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Mobile Fashion Advisor- A Novel Application in Ubiquitous Society

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Abstract

In this paper, we propose an intelligent system, called "Mobile Fashion Advisor", aimed to create a virtual fashion assistant to give suggestions on the usage of clothing and help users avoid buying clothes that are never worn. Many different computer theories and techniques are exploited in the system. Digital image processing techniques, such as edge detection and color histogram, are employed to obtain the essential data of garments. Fuzzy theories are applied for gathering fashion matching rules. Users can simply use a smart phone to take a photo of the garment when shopping and submit it to the clothes server through ubiquitous network.Then Attire Scheme Harmony Evaluator follows match rules to search whether there are clothes in her personal garment database that matches the new one. The results of matching and grades of whether to buy are sent back and shown on the phone. The work is to provide such a user-centric services system that functions as a personal fashion advisor for clothes shopping.

1. Introduction

Many people are delighted to discover how smart home technologies are enhancing their lifestyles right now. With "intelligent" applications, mobile devices, and ubiquitous network, life becomes simple and convenient. The work proposed here aims to develop an intelligent system which has the ability to automatically search for matching garments from personal wardrobe for giving shopping suggestions. It solves the problem of spending money on buying clothes that are never worn. A general concept about how the system comes out is given in the following sub-sections.

1.1. Motivation

Many people have experienced the situation where they were standing in front of their wardrobe, searching for an outfit, yet their mind goes blank, even though their closets are full of garments. Some may find it difficult to pick a garment from their personal closet to match the new piece of clothing just bought from a clothes shop. There is always lack of one garment. Therefore, many people spend a lot of money on buying new garments for another new garment. Another situation lots of people have been through is buying lots of garments while shopping, and finding out that the new clothes don't suit their wardrobe after going home. How wonderful it would be if we have a personal fashion advisor when we were shopping for clothes! However, it is impossible for everyone to have a personal fashion advisor since a personal fashion advisor providing professional dressing suggestions in the real world costs a lot.

With computer technology growing rapidly, researchers keep working hard on innovating computer applications which can make our daily life easy and convenient.

Artificial intelligence, for example, is one of the popular research fields and aims to develop AI agents to work for human beings. A decision support system always helps people analyze business data and make business decisions easier, such as market selecting strategies. Fuzzy methods always help to solve problems with intermediate values defined between conventional evaluations, like yes/no, true/false, black/white, and so on. Moreover, the founder of Ubiquitous Mark Weiser, claims that in the future society, computational services could be delivered through a number of different devices, the design and location of which would be tailored to support various tasks [1].

Furthermore, there are other computer technologies on clothing already developed, such as cloth simulation and virtual dressing [2][3][4]. We found most of them applied on e-business and fashion design industries to provide a realistic motion for virtual clothing. Specific knowledge is certainly required. Hence, a knowledge-based clothes searching system which functions as a personal shopping consultant to general users, is a useful application in the modern fashion society.

Our research aims to integrate mix-matching fashion style, clothing psychology, and digital image processing techniques to create an innovative application of clothing, named 'Mobile Fashion Advisor', functioning as a personal fashion consultant to helps shoppers save money on clothes they do not need. In doing so, we address challenging issues and solutions for demanding tasks at each phase of the system.

1.2. System Overview

The proposed system is an application in ubiquitous society. It is a visual-based knowledge extraction which functions as a personal image consultant to provide mix and matching support to help users on shopping decisions. An overview of the system architecture is shown in Figure 1. The process is basically divided into offline and run-time stage. During offline stage, mixing and matching fashion rules are extracted using questionnaires and fuzzy logics to construct a Attire Scheme Harmony Evaluator. The second important component of the system is to a digital personal wardrobe create by the user, because the system is a kind of personal assistant, providing user-centric services.. The users takes a photo for each flat garment from the front as the input information, which the Image Analyzer uses to detects physical characteristics, such as major hue and print style, and so the personal garment database is built. During online stage, users can connect to the server of the Fashion Advisor via ubiquitous network and personal mobile device to query for shopping recommendations while trying on clothes. The user takes a photo of the garment of interest and then sends it back to the server through ubiquitous network and personal mobile device. Attire Scheme Harmony Evaluator of the proposed system then searches for matching garments within user's garment database and makes evaluations. The results of matching and grades of whether to buy are eventually sent back and shown on the cell phone.

This research takes the issue of integrating computer technology and making computer more intelligent into consideration. Specialized areas such as psychology knowledge extraction, e.g., color and clothing cultures, as well as computer graphics technologies, e.g., image process techniques and category learning, have all been taken into account to create an intelligent personal fashion consultant to give advice on

buying clothes. It provides users a friendly interface in which they can instantly gain recommendations of whether to buy while shopping for clothes. The main objective of this system is to use computer technology to make life more convenient.

