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**Chhibber et al.**

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(54) **SYSTEMS AND METHODS FOR RECOMMENDING COSMETIC PRODUCTS FOR USERS WITH MOBILE DEVICES**

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(22) Filed: **Mar. 25, 2014**

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***G06K 9/00*** (2006.01)
*A45D 44/00* (2006.01)

(52) **U.S. Cl.**
CPC ..... ***G06K 9/00234*** (2013.01); ***A45D 44/005*** (2013.01); *A45D 2044/007* (2013.01)

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CPC ..... A45D 2044/007; A45D 44/005; G06K 9/00221; G06K 9/00234; G06K 9/00
USPC ..... 382/165
See application file for complete search history.

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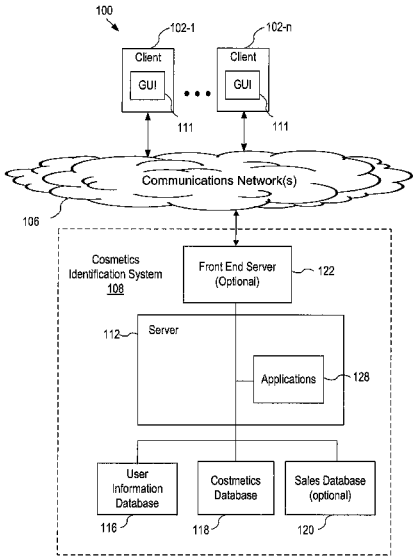
(57) **ABSTRACT**

An electronic device for analyzing a skin of a subject and identifying a cosmetic product for the subject includes one or more processors and memory storing one or more programs for execution by the one or more processors. The device transfers a digital image of at least a portion of a face of the subject. The digital image includes a plurality of pixels. Skin pixels in the plurality of pixels are identified. Color space values are identified from the skin pixels. A cosmetic product is identified at least based on the color space values. The device transfers information of the cosmetic product.

**15 Claims, 8 Drawing Sheets**



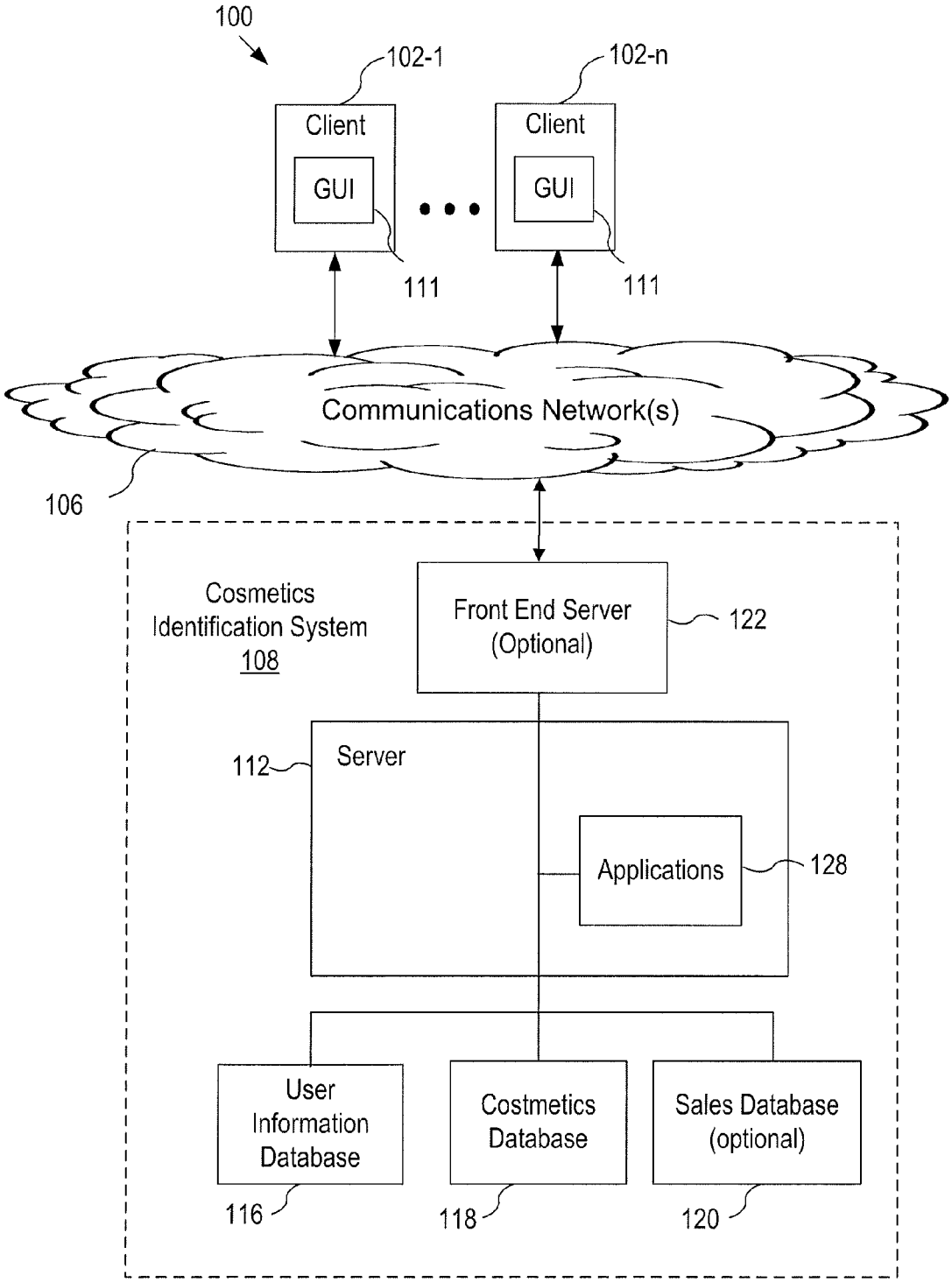

100
102-1
102-n
Client
GUI
Client
GUI
111
111
Communications Network(s)
106
Cosmetics
Identification System
108
Front End Server
(Optional)
122
112
Server
Applications
128
User
Information
Database
Costmetics
Database
Sales Database
(optional)
116
118
120

