UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

FILED: MAY 27, 2009
09CV3180
JUDGE PALLMEYER
MAGISTRATE JUDGE COX
BR

IQ BIOMETRIX, INC., Plaintiff, v. PERFECT WORLD ENTERTAINMENT, INC., PERFECT WORLD CO, LTD., AND WAGWARE SYSTEMS, INC., Defendants.	Case No. **Jury Trial Demanded**

IQ BIOMETRIX'S COMPLAINT FOR PATENT INFRINGEMENT

Plaintiff IQ Biometrix, Inc. ("IQ Biometrix"), for its complaint against Defendants Perfect World Ent., Inc. ("Perfect World Ent."), Perfect World Co., Ltd. ("Perfect World Co.") (Perfect World Ent. and Perfect World Co. referred to collectively as "Perfect World") and Wagware Systems, Inc. ("Wagware") (Perfect World and Wagware referred to collectively as "Defendants"), hereby demands a jury trial and alleges as follows:

NATURE OF THE ACTION

1. This is an action for patent infringement arising under the patent laws of the United States, 35 U.S.C. §§ 271 *et seq*.

PARTIES

2. Plaintiff IQ Biometrix, owner of the patents identified below, is a corporation organized and existing under the laws of the State of Delaware, with its principal place of business at 1525 Lakeville Drive, Suite 200, Kingwood, Texas 77339. IQ Biometrix provides facial image composite software marketed under the name FACES. The FACES software is used by thousands of law enforcement agencies worldwide, including the CIA and the FBI, as well as the U.S. Military. The FACES software has received numerous awards, including the Crime Stoppers International President's Award and the National Parenting Center Seal of Approval Award.

3. Upon information and belief, Defendant Perfect World Ent. is a corporation organized and existing under the laws of the State of Delaware, with its principal place of business at 2200 Bridge Parkway, Suite 201, Redwood City, California 94065.

4. Upon information and belief, Defendant Perfect World Co. is a company organized and existing under the laws of the People's Republic of China, with its principal place of business at 8th Floor, Huakong Building, No. 1 Shangdi East Road, Haidian District, Beijing 100085, People's Republic of China.

5. Upon information and belief, Defendant Wagware is a corporation organized and existing under the laws of the State of Alabama, with its principal place of business at 218 Sarasista Circle, Harvest, Alabama 35749.

JURISDICTION AND VENUE

6. This action arises under the patent laws of the United States, Title 35, United States Code.

7. This Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a).

8. Upon information and belief, Perfect World Ent. has done substantial business in the State of Illinois and has committed and continues to commit acts of patent infringement in this judicial district.

9. Upon information and belief, Perfect World Co. has done substantial business in the State of Illinois and has committed and continues to commit acts of patent infringement in this judicial district.

10. Upon information and belief, Wagware has done substantial business in the State of Illinois and has committed and continues to commit acts of patent infringement in this judicial district.

11. Upon information and belief, this Court may exercise personal jurisdiction over each of the Defendants because each has at least minimum contacts with this forum as a result of business regularly conducted within the State of Illinois and this judicial district. Such jurisdiction exists generally as well as specifically as a result of, at least, the Defendants offering to sell and/or selling products in this judicial district that are claimed to infringe claims of one or more of U.S. Patents Nos. 6,731,302 and 7,289,647. Each Defendant's conduct and connections with this judicial district are and have been such that it reasonably should have anticipated being brought into court in this judicial district.

12. Venue is proper in this judicial district pursuant to 28 U.S.C. §§ 1391 and 1400(b).

INFRINGEMENT OF U.S. PATENT NO. 6,731,302

13. On May 4, 2004, the United States Patent and Trademark Office duly and legally issued U.S. Patent No. 6,731,302 ("the '302 patent"), entitled "Method and Apparatus for Creating Facial Images." IQ Biometrix has been assigned sole title to the '302 patent and has the right to sue and recover for infringement. A copy of the '302 patent is attached as Exhibit A to this Complaint.

14. Upon information and belief, Perfect World and its products, including, at least, the Perfect World online game, have been and are infringing one or more claims of the '302 patent directly, contributorily and/or by inducement, in violation of 35 U.S.C. § 271.

15. IQ Biometrix has been damaged by Defendants' infringement of the '302 patent.

INFRINGEMENT OF U.S. PATENT NO. 7,289,647

16. On October 30, 2007, the United States Patent and Trademark Office duly and legally issued U.S. Patent No. 7,289,647 ("the '647 patent"), entitled "System and Method for Creating and Displaying a Composite Facial Image." IQ Biometrix has been assigned sole title to the '647 patent and has the right to sue and recover for infringement. A copy of the '647 patent is attached as Exhibit B to this Complaint.

17. Upon information and belief, Perfect World and its products, including, at least, the Perfect World online game, have been and are infringing one or more claims of the '647 patent directly, contributorily and/or by inducement, in violation of 35 U.S.C. § 271.