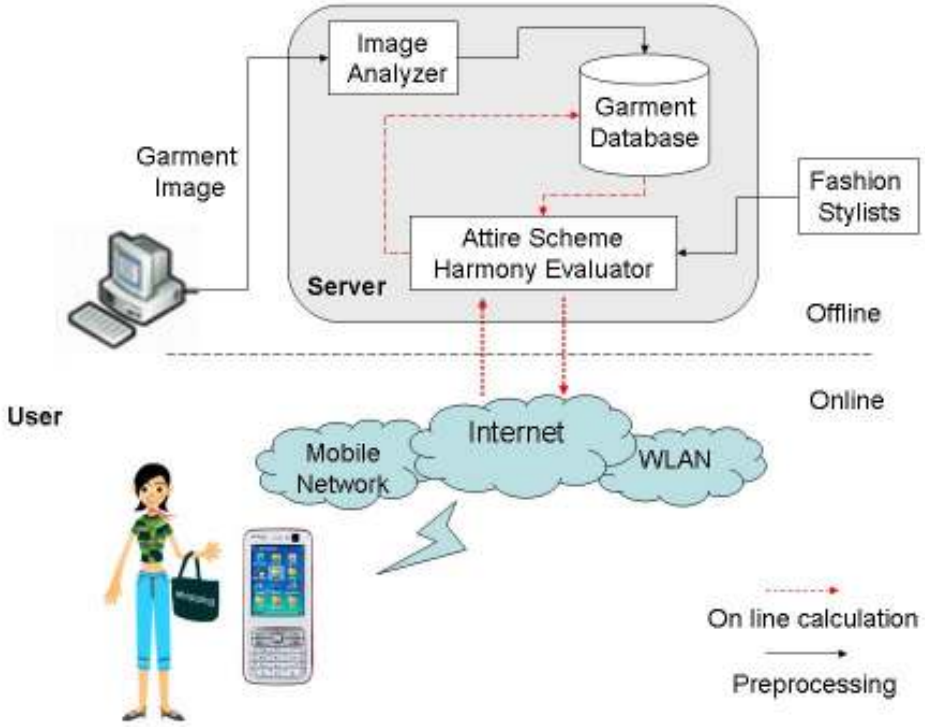

Figure 1. The workflow of proposed system. The process is divided into offline and run-time stages. Garment database and attire scheme harmony evaluator have to be done in the offline stage, while the queries are made by user in the online stage.

2. Related Work

Life becomes more efficient and convenient as computer technology rapidly grows. Researchers keep working hard on innovating computer applications to enhance our daily life. Many applications of clothing and online shopping are developed in the recent decade. Magic Mirror, is an intelligent mix-and-match system, proposed by the Hong Kong Polytechnic University in 2006, using smart fitting room and smart dressing mirror. The system uses the technology of RFID to detect a item brought into a fitting room or placed in front of a dressing room. The intelligent mix-and-match database of the system then delivers recommendations on what looks good with the item to the customer [5]. Another new application called Social Retailing mirror system, lets consumers try on clothing at a store and enables other people, wherever they are, to watch and make comments via the Internet. It was developed by IconNicholson, a digital design and services firm, on 2007. The system could also show viewers other clothing that is in stock or in a catalog, and could recommend items that might look better or go well with the clothes the shopper has tried on [6].

However, the process of identifying garments and determining whether they match is recorded in advance, and relies on the RFID. It is a important issue in textile industries. Nevertheless, out proposed system aims to achieve that the system swiftly finds clothes from user's personal closet to match the new one in the shop. This concerns personalized mix and matching fashion, thus RFID does not suit the proposed system.

There is another application, attributable to Virtual Stylist Project[7], was proposed in 2003 by Masataka Tokumaru, helping users to find out their favorite clothes from Web server in clothing shops on the Internet. The system searches through clothes database for clothes on the basis of the harmony and sensation of colors that are used in them. In the case that a user requires a jacket and pants which she might wear with her own shirt, the system searches for some jacket and pants whose colors are in harmony with image sensation seems to fit her imagination of dressing. However, color is not the only one factor affecting clothing sensation when people first see. Clothing image is usually affected by its outline shape, print types, major color, and fabric material. People often feel a top with chiffon material soft and relax even though the color is dark. Hence, a knowledge-based clothes matching advising system which works as a real personal fashion consultant to general users, is a useful application in the modern fashion society.

In addition, for the past ten years, Korea has been at the forefront of transformation into a nation of information, with world-class IT (Information Technology) infrastructure with 12 million high speed Internet users and 35 million mobile phone owners. Ubiquitous Dream Hall [8], which is a project established by Korean government and IT industries, has achieved ubiquitous society. The living environment, including services of healthcare, video on demand, home networking, home shopping and home banking, is developed for enhancing life convenience. The issued application concerning with clothing in the Ubiquitous Dream Hall is a kind of smart wear using a RFID mirror. Users stand in front of the mirror and pick up one image of those garments they own. The image is then fitted on the user's body figure using the virtual try-on simulator of the system. With this system, people can virtually try on each garment they want without spending much time on putting on and taking off. Hence, developing intelligent applications for improving convenience is a main objective in the upcoming future life.

