability to filter by size and color makes them more likely to buy. [1]

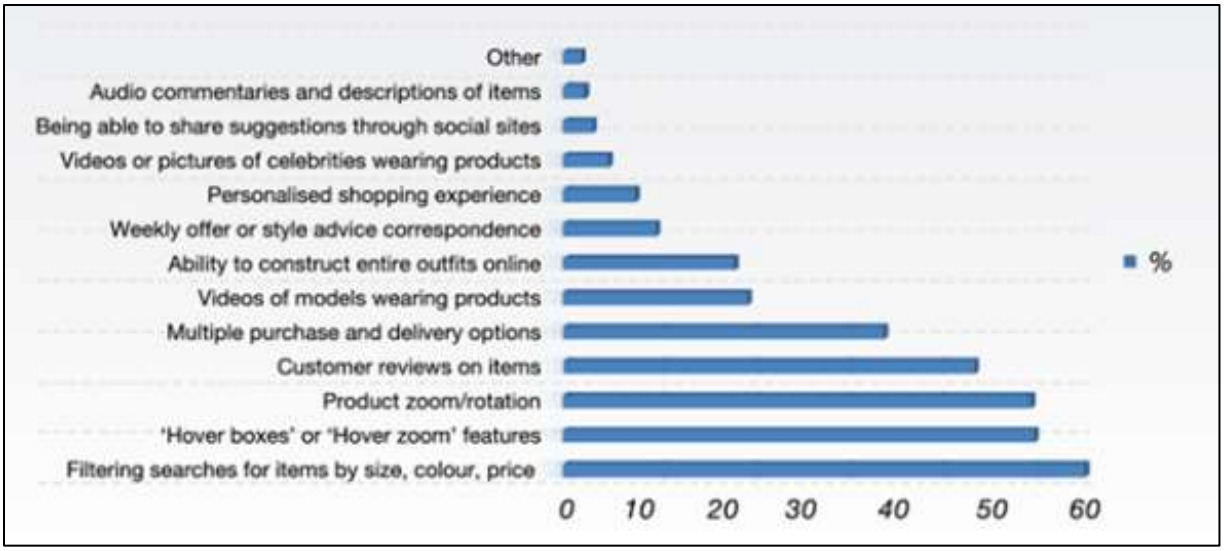

Figure 1: Importance of effective filters on fashion sites

However, filtering items by size is not completely reliable. Different apparel brands have different size scale and users find it difficult to map their size across these brands. Due to this, the e-commerce websites face huge monetary losses owing to high apparel return rate by unsatisfied customers. 48% of e-commerce websites report a return rate between 25% to 50%. [2] Since users are aware of the replacement policies, they are never serious about determining the accurate size of the apparel. Replacing apparels for a different size has become a standard practice. This spoils the underlying business-to-customer relationship.

To solve this problem, we have implemented a system that allows users to filter t-shirts accurately. The idea is to assist the user in recognizing his t-shirt size rather than relying on his size selection judgement. This is achieved by processing information either by doing image analysis of the user holding a CD (compact disc) close to his chest or by mapping a brand and size of a an owned and fit t-shirt. By determining the diameter of the CD in the image, the system computes the shoulder size of the user. This is analogous to the task of actually measuring one's shoulder size before trying out. By mapping the brand-size information across different brands, we remove any size-scale-related dependency. After this, the processed information will automatically be retrieved every time the user logs in. A simple check under the size filter will enable the user to filter the t-shirts based on this information.

The following scenarios provide a detailed understanding about the representative tasks in the system:

Scenario 1: Daniel visits an online shopping website to purchase a t-shirt. He finds number of brands, but not sure which size would fit him. He finds a button 'Know The Size That Fits You' where he encounters three options; first, to click a picture using web camera; second, to upload an image from his laptop; third, to enter brand-size pair. He chooses to use a web camera and stands in front of his laptop with a CD held close to his chest. After the user clicks on 'Snap', a countdown of 5 seconds starts and a picture is clicked. Now he clicks on the 'Filter By Best Fit' button to get the filtered t-shirts of his size.

Scenario 2: Peter visits an online shopping website to purchase a t-shirt. Along with a range of filter options he finds a 'Know The Size That Fits You' button which can provide him personalized size recommendations. After reading the instructions, he then finds out that a photo with a CD held close to his chest is required. Since his web-camera is not functional, he decides to take a photo with his mobile phone. He holds a CD close to his body and asks his friend to click his photo. Peter then uploads this photo and

clicks on ‘Filter By Best Fit’. He then finds search results tailored according to his size for all the brands. This makes his shopping experience easy.