Figure 1

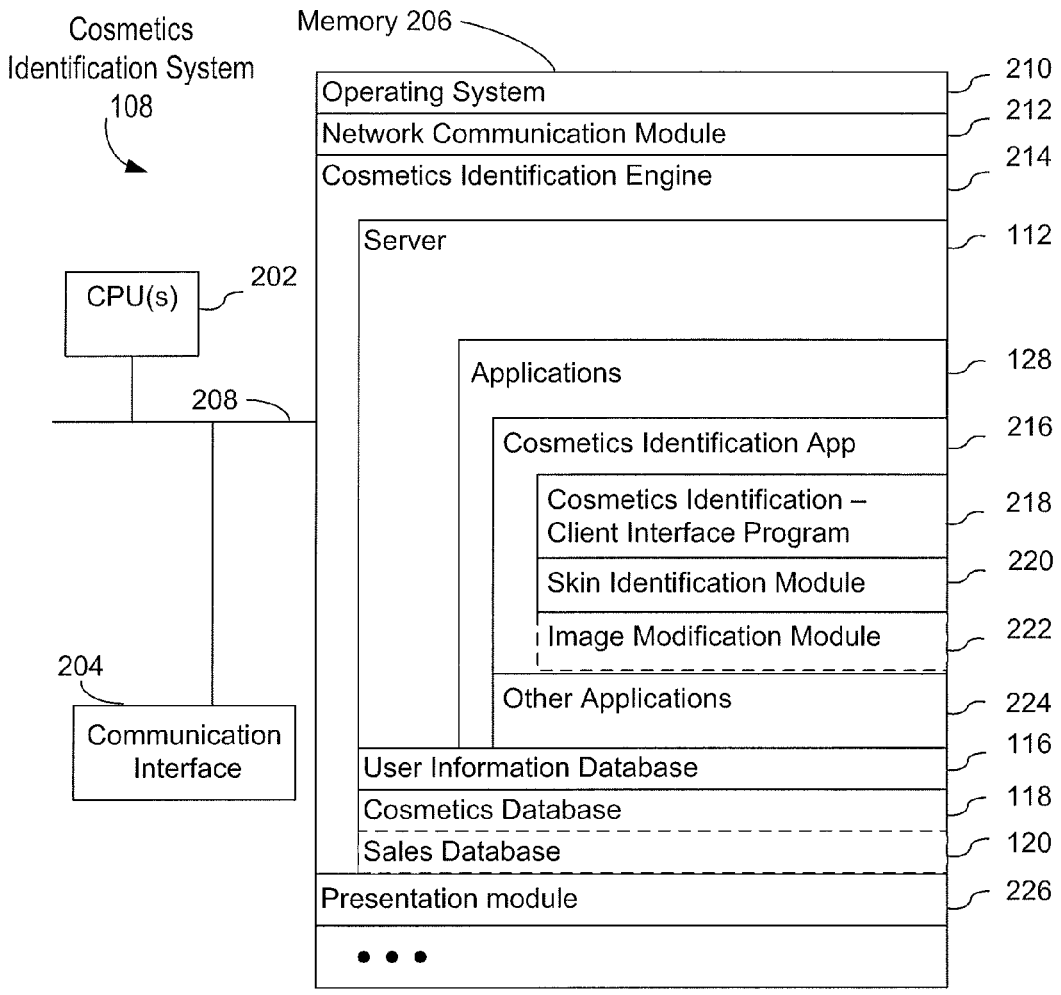

Cosmetics Identification System
108
Memory 206
Operating System
210
Network Communication Module
212
Cosmetics Identification Engine
214
Server
112
CPU(s)
202
Applications
128
208
Cosmetics Identification App
216
Cosmetics Identification – Client Interface Program
218
Skin Identification Module
220
Image Modification Module
222
204
Other Applications
224
Communication Interface
User Information Database
116
Cosmetics Database
118
Sales Database
120
Presentation module
226
• • •

Figure 2

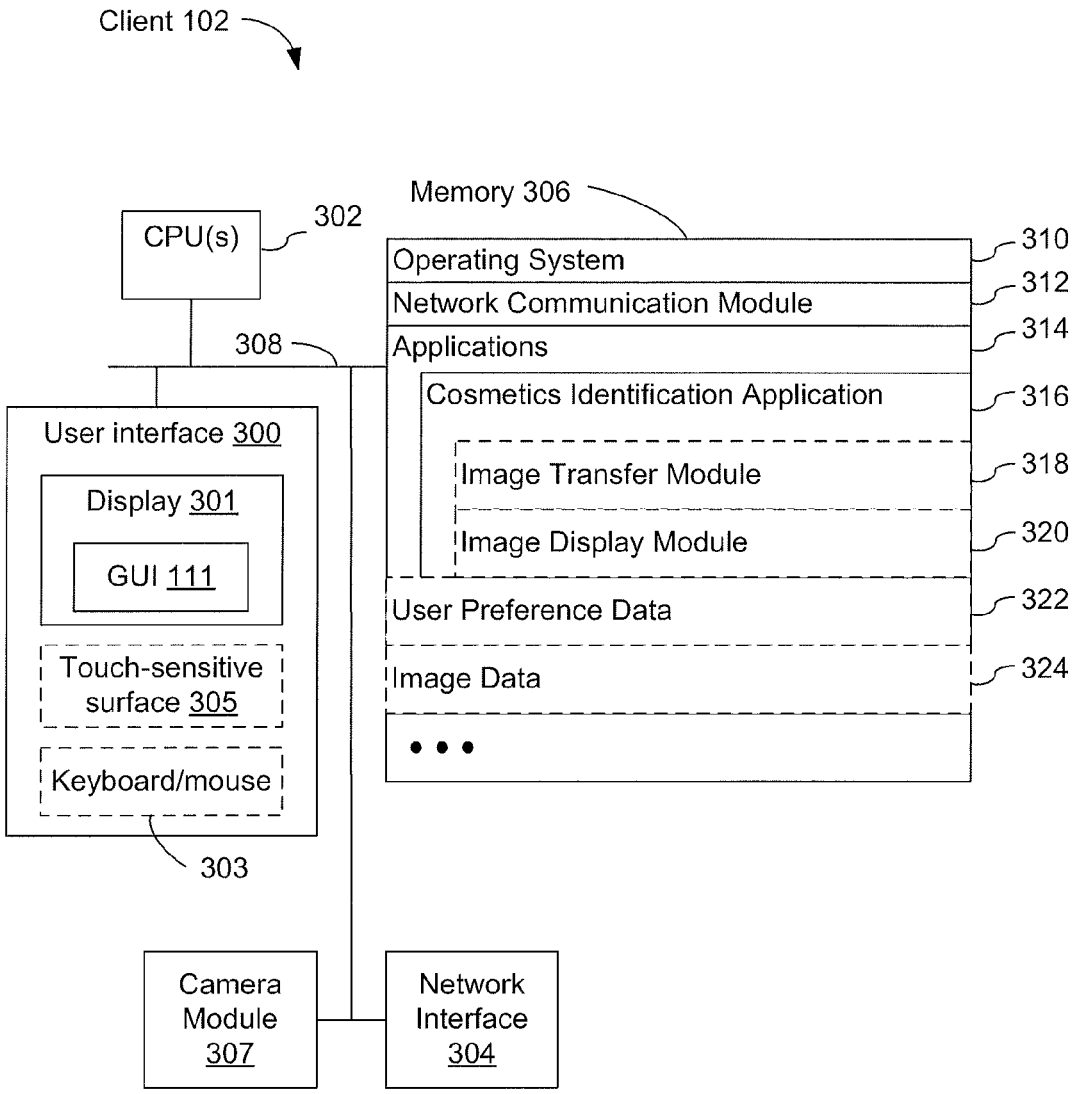

Client 102
Memory 306
CPU(s)
302
Operating System
310
Network Communication Module
312
308
Applications
314
Cosmetics Identification Application
316
User interface 300
Display 301
GUI 111
Image Transfer Module
318
Image Display Module
320
User Preference Data
322
Touch-sensitive surface 305
Image Data
324
Keyboard/mouse
303
Camera Module 307
Network Interface 304

Figure 3

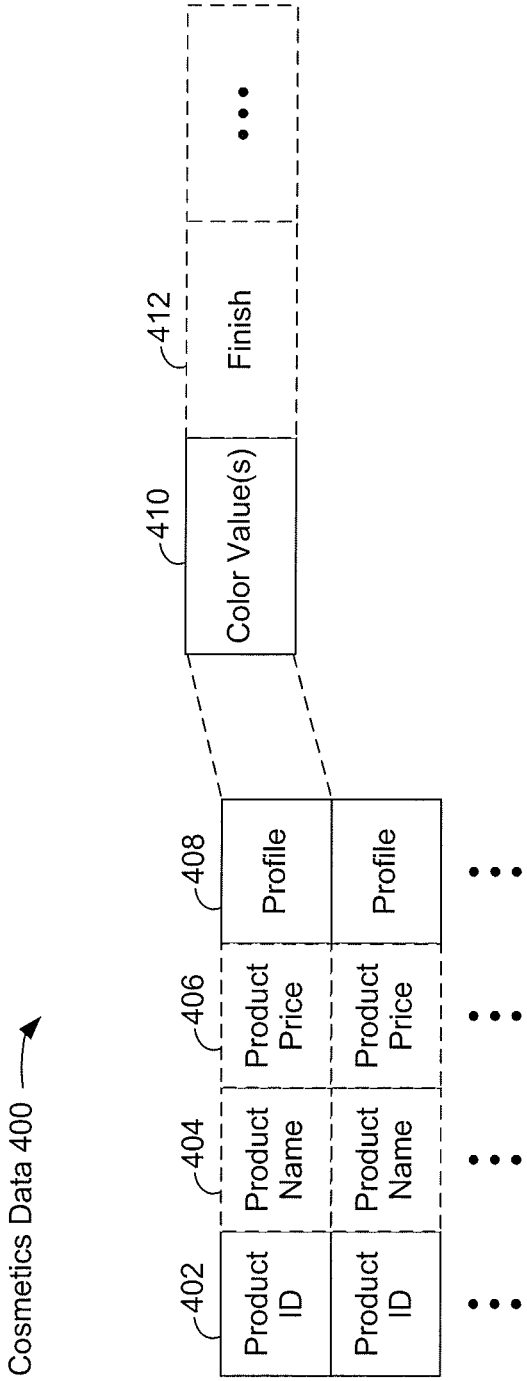

Cosmetics Data 400
402
Product ID
Product ID
404
Product Name
Product Name
406
Product Price
Product Price
408
Profile
Profile
410
Color Value(s)
412
Finish