3. Approaches

The proposed system aims to provide shoppers recommendations for the use of clothing to avoid buying clothes that are never worn. There are two major tasks that have to be accomplished, building a personal digital wardrobe, and developing Attire Scheme Harmony Evaluator. It integrates several different technologies, such as digital image processing and fuzzy logics. The following subsections describe those methodologies in details.

3.1. Building Digital Wardrobe – Garment Database

The digital personal wardrobe is a garment database in which each garment the user owns is presented as one record. For clearly representing and reusing a garment in the system, we need to define some specific garment attributes. Fashion trend and style cognition in recent two decades were considered and found that color, print style,

outline shape and fabric material are main factors affecting clothing image [9][10][11]. 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. The research reported in [12] proposed that lines, style, color, pattern and material of the clothing all have abundant emotion contents. Hence, we define "color", "print style", "outline shape", and "fabric material" as the physical essentials of a garment. The first three essentials can be analyzed from a digital image by exploiting several techniques of digital image processing, while the last essential can be gained by user input since textile processing is not in the scope of the research.

A technique of color histogram is applied to gain the major color tone of a garment. The secondary color and the third color of the garment are also filtered out according to the amount of color pixels within the digital image. 'Print style' of a garment is determined using the number of color and the distribution of color on the garment surface. Therefore, techniques concerned with edge detection and fuzzy clustering of color pixel are cooperated. The outline shape of a garment is affirmed by the comparison with template shape since we use chain code to describe the garment boundary. The chain encoding scheme takes advantage of Freeman's chain code [13] and the scheme proposed in [14]. The following describes the technologies for gaining garment essentials.

3.1.1. Major Color: From social psychology and fashion design, 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 [15][16][17]. Additionally, in the research of digital color, several color models are built to describe and represent color. RGB color model is an additive model in which red, green, and blue are combined in various ways to produce other color. It is useful to represent color in lighting equipments, such as monitor, video camera, and projector. The CMY (cyan, magenta, yellow) or CMYK (CMY plus black) model is the other well known color model used for color printing. HSI, also called HSB or HSV, is another color model in which color is presented by hue, saturation, and intensity. HSI model is generally used for humans' description and interpretation of color. According to Matsuda's Color Coordination [18], a color scheme type is composed based on the relationship between a hue type and a tone type. Hue types are defined using hue of a color in Munsell Hue Circle, and tone types are defined using value and saturation of a color in Munsell Color Space. In this research, the color of a garment is originally presented in RGB color format since all information of a garment is basically from a digitalized color image. In addition, there may be many colors displayed on a garment. Hence, a color histogram technique is firstly applied on the garment image to gain the coarse distribution of the colors in an image. Two colors with different values of color elements (i.e., R, G, and B) fall into two different bins even though they might be very similar to each other. Hence, a simple similarity function D is employed to separate colors into few color domains. Through our experiments, the threshold t is set to 0.3.

$$D = \sqrt{\frac{(r_1 - r_2)^2}{255} + \frac{(g_1 - g_2)^2}{255} + \frac{(b_1 - b_2)^2}{255}}$$

if D>0.3, they are in different color domain, else they are in the same gamut.

The biggest bin of the color histogram represents the major color of the garment, and the next bin indicates the secondary color of the garment.

Further, in the field of color psychology, 'hue' generally brings the sensation of warm and cold to human; 'saturation' brings the feel of strong and light; and 'intensity' brings the feel of soft and hard. Hence, a color space conversion from RGB to HSI is performed. Figure 2 illustrates the transformation from RGB color to Matsuda's Color Coordination. The HSI components can be obtained using

$$H = \begin{cases} \theta & \text{if } B \leq G \\ 360 - \theta & \text{if } B > G \end{cases}$$

$$\theta = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{1/2}}\right\}$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)]$$

$$I = \frac{1}{3}(R+G+B)$$

where the RGB values have been normalized to the range [0,1].

The color distribution of the garment and their HIS value would be all stored into color distribution table in garment database.