18. Upon information and belief, Defendant Wagware and its products, including at least the MakeFaces computer game, have been and are infringing one or more claims of the ’647 patent directly, contributorily and/or by inducement, in violation of 35 U.S.C. § 271.

19. IQ Biometrix has been damaged by Defendants’ infringement of the ’647 patent.

JURY DEMAND

20. Pursuant to Rule 38(b) of the Federal Rules of Civil Procedure, IQ Biometrix hereby respectfully requests a jury trial on all issues and claims so triable.

PRAYER FOR RELIEF

WHEREFORE, IQ Biometrix prays for judgment as follows:

(A) That Perfect World has infringed the ’302 and ’647 patents;

(B) That Wagware has infringed the ’647 patent;

(C) That Perfect World and its officers, agents and employees, successors and assigns and those persons in active concert or participation with any of them be permanently enjoined from direct and indirect infringement of the ’302 and ’647 patents;

(D) That Wagware, its officers, agents and employees, successors and assigns and those persons in active concert or participation with any of them be permanently enjoined from direct and indirect infringement of the ’647 patent;

(E) That an accounting be had for the damages to IQ Biometrix arising out of Defendants' infringing activities together with prejudgment interest and costs, and that such damages be awarded to IQ Biometrix;

(F) That this case be deemed exceptional under 35 U.S.C. § 285, and that reasonable attorney fees, expenses and costs incurred in this action be awarded to IQ Biometrix; and

(G) That IQ Biometrix be awarded such other and further relief as this Court deems just and proper.

Dated: May 27, 2009

Respectfully submitted,

KIRKLAND & ELLIS LLP

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EXHIBIT A

US006731302B1

(12) **United States Patent**
Côté

(10) **Patent No.: US 6,731,302 B1**
(45) **Date of Patent: May 4, 2004**

(54) **METHOD AND APPARATUS FOR CREATING FACIAL IMAGES**

(75) Inventor: **Pierre Côté** , St-Charles-sur-Richelieu (CA)

(73) Assignee: **IQ Biometrix, Inc.**, Fremont, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/087,599**

(22) Filed: **Apr. 29, 1998**

(30) **Foreign Application Priority Data**

Apr. 29, 1998 (CA) 2236388

(51) **Int. Cl.**[7] **G06T 11/80**
(52) **U.S. Cl.** **345/619**; 345/646
(58) **Field of Search** 345/433, 441, 345/435, 473, 432, 430, 442, 443, 444, 423, 424, 428, 581, 582, 583, 626, 619, 646, 647, 648, 469.1, 470, 635, 629

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,214,758 A		5/1993	Ohba et al.	
5,267,154 A		11/1993	Takeuchi et al.	
5,375,195 A		12/1994	Johnston	
5,459,830 A		10/1995	Ohba et al.	
5,537,662 A	*	7/1996	Sato et al.	345/435
5,563,992 A		10/1996	Murata et al.	
5,600,767 A		2/1997	Kakiyama et al.	
5,644,690 A	*	7/1997	Yoshino et al.	345/435
5,649,086 A	*	7/1997	Belfer et al.	345/441
5,680,531 A	*	10/1997	Litwinowicz et al.	345/473

FOREIGN PATENT DOCUMENTS

WO	WO 94/08311	4/1994

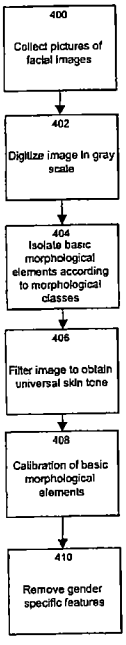
* cited by examiner

Primary Examiner—Matthew Luu
Assistant Examiner—Thu-Thao Havan
(74) *Attorney, Agent, or Firm*—Fleshner & Kim, LLP

(57) **ABSTRACT**

The invention relates to a method and an apparatus for creating facial images, more particularly to a composite picture system and method utilising a library of basic facial components. In typical composite picture systems, the process of creating facial images includes the steps of selecting various facial components, herein designated as basic morphological elements, from a library and assembling them. The novel method comprises the introduction of a component calibration step allowing the different basic morphological elements of a facial image to be merged into a single synthetic facial image with proportional components. A universal skin tone, created using a set of filters on the original images, is also used to reduce the contrasts between the individual basic morphological elements. In addition, each basic morphological element is encoded and uniquely describes each facial image. The use of the encoding facilitates the transmission of such images requiring only the code to be sent. The invention further provides a computer readable medium comprising a library of basic morphological elements and a program element that direct a computer to implement the composite picture process.

