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# A Decision Making Framework for Dressing Consultant

Ching-I Cheng and Damon Shing-Min Liu

***Abstract*—The project, Dressing Consultant, aims to provide a system which functions as a personal wearing advisor to help general users choose a correct clothing for occasions. ALCOVE (Attention Learning Covering network) neural network model is used to train the matchmaker as a fashion editor. In addition, image processing techniques are employed at pre-processing stage to obtain the essential data of garments and to build a digital wardrobe for individuals. On the occasions when user has trouble finding an outfit for a special event, what user could do is to make a decision of the style of apparel to the system and let the system go through piece of garments in the digital wardrobe, and the Matchmaker will then find several matched pairs. Eventually, the most similarly suitable and matched garments pair is shown in 3D Show Room. This paper focuses on making decision of correct clothing according to those classifying and matching rules extracted from fashion industry.**

## I. Introduction

ALTHOUGH "Vogue" can be seen everywhere in daily life, in general people do not know exactly how to get good stylish attire to show confidence with fashion, and to say the right things with the right appearance to the right occasion. Many people have experienced the situation when standing in front of wardrobe and finding their mind goes blank. "What shall I wear?" and "How shall I dress?" are two popular daily questions for most people before going out for dates.

People often try to hide colossal diffidence and prove personal value, attract attention and sometimes to confirm the superiority with the help of some attire. Clothing therefore becomes a part of large context in appearance and is influenced by different culture and environment [1-4]. Some social scientists emphasize that appearance is not only a visual image, but also a process when thought of in terms of social relations [5]. However, taking two matched pieces of garments from the wardrobe and making sure they suit to the appearance one likes is not an easy job. Completing this procedure needs kinds of knowledge including color psychology, clothing psychology, and fashion sense, creating not only for a great appearance but also for the right scenes. It would be a plus if we had a personal style consultant to give clothes matching suggestions before having an important appointment. This is where the original idea of our research came from.

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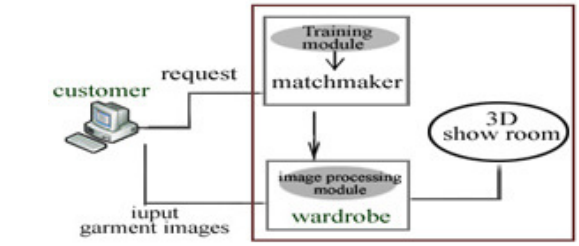
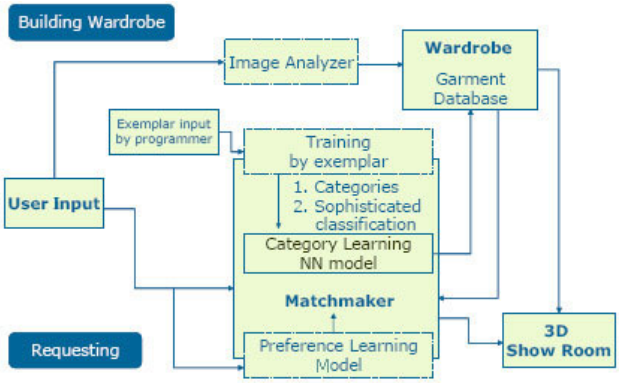



(A)




(B)

Fig 1. (A) An architecture of the system. Users firstly input their garment images to build the wardrobe, and then request for clothing advices. Eventually, matched garments will then be shown in 3D Show Room. (B) Demonstration of the detailed working flow.

With computer technology rapidly growing, researchers keep working hard on innovating computer applications which can enhance our daily life easily and conveniently. Artificial intelligence, for example, is one of the popular research fields and aims to developing AI robots to work for human beings. A decision support system always helps people analyze business data and make businesses decision easily, such as market selecting strategies. Three-dimensional fashion design system helps designer work on 3D view instead of paper work. Hence, a knowledge-based clothes matching system which functions as a personal style advisor to general users, is a useful application in the modern fashion society. Our research is to integrate clothing psychology, digital image process techniques and categories learning techniques to build a semi-automatic personal clothing consultant.