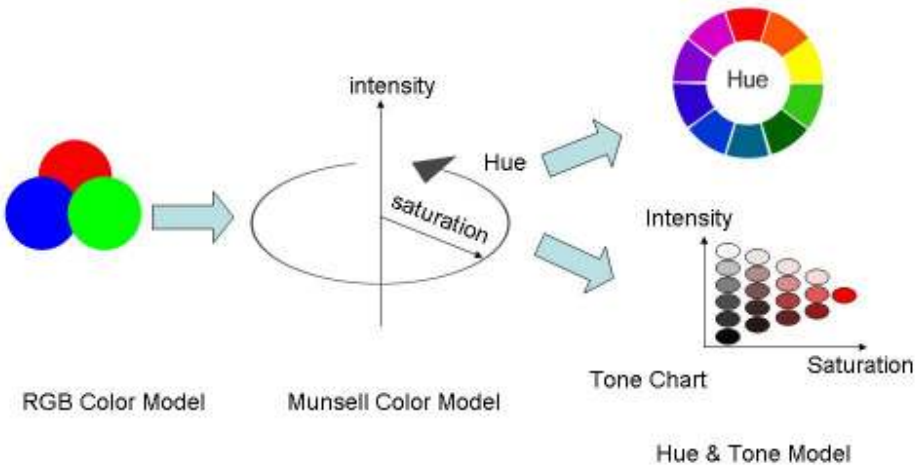

Figure 2. Transformation from RGB color to Matsuda's Color Coordination.

3.1.2. Print Style: Small floral print bring sweet feel, and bold stripes lend a nautical feel. Fashion designers always use print cloth to put pizzazz to a garment. Print is thus one of the important visual factors affecting clothing image. Nevertheless, not every kind of prints can be put together. Wearing a striped top, for instance, with a floral bottom looks inharmonious. In addition, print style is highly changeable and difficult to

give a clear definition. Hence, we define that print style is the loudness of a garment after discussing with stylists. To this end, we decided that the frequency of changing color and the locality of the color-change occurred are the parameters to determine the loudness of a garment.

A typical edge may occur when color obviously changes. For instance, the border between a block of red color and a block of yellow is an edge. Hence, an edge detection operator is firstly performed to detect the frequency of changing color. Sobel operator, also related is Prewitt Gradient Edge Detector, is the edge detector used in the proposed system. The main reason we employed Sobel operator is that it is less sensitive to noise. Further, in order to record the locality of the color-change occurred, grid cells are placed on the garment image from the middle (see Figure 3). The amount of grid cells is changed dynamically according to the garment boundary. The process of how to determine the loudness of a garment is as follows:

1. Performing Sobel operator to produce a black-white edge image, where white pixels are the border of different colors, say, turning points.
2. Counting the amount of black and white pixels within each grid cell of the black-white edge image. The corresponding RGB value of the color image is also recorded while traversing those pixels.
3. If the number of the grid cell with few turning points is higher than a threshold, the garment is not loud at all.
4. A color counting process within each grid cell has to be processed when statement in step 3 is false as the turning point on the garment image may be occurred by creases. The number of different colors in each cell and which cell with many different colors are to determine the degree of loudness of the garment.

After processing the loudness determination for a garment, the value of loudness attribute is given from 0 to 1, presenting as not loud to very loud. Besides, the black-white edge image is also used for detecting regular texture, such as stripes and checks.

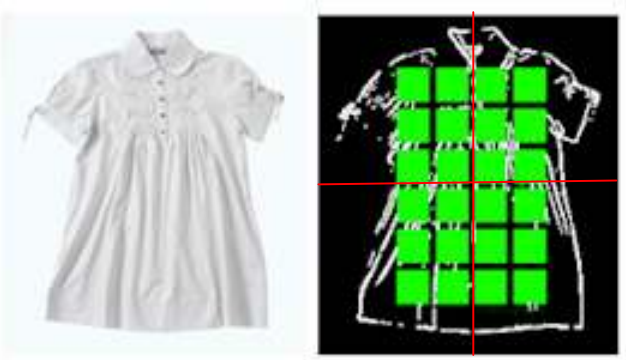

Figure 3. Input garment image and the black-white edge image. Those green blocks are the grid set for recording locality.

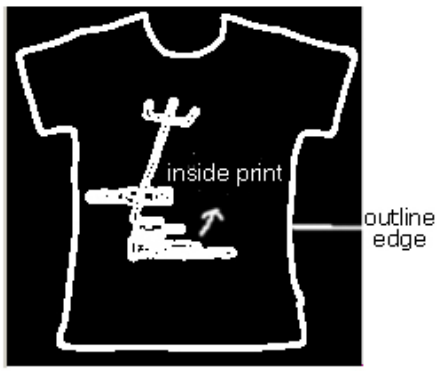

Figure 4. An image after processing Sobel edge detector. Those edges inside garment are print silhouette, while the outer edge is outline edge.