Scenario 3: Sam wants to purchase a t-shirt form an online shopping website. On visiting the website, he filters his search as per clothing brands. However he is not sure which size of each brand fits him the best. Then he finds a ‘Know The Size That Fits You’ button on the website which has three options. First two options: ‘Click Picture’ and ‘Upload Image’ requires a CD which he doesn’t have. So he uses the third option of ‘Enter Known Brand Size’ which asks him to enter the size and brand information of a t-shirt which fits him well. He remembers that M size t-shirt of ‘Allen Solly’ brand fits him, so he enters this information on the website. After entering he clicks on ‘Filter By Best Fit’ by which he gets a personalized page displaying t-shirts of all brands that fit him.

3. LITERATURE REVIEW

There have been continuous efforts in the field of human-computer interaction (HCI) to improve the quality of interaction between the users and the system. Using image processing to identify real world objects is one of the major research areas in this field. It aims to develop system which can respond appropriately to user’s intention and anticipate his needs. This functionality can be achieved by integrating a wide variety of visual functions like localization, object tracking and recognition, edge recognition, etc.

The usage of image processing in the field of e-commerce was recently adopted by an Indian online glasses business – Lenskart [3]. It utilizes the face-recognition aspect of image processing and provides a ‘3D Try-On’ to the user in which they virtually impose the glasses on the user’s face and provide a 3D view in which the user can see how the glasses look on his face in 3D. This is one of the major breakthroughs in terms of HCI and image processing.

Most of the research in HCI is connected with analysis of the dynamics of human face and body. For the core implementation of our project, we required image processing techniques to detect the standard object (CD) as well as detect the edges of the person holding the CD in order to find out his shoulder boundaries. We have used the following image processing concepts and techniques in our implementation.

Circle Hough Transform: The first implementation challenge that we faced was to detect the CD in the image. CD, being a circular object, can be detected by detecting circles in the image. Furthermore, CD has a specific structure of concentric circles which can be used for its accurate detection. For detecting circles in an image, Circle Hough Transform provides a specialization of Hough Transform which uses the mathematical equation of a Circle across the 2D pixel space of the image. [4] The idea here is to keep on drawing circles from each pixel with a specific radius. Since the circles drawn from the points on the circumference of a circle would always pass through the center, it can be used to detect centers of circles with that specific radius. Once the center and the radius is known, the circle can then be highlighted.

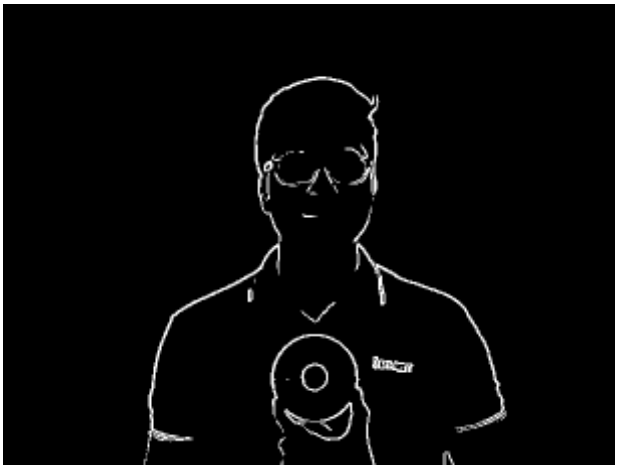

Figure 2: Image after edge detection

Edge Detection: The next challenge was to find out the location of the shoulders of the user in order to compare it with the size of the CD circle detected. To achieve this, the first task is to detect all the possible edges in the image. An edge in an image is a contour across which the brightness of the image changes abruptly. [5] To detect edges in an image, wavelet transforms are used as mathematical tools to analyze the singularities in the image. To implement edge detection, we used Frei and Chen edge enhancement masks. This mask, when compared to the other edge enhancement, operations, is more sensitive to a configuration of relative pixel values independent of the brightness magnitude [6], and provided better edge detection. Figure 2 represents the output when edge detection is applied to a normal image. The edges detected are traced in white whereas everything else is black.

