The Design and Development of a Web-Based Virtual Closet: The Smart Closet Project

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***Abstract*—Smart Closet is a web-based recommendation system where users can register and create their own virtual closet .In the Smart Closet system; users can add items, search, and find matches for items from the personal collection of clothing within the internal database. Moreover, users can search for matches of their clothing items from virtual vendors collections that exist in the database .The system can also make recommendations based on the user's pre-specified preferences, sex, item type, seasonal fabrics and colors. Thus, the aim of the system is to introduce a centered virtual location that can put the user, his clothes and the vendors in one place of interaction through the invention of a smart recommendation algorithm that can lead to the simplification of the processes involved in choosing, buying and searching for a clothe. Furthermore, future improvements can be applied to put this system in the real closets and allow the users to share their outfits and to make it a social networking environment. This paper describes the design and development of this virtual closet system; design implications are also discussed.**

***Index Terms*—virtual closet, recommendation, persuasive computing**

I. Introduction

As technology advances, life becomes easier; and as developers we aim to achieve this goal by providing easy and useful applications that simplify tasks in people's daily life.

Selection of clothing is part of the daily routine of individuals and there are often problems in selection and management of clothing. Users often find it difficult to select key items of clothing from a large personal collection. The problem of searching in large collections of inventory has been reported in many domains like keeping track of hardware or software in labs or in academic institutions. Problems related to inventory management have been reported in EMCO Network Inventory [1], the Inventory System designed for the Commerce Server [2], Managing Laboratory Chemical Inventory [3] and An Inventory Management Problem [4].With personal collections of clothing, fewer systems have been designed that actually address the needs of an individual user who often experiences difficulties in finding pieces of clothing, and matching items of clothing. Furthermore, the complexity and time involved for the purpose of pulling together a coordinated outfit remains a challenge for many individuals either due to the large collections, lack of knowledge of season-specific or expertise in the variations between casual and formal styles. From all above, the concept of a virtual representation of a 'smart closet' emerged to address the issues of cost, time and effort in locating items to complete an outfit and managing the selection of items. So our smart closet system was designed to help users manage the clothing inventory in their closets and have the intelligent assistance of recommender system to help them find the right matches and appropriate styles for the season of the venue.

Our virtual closet aims to arrange a user's virtual collection as a closet as shown in Fig. 1.

It suggests many forms of matches that are not taken only from the individual's own closet but also from a group of leading designers and specialists in the fashion industry from across the world. The concept of the system is to facilitate connecting with those fashion

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vendors and key players in the industry by providing an opportunity for them to reach out to customers with channels of dissemination of their seasonal collections.

An important point is that this software is envisioned to be developed further to be integrated in real closets and become ubiquitous within the daily routine of the individual's personal interaction with technology. This paper describes the main phases we followed in developing our Smart Closet which are: analyzing, designing, implementing and testing the system.

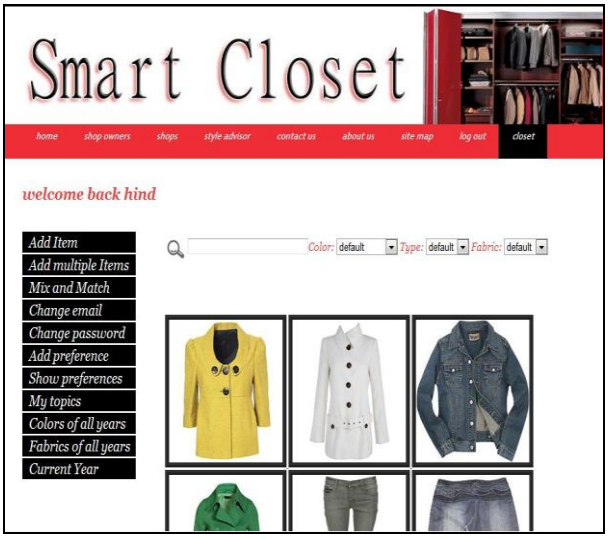

Figure 1. Example of a virtual closet

II. Virtual Closets

Our aim is to benchmark our smart closet system to what exists in the field so as to compare features and identify opportunities for improving the design of such systems. Several systems have been developed in recent years that are concerned with fashion. Some of these systems are designed as websites that provided a virtual closet for the customer to add his clothes, but not all of those websites provide the recommendation service. Although advances in computing have led to the design and development of intelligent recommender systems, for example: A recommender system for on-line course enrolment [5] and A recommender system to provide adaptive and inclusive standard-based support along the e-learning lifecycle [6], the trend is less evident in personal collection of clothing inventory such as the context of our system. Existing virtual closets systems also differ in the key functionalities that they include and thus utility is inadequate in such systems.