Wardrobe, Matchmaker and 3D Show Room are the three major parts studied in this project (see Fig.1). Each person has different wardrobe, so building a virtual personal wardrobe is the main task in user pre-processing stage. Users need to take two photos for each garment (with the same camera angle and environment), one from the front and the other from the back, as the input information for the garment


Fig 2. The enquiry platform of the project. Users can query for fashion match suggestions by simply submitting several key requests, such as appearance, occasion, and weather, to the system.

analyzer and to build the personal garment database. An image processing module is added to analyze the essentials of garments, such as major hue and outline. Once the database has been built, users can query for fashion match suggestions by simply submitting several key requests to the system. (Fig. 2 depicts the enquiry platform.) Matchmaker then follows those rules extracted from Training Module to search matched garments within personal wardrobe. The third part of the framework is a 3D Show Room, it gives the user a 3D visualization of a number of garments that were selected by the system. The user can then browse those highly matched clothes in 3D view. The specific dress code discussed in this paper is being implied by the society, and how the fundamental rules of matching were distilled from the stylists in fashion business.

It is generally known that a great portion of population would spend a great deal of time for their appearance. Some may have tens and thousands of clothes but still have trouble finding a suitable and stylish pair from their wardrobes each time. The system we proposed provides general users a friendly platform in which they can gain clothing recommendations instantly. In addition, via mobile network users can know immediately whether they have anything matching in their wardrobe while shopping in a store by transmitting a photo, which is taken at the shop, to the system. It makes shopping efficient and economic. People will not waste money on buying things they never wear. The main objective of this system is to use computer technology to make life more convenient, saving time and money for people who are following fashion trend.

This paper has taken the issue of making computer more intelligent into consideration. The specialized area such as psychology, e.g., color and clothing cultures, as well as computer technologies, e.g., image process techniques, category learning neural network model, and cloth simulation, have all been taken into account to form an semi-automatic personal clothing consultant.

## II. Related Work

### A. Artificial Neural Network

In practice, neural networks (NNs) are especially useful for classification and function approximation problems. It has been widely known that NNs can serve as a powerful tool for pattern classification [9], especially when the distribution of the objective classes is unknown or can not be expressed as mathematical models. There are also studies showing that neural networks can be used as a tool for feature extraction, i.e., to produce new features based on the original features or the inputs to a neural network [10].

Cognitive scientists view neural networks as a possible apparatus to describe models of thinking and consciousness [11]. ALCOVE (Attention Learning Covering network) is a good choice in categories learning, which is done by John A. Kruschke in 1992 [12]. This model is designed to describe how people, relying on similarity, learn to classify items into different categories. [13] shows the comparison of backpropagation artificial neural network model and ALCOVE model. ALCOVE is relatively more efficient than backpropagation in its classification simulation. Additionally, SUSTAIN (Supervised and Unsupervised STratified Adaptive Incremental Network) is another selection of NN models, which has been developed by Bradley C. Love and his colleagues, and was published in 2004 [15]. This model applies both supervised and unsupervised learning mechanism to forming categories. SUSTAIN initially assumes a simple category structure. If simple solutions prove inadequate and SUSTAIN is confronted with a surprising event (e.g., it is told that a bat is a mammal instead of a bird), SUSTAIN recruits an additional cluster to represent the surprising event.

### B. Cloth Simulation

Significant work has been done on modeling and cloth simulation in the recent decades [18-22]. Along the evolution of cloth simulation techniques, the focus was primarily aimed to address realism through the accurate reproduction of the mechanical features of fabric materials. The early models, developed a decade ago, had to accommodate very limited computational power and display device, therefore these were geometrical models that were only meant to reproduce the geometrical features of deforming cloth. A more detailed survey on cloth modeling techniques can be found in the paper by Ng and Grimsadale [20]. In addition, Pascal Volino and Nadia Magnenat-Thalmann in MIRALAB proposed an accurate garment prototype to improve the cloth motion and realism [21].