Figure 4A

AT&T
9:32 AM
Anticipated Results
Your Shade Match
CONTINUE >>
Your Match
Recommendations
Track Results
Bag

Figure 4B

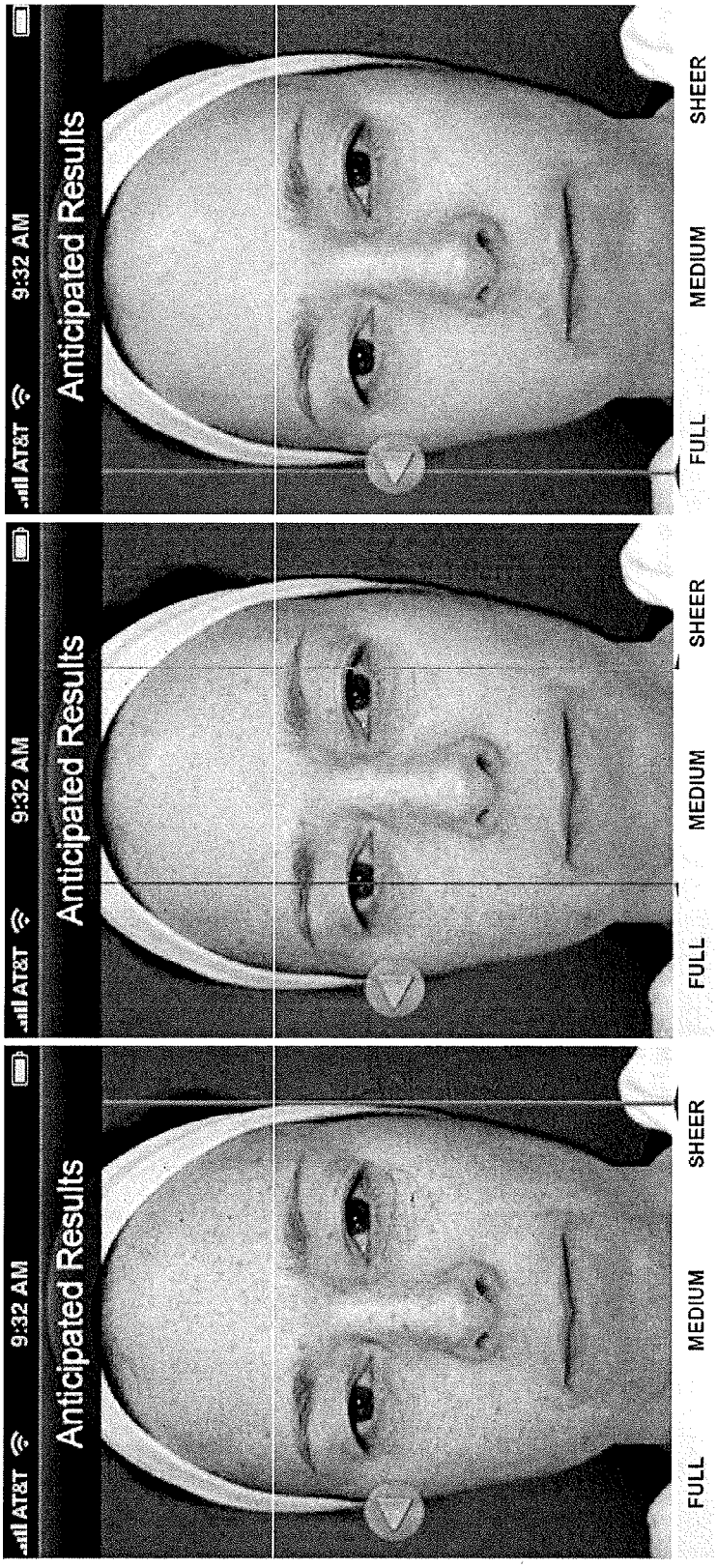

AT&T
9:32 AM
Anticipated Results
FULL
MEDIUM
SHEER
Left
AT&T
9:32 AM
Anticipated Results
FULL
MEDIUM
SHEER
Middle
AT&T
9:32 AM
Anticipated Results
FULL
MEDIUM
SHEER
Right

Figure 4C

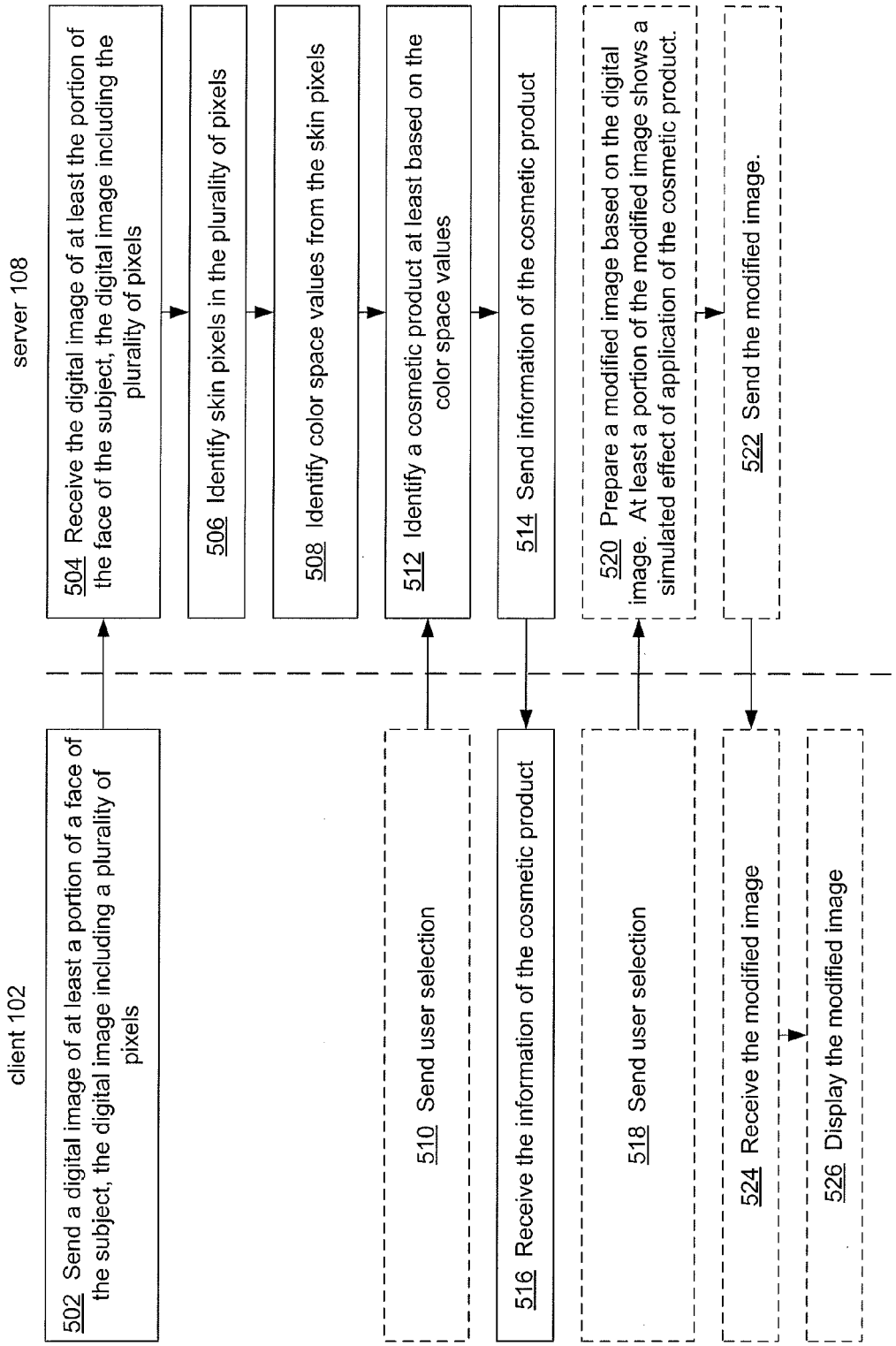

client 102
server 108
502 Send a digital image of at least a portion of a face of the subject, the digital image including a plurality of pixels
504 Receive the digital image of at least the portion of the face of the subject, the digital image including the plurality of pixels
506 Identify skin pixels in the plurality of pixels
508 Identify color space values from the skin pixels
510 Send user selection
512 Identify a cosmetic product at least based on the color space values
514 Send information of the cosmetic product
516 Receive the information of the cosmetic product
518 Send user selection
520 Prepare a modified image based on the digital image. At least a portion of the modified image shows a simulated effect of application of the cosmetic product.
522 Send the modified image.
524 Receive the modified image
526 Display the modified image