16 Claims, 6 Drawing Sheets



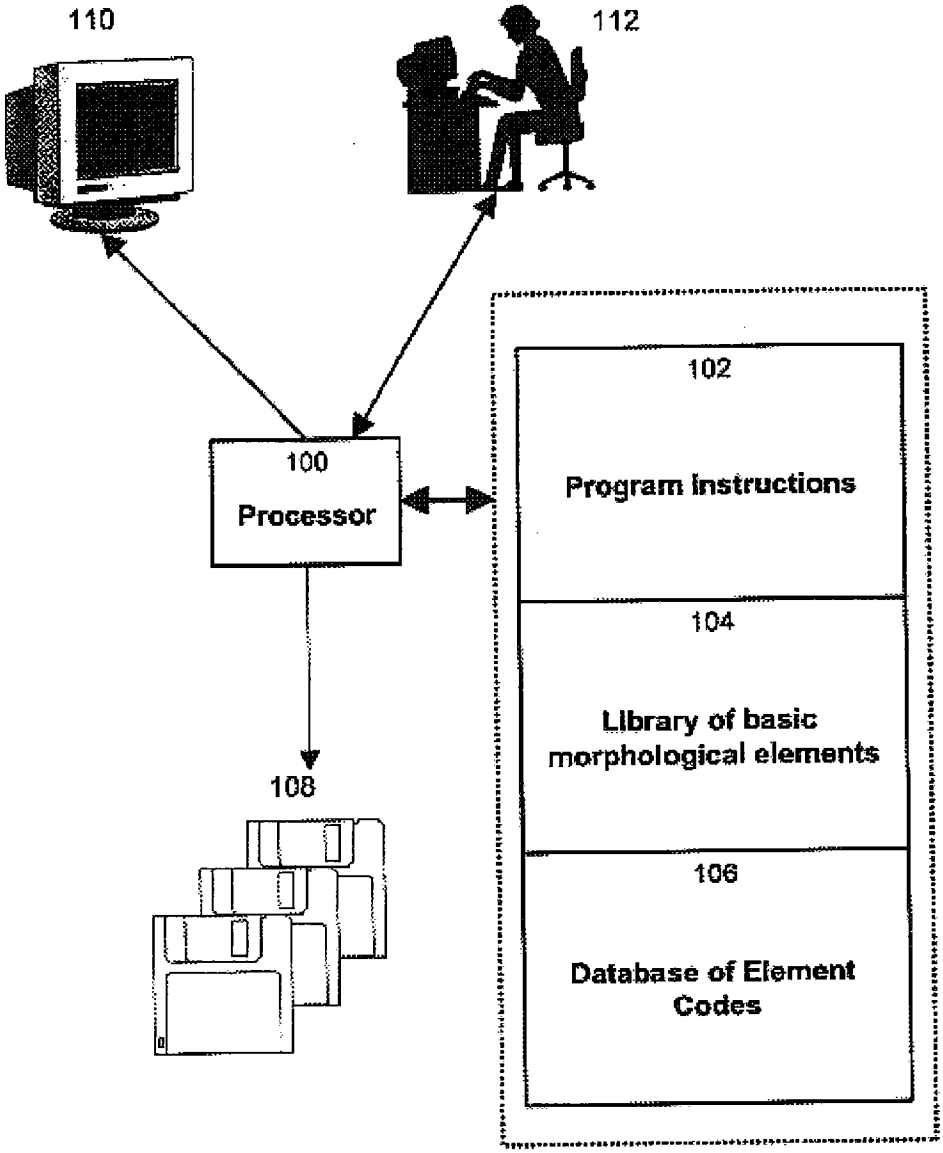

110
112
102
Program Instructions
100
Processor
104
Library of basic morphological elements
108
106
Database of Element Codes