Binary Image Processing: A binary image only has binary values per pixel and is a useful image type which can be used for object detection. After detecting edges in an image, we converted it into a binary image for further processing. The idea here was to start from the image corners and scan each pixel in order to find the first edge of 1s indicating the start of the human body. The binary image of figure 2 is 640x480 matrix with 0's and 1's where 0 denotes a black-colored pixel and 1 denotes a white-colored pixel.

The only drawback of this approach is that there should not be any noise in the image background, which can lead to an unwanted stream of 1s in the background of the image. This may lead to false edge detection of the human body, resulting in an incorrect detection. However, this can be enhanced by doing image smoothing which removes the background noise from the image [5].

4. DESIGN AND IMPLEMENTATION

The process of design started with the discovery phase. A discovery script was prepared (Appendix 2) with an aim to understand whether user acknowledged the existing problem and accepted our proposed solution. Contextual-inquiry revealed that users preferred laptops for online apparel shopping. This helped us to determine that the website should be laptop/desktop compatible. Users didn't specify any particular time of the day but they are usually at home when they do this task. Hence clicking picture with a CD wouldn't be an uncomfortable task. The home environment also allows the user to have easy access to his clothes, in case he needs to change or look into its brand and size. Additionally, we decided to keep the upload functionality as most desktops do not have built-in cameras. With this functionality set, we laid out paper prototypes.

Paper prototyping (see Appendix 3) was carried out to sketch an outline of the interface. Initially, we went with the assumption of loading a different page for each functionality (prototype set 1). But it was evident that new pages would distract user from his primary goal of selecting t-shirts. Hence we shifted to lightbox based interaction (prototype set 2). Lightbox displays the content as an overlay over the main page while the main page content is darkened and inactivated in the background. They increase response rate if they occupy large space and are easy to close. [7]

To simulate the homepage of an actual e-commerce website, we have used a CSS template. [8] This would give the user a better idea of how the proposed system would look. The proposed functionality consists of three options in a lightbox: 'Click Picture', 'Upload Picture' and 'Enter Brand-Size'. This lightbox can be opened by clicking the 'Know The Size That Fits You' button. Since this button is related to filtering and is a core part of our system, we have placed it on the top-left region where filters section begins.

User control and freedom is kept in mind while designing various lightboxes. Thus every lightbox has a 'Back' button to switch back to a previous box and 'Cancel' button to close the lightbox.

Implementation can be categorized as back-end and front-end. The back-end comprised of a Java program that performed image analysis and object detection using OpenCV and Java Advanced Imaging (JAI) libraries. The front-end consisted of the homepage along with the 'Know The Size That Fits You' button and the series of lightboxes consisting of the flow for each option. It also has a JSON object that maps sizes across different brands.

The final involved integrating back-end with front-end. The back-end was transformed into RESTful web service in spring framework and MAVEN dependencies to import the required java libraries. The AJAX calls to this web service was written in front-end. An end-to-end testing was carried out before conducting usability tests.

5. ANALYTICAL EVALUATION

Keystroke-Level Model (KLM) is an analytical modeling technique which is used to find out the approximate time a user will take to complete a task without errors. In this project implementation, the website is the only interaction method for the user to interact with the system. The interaction in each scenario described before, mainly consists of clicking on various buttons/links/images on the webpage. As a result, KLM would be an ideal fit in these scenarios, to find out the time it takes for a user to complete each scenario.

For applying KLM to our website, we need to refine each scenario into a sequence of operations that are performed in each step of execution. Once we have the sequence of operations, we can categorize them into KLM operators and then apply KLM rules.

Operator	Description	Standard time to carry out (seconds)
M	Mentally preparing for executing physical actions	1.35
P	Pointing to a target on a display with a mouse	1.1
B	Mouse button press or release	0.1
R	Response time of the system	System Dependent

Table 1: KLM Operators used in the scenarios

Scenario 1: In this scenario, the user uses the 'Click Image' option to know his t-shirt size. This scenario can be broken down into the following sequence of operations.