Figure 5

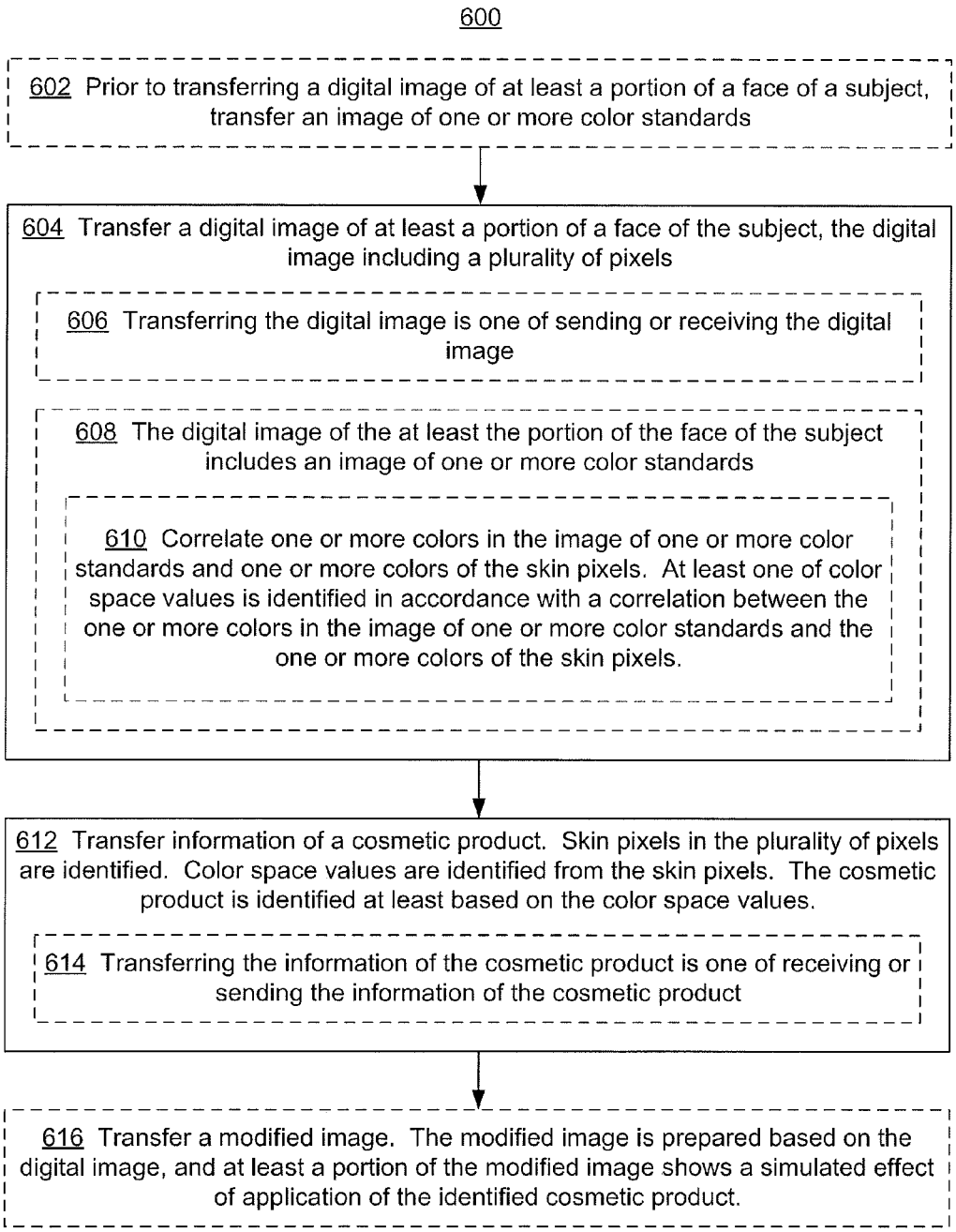

600
602 Prior to transferring a digital image of at least a portion of a face of a subject, transfer an image of one or more color standards
604 Transfer a digital image of at least a portion of a face of the subject, the digital image including a plurality of pixels
606 Transferring the digital image is one of sending or receiving the digital image
608 The digital image of the at least the portion of the face of the subject includes an image of one or more color standards
610 Correlate one or more colors in the image of one or more color standards and one or more colors of the skin pixels. At least one of color space values is identified in accordance with a correlation between the one or more colors in the image of one or more color standards and the one or more colors of the skin pixels.
612 Transfer information of a cosmetic product. Skin pixels in the plurality of pixels are identified. Color space values are identified from the skin pixels. The cosmetic product is identified at least based on the color space values.
614 Transferring the information of the cosmetic product is one of receiving or sending the information of the cosmetic product
616 Transfer a modified image. The modified image is prepared based on the digital image, and at least a portion of the modified image shows a simulated effect of application of the identified cosmetic product.

**Figure 6**

# SYSTEMS AND METHODS FOR RECOMMENDING COSMETIC PRODUCTS FOR USERS WITH MOBILE DEVICES

## RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application Ser. No. 61/805,126, filed Mar. 25, 2013, entitled "Systems and Methods for Recommending Cosmetic Products for Users with Mobile Devices," which is incorporated by reference herein in its entirety.

This application is related to U.S. patent application Ser. No. 13/240,969, filed Sep. 22, 2011, entitled "Systems and Methods for Determining a Surface Profile Using a Plurality of Light Sources" and U.S. patent application Ser. No. 13/078,834, filed Apr. 1, 2011, entitled "Methods and Systems for Imaging and Modeling Skin Using Polarized Lighting," which claims priority to U.S. Provisional Application Ser. No. 61/320,627, filed Apr. 2, 2010, entitled "Methods and Systems for Imaging and Modeling Skin Using Polarized Lighting," and is a continuation-in-part of U.S. patent application Ser. No. 12/731,072, filed Mar. 24, 2010, entitled "Methods and Systems for Imaging Skin Using Polarized Lighting," which claims priority to U.S. Provisional Application Ser. No. 61/164,356, filed Mar. 27, 2009, entitled "Methods and Systems for Imaging Skin Using Polarized Lighting." All of these applications are incorporated by reference herein in their entirety.

## TECHNICAL FIELD

The disclosed embodiments relate generally to imaging skin, and more particularly, to determining a color of skin and recommending a cosmetic product.

## BACKGROUND

Selection of cosmetic products for a user typically involves many trials with different products. It often takes time and efforts to find a cosmetic product that works well for the user, which can be frustrating and cumbersome. Furthermore, a cosmetic product that has been selected solely based on a visual perception of the user may not be a correct cosmetic product for the user.

## SUMMARY

Accordingly, there is a need for systems that can identify a cosmetic product for a user. The above deficiencies and other related problems are addressed by the systems and methods described herein. In some embodiments, a method includes transferring a digital image of at least a portion of a face of the subject, the digital image including a plurality of pixels. Skin pixels in the plurality of pixels are identified, color space values are identified from the skin pixels, and a cosmetic product is identified at least based on the color space values. The method also includes transferring information of the cosmetic product.

In some embodiments, an electronic device includes one or more processors; and memory storing one or more programs for execution by the one or more processors. The one or more programs including instructions for transferring a digital image of at least a portion of a face of the subject, the digital image including a plurality of pixels. Skin pixels in the plurality of pixels are identified, color space values are identified from the skin pixels, and a cosmetic product is identified at least based on the color space values. The one or more programs also include instructions for transferring information of the cosmetic product.