Fig. 1

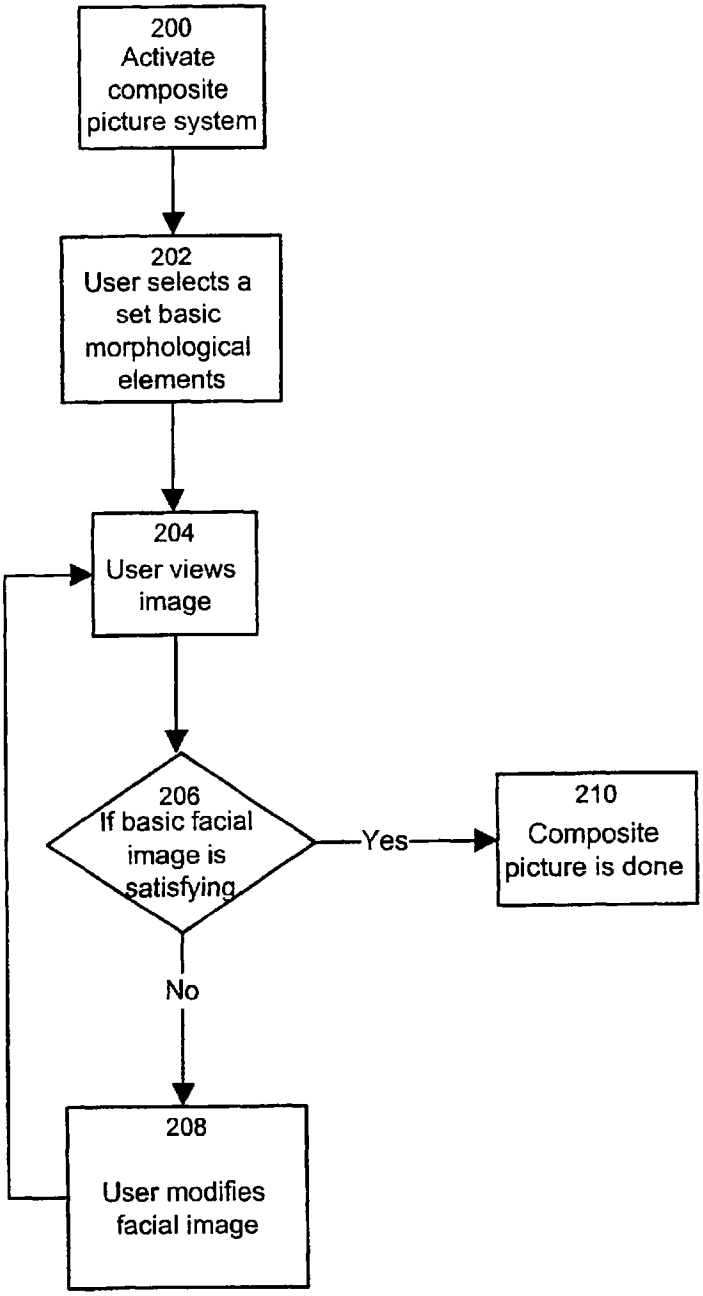

200
Activate composite picture system
202
User selects a set basic morphological elements
204
User views image
206
If basic facial image is satisfying
Yes
210
Composite picture is done
No
208
User modifies facial image