In our review, we selected four websites which were the closest to our proposed idea for an in-depth analysis of functionality. These websites are: Closet Bank [7], Polyvore [8], Closet Couture [9] and Shop for Clothes [10]. The Closet Bank was found to be the most comprehensive in terms of functionality for the context of available virtual closets. However, it was lacking the recommendation aspects of clothing and the virtual community that can connect individuals with similar interest which can also provide opportunities for crowd-sourcing opinions on such a subjective task. Smart closet is designed to suggest what to wear; in contrast, the closet bank just gives the user the ability to browse his clothes and use the drag and drop facility to arrange them and have a look what it may look like when he wears these items together. So it doesn't really save the user's time because users are involved in all the matching work without any assistance from the system. In addition, Polyvore and Closet Couture don't actually suggest what to wear but you can ask other people for a style advice. Furthermore, we found that Shop for Clothes provides the suggestion service based on the user's preferences and personal information only. Also, it is mainly a shopping website which allows the user to create a virtual closet that doesn't include the real clothes of the user, instead, the items must be chosen from the vendors. It differs from our closet in that our closet items are of two kinds: the real clothes that exist in the personal collection of the individual and the items that the user can consider purchasing via shopping sites affiliated to the system.

III. System Models

In the design of our system, we were guided by a series of system models to conceptualize and construct our virtual closet and recommender system. And because our system is better described by functions rather than classes, we chose to model it using the structured approach. The structured approach is based on the representation of the functions and processes within the system.

The DFD of our system is illustrated in Fig. 2, and shows the key users interacting with the system and the flow of information exchange that occurs between these entries.

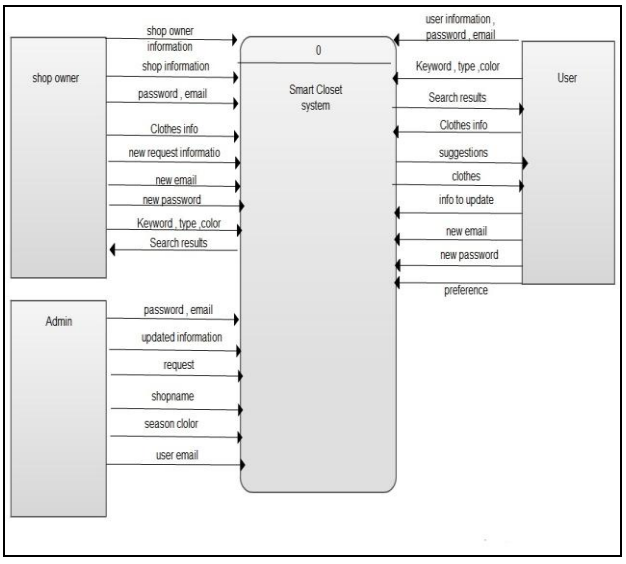

Figure 2. DFD context diagram

IV. Recommendation System Implementation

The smart closet facilitates a lot of features to the user, but the suggestion mechanism is what really makes it stand out from other similar systems. In order to implement the recommender aspect of the system to

suggest items for users, we have to put in mind a lot of considerations and limitations to get to the best suggestions. We are mainly using the limitation process by means of eliminating inappropriate selections of items in the inventory (i.e. the clothes) whenever possible. For example, at a high level of reasoning, the system can eliminate any dress item if the user was a male and the similar logic is embedded at lower levels of implementation. Table I. describes and explains the most important factors that we followed in the clothing suggestions' process.

TABLE I. FACTORS CONSIDERED IN OUR RECOMMENDER SYSTEM

Factor	Description
Preferences	Each user can set his preferences of color matching and the algorithm will put it first.
Sex	For each sex type its own set of clothes types. Some items can be pre-tagged for its appropriateness for one gender and not the other.
Item type	For each clothing type, there are specified other types to wear with. For example, the system doesn't recommend wearing a skirt with pants, but recommends wearing a blouse with a skirt.
Season color	We put results that match current season colors first after preferences "if there are any".
Fabric	Each season has its own fabric, for example: wool can't be worn on summer.

The suggestion could be one of two types either to suggest user clothes from his own closet or to suggest matches with items that do not exist in the personal collection but rather from other vendors linked to the Smart Closet.

V. IMPLEMENTATION METHOD

There are several methods to implement the concept of a smart closet, for example it can be implemented as separate software that can be downloaded to users computers or as a website, and we chose to implement our project as a website for different reasons:

- To reach the maximum audience.
- No need for download.
- Easier to update automatically, in case software users need to download updates.
- Can work in different platforms (we don't need to implement two versions for different operating systems such as, Windows or MAC OS).
- We can develop with different programming languages simultaneously in an effective platform.