In some embodiments, a non-transitory computer readable storage medium stores one or more programs for execution by one or more processors of an electronic device. The one or more programs include instructions for transferring a digital image of at least a portion of a face of the subject, the digital image including a plurality of pixels. Skin pixels in the plurality of pixels are identified, color space values are identified from the skin pixels, and a cosmetic product is identified at least based on the color space values. The one or more programs also include instructions for transferring information of the cosmetic product.

Thus, systems for identifying a cosmetic product based on an image of a user are provided, thereby increasing the speed, quality, accuracy, and details of identifying a cosmetic product for the user.



## BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the aforementioned embodiments, reference should be made to the Description of Embodiments below, in conjunction with the following drawings in which like reference numerals refer to corresponding parts throughout the figures.

FIG. **1** is a block diagram illustrating an exemplary distributed computer system in accordance with some embodiments.

FIG. **2** is a block diagram illustrating a cosmetics identification system in accordance with some embodiments.

FIG. **3** is a block diagram illustrating a client in accordance with some embodiments.

FIG. **4**A is a block diagram illustrating an exemplary cosmetics data in accordance with some embodiments.

FIG. **4**B illustrates a graphical user interface in accordance with some embodiments.

FIG. **4**C illustrates graphical user interfaces in accordance with some embodiments.

FIG. **5** is a flowchart illustrating operations performed by a client and a server in accordance with some embodiments.

FIG. **6** is a flowchart illustrating a method of identifying a cosmetic product for a user in accordance with some embodiments.

Like reference numerals refer to corresponding parts throughout the drawings.

## DESCRIPTION OF EMBODIMENTS

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present inventions. However, it will be apparent to one of ordinary skill in the art that the present inventions may be practiced without these specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail so as not to unnecessarily obscure aspects of the embodiments. In addition, it should be noted that at least some of the drawings are not drawn to scale.

It will also be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first image could be termed a second image, and, similarly, a second image could be termed a first

image, without departing from the scope of the present invention. The first image and the second image are both images, but they are not the same image.

FIG. **1** is a block diagram illustrating an exemplary distributed computer system **100**, according to certain embodiments. In FIG. **1**, system **100** includes one or more client device **102**, communications network(s) **106**, and cosmetics identification system **108**. Various embodiments of the cosmetics identification system **108** implement the cosmetics identification methods described in this document.

Client device **102** can be any of a number of electronic devices (e.g., Internet kiosk, personal digital assistant, cell phone, gaming device, desktop computer, laptop computer, handheld computer, or combinations thereof) used to enable the activities described below. Client device(s) **102** is also referred to herein as client(s). Client **102** includes a graphical user interface (GUI) **111**. Client **102** is described in greater detail below with reference to FIG. **3**. Client **102** is connected to cosmetics identification system **108** via communications network(s) **106**. As described in more detail below, GUI **111** is used to display information of cosmetic products. Cosmetics identification system **108** provides cosmetics identification services to a plurality of users who access cosmetics identification system **108** from clients **102**.

Cosmetics identification system **108** includes one or more servers, such as server **112**, connected to communications network(s) **106**. Optionally, the one or more servers are connected to communications network(s) **106** via front end server **122** (e.g., a server that conveys (and optionally parses) inbound requests to the appropriate server of system **108**, and that formats responses and/or other information being sent to clients in response to requests). Front end server **122**, if present, may be a web server providing web based access to cosmetics identification system **108**. Front end server **122**, if present, may also route communications to and from other destinations, such as an online transaction server (e.g., a server for merchandise sales).

Cosmetics identification system **108** includes user information database **116**, cosmetics database **118**, and optionally, sales database **120**. In some embodiments, cosmetics identification system **108** also includes or has access to one or more other databases, such as image database (not shown). In some embodiments, the image database is a cloud database. Server **112** includes applications **128**. Server **112** communicates with databases internal to cosmetics identification system **108**, such as user information database **116**, cosmetics database **118**, and optionally, sales database **120**, and in some embodiments, an image database (not shown) using a local area network, by internal communication busses, or by any other appropriate mechanism or combination of mechanism.

Server **112** communicates with clients **102** via front end server **122** (if present) and communication network(s) **106**. In some embodiments, communications network(s) **106** is the Internet. In other embodiments, communication network(s) **106** can be any local area network (LAN), wide area network (WAN), metropolitan area network, or a combination of such networks. In some embodiments, if server **112** is used within an intranet, it may be an intranet server.

Applications **128** include application programs used for managing an online cosmetics identification system. In some embodiments, applications **128** also include a user information processing module, where the user information processing module assists in accessing and updating user information database **116**. User information database **116** stores various information associated with the users of cosmetics identification system **108**, including user preferences, digital images, and optionally other information such as user survey results. In some other embodiments, sales database **120** stores purchase history of users.

In some embodiments, cosmetics database **118** stores information concerning various cosmetic products (e.g., name, price, type, and color). The details of cosmetics data stored in cosmetics database **118** is described in detail with respect to FIG. **4**A.

In some embodiments, user information database **116** includes user information records having information relevant to the identification of cosmetic products. For example, the user information record for a respective user may include, in addition to identifying information for the user, user preferences (e.g., preferred finish of a cosmetic product, color perception of the user, etc.).

In essence, server **112** is configured to manage certain aspects of cosmetics identification system **108**, including transferring information of a cosmetic product to a respective client **102**.

Optionally, cosmetics identification system **108** is implemented as part of an online cosmetics store system that provides cosmetics sales services to users.

In some embodiments, fewer and/or additional modules, functions or databases are included in cosmetics identification system **108** and server **112**. The modules shown in cosmetics identification system **108** and server **112** represent functions performed in certain embodiments.

FIG. **2** is a block diagram illustrating cosmetics identification system **108** in accordance with some embodiments. Cosmetics identification system **108** typically includes one or more processing units (CPUs) **202**, one or more network or other communications interfaces **204**, memory **206**, and one or more communication buses **208** for interconnecting these components. In some embodiments, communication buses **208** include circuitry (sometimes called a chipset) that interconnects and controls communications between system components. In some other embodiments, cosmetics identification system **108** includes a user interface (not shown) (e.g., a user interface having a display device, a keyboard, and a mouse or other pointing device), but more typically cosmetics identification system **108** is controlled from and accessed by various client systems (e.g., a desktop or a laptop).

Memory **206** of cosmetics identification system **108** includes high-speed random access memory, such as DRAM, SRAM, DDR RAM or other random access solid state memory devices; and may include non-volatile memory, such as one or more magnetic disk storage devices, optical disk storage devices, flash memory devices, or other non-volatile solid state storage devices. Memory **206** may optionally include one or more storage devices remotely located from the CPU(s) **202**. Memory **206**, or alternately the non-volatile memory device(s) within memory **206**, comprises a non-transitory computer readable storage medium. In some embodiments, memory **206** or the computer readable storage medium of memory **206** stores the following programs, modules and data structures, or a subset thereof:

- Operating System **210** that includes procedures for handling various basic system services and for performing hardware dependent tasks;
- Network Communication Module (or instructions) **212** that is used for connecting the cosmetics identification system **108** to other computers (e.g., clients **102**) via one or more communications interfaces **204** and one or more communications networks **106** (FIG. **1**), such as

the Internet, other wide area networks, local area networks, metropolitan area networks, and so on;

Cosmetics Identification Engine **214** that receives cosmetics identification requests from and provides responses to clients **102**; and

Presentation module **226** that formats results from cosmetics identification engine **214** for display at respective clients; for example, presentation module **226** may generate a web page or XML document that includes information for cosmetic products or an image showing a simulated effect of application of a cosmetic product; in some embodiments, presentation module **226** is executed by front end server **122**, which comprises one of the servers implementing cosmetics identification system **108**; optionally, presentation module **226** is a module of cosmetics identification engine **214**.

In some embodiments, cosmetics identification engine **214** includes the following programs, modules and data structures, or a subset or superset thereof:

Server **112** for managing certain aspects of cosmetics identification system **108** including applications **128**, including cosmetics identification application **216** for performing the primary functions of an online cosmetics identification system; cosmetics identification application **216** includes cosmetics identification-client interface program (or module) **218** for receiving cosmetics identification requests from clients and generating responses to the requests, skin identification module **220**, and (optionally) image modification module **222**; applications **128** may optionally include other applications **224**;

User information database **116** that stores records for users;

Cosmetics database **118** that includes concerning various cosmetic products (e.g., name, price, type, and color); and

(Optional) Sales database **120** that stores purchase history of users; sales database **120** may include other information (e.g., product availability, lead time, promotions, etc.).