Fig. 2

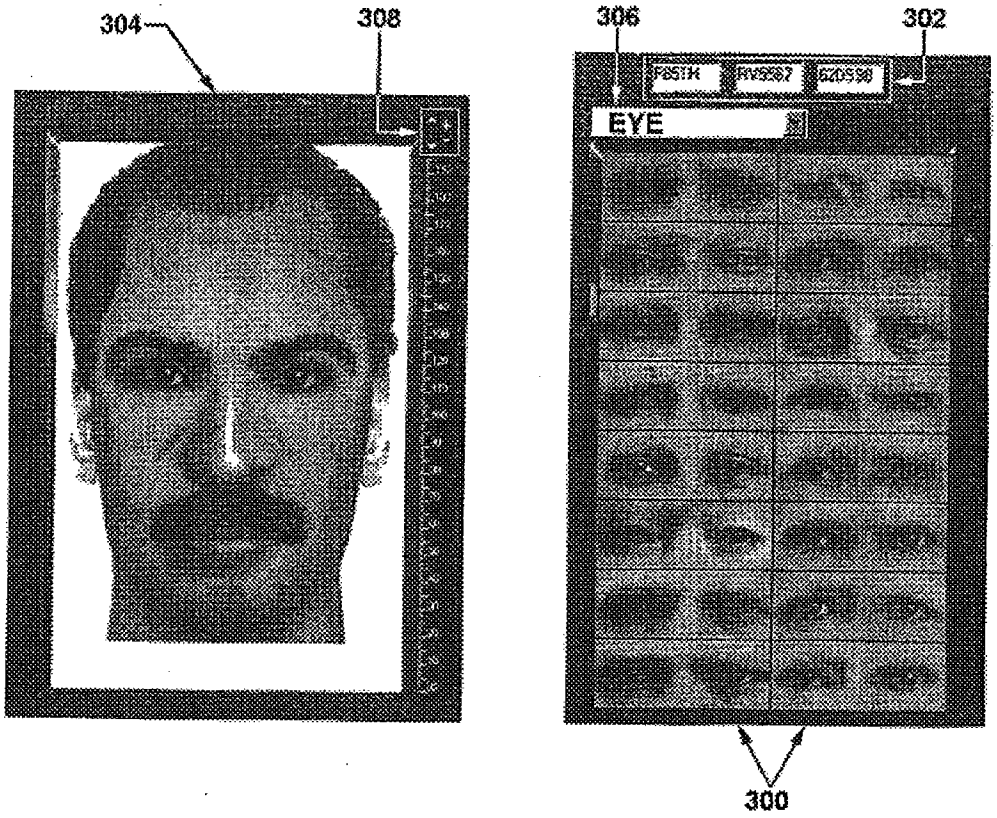


Fig.3

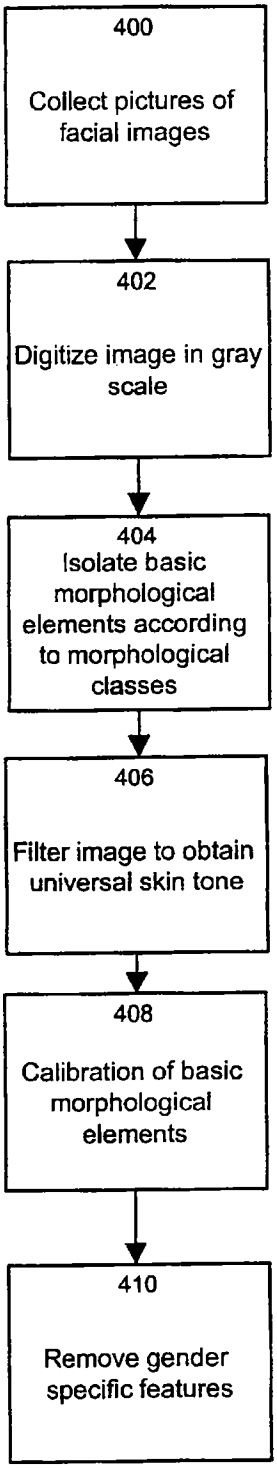

400
Collect pictures of facial images
402
Digitize image in gray scale
404
Isolate basic morphological elements according to morphological classes
406
Filter image to obtain universal skin tone
408
Calibration of basic morphological elements
410
Remove gender specific features

Fig. 4

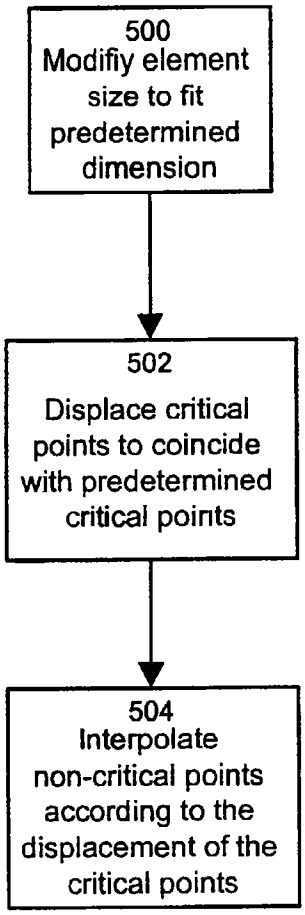

500
Modifiy element size to fit predetermined dimension
502
Displace critical points to coincide with predetermined critical points
504
Interpolate non-critical points according to the displacement of the critical points

Fig. 5

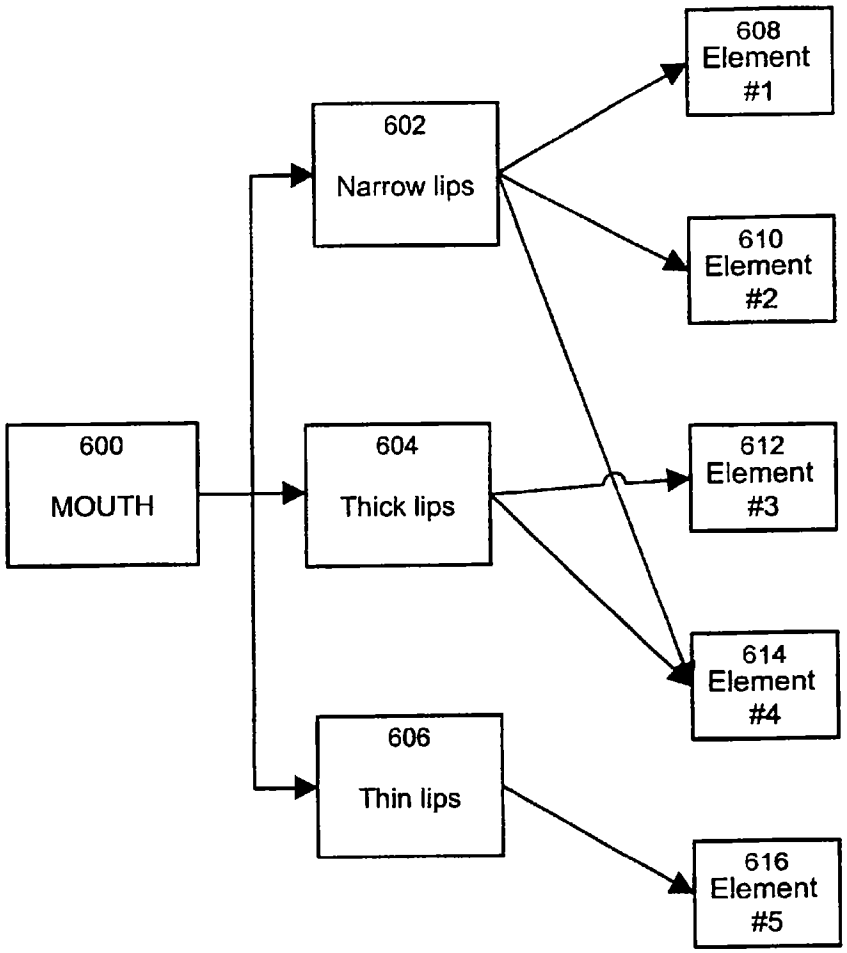

600
MOUTH
602
Narrow lips
604
Thick lips
606
Thin lips
608
Element
#1
610
Element
#2
612
Element
#3
614
Element
#4
616
Element
#5

Fig. 6

METHOD AND APPARATUS FOR CREATING FACIAL IMAGES

FIELD OF THE INVENTION

This invention relates to a system for creating facial images. It is applicable to the creation of composite pictures, specifically to systems used in law enforcement, artistic creations, recreation and education.