1. Click on 'Know The Size That Fits You' on the left hand side of the screen
2. Click on 'Click Picture' from the dialog box
3. Read the instructions for clicking a picture and then click on 'I Got It' to proceed
4. Adjust the laptop/webcam to align the camera, adjusting themselves to fit inside the camera frame, in a noise free background while holding the CD in the correct position
5. Click on 'Snap' to click a picture
6. The system then runs down a countdown of 5 seconds for the user to create a stable pose with the CD
7. System then processes the image, and predicts the shoulder size of the user and displays it on the screen
8. Click on 'Filter By Best Fit' to generate best fit recommendations
9. System then processes the shoulder size and maps it across different brands

Step number	Is mental preparation required?	KLM Operators	Estimated Time Required (in seconds)
1	Yes	M P B	2.55
2	Yes	M P B	2.55
3	Yes	M P B	2.55 (Can vary because of the reading involved)
4	Yes	-	30.00 (Estimated by experimentation – expected value)
5	Yes	M P B	2.55
6	No	R	5.00 (5 seconds constant wait)
7	No	R	1.20 (Calculated as average processing time of the Image processing algorithm)
8	Yes	M P B	2.55
9	No	R	0.20 (Based on the data set we had to filter)
Total Time	-	-	49.15

Table 1: Total time required by KLM operators for scenario 1

The KLM model fits almost perfectly in all the steps of the execution sequence except step 3 and 4. In step 3, the user has to read the instructions on the webpage before proceeding for snapping his image. Now these instructions have a few constraints as it requires the user to hold the CD in a specific manner. So to read and understand these instructions, the user might take up more time. Also the instructions demand for the use of a CD, so the user might have to actually find out a CD in order to proceed. This may require additional time, depending on the surrounding environment that the user is. If he's using a desktop on a desk table, then it's more likely that he'll find a CD nearby. But if he's just using a laptop on his bed, then this might require him to get up and search for a CD. Because of this unpredictability, we cannot accurately predict the time required to complete this step. In step 4, the user has to adjust the laptop/camera, while holding the CD in the required position. We had to empirically determine the amount of time required to perform this step, as KLM does not fit in this sub-task. But barring these steps, KLM gives a fair idea as to how much time it will take to complete the scenario. The estimated time of 49.15 does give us a close estimation of the actual time required by the user to carry out this scenario.

Scenario 2: In this scenario, the user uses the 'Upload Image' option to know his t-shirt size. This scenario can be broken down into the following sequence of operations.

1. Click on 'Know The Size That Fits You' on the left hand side of the screen
2. Click on 'Upload Picture' from the dialog box
3. Read the instructions for clicking a picture and then click on 'I Got It' to proceed
4. Click on 'Choose Image' to choose a picture
5. Browse for the Image on the Computer
6. Select that Image from the Computer
7. Press 'Ok'
8. Click on 'Upload Image'
9. System then processes the image, and predicts the shoulder size of the user and displays it on the screen
10. Click on 'Filter By Best Fit' to generate best fit recommendations
11. System then processes the shoulder size and maps it across different brands.

Step number	Is mental preparation required	KLM Operators	Estimated Time Required (seconds)
1	Yes	M P B	2.55
2	Yes	M P B	2.55
3	Yes	M P B	2.55 (Can vary because of the reading involved)
4	Yes	M P B	2.55
5	Yes	-	8.00 (Estimated by experimenting the average time required for an expert user to navigate to the directory which contains the file)
6	Yes	M P B	2.55
7	No	P B	1.20
8	Yes	M P B	2.55
9	No	R	1.20 (Calculated as average processing time of the Image processing algorithm)
10	Yes	M P B	2.45
11	No	R	0.20 (Based on the data set we had to filter)
Total Time	-	-	28.35

Table 1: Total time required by KLM operators for scenario 2

The KLM model fits better in this scenario, as it does not involve any external factors in the process of execution. The only step which does not fit in the KLM model is the step 5 which involves the user to browse for the image file on his Computer. This cannot be broken down into number of clicks as it would vary based upon the directory location of the file on the Computer. For incorporating this step in the KLM model, we evaluated by noting the average time required by an expert user to browse for a file in the 'browse file' dialog box. On average it turned out to be around 8 seconds, and this value can now be included in the sequence of operations in the KLM model. Overall this scenario takes 28.35 seconds which is slightly lower than scenario 1, and also more accurate due to the absence of external factors.

Scenario 3: In this scenario the user uses the 'Known Brand-Size' option to determine his t-shirt size. This scenario can be broken down into the following sequence of operations:

1. Click on 'Know The Size That Fits You' on the left hand side of the screen
2. Click on 'Enter Brand-Size' from the dialog box
3. Click 'Select' on the dropdown box adjacent for brands

4. Select the appropriate brand.
5. Click ‘Select’ on the dropdown box adjacent for size
6. Select the appropriate size.
7. Click on ‘Filter By Best Fit’ to generate best fit recommendations
8. System then processes the entered brand-size and maps it across different brands.