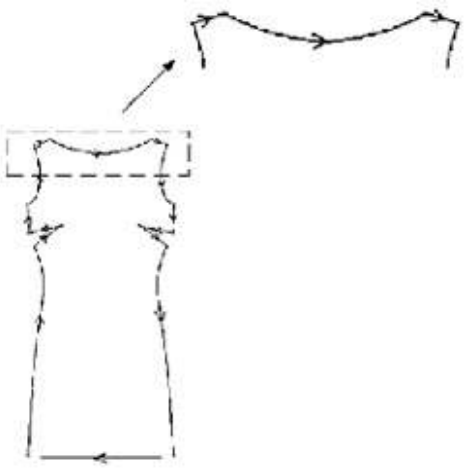

Figure 5. Boundary of the garment pattern represented as a directional closed loop L.

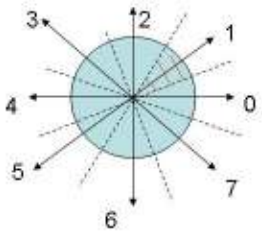

Figure 6. The eight directions defined for garment outline.

3.1.3. Outline Shape: Fashion design consists of three shape parts: silhouette, detail and trimming. Silhouette is outline or outlook shape that expresses whole characteristic of a garment. Detail is subdivided parts of silhouette including neckline, sleeve, skirt, etc. Trimming is a generic term of all finishing ornaments. Here we focused on detail elements. Garments are basically divided into tops and bottoms according to the shape. Shirt and one-piece-dress are two sub-categories within 'tops', while trouser and skirt are two sub-categories within 'bottoms'. There are different elements within each group

for determining the garment outline. After reviewing literatures in textile [19][20], we conclude some elements for each garment group (as shown in Table 1).

Moreover, the result of performing Sobel edge detector shows how abruptly the image changes at that point, and therefore how likely the image represents an edge. As shown in Figure 4, edge of a digitalized garment image after performing Sobel edge detector represents garment silhouette and inside print. In the case, we only consider the outline edge to process feature points detection. According to [21], the boundary of a 2D garment pattern is represented as a directional closed loop L={c_1,…,c_n}, where c_i represents a parametric curve segment. prev(c_i) represents the preceding curve segment of, and next(c_i) represents the next curve of c_i with respect to the direction of Loop L, as shown in Figure 5. Thus, after processing feature points detection, we calculate chain code, including the values of direction and length, for each two neighboring feature points, then use them to recognize the outline of the garment. To this end, we define 8 directions, labelled 0~7, as the chain code, then calculate the directions and length for each segment anticlockwise from the first feature point. This is illustrated in Figure 6. After a chain code comparison, we can get the outline of the garment user input as well as the feel categorized of the garment. Afterwards, outline shape is transformed to fitness sensation according to a fuzzy set operation.

Table 1. The relation table of Garment-outline-to-outlook-images.

Garment group	Elements	Outline Shape
Top	Neckline	⌣
		V
		⎯
	Sleeve	Bell
		Tapered
		Puffed
		Sleeveless
	Waist	Fitted
		Loose
Trouser	Waist line	Natural
		Sit below
	Length	Long
		Short
		Knee-length
	Bottom	Flare
		Boot-cut
		Straight
Skirt	Bottom	Pleated
		Broomstick
		A-line
		Straight
		Mini

3.2. Developing Inference Engine – Attire Scheme Harmony Evaluator

Attire Scheme Harmony Evaluator of the proposed system is constructed for searching match garments within user's garment database and making evaluations. After evaluation, shoppers can gain the results of matching process and grades of whether to buy on the cell phone via ubiquitous networking. As we discussed in previous section, "color", "print style", "outline shape", and "material" are the essentials to present a garment. The visual images are also affected by fusion of these four garment essentials. Hence, whether garments are harmony is based on harmonization of those essentials. Section 3.2.1 gives some general harmony principles of mixing and matching fashion concluded by fashion stylists. Section 3.2.2 describes the process of Attire Scheme Harmony Evaluator.

Figure 7. Any color which is side by side on a color wheel is similar, whereas any color which is directly opposite to each other is complementary color.

3.2.1. Harmony Principles: The work aims to provide shopping advice to users by finding matched garments, from their own closet, which are appropriate and trendy. Hence, garment match rules have to be acquired from fashion literatures and trends for developing a creditable match engine. There are many principles for gathering two garments harmonized, such as color harmony, print style harmony, and fabric material harmony. The conceptual descriptions are described below:

Color harmony principle:

Apparel is like second skin – and, like a chameleon, you can change your colors to influence how others perceive you. According to color researches and the art of color harmony [8][9], when two or more colors are brought together to produce a satisfying affective response, they are said to be harmonised. There are many theories of harmony. Combining colors with different degrees of brightness in the same hue gamut is a common principle to show color harmonization while applying to clothing. Generally speaking, a color scheme based on analogous tone gives pleasant impression, and a color scheme based on complementary gives active impression. Analogous colors are any three colors which are side by side on a color wheel, whereas complementary colors are any two colors which are directly opposite to each other (Figure 7).