BACKGROUND OF THE INVENTION

Human facial characteristics can convey a large amount of information and are a very common means for quickly identifying individuals. These facial characteristics are particularly useful in the area of law enforcement where composite facial images are often used to identify criminal suspects. They are also useful to create portraits in cases where no picture of the person to be graphically described is available.

Traditionally, these composite pictures are created by graphic artists who confer with an eyewitness. Through lengthy trial and error sessions, attempts are made to create a composite picture of a suspect.

The traditional method described above presents two problems. The first is that the accuracy of a composite picture is related to the graphic artist's ability to translate the description of an eyewitness into an image. During the process, the memory of an eyewitness may be inadvertently altered by comments from the artist or from other third parties resulting in a less than accurate portrait of the suspect. The second problem with the traditional method is the high labor costs associated with the graphic artists themselves. Because police departments, in particular those in large urban centers, are likely to require several of such composite pictures, the associated labor costs are significant. Consequently, in order to overcome these problems, numerous attempts have been made to permit the witnesses to create the facial image with little or no interference from third parties. In addition to limiting the influence of a third party on the witness, the labor costs associated with the creation of composite pictures are also reduced.

One early technique for synthesizing single images of faces involved horizontally dividing the image of a face into bands for different features of the face such as hair, eyes, nose, mouth, and chin, respectively. Paper strips containing exemplary features could then be combined to form a composite drawing of a face.

One disadvantage of these systems is the presence of discontinuities between the various bands. For example, the size of the eyes may be disproportionate with that of the head or mouth. Furthermore, the skin tone between different bands may not be identical. These discontinuities often create and image which is cartoon-like and which bears little resemblance to the real life image the user of the system may wish to create.

Other techniques involve selecting individual components and combining them on a pre-selected face. In a typical interaction, the user first selects the shape of the face then eyes, nose, mouth and other components and combines them to form a facial image. Many variations on this theme can be used as described in Kakiyama et al. U.S. Pat. No. 5,600,767, Yoshino et al. U.S. Pat. No. 5,644,690, Sato et al. U.S. Pat. No. 5,537,662 and Belfer et al. U.S. Pat. No. 5,649,086 whose contents are hereby incorporated by reference. For example, the Sato et al. Patent, entitled Electronic Montage composing apparatus, describes a system for creating a montage image of a face using a plurality of basic parts stored in a library. In a typical interaction, the user selects a basic face from a plurality of basic faces and replaces the parts of the face in order to obtain the desired final result. Only the parts that are different from the ones desired need to be modified. This allows the user to quickly obtain a facial image without requiring the selection of each individual part. The Belfer et al. Patent describes another variation on this combination of individual components. This invention includes a database of exemplar images, or model components, which are stored and indexed according to various characteristics. Images are created by interpolating among the exemplar images in the database based on user selection of parameter values. Examples of high level parameters are gender and expression (surprise, anger). Examples of low level parameters are nose length, nostril width, hair thickness and so on. This system allows storing a reduced number of components by producing combinations of the components through interpolation. By allowing the user to vary parameters across a range of extreme values, facial images with the desired appearance can be created.

Although the use of individual components allows the user to position them at the desired location on the face, the proportions of the components often remains unsatisfactory. Furthermore, discontinuities remain and are often significant particularly when the facial images created comprise components selected from various genders and races. Furthermore in the case of the Belfer et al. Patent, tuning the parameters to obtain the desired appearance may be lengthy and difficult to master for the inexperienced user requiring the presence of an experienced technician.

Thus, there exists a need in the industry to refine the process of creating facial images such as to obtain a better composite picture system particularly applicable to law enforcement, artistic creations, recreational use and education.

OBJECTS AND STATEMENT OF THE INVENTION

An object of the invention is to provide a novel method and an apparatus for creating facial images.

Another object of this invention is to provide a computer readable storage medium containing a novel program element that directs a computer to perform the creation of a facial image.

Another object of this invention is to provide a computer readable storage medium containing novel library of basic morphological elements.

Another object of this invention is to provide a novel method for creating a library of basic morphological elements.

As embodied and broadly described herein the invention provides an apparatus for generating a composite facial image, said apparatus comprising:

- machine-readable storage medium for storing a set of data elements, said data elements being representative of basic morphological elements, said data elements being in a format such that graphical representations of the basic morphological elements associated with the data elements are proportionate to one another;
- an input for receiving user data indicative of a plurality of data elements;
- processing means in operative relationship with said machine-readable storage medium for processing the plurality of data elements to provide a digital representation of a facial image resulting from a combination of the basic morphological elements associated with the plurality of data elements.

For the purpose of the specification, the expressions "morphological element", "morphological component" and

"basic morphological elements" are used to describe a part of a specific facial image. Examples of morphological elements are noses, eyes, mouths and eyebrows. In the preferred embodiment, morphological elements are grouped into morphological classes. For example, all nose elements are grouped into the "NOSE" morphological class and all the eye elements are grouped in the "EYE" morphological class. Optionally, the classes are divided into subclasses to further specify the types of elements stored. For example, the morphological class "MOUTH" may be subdivided into "thick lips", "narrow", "thin lips" subclasses.