Each of the above identified modules and applications correspond to a set of instructions for performing one or more functions described above. These modules (i.e., sets of instructions) need not be implemented as separate software programs, procedures or modules, and thus various subsets of these modules may be combined or otherwise re-arranged in various embodiments. In some embodiments, memory **206** may store a subset of the modules and data structures identified above. Furthermore, memory **206** may store additional modules and data structures not described above.

Notwithstanding the discrete blocks in FIGS. **1** and **2**, these figures are intended to be a functional description of some embodiments rather than a structural description of functional elements in the embodiments. One of ordinary skill in the art will recognize that an actual implementation might have the functional elements grouped or split among various components. In practice, and as recognized by those of ordinary skill in the art, items shown separately could be combined and some items could be separated. For example, in some embodiments, user information database **116** is part of or stored within server **112**. In other embodiments, user information database **116** is implemented using one or more servers whose primary function is to store and process user information. In some embodiments, user information database **116** includes sales database **120**, or vice versa. Similarly, an image database (not shown) can be implemented on one or more servers.

The actual number of servers used to implement cosmetics identification system **108** and how features are allocated among them will vary from one implementation to another, and may depend in part on the amount of data traffic that the system must handle during peak usage periods as well as during average usage periods, and may also depend on the amount of data stored by the cosmetics identification system. Moreover, one or more of the blocks in FIG. **1** may be implemented on one or more servers designed to provide the described functionality. Although the description herein refers to certain features implemented in client **102** and certain features implemented in server **112**, the embodiments are not limited to such distinctions. For example, features described herein as being part of server **112** can be implemented in whole or in part in client **102**, and vice versa.

FIG. **3** is a block diagram illustrating a client, also called client systems or client devices, in accordance with some embodiments. Client **102** as shown in FIG. **3** is configured for use by a user of cosmetics identification system **108**. Client **102** includes a user interface **300**, which typically includes display device **301**, and one or more input devices. In some embodiments, the one or more input devices include touch-sensitive surface **305**. In some embodiments, touch-sensitive surface **305** is located on display device **301** (e.g., a touch-sensitive display). In some embodiments, the one or more input devices include a keyboard and a mouse or other pointing device (**303**). As noted above, client **102** includes graphical user interface (GUI) **111**, which is displayed on display device **301**. Client **102** typically includes one or more processing units (CPUs) **302**, one or more network or other network communications interfaces **304**, memory **306**, camera module **307**, and one or more communication buses **308** for interconnecting these components. In some embodiments, camera module **307** is connected to one or more communication buses through a peripheral module controller (not shown). Communication buses **308** may include circuitry (sometimes called a chipset) that interconnects and controls communications between system components.

Memory **306** includes high-speed random access memory, such as DRAM, SRAM, DDR RAM or other random access solid state memory devices; and may include non-volatile memory, such as one or more magnetic disk storage devices, optical disk storage devices, flash memory devices, or other non-volatile solid state storage devices. Memory **306** may optionally include one or more storage devices remotely located from the CPU(s) **302**. Memory **306**, or alternately the non-volatile memory device(s) within memory **306**, comprises a non-transitory computer readable storage medium. In some embodiments, memory **306** or the computer readable storage medium of memory **306** stores the following programs, modules and data structures, or a subset thereof:

Operating System **310** that includes procedures for handling various basic system services and for performing hardware dependent tasks;

Network Communication Module (or instructions) **312** that is used for connecting client **102** to other computers (e.g., cosmetics identification system **108** and other clients **102**) via the one or more communications network interfaces **304** and one or more communication networks **106** (FIG. **1**), such as the Internet, other wide area networks, local area networks, metropolitan area networks, and so on;

Applications **314**, including cosmetics identification application **316**; in some embodiments, cosmetics identification application **316** includes image transfer mod-

ule **318** for transferring images to and from cosmetics identification system **108** and/or image display module **320** for displaying one or more images on display device **301**;

(optional) User preference data **322**, which is a locally stored subset of the user's preferences; and

(optional) Image data **324**, which is a locally stored subset of the user's images (e.g., images of user's skin).

FIG. **4**A is a block diagram illustrating exemplary cosmetics data **400** in accordance with some embodiments. In some embodiments, cosmetics data **400** is stored in cosmetics database **118**. Cosmetics data **400** includes information for cosmetic products. Cosmetics data **400** typically includes a plurality of entries, each entry storing information for a respective cosmetic product.

An entry in cosmetics data **400** includes the following data for a cosmetic product, or a subset or superset thereof:

Product ID **402** that uniquely identifies a respective cosmetic product;

(optional) Product Name **404** that identifies a name of the respective cosmetic product;

(optional) Product Price **404** that identifies a price of the respective cosmetic product; and

Product Profile **408** that identifies properties of the respective product.

In some embodiments, product profile **408** includes color space values (e.g., chroma and luma values). In some embodiments, product profile **408** includes indication of a finish of the respective product (e.g., semi-matte, natural, or radiant). In some embodiments, product profile **408** includes product performance attributes. In some embodiments, product profile **408** includes product performance claims. In some embodiments, product profile **408** includes product hierarchy (e.g., "hero" or "must-have" status over other products). In some embodiments, product profile **408** includes an area of application (e.g., one or more target facial zones, such as a nose, forehead, and chin).

FIG. **4**B illustrates a graphical user interface in accordance with some embodiments.

In FIG. **4**B, the graphical user interface shows a portion of the digital image. The displayed portion of the digital image includes a first portion of the face of the user. The first portion typically indicates a face without application of a cosmetic product. The graphical user interface shown in FIG. **4**B also includes a portion of a modified image. The modified image includes a second portion of the face of the user. The second portion typically includes a face with application of a cosmetic product. In some embodiments, the second portion includes a face with simulated application of the cosmetic product.

FIG. **4**C illustrates graphical user interfaces in accordance with some embodiments.

Shown on the left side of FIG. **4**C is an image of a face of a user. The image shown on the left side of FIG. **4**C corresponds to the face of the user without application of a cosmetic product.

The image shown on the left side of FIG. **4**C also includes red and green vertical lines. The red and green lines may be moved horizontally based on a user input (e.g., a horizontal drag gesture on a touch-sensitive display). In some embodiments, the red line is used to change a portion of the image that represents a portion of the face without application of a cosmetic product. In some embodiments, the green line is used to change a portion of the image that represents a portion of the face with full application of the cosmetic product.

Shown in the middle of FIG. **4**C is an image of the face wherein a first portion of the face is shown without application of the cosmetic product, a second portion of the face is shown with sheer application of the cosmetic product, and a third portion of the face is shown with medium or full application of the cosmetic product. As shown in FIG. **4**C, a portion of the face on a left-hand side of the red line is shown without application of the cosmetic product, a portion of the face between the red line and the green line is shown with sheer application of the cosmetic product, and a portion of the face on the right-hand side of the green line is shown with medium or full application of the cosmetic product.

Shown in the right side of FIG. **4**C is an image of the face wherein red and green are moved to the left side of the face. The image of the face is shown with simulated medium or full application of the cosmetic product.

FIG. **5** is a flowchart illustrating operations performed by a client and a server in accordance with some embodiments.

As shown in FIG. **5**, client **102** sends (**502**) a digital image of at least a portion of a face of the subject (e.g., a user) to server **108**.

Server **108** receives (**504**) the digital image of at least the portion of the face of the subject.

Server **108** identifies (**506**) skin pixels in the digital image. In some embodiments, server **108** performs a facial recognition in the digital image. In some embodiments, performing a facial recognition includes locating non-skin regions (e.g., eyes, nose, mouth, and hair) of the user in the digital image, and precluding the non-skin regions in a face of the user in the digital image. For example, server **108** identifies forehead, cheek, and chin regions of the user in the digital image as skin pixels.

In some embodiments, server **108** identifies a gradient in a brightness of the portion of the face in the digital image, and selects a portion of the face that has a medium brightness (e.g., an average brightness or a median brightness). This precludes regions with reduced lighting or excessive lighting from affecting identifying color space values.