In addition, women tend to dress either entirely neutral tones or in full on color assault. Light and shade are an integral part of style and fashion. One of the most successful examples of this is the color combination of pink and brown. These seemingly unrelated colors perfectly compliment one another because the quiet but rich brown acts as a base form which the vibrant pink can shine. It forms a classic color combination that exudes a real sense or freshness but at the same time lashings of sophistication.

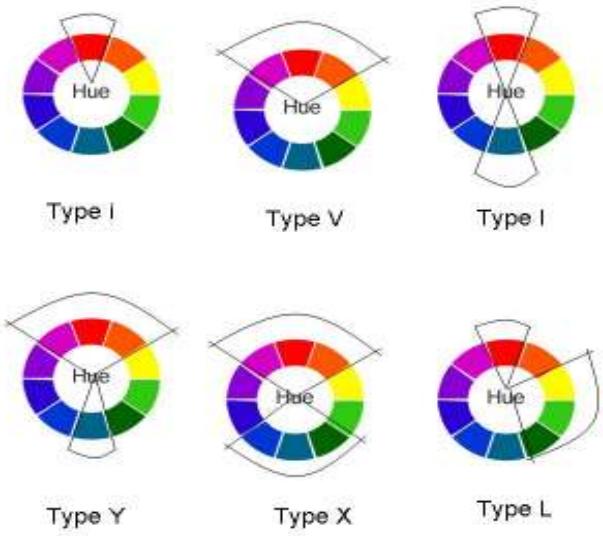

Figure 8. Hue type harmony. [4]

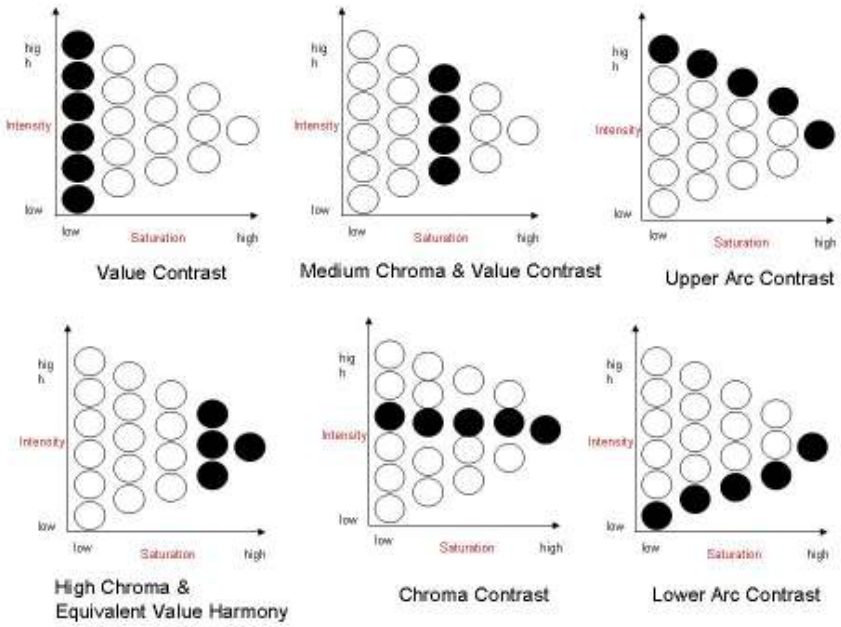

Figure 9. Tone type harmony. [4]

Further, Virtual Stylist Project, done by Masataka Tokumaru and his colleagues, focuses on harmony and image sensations of color combination of clothes [4]. The method of Matsuda's Color Coordination proposed by Yutaka Matsuda is useful to compose the color scheme harmony evaluation part of the system. In his research, color schemes are classified into 8 hue types or 10 tone types. A color scheme type is composed based on the relationship between a hue type and a tone type. Our research employs and modifies the color scheme harmony evaluation in Virtual Stylist Project. Figure 8 illustrates the modified hue type harmony. Type i indicates that coordinate colors in the same hue. Type V indicates that coordinate colors with similar hue. Type L indicates that coordinate colors with a certain difference of hue. Type I indicates complementary color harmony. Type Y and Type X are two modified types of Type I. On the other hand, Figure 9 illustrates tone type harmony. There are six types of tone harmony. Value Contrast, for instance, demonstrates that coordinate colors with different illuminate in the same hue. Chroma Contrast indicates that coordinate colors with different degree of saturation in the same hue.