For the purpose of the specification, the expression "calibrating" is used to designate the process of modifying the proportions of a set of distinct morphological components in order to improve their interaction. For example, the basic morphological elements in the library of basic morphological elements are calibrated to produce a facial image where the various parts can be connected with reduced discontinuities at their juncture. This is particularly useful when the volumes of the heads of different individuals from which the basic morphological elements were taken vary significantly.

For the purpose of the specification, the expressions "skin texture" and "skin tone" are used to designate the graphical appearance of the skin components of an image. The graphical appearance generally comprises the color shading of the skin. In the preferred embodiment a "universal" skin tone is used to facilitate the combination of different facial components by reducing the color contrasts of different skin types.

For the purpose of the specification, the expression "non-volatile storage" is used to designate a machine-readable storage unit that maintains its contents even if the storage device has no power such as non-volatile RAM (NVRAM) or a hard disk.

In a most preferred embodiment of this invention, the composite picture system creates images of a face on the basis of images of individual facial parts, herein referred to as basic morphological elements. In the preferred embodiment, the composite picture system provides two modules namely a library of basic morphological elements and an image creation and modification module interacting with the library of basic morphological elements.

The image creation and modification module provides a means for creating a facial image. In a typical interaction, once the composite picture system is activated, the user of the system selects, through an interface, basic morphological elements from the library of basic morphological elements. These basic morphological elements represent images of facial parts such as eyes, noses, hair and so on. The operator interface to the composite picture system may be a keyboard, pointing device, touch screen or any other suitable command/data input means. Preferably for a given facial image, a single basic morphological element is selected from a given morphological class. Following this, the selected basic morphological elements are combined to form a facial image. In the preferred embodiment, voids between the part forming the mosaic of basic morphological elements are uniformly filled by a predetermined texture, herein referred to as the universal skin tone. The system then displays the facial image to allow the user to view it. The display may be a computer screen, a printed image or any other suitable means for displaying the facial image to the user. If the facial image is to the user's satisfaction, the process is complete. If the facial image is not satisfying, the user may select other basic morphological elements through the user interface in order to get the desired result. Preferably, the composite picture system also includes vertical and horizontal controls allowing the user to modify the position of the basic morphological elements in the facial image. The user may modify the basic morphological elements until the image obtained is the one desired.

The second module of the composite picture system is the library of basic morphological elements. Each basic morphological element in the library is an image of a facial part or an accessory such as glasses, earrings or other. In a preferred embodiment, the basic morphological elements are collected by gathering photographs of individuals and isolating basic morphological elements. The accessories may be pictures or may be synthetically created with the use of graphing tools without detracting from the spirit of the invention. In a preferred embodiment, the system includes approximately 2,000 (two thousand) pictures of faces wherein selected individual basic morphological elements have been isolated. It is also desirable to include in the library of basic morphological elements images from both genders, images from a wide range of age groups and images from different races in order to have a good representation of the various facial characteristics of humans. Once the pictures have been collected, a processing operation is performed. The basic morphological elements are isolated and grouped according to the facial part they represent herein referred to as morphological class. In the preferred embodiment, the following basic morphological classes have been used: hairstyle, forehead, eyebrows, eyes, nose, mouth, chin, moustache, beard, wrinkles and glasses. Following this, a sequence of operations is performed on each individual basic morphological element in order to allow the facial parts to be compatible one with the other. As a first step the skin of the images are modified so all the skin parts of the basic morphological elements have a common skin tone herein referred to as universal skin tone. A filter operation may be applied to either darken the skin tone or lighten the skin tone. In the preferred embodiment, the facial image is created in a gray shade and the universal skin tone is a predetermined shade of gray. Preferably, the shade of gray is chosen such that it is neither dark nor pale such as to be able to represent a wide range of skin types. The selection of the shade of gray is subjective and depends on the preference of the designer and user. The basic morphological elements are then mapped onto a universal skin tone background. The following step involves a calibration operation of the basic morphological elements. This is of particular importance since the volume of the head of different individuals is variable. The variation in volume often creates discontinuities around the facial edges and the calibration step permits a reduction or elimination of these discontinuities. The calibration may also include positioning critical points in the facial image such as the eyes, nose, mouth and others at a predetermined position and interpolating the pixels in between the critical points. Once the calibration is complete, the basic morphological elements are cut into a shape suitable for use in the composite picture system. Optionally, once the processing operation has been completed, each basic morphological element is assigned a unique identifier, herein referred to as element code.