Other researchers concentrated on a specific domain in cloth simulation, collision handling, for getting more realistic cloth motion [22-24]. Reference [25] shows some techniques of cloth simulation applied to apparel industry for helping fashion designer to sew CAD two-dimensional cloth pattern and display complete garment in three-dimension.

### C. *Internet Application*

The Internet makes life convenient. Many services are now provided on the Internet such as online banking and shopping, communicating applications, and hotel reservation. Various computer technology research fields of the Internet have been developing for enhancing the convenience and quality of life, such as signal transmission for online learning (as known as E-learning) [26-28], Internet security for online shopping (E-commerce), efficient navigation with Internet, and virtual reality on the Web.

A Web application for online garment sales has done in MIRLAB and is one of the recent remarkable works, covered most of the process of garment modeling [17, 22]. Another application is a virtual clothes shop on the Web in which customers can see their virtual twin wearing clothes they choose and can then decide whether to put the items in shopping cart [16]. However, these developed applications only provide a platform for online shopping. Customers need to decide what to put in the cart. The application we proposed is concentrated on automatically providing clothes matching with personal wardrobe for general users.

## III. METHODOLOGIES

### A. *Training Process- Classification*

According to *The Social Psychology of Clothing* [1], clothing is a part of larger context of appearance affected by different culture and environment. Clothes say who we are and what we are, and present the inner self. Dressing well is an acquired skill. Through social learning, people may have the capability to recognize the outlook styles, such as "classic style" or "sexy look", with modern fashion sense and their culture. However, computers would not know those classifications of attire. This study employed supervised neural network for training the system to learn what style is.

In supervised learning, the correct results (target values and desired outputs) are known and are given to the NNs during training so that the NN can adjust its weights to try to match its outputs to the target values. Categorical variables may have symbolic values, e.g., "red", "green" and "blue", that must be encoded into numbers before given to the network. Thus, we integrated several social studies of clothing psychology and modern fashion trend [6-8], and found four major factors, color, patterned print, cut and material, affect the mean of attire (Table Ⅰ concludes some presentations of cut type). And we also categorized clothes into eight different styles, which are expert style, classic, luxuriant, smart and wistful, sexy look, gentility, sweetness, and casual sport. Large amount of samples of clothing-factors-to-styles set are gained from public questionnaires and then provided as training exemplars to the ALCOVE-based NN model. (Fig. 3 is the architecture of category learning with ALCOVE-based NN model for tops.) [12] described ALCOVE in details. After the training process each cloth would be sorted according to a

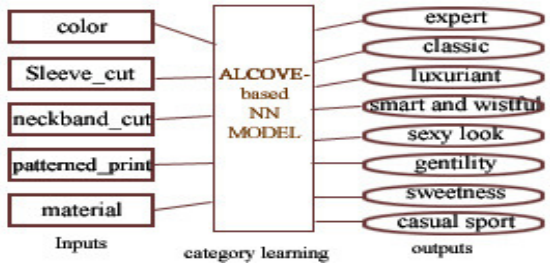



Fig. 3. The architecture of category learning for tops. Color, sleeve-cut, neckband-cut, patterned print and material are the inputs. Outputs are styles of expert, classic, luxuriant, smart and wistful, sexy look, gentility, sweetness, and casual sport.

TABLE I
FEELING CATEGORIES WITHIN DIFFERENT CUT SHAPES

| group | Elements | Cut Shape | Feeling categories |
|---|---|---|---|
| Top | Neckline | ⌣ | Casual, classic, |
| | | V | Sexy, smart, expert |
| | | _ | Sweetness, gentility |
| | Sleeve | Bell | Sweetness, luxuriant |
| | | Tapered | Classic, expert |
| | | Puffed | Casual |
| | | sleeveless | Sexy, |
| | Waist | Fitted | gentility, sexy |
| | | Loose | Casual |
| trouser | Waist line | Natural | Classic, casual |
| | | Sit below | Sexy, gentility |
| | length | Long | Classic |
| | | Short | Casual, sweetness |
| | | Knee-length | Smart |
| | Bottom | Flare | sexy, gentility, smart |
| | | Boot-cut | expert, casual |
| | | Straight | Classic |
| Skirt | Bottom | Pleated | Classic, gentility |
| | | Broomstick | Gentility, classic |
| | | A-line | Smart, casual |
| | | Straight | Casual |
| | | mini | Sexy, sweetness |
| | | Long-length | Classic, gentility |
| | | Knee-length | Expert, casual, smart |

Garments are separated into three kinds: top, trouser, and skirt. We considered different elements for each group. This table shows what corresponding category of feeling with each different cut shape is.