Print style harmony principle:

As discussed in previous section, different print style lends different visual image. The challenges get more intense when attempts are made at coordinating three or four different print styles at the same time. Brining different print styles into harmony is tough. Hence, there are many rules to make an integral balance of garments with different prints styles. Generally speaking, the major principle of mixing and matching print style is not to allocate many colors together. Other harmony principles with print style concluded by fashion stylists are listed below:

1. The safe way is that not wearing floral print on upper body and lower body at the same time.
2. Putting a plain bottom and a patterned print top together makes harmonious. In this case, the color of the bottom is the major color of the pattern.
3. Collating a floral blouse with a bottom is similar to the first rule. Find out the major color of the blouse, and then put together a plain bottom whose color is in the same hue gamut. Note that it will be imbalance while the blouse is with large floral print. Wearing a plain bottom with opposite color or white lends balance when the blouse is with large floral print or large abstract.
4. For the overall best effect on fashion dress style, mixing two similar patterns boils down to the concept of using two designs with different scales and different spacing.
5. Putting different print style together looks garish. When doing such combination, the first thing is to understand which pattern is primary and which one is secondary. Naturally, the primary pattern is usually the one that takes up most of your body and the secondary should be the one creating the accent. And also good color coordination between the second pattern and the first pattern has to be maintained.

As discussed in Section 3.1.2, some regular textures, such as stripes and checks, are filtered out by Image Analyzer and stored in the garment database. Different texture

cannot be together according to those harmony principles. In addition, Image Analyzer has also transformed print style to degree of loudness. A top with high degree of loudness is suggested to go well with a bottom with lower degree of loudness. Color contribution is also taken into consideration to make print style harmony.

Fabric material harmony principle:

Different fabric brings different degree of softness. Softness usually can be extended to the sensations of feminity and masculine. Soft fabric clothes, such as silk, generally go well with clothes fabric, which has similar softness. This combination of garments brings a feel of feminity and elegant to public. A simple way to mix and match is to choose clothes with similar softness. However, the current trend towards mixing and matching fashion. People can develop their creativity on mixing fashion. The ultimate challenge is mixing different fabric together but not looking ridiculous at all. For mixing fabrics of different softness, there is a principle that fabric of bottom must be harder than top. Overall, the aim of coordination for fabric is to achieve naturalness as well as bringing out the best blend that brightens up overall look.

3.2.2. Evaluation of Attire Scheme Harmony: Attire Scheme Harmony Evaluator aims to make evaluations on clothing harmony. After evaluation, shoppers can gain the results of matching process and grades of whether to buy on the cell phone via ubiquitous networking. When a consumer is interested in a garment at a shop but cannot make her mind of whether she has clothes to match. She can use her camera phone to take a photo of the interested garment from front side as input information for the system. User has to point out where the garment region is since the background of the picture is various. Image Analyzer, which is embedded in the camera phone, is then performed to detect major color and print style of the garment. In addition, she has to indicate corner points and fabric material of the garment on her camera phone. These information and garment image is then sent back to the server via ubiquitous networking.

Attire Scheme Harmony Evaluator is activated while receiving the inquiry from user. It firstly determines what basis clothes group the garment belongs to (top or bottom). Tops search for bottoms while bottoms search for tops. It then eliminates tops (bottoms) which do not match based on those harmony principles in the order of print style harmony principle, color harmony principle, fabric material harmony principle, and outline shape principle. A group of clothes may match to the interested garment is sift out. Attire Scheme Harmony Evaluator pairs up the interested garment with every garment in the match group, and evaluates the coordination of each garment pair according to harmony principles. The weight of color harmony is the highest since color affects visual image most. Print style is the second factor affecting clothing image, so the weight of print style harmony principle is the second highest one. And then the weight of fabric material is lower than the weight of print style principle since the current trend is towards mixing fashion.

4. Discussions

After going through the details of the methodologies used on our Mobile Fashion Advisor, we shall now take you through the process a user goes through using our system, and show you the results of experiments done on a PDA phone.

4.1. Functioning Scenario

After technical description of each individual components of the system is given, we describe a complete operational scenario when using the prototype system (as demonstrated in Figure 10). The detail descriptions are as follow:

1. Building a personal virtual closet on server. Users need to take a photo for each flat garment in their real closets from front side and submit to the system one by one. Image Analyzer is then activated for detecting garment essentials, including major color, print style, and outline shape. This process is done during preprocessing stage.