Step number	Is mental preparation required	KLM Operators	Estimated Time Required (seconds)
1	Yes	M P B	2.55
2	Yes	M P B	2.55
3	Yes	M P B	2.55
4	No	P B	1.20
5	Yes	M P B	2.55
6	No	P B	1.20
7	Yes	M P B	2.55
8	No	R	0.20 (Based on the data set we had to filter)
Total Time	-	-	15.35

Table 1: Total time required by KLM operators for scenario 2

All the steps in this scenario can be easily mapped onto KLM operators which summed up to a total of 15.35 seconds. The only constraint which can affect the estimated time is the knowledge about the known brand-size to the user. If the user knows it before hand, then the estimation holds true. But if the user does not know his perfect fit brand-size combination, he’ll take more time to actually recollect the information, or else even check his own t-shirts to find out the correct combination. This cannot be taken into account in the KLM model for the execution time estimation, but it might play a significant role when this is experimented in practice.

Analysis of the results:

The result of the analytical evaluation infers that scenario 3 would take up the least time to accomplish. However, there are constraints which will determine which scenario is the best approach for the user to find out his t-shirt perfect fit.

Scenario 1 constraints –

1. Must have a working web-camera
2. Must have a CD
3. Must provide the correct position of the CD in the image
4. Must wear a t-shirt contrasting with the background so that the edges would be refined

Scenario 2 constraints –

1. Must have an image beforehand with the specific constraints
2. For having such an image, the user should also follow constraints 2, 3 & 4 of scenario 1

Scenario 3 constraints –

1. Must have knowledge about size and brands
2. Must know his perfect fit in at least 1 brand

Upon analyzing the constraints, we can infer that each scenario has its own set of prerequisites which are a must for the user to perform, in order to correctly utilize the system. So, based on the KLM results we cannot distinguishably say which scenario is the perfect for any user. Each user will have its own preferences and knowledge, which might fit well in one scenario's constraints than the other. This is the reason why, we decided to provide all the three options for the user to decide from, implementing all 3 functionalities. It is then purely up to the user to decide and choose the most appropriate option.

6. EMPIRICAL EVALUATION

Test Plan

The aim of the user testing was to judge the usability of the system from end user point of view. The users were given the freedom to choose the test environment. The tests were conducted at the users' apartment as per their preference. The implemented system was first introduced to the users and its functionality was explained in detail. Three scenarios were presented to the users which required them to perform a set of tasks on the system. The test was meant to analyze the ease with which the users performed these tasks. The test considered 'time' as a parameter for quantitative analysis. The time taken by the users to perform each task was recorded. The test also measured the accuracy of the results and compared the actual and computed values. A feedback was taken from the users at the end of the test to measure the satisfiability of the system.

Users Involved in the Test

The system was tested by 4 users. All of them are Computer Science graduate students at NC State. All of them were in the age group of 20-25 years. Three out of them were non-HCI students and one of them was an HCI student. The users had prior experience on online shopping. Being from a technical background, they proficient in the use of computing devices like laptop and mobile.

Tests Conducted and Results

Given below are the results of the test for the four users. The time taken by them to complete tasks in each scenario along with the problems they faced were recorded.

Accessing the functionality:

The users were asked to search for a functionality wherein he can obtain recommendations for t-shirt size across brands. For this they were required to search a button with label 'know the size that fits you'. Given below is the table which records the time taken by each user to find this functionality.

Users	Time to locate 'Know the size that fits you' button (seconds)
Glen	12
Raunak	08
Abhishek	18
Deepak	03

Table1: Time taken by user to find the 'know the size that fits you' button

As seen from the table above some users required more time to locate this button. This is because the users felt that the button was not properly highlighted and should have been catchier as it is a unique and

important feature of the website. Some, mistook the button as an advertisement and hence refrained from clicking it.

Scenario 1 - Capturing image with CD using Web-Camera to obtain t-shirt size recommendation:

Users were required to hold a CD close to chest in front of the web camera. They had to position themselves properly in front of the web camera and also adjust the position of the CD. Given below is the time required to carry out scenario 1 and also the number of attempts required before a correct image was captured.