TABLE Ⅱ
THE CORRESPONDENCE BETWEEN FEATURE POINT AND BODY SEGMENT

| Feature Point | Body segment |
|---|---|
| Neck (l,r) | Neck |
| Neck front | Neck |
| Neck back | Neck |
| Biceps (l,r) | Upper arm |
| Elbow (l,r) | Upper and lower arm |
| Wrist (l,r) | Lower arm, hands |
| Waist girth point | Lower torso |
| Hip (l,r) | Lower torso |
| Nipple (l,r) | Upper torso |
| Ankle inseam (l,r) | Lower leg, feet |
| Knee (l,r) | Lower and upper leg, lower torso |

The defined correspondence between feature points and body segment is the same as in [24]. It is used for cutting the shape and placing the cloth-grid onto virtual actor in 3D Show Room.

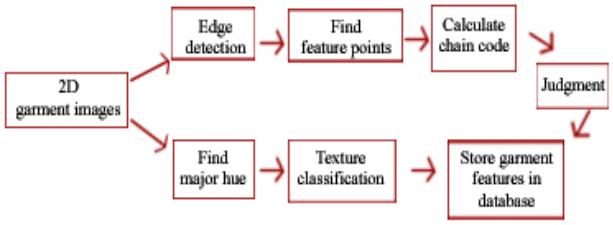



Fig. 4. Two flat garment images are the input for extracting the essentials, such as feature points, chain code, length, hue, texture type, and all information is stored in the garment database.

specific factor (color, texture, cut, and material); later the cloth would then be assigned into a category. In addition, the categorized groups would be used as a reference for other NN models and previous learning process would also be passed on to other models in order to classify sophisticated garment such as - feeling. Garments, for example, classified as *sexy*, could be further graded as *extremely sexy*, *sexy*, or a *moderately sexy*. Garments were separated into three types: top, trouser, and skirt, and designing three NN models for each type to learn the feeling of the category for each piece of garment.

### B. *Image Processing- Build Customized Wardrobe*

Traditional CAD application for the apparel industry [24, 25], which use feature points to cut the garment shape within a cloth grid, smoothing the surface of patterns, positioning patterns with face vector, seaming patterns to be a garment, resizing and collision handling to make it real on virtual actor. Table Ⅱ is the definition of correspondence between the feature points and body segment in the project. It is the same as the definition in [24]. All information needed for sewing patterns is from CAD file. However, the project is to provide general users a personalized friendly fashion match consultant, it is not able to get specific CAD file for each garment for the users' real closets. Hence, we integrate several image processing techniques to analyze garment images for getting feature points, major hue and patterned print. Feature points are used for reconstructing a 3D garment models in a 3D showroom as previous researches did. (The image processing flow refers to Fig. 4) In addition, fashion trend in recent two decades were considered and found that color, patterned print, cut, and material are main factors affecting the sensational meaning of a garment. For example, *shorts* show relaxation in general; *white* shows innocent according to color psychology; *silk* gives soft and gentle feel; a little petal signature shows sweetness more than a large amoeba pattern does.

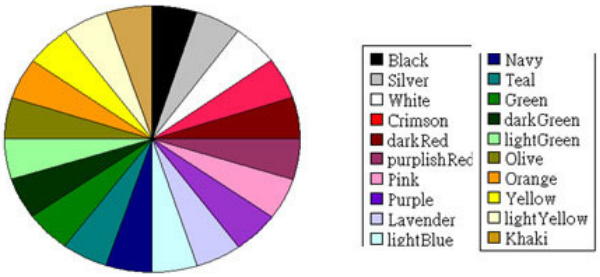



Fig. 5. We process color histogram to determine the garment tone and then assign one category in the color wheel to the garment.