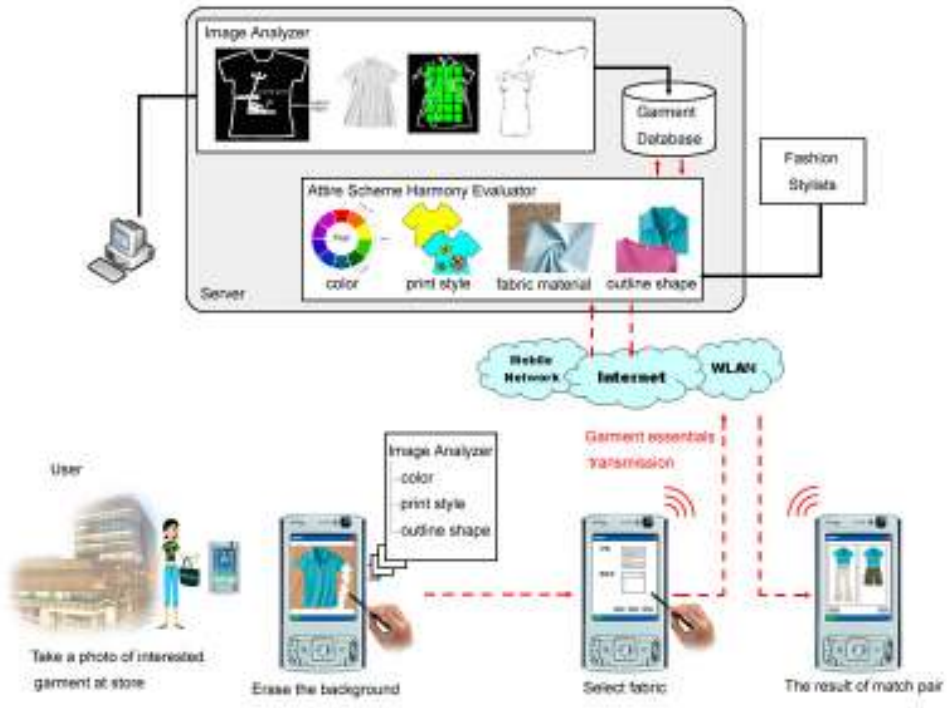

Figure 10. A complete functioning scenario when using the prototype system.

2. When a consumer is unable to make her mind of a purchase of a garment at a shop, she can invoke Mobile Fashion Advisor for help. Taking a photo of an interested garment at clothes store using a camera PDA phone is the first step.
3. Mobile Fashion Advisor provides a function to clear background off the garment image. Since the garment photo can be taken at anywhere, the background may not be completely clear. Consumer needs to erase the residual background of the image by directly using a pen drawing on the touchscreen.
4. Image Analyzer which is installed in the phone is then activated for detecting major color, print style, and outline shape of the garment.
5. Next, consumer has to select one fabric type of the garment.
6. The garment image is then transformed to several digitalized information, and sent back to the server through ubiquitous network.

7. Attire Scheme Harmony Evaluator on the server is activated while receiving the inquiry from user, and searches for match garments within existed garment database.
8. The result of match garments and evaluated grades are eventually sent back to the user via network.

Mobile Fashion Advisor is a value-added service in ubiquitous society that provides supports on smart shopping. Shoppers can browse recommendations by using their personal camera PDA phone.

4.2. Experiments

We have implemented two image processing functions required by the Mobile Fashion Advisor in C# on the operating system Windows Mobile 5.0., on Mio A700, a PDA phone with a Intel Xscale PXA-270 520 MHz processor, 128MB ROM, and 64MB RAM, and a 1.3 mega pixel digital camera (as shown in Figure 11). The first function clears the background off the garment image, and the other function determines how fancy the clothing is.

Figure 11. The left image is the PDA phone we used in the experiments, and the right image illustrates that a garment image is taken and the background is cleared.

We have tested the two image processing functions on two images of different pixel dimensions on the PDA. Both images were taken in a reasonably lighted room, with the background a plain, distinct color from both pieces of clothing. For both images of 240*320, it took 6 seconds total executing both image processing functions. As for the other two images of 120*160, it only took 2 seconds. The results are concluded in Table 2.

We have gotten satisfactory results from our image processing function, each doing a good job in a few mere seconds. However we are striving for faster functions, and aiming to make it work on images with a more complex background. We keep experimenting on several different approaches to find out which one suits to the system.

Table 2. The experimental results of image processing function executed on our PDA camera phone.

Image				
Pixel dimensions	240*320	120*160	240*320	120*160
Total time (s)	6	2	6	2

5. Conclusion

A fashion consultant in real world is the critical eye and can help consumers save money on clothes they do not need or that do not suit them. Other than a sales representative at a department store, a fashion consultant's job is to make you look the best and not to try to sell clothes. In the same way, Mobile Fashion Advisor is an intelligent clothes shopping consultant that helps users to make a correct decision on buying a new garment, and ending up overspending on clothing. Digital image processing, including extracting feature points and determining outline shape, major hue and print style, is exploited in Image Analyzer for extracting garment essentials to build a customized digital garment database. The system thus gains knowledge from visual image, and has the capability that allows people to digitalize their closets and to automatically find match garments by submitting the requirements to the system. With PDA camera phones and mobile networking, people are able to take garment pictures while shopping and get supports of whether to buy the garment immediately. The system is good for people who overspend on new clothes. Furthermore, this helps to make the most available out of each garment in our closet and without wasting a penny on an inappropriate garment. It helps to develop the sense of style and fashion for people, and so to make shopping more efficient and economic.

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