Server **108** identifies (**508**) color space values from the skin pixels. A respective skin pixel in the digital image typically includes multiple color values, such red (R), green (G), and blue (B) values. In some embodiments, server calculates L, a, and b values (values in a Lab color space, such as a Lab color space specified by the International Commission on Illumination) as color space values. In some embodiments, the L, a, and b values are referred to as Lab values. The methods for converting the RGB values to Lab values are well known. For example, in some embodiments when RGB values range from 0 to 255, Lab values are obtained in accordance with the following equations:

$$r = R/255$$

$$g = G/255$$

$$b = B/255$$

$$r' = \begin{cases} (r+0.055)/1.055)2.4 & (\text{if } r > 0.04045) \\ r/12.92 & (\text{if } r \leq 0.04045 \end{cases}$$

$$g' = \begin{cases} (g+0.055)/1.055)2.4 & (\text{if } g > 0.04045) \\ g/12.92 & (\text{if } g \leq 0.04045 \end{cases}$$

$$b' = \begin{cases} (b+0.055)/1.055)2.4 & (\text{if } b > 0.04045) \\ b/12.92 & (\text{if } b \leq 0.04045 \end{cases}$$

$$r'' = r' \times 100$$

-continued

$$g'' = g' \times 100$$

$$b'' = b' \times 100$$

$$x = 0.04124 \times r'' + 0.3576 \times g'' + 0.1805 \times b''$$

$$y = 0.2126 \times r'' + 0.7152 \times g'' + 0.0722 \times b''$$

$$z = 0.0193 \times r'' + 0.1192 \times g'' + 0.9505 \times b''$$

$$x' = \begin{cases} x^{1/3} & (\text{if } x > 0.008856) \\ 7.787 \times x + 16/116 & (\text{if } x \leq 0.008856 \end{cases}$$

$$y' = \begin{cases} y^{1/3} & (\text{if } y > 0.008856) \\ 7.787 \times y + 16/116 & (\text{if } y \leq 0.008856) \end{cases}$$

$$z' = \begin{cases} z^{1/3} & (\text{if } z > 0.008856) \\ 7.787 \times z + 16/116 & (\text{if } z \leq 0.008856) \end{cases}$$

$$L = 116 \times y' - 16$$

$$a = 500 \times (x' - y')$$

$$b = 200 \times (y' - z')$$

Some of these equations assume illumination that corresponds to International Commission on Illumination (CIE) standard illumant D65. However, a person having ordinary skill in the field of colorimetry would understand that different equations can be used to obtain Lab values for different illumination conditions. A person having ordinary skill in the field of colorimetry would also understand that these equations can be presented in more compact forms.

In some embodiments, RGB values of multiple skin pixels are used. This eliminates the effect of imperfections (e.g., spots and/or wrinkles) shown in the digital image from affecting the Lab values of the skin pixels. For examples, average RGB values over a skin region may be used.

In some embodiments, client **102** sends (**510**) user selection (or user preference) to server **108**, and server **108** receives the user selection (or user preference). In some embodiments, the user selection (or the user preference) includes a user preference to use a lighter or darker color.

In some embodiments, prior to client **102** sending user selection, server **108** sends the color space values to client **102**, and client **102**, in response, presents the color space values to the user. In some embodiments, client **102** presents the color space values in a graphical form to the user (e.g., show the color that corresponds to the color space values concurrently with an image including at least a portion of the face of the subject). Subsequent to presenting the color space values, client **102** receives user selection to use a lighter or darker color, and sends the user selection to server **108**.

Server **108** identifies (**512**) a cosmetic product at least based on the color space values. In some embodiments, server **108** compares the Lab values of the skin pixels to Lab values of cosmetic products. In some embodiments, server **108** retrieves Lab values of cosmetic products from cosmetics database **118** (FIG. **1**). In some embodiments, server **108** selects a cosmetic product that has a color that most closely matches the color of the skin pixels. In some embodiments, server **108** identifies a cosmetic product that has a color with a shortest Euclidean distance to a color of the skin pixels. In other embodiments, server **108** selects a cosmetic product that has a color that is close to the color of the skin pixels in accordance with the following equations:

$$\Delta E = \sqrt{(0.5\Delta V_J)^2 + (\Delta W_X)^2 + (0.4\Delta W_Z)^2}$$

$$W_X = \left(\frac{x/x_n}{y/y_n} - 1\right)V_J,$$

where

$$W_Z = \left(\frac{z/z_n}{y/y_n} - 1\right)V_J,$$

$x_n$, $y_n$, $z_n$ are chromaticities of a reference white object, and

$V_J$ is the Newhall-Nickerson-Judd value function.

In some embodiments, when the user selection is received, server **108** identifies a cosmetic product at least based on the color space values and the user selection.

Server **108** sends (**514**) information of the identified cosmetic product to client **102**.

Client **102** receives (**516**) the information of the identified cosmetic product. In some embodiments, client **102** presents the information of the identified cosmetic product to the user. For example, client **102** displays an image of the identified cosmetic product.

In some embodiments, client **102** sends user selection for generating a modified image. In some embodiments, the user selection for generating a modified image includes a level of coverage (e.g., sheer coverage, sheer-medium coverage, medium-full coverage, etc.). In some embodiments, the user selection for generating a modified image includes a finish (e.g., semi-matte, natural, radiant, etc.). In some embodiments, server **108** receives the user selection for generating a modified image.

In some embodiments, server **108** prepares (**520**) a modified image based on the digital image. At least a portion of the modified image shows a simulated effect of application of the cosmetic product. For example, the modified image may include a portion of the face of the subject that does not have a cosmetic product applied and another portion of the face of the subject with a simulated application of the cosmetic product. In some embodiments, the modified image includes three or more portions, each portion corresponding to a respective level of coverage and/or finish. For example, the modified image may include a first portion with a semi-matte finish, a second portion with a natural finish, and a third portion with a radiant finish. In another example, the modified image may include a first portion with a full coverage, a second portion with a medium coverage, and a third portion with a sheer coverage.

In some embodiments, server **108** prepares the modified image by mixing the digital image with a layer with a selected color (called "cosmetic layer" herein). In some embodiments, the selected color is based on the identified color space values. In generating the modified image, the cosmetic layer is applied to the skin pixels. In other words, the cosmetic layer is not applied to eyes, mouth, and hair that do not typically receive application of a particular cosmetic product (e.g., a foundation). This allows eyes, mouth, and hair to look natural in the modified image. In some embodiments, the modified image is prepared by mixing the digital image with the cosmetic layer based on preselected weights. For example, in simulating a sheer application of the cosmetic product, the cosmetic layer is given a low weight (e.g., 10% or 20%) and, in simulating a full application of the cosmetic product, the cosmetic layer is given a high weight (e.g., 60% or 70%). Thus, the modified image is useful in illustrating the product performance as described for a cosmetic product. In some embodiments, the product per-

formance is illustrated by modifying one or more portions of the digital image. For example, for a cosmetic product that is effective in reducing wrinkles in an eye area, the modified image is created by reducing visual features (e.g., wrinkles) in a corresponding area (e.g., eye area).

In some embodiments, server **108** sends (**522**) the modified image to client **102**.

In some embodiments, client **102** receives (**524**) the modified image and displays (**526**) the modified image.

In some embodiments, client **102** receives user input manipulating on the modified image, and sends the user input to server **108**. For example, the user input may change a portion of the face with a simulated application of the cosmetic product (e.g., increase the portion of the face with a simulated application of the cosmetic product). In another example, the user input may include a change of the level of coverage and/or finish. Server **108**, in response, revises the modified image and sends the revised image to client **102**. Client **102** replaces the modified image with the revised image.

Details of certain operations shown in FIG. **5** are described below with respect to FIG. **6**. Certain details of operations described above with respect to FIG. **5** are applicable to operations shown in FIG. **6** (e.g., identifying skin pixels in the digital image, identifying color space values from the skin pixels, and identifying a cosmetic product). For brevity, these details are not repeated.

FIG. **6** is a flowchart illustrating method **600** of identifying a cosmetic product for a user in accordance with some embodiments. In some embodiments, the method is performed at a cosmetics identification system (e.g., cosmetics identification system **108** in FIGS. **1** and **2**) or a client (e.g., client **102** in FIGS. **1** and **3**).