Color is the first visual factor affecting the impression while apparel communicates. Researchers today in the fashion design industry and color psychology field have introduced a general sense of costume color [8, 28, 29]. We define a color wheel (Fig. 5) containing twenty hues for the assignment, and process a color histogram technique for each garment image to analyze the major hue at user input stage. All information analyzed at this stage would be stored at digital garment database as essential information for the garment.

### C. *Matchmaker*

During the programming period, the category learning was carried out and factors weights were obtained. At user input stage, the system is able to get the categories of the feeling and the essential information of each garment, such as its major hue, cut type, patterned print and material. User preference is also learned in the pre-processing stage by manually filling a graphical questionnaire, indicating what types and colors of garments user preferred to wear for a specific occasion. After receiving the request from users, Matchmaker then follows the appearance category to search garments in the user's wardrobe. A group of garments having the same classification can be obtained at this step. For each piece of garment in this group, Matchmaker is looking for a matched item within the wardrobe based on the principle of color match (Fig. 6) extracted from color psychology and style tips concluded by fashion editors. The second group of garments is then acquired after the match procedure. Finally, Matchmaker would make decision based on the occasion, weather, material, and user preference from the second group and pair up three suit of garments that is highly stylish, occasion matched, and characteristic. The user preference, including major color and garment type, is updated by selecting one of these three pairs.

## IV. Conclusion and Future Works

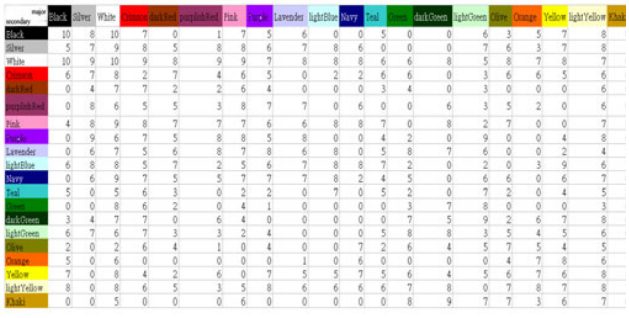


Fig. 6. Color match score table. Each column indicates one specific major color tone and each row indicates a secondary color. The number here indicates the match value of one major color and one secondary color, '10' means these two colors are perfectly matched, and scored '0' means unmatched.

The proposed framework of knowledge-based clothes matching system will not only help users to choose a proper garment for the occasion but also show the intended given impression to the public. We integrated many different techniques concerned with image processing and knowledge representation. Category learning with neural network is used to train the system to enable it to do outlook classification for the garments. Digital image processing, including extracting feature points and cutting shape, major hue and print, is used for building a customized digital garment database. Matchmaker contains knowledge of color psychology, fashion match and style tips for clothes match making. The project thus has the capability that allows people to digitalize their closets and to find suitable pairs automatically by submitting the requirements to the system. Furthermore, this helped to make the most available out of each garment in our closet and our closet without wasting a penny on an inappropriate garment.

However, clothing is mainly affected by cultures, age, and social relations. The same garment might bring different meaning in different cultural regions. White color, for example, is the main tone in a Japanese wedding but is considered unlucky in a Chinese wedding. A mini-cut skirt for an eighteen-year-old school girl presents a cute and fresh style, but is a sexy style for a thirty-year-old office lady. Thus, the project could not be applied in general to everyone in the world. The framework is focusing on the age of twenty-five to thirty-five office ladies. In the future, a module for age classification which employs different categories and match rules for different age will be augmented. In addition, a matchmaking module for male is needed to complete the system function.

After enabling the clothing consultant system works on single-machine, make it works online is another future work. With mobile devices and networking, people are able to access their personal clothing consultants online immediately to request if they have any garment in the wardrobe matched to the one they want to buy while shopping. The system is to save time and money for user and to make shopping more efficient and economic.

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