We implemented the project using PHP as the main programming language; we also used Java Script and SQL for developing the functionality of the Smart Closet.

VI. SUGGESTION ALGORITHM

Since the suggestion aspect of the Smart Closet is the key contribution of this virtual closet, this section describes the basis we followed in writing the source code in detail. Fig. 3 shows an example of a suggestion generated by the system. Fig. 4 shows how the mix and match facility looks like.

Figure 3. Example of a suggestion generated by the system

Figure 4. Mix and match page

The most important factors that we followed in suggestion process and how it was implemented are listed below:

A. *Preferences*

Each user can set his preferences of color matching and the algorithm will put it first by requesting the preferences list of a specified user id and rearrange the chosen styles to put any item with a preferred color at first.

B. *Sex*

For each sex type, the clothes types are specified. Women can wear dresses, skirts, jackets, pants, blouses, and tops where men can wear jackets, pants, tops and blouses. If the suggestion was from other shops which contain clothes for both men and women, we have to make sure that we don't suggest a women item for a man or a man item for a women, so the shop owners must specify if the item they add is for men or for women and then we will compare the information with the one in the user's profile.

C. *Item Type*

For each item type, there are specific other types to wear with. The item types are specified by the user and

the database contains the rules for mapping each type to another to make a correct match, so we can easily set this condition.

D. Season Color

We put results that match current season colors first after preferences "if there is any". The algorithm will put it second by requesting the season color from database and rearrange the chosen styles to put them after the preferred ones if there is any.

E. Fabric

Each season has its own fabrics, mainly most of fabrics are suitable for all seasons but we put if conditions for some fabric type, for example

If season = summer or spring

Find all item types with fabric != wool.

VII. System Integration

Our system is composed of three main components; the first component is related to the ordinary user, the second for shop owners, and the third for the administrative management of the system.

We first implemented the ordinary user component and then we implemented the shop owner component and related it to the ordinary user part to deliver suggestions from shops and finally the admin component and relate it to shop owner component to track their registration information. Each system component is designed to work individually except for few related functions.

The integration of system components involved a number of steps. First, when we started integrating our website, a local host program was used, XAMPP software which is a free open source package that contains Apache HTTP server and MY SQL database and interpret server side scripting languages such as PHP language. Exporting to the host server involved a number of database adaptations to facilitate the effective implementation of the recommender system. Second, in changing email function in the user account and shop owner account, we faced a problem that if the email changed and then back to the closet page or shop styles page, the clothes are changed according to that, because the closet page display clothes according to the user email stored in the session. This problem was addressed, by signing out the user or shop owner (to clear the session) and ask users to sign in again. Further integration was completed without complexities in the component performance.

VIII. User Acceptance Testing

We have conducted a survey to examine the user opinions with our website's look and feel and usability level. Key questions that were explored were:

- I found the system interface more interactive with user.
- I think the system was easy to use and do not need skills
- I found the various functions in this system were well integrated for user.
- I found the system easy to read (both font style and size).
- I felt very confident when using the system.

After conducting the surveys, we discover some issues that were perceived as confusing to users like:

- When logging in with wrong password, they suggest to us to put a link to go back to log in page.
- Some users don't know exactly the current date and month especially unemployed people so, they suggest to us to put a link to a page that displays the season, colors and fabrics that keep pace with fashion in this current period in fast and easy way without the need to search for the information.
- Some users find beautiful clothes in the closets of shop owners and buy them online or offline so, they suggest to us to put option "add clothing" for each clothing item in the closets of shop owners to allow them to directly add the clothe information to their closet without the need to do this by themselves as a normal add of clothe.

Some users mentioned that adding one item at a time wastes time, as a result we implement adding more than one clothe simultaneously.

IX. Conclusion

In this paper we described the virtual closet recommendation system. In the development phase we built a smart recommendation algorithm that makes clothing suggestions to the users either from their own clothes or from the items of the vendors who are registered in our website.

It is envisioned that this type of system can assist users to easily manage and search their closets to save their time. They also save money, helping them not to buy unnecessary items and browse shops instead of going to malls. It is also envisioned to help people to stay up to date with the latest fashion trends by supporting their knowledge with expert recommendations and crowd-sourced opinions from the virtual community that is embedded within the design of our Smart Closet.

On the vendor level, this system offers virtual shops that people can visit and view items. This system may be interesting since it can advertise the shop items by suggesting them to users "when appropriate". Also the smart closet builds a small virtual community for all people who are interested in fashion and let them share their opinions and tastes. They also can benefit from the fashion topics and posts that are written by designers and experts who registered.

Future work involves special device that saves the picture of the item and analyzes it to come up with its specifications. We can optimize the original web site after people use it and provide feedback through acceptance testing, in order to better address their needs.

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