In some embodiments, the system, prior to transferring the digital image of at least the portion of the face of the subject, transfers (**602**) an image of one or more color standards. In some embodiments, the image of one or more color standards and the digital image of at least a portion of a face of the subject are captured in a same lighting environment. For example, client **102** acquires an image of one or more color standards (e.g., a color wheel, a color standard card that shows multiple standard colors, etc.) and sends the image to server **108**. In another example, server **108** receives the image of one or more color standards. Typically, the one or more color standards are one or more preselected color standards.

The system transfers (**604**) a digital image of at least a portion of a face of the subject (e.g., a user). The digital image including a plurality of pixels. For example, the digital image includes an image of the entire face of the user or a portion thereof, such as a cheek portion of the user.

In some embodiments, the system determines whether the digital image of at least a portion of a face of the subject is suitable for cosmetic recommendations. In some embodiments, the system determines one or more areas in the digital image of at least a portion of a face of the subject for cosmetic recommendations. In some embodiments, the determination is based on a presence of a face and facial characteristics in the digital image. In some embodiments, the determination is based on a presence of facial characteristics in the digital image such that a skin model can be created. In some embodiments, the determination is based on a size of the face in the digital image. In some embodiments, the system corrects an orientation of the digital image. For example, a digital image taken upside down is rotated to have a correct orientation.

In some embodiments, transferring the digital image is (**606**) one of sending or receiving the digital image. For example, client **102** sends the digital image to server **108**. In another example, server **108** receives the digital image.

In some embodiments, the digital image of the at least the portion of the face of the subject includes (**608**) an image of one or more color standards. For example, the one or more color standards are located adjacent to the portion of the face in the digital image. In some embodiments, this is achieved by placing the one or more color standards below the user's chin when the digital image is acquired.

In some embodiments, the system correlates (**610**) one or more colors in the image of one or more color standards and one or more colors of the skin pixels. For example, a standard red color in the one or more color standards may not appear as a standard red color in the image. Thus, in some embodiments, the system determines that a color that matches a standard red color as shown in the image has a standard red color. At least one of the color space values is identified in accordance with a correlation between the one or more colors in the image of one or more color standards and the one or more colors of the skin pixels. For example, in some embodiments, colors in the digital image are calibrated based on the image of one or more color standards. In some embodiments, the system processes the image of one or more color standards. For example, the system processes the image of one or more color standards to correlate colors that appear in the image of one or more color standards and one or more colors that the image of one or more color standards represents. In some embodiments, the system processes the image of one or more color standards. In some embodiments, the processing includes a shape recognition (e.g., identifying colors in the image of one or more color standards based on a location of the one or more color standards in the image). For example, a Macbeth color checker chart or any other color checker chart may be used.

In some embodiments, the system performs white balancing on the digital image. In some embodiments, the system receives a user selection of a light source (e.g., outdoor light condition, such as sunny, partly cloudy, and cloudy, or indoor light condition, such as bright white, soft white, and yellow and/or incandescence light or fluorescence light).

The system transfers (**612**) information of a cosmetic product. Skin pixels in the plurality of pixels are identified. Color space values are identified from the skin pixels. The cosmetic product is identified at least based on the color space values.

In some embodiments, transferring the information of the cosmetic product is (**614**) one of receiving or sending the information of the cosmetic product.

In some embodiments, the system transfers (**616**) a modified image. The modified image is prepared based on the digital image, and at least a portion of the modified image shows a simulated effect of application of the cosmetic product.

In some embodiments, the electronic device is selected (**618**) from a group consisting of a wireless phone, a wireless tablet, and a wireless computer. In some embodiments, the electronic device is a connected device. In some embodiments, the electronic device is a wired device.

The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the inventions to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the

principles of the inventions and their practical applications, to thereby enable others skilled in the art to best utilize the inventions and various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

**1**. A method for analyzing a skin of a subject and identifying a cosmetic product for the subject, comprising:

at an electronic device with one or more processors and memory storing one or more programs for execution by the one or more processors:

calibrating colors of a first digital image, wherein the first digital image depicts at least a portion of a face of the subject, and the first digital image includes a plurality of pixels, and wherein calibrating colors of the first digital image is based on a second digital image of one or more color standards;

transferring the first digital image, but prior to transferring the first digital image, transferring the second digital image of one or more color standards;

using the second digital image of one or more color standards to correlate one or more colors of one or more color standards and one or more colors of the skin pixels, wherein at least one color space value is identified in accordance with a correlation between the one or more colors of one or more color standards and the one or more colors of the skin pixels; and

transferring information of a cosmetic product, wherein skin pixels in the plurality of pixels are identified, color space values are identified from the skin pixels, and the cosmetic product is identified at least based on the color space values.

**2**. The method of claim **1**, wherein transferring the first digital image is one of sending or receiving the digital image.

**3**. The method of claim **1**, including:

transferring a modified image, wherein the modified image is prepared based on the first digital image, and at least a portion of the modified image shows a simulated effect of application of the cosmetic product.

**4**. The method of claims **1**, wherein the first digital image further depicts one or more color standards.

**5**. A method for analyzing a skin of a subject and identifying a cosmetic product for the subject, comprising:

at an electronic device with one or more processors and memory storing one or more programs for execution by the one or more processors:

calibrating colors of a first digital image, wherein the first digital image depicts at least a portion of a face of the subject, and the first digital image includes a plurality of pixels;

displaying the first digital image;

dividing the display of the first digital image into two sides, wherein one side of the first digital image is displayed with no cosmetic product applied, and one side of the first digital image is displayed with a simulated application of a cosmetic product;

transferring the first digital image; and

transferring information of a cosmetic product, wherein skin pixels in the plurality of pixels are identified, color space values are identified from the skin pixels, and the cosmetic product is identified at least based on the color space values.

**6**. An electronic device, comprising:

one or more processors; and

memory storing one or more programs for execution by the one or more processors, the one or more programs causing the electronic device to perform a method comprising:

calibrating colors of a first digital image, wherein the first digital image depicts at least a portion of a face of the subject, and the first digital image includes a plurality of pixels;

transferring the first digital image;

displaying the first digital image;

dividing the display of the first digital image into two sides, wherein one side of the first digital image is displayed with no cosmetic product applied, and one side of the first digital image is displayed with a simulated application of a cosmetic product; and

transferring information of a cosmetic product, wherein skin pixels in the plurality of pixels are identified, color space values are identified from the skin pixels, and the cosmetic product is identified at least based on the color space values.

**7**. The method of claim **6**, wherein calibrating colors of a first digital image is based on a second digital image of one or more color standards.

**8**. The electronic device of claim **7**, wherein the method includes, prior to transferring the first digital image, transferring the second digital image of one or more color standards.

**9**. The electronic device of claim **6**, wherein the method includes:

transferring a modified image, wherein the modified image is prepared based on the first digital image, and at least a portion of the modified image shows a simulated effect of application of the cosmetic product.

**10**. The electronic device of claim **6**, wherein the first digital image further depicts one or more color standards.

**11**. A non-transitory computer readable storage medium storing one or more programs for execution by one or more processors of an electronic device, the one or more programs causing the electronic device to perform a method comprising:

calibrating colors of a first digital image, wherein the first digital image depicts at least a portion of a face of the subject, and the first digital image includes a plurality of pixels;

transferring the first digital image;

displaying the first digital image;

dividing the display of the first digital image into two sides, wherein one side of the first digital image is displayed with no cosmetic product applied, and one side of the first digital image is displayed with a simulated application of a cosmetic product; and

transferring information of a cosmetic product, wherein skin pixels in the plurality of pixels are identified, color space values are identified from the skin pixels, and the cosmetic product is identified at least based on the color space values.

**12**. The computer readable storage medium of claim **11**, wherein calibrating colors of the first digital image is based on a second digital image of one or more color standards.

**13**. The computer readable storage medium of claim **11**, wherein the method includes:

transferring a modified image, wherein the modified image is prepared based on the first digital image, and at least a portion of the modified image shows a simulated effect of application of the cosmetic product.

**14**. The computer readable storage medium of claim **11**, wherein the method includes, prior to transferring the first digital image, transferring the second digital image of one or more color standards.

**15**. The computer readable storage medium of claim **11**, wherein the first digital image further depicts one or more color standards.

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