Users	Time taken to complete Scenario 1 (seconds)
Glen	124
Raunak	115
Abhishek	65
Deepak	40

Table 2: Time taken by users to complete tasks in scenario 1

As seen from the above table, this scenario had time consuming tasks. These tasks required user involvement and hence were considered demanding by the users.

Users	Total number Of Attempts for Correct size determination (using webcam)
Glen	2
Raunak	2
Abhishek	1
Deepak	1

Table 3. Number of attempts required to capture an image required to obtain correct shoulder dimensions when image was captured using webcam

In some cases, it was required to capture the image more than once because the users did not hold the CD as per the instructions or there was noise in the image background. The system, asked the users to recapture their image. This increased the amount of time required by the users to complete this functionality.

Scenario 2 – Uploading the image from the PC to obtain t-shirt size recommendation:

Here, the users already had an image stored in their PC as required by the system. Given that the image had already been captured in the required format, the users required lesser time to complete this scenario.

Users	Time taken to complete Scenario 2 (seconds)
Glen	35
Raunak	32
Abhishek	45
Deepak	28

Table 3: Time taken by users to complete tasks in scenario 2

This functionality could come in handy in scenarios where capturing image using webcam is not possible because of surrounding problem (example: Insufficient light, plain t-shirt or environment not available etc.)

Scenario 3 - Enter the Brand - Size information of an owned t-shirt that fits perfectly to obtain t-shirt size recommendations across brands:

This functionality was the most preferred one and users found it easy and quick. Since most of the users possessed a t-shirt of a known brand which fit them perfectly, they could easily enter the required information and obtain results.

Users	Time taken to complete Scenario 3 (seconds)
Glen	30
Raunak	36
Abhishek	42
Deepak	10

Table 4: Time taken by users to complete tasks in scenario 3

As seen from the above table, the time required by the users in this scenario was minimum as compared to the first two. But this functionality requires its users to recall the brand and size information.

Accuracy of results obtained:

The effectiveness of the system is determined by the accuracy of the results provided by the system. A system's accuracy determines if it can actually be deployed in real time. The actual shoulder size of the users was measured by using a measuring tape, prior to the test. These values were then compared with the values computed by the system.

User	Actual Shoulder Size (inch)	Observed Shoulder size (inch)	% Accuracy
Glen	17.25	17.00	98.55 %
Raunak	19.70	20.00	98.47 %
Abhishek	17.50	17.00	97.14 %
Deepak	18.00	18.00	100.00 %

Table 2. Actual and Observed shoulder sizes of users with % accuracy

As seen from the above table, the system provides pretty accurate measurements. With such an accuracy, the user is likely to receive perfect size recommendations. From the feedback, it was evident that the users were satisfied with the results

Feedback from the users

After conducting the test, the users were asked to rate their usage experience while using the system. The rating reflects the ease with which the tasks were performed by the users. They were asked to rate on a scale of 1 to 5, wherein 1 is the lowest and 5 is the highest rating.

Users	System Rating Scale 1(low) - 5(high)
Glen	3
Raunak	5
Abhishek	3
Deepak	4

Table 4: Rating provided by the users in the feedback after the test

The users found the User Interface very easy to use and intuitive. They found the functionality of using light boxes (pop-up windows) very easy to use as it prevented redirection to different pages. This facilitated ease of navigation between screens and ease of accessibility. The results of the recommendation system

were accurate and hence the users were ready to accept the t-shirt sizes recommended by the system (refer appendix for user interviews). Users were also ready to use a website where the new filter system replaced the older, traditional size-filters.

Conclusion

The results obtained were close to the ones predicted by the analytical evaluation done by using Key Stroke Level Mode. Since, the system sometimes required to recapture user image using web camera due to noisy image, the required time in these cases exceeded the expected time. The system has an area of improvement, wherein it can provide dynamic feedback to the users before capturing image about the correctness of user and CD position. This can avoid recapturing of image and thereby reduce user stress.

It can be inferred from the above results that the user size calculation and t-shirt size recommendation results were satisfactory. The system provides a good user experience and is incorporated into current systems, has the ability to increase their effectiveness. From the feedback, it was evident that the users were ready to replace the traditional size filters with this new type of personalized size filtering. It means that the system is sure to improve the usability of the exiting e-commerce websites.

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