Typically, this identifier is a sequence of alphanumeric characters. A facial code for a facial image is created by combining the identifiers of the basic morphological elements constituting the facial image. The combination may be a concatenation of the element codes or any other means of combining the identifiers provided that the resulting facial code is unique to that set of basic morphological elements and their coordinates. The facial code allows each facial image to be described with a very small number of characters permitting the rapid transmission of the composite picture over data lines. For example, a police station A using the facial code can transmit the entire composite picture of a suspect to police station B by simply sending the code for that facial image. At the reception, police station B enters the code into the composite picture system that displays the composite picture. The communication between location A and location B may be a telephone line with a set of modems, an Ethernet connection or any other communication means suitable for the transfer of data.

In another preferred embodiment of the invention, the apparatus for creating facial images is integrated into a non-electronic composite picture system using a library of basic morphological elements in the form of physical modules on transparencies. The composite picture system provides two modules namely a library of basic morphological elements and an image combination fixture for holding the transparencies in a superposed relationship such that the morphological elements as the transparencies visually unite with one another to form a complete facial image.

The image combination fixture provides a handy tool for combining the basic morphological elements to create a facial image. In a typical interaction, the user selects a set of transparencies containing images of basic morphological elements from a library of basic morphological elements. These basic morphological elements represent images of facial parts such as eyes, noses, hair and so on. Following this, the selected basic morphological elements are combined to form a facial image. Typically the combination is done by superposing the selected transparencies in an order appropriate for the correct visioning of the image. The image combination fixture may be a simple tray designed to hold the transparencies in the proper alignment. As a variant, an overhead projector can be used with the transparencies to display the combined result on a screen. If the facial image is to the user's satisfaction, the process is complete. If the facial image is not satisfying, the user may add a transparency or replace one of those selected previously until the desired result is obtained. Preferably, the vertical and horizontal coordinates of the basic morphological elements in the facial image can be changed by sliding the transparencies in the fixture or over the projector to the correct position.

In the preferred embodiment, the non-electronic composite picture system comprises a library of basic morphological elements. In the preferred embodiment, the basic morphological elements are collected by gathering photographs of individuals and isolating basic morphological elements. Once the basic morphological elements have been collected a processing operation is performed. In order to facilitate the processing operation, it is preferable to perform the processing operation with a general-purpose digital computer and to print the results on transparencies. The processing operation preferably includes the step of calibrating the basic morphological elements in order to allow the facial parts to be compatible one with the other and the step of modifying the skin tone of all the skin parts of the basic morphological elements such that the skin tone is uniform throughout the library. Optionally, once the processing operation has been completed, each basic morphological element is assigned a unique identifier. The coordinate part of the identifier is measure from the center point of the transparency and is the displacement with respect to a fixed point. Other methods for measuring the position of the transparencies may be used without detracting from the spirit of the invention. The facial code for a facial image may then be created by combining the identifiers.

As embodied and broadly described herein, the invention provides a method for generating a composite facial image, said method comprising the steps of:

- providing a machine-readable storage medium for storing a set of data elements, said data elements being representative of basic morphological elements, said data elements being in a format such that graphical representations of the basic morphological elements associated with the data elements are proportionate to one another;
- receiving user data indicative of a selection of a plurality of data elements;
- processing the plurality of data elements to provide a digital representation of a facial image resulting from a combination of the basic morphological elements associated with the plurality of data elements.

As embodied and broadly described herein, the invention also provides a computer readable storage medium containing a program element for directing a computer to create a facial image, said computer including:

- memory means including:
  - a set of data elements, said data elements being representative of basic morphological elements, said data elements being in a format such that graphical representations of the basic morphological elements associated with the data elements are proportionate to one another;
- processor means in operative relationship with said memory means, said program element instructing said processor means for:
  - receiving user data indicative of a selection of a plurality of data elements;
  - processing the plurality of data elements to provide a digital representation of a facial image resulting from a combination of the basic morphological elements associated with the plurality of data elements.

As embodied and broadly described herein, the invention also provides a method for generating an electronic library of basic morphological elements suitable for usage in a composite picture system, said method comprising the steps of:

- providing a plurality of facial images;
- digitizing said facial images;
- processing the digitized facial images to create a plurality of data elements, each data element being representative of a basic morphological element of a certain facial image;
- calibrating said data elements such that all basic morphological elements are substantially proportional to one another;
- storing the calibrated data elements in a computer readable storage medium.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the present invention will become apparent from the following detailed description considered in connection with the accompanying drawings. It is to be understood, however, that the drawings are designed for purposes of illustration only and not as a definition of the limits of the invention for which reference should be made to the appending claims.

FIG. **1** shows an apparatus in accordance with an embodiment of the electronic composite picture system in accordance with the spirit of the invention;

FIG. **2** is a flow chart of a process for creating a composite picture with the system depicted in FIG. **1**;

FIG. **3** shows an example of a user interface of the system of FIG. **1**;

FIG. **4** shows a flow chart of an example of the process for generating the library of basic morphological elements;

FIG. **5** shows a flowchart a process of the calibration operation in accordance with the invention;

FIG. **6** shows an example of a class and subclass structure of the electronic library of basic morphological elements in accordance with the invention;

DESCRIPTION OF A PREFERRED EMBODIMENT

The composite picture system in accordance with the invention creates images of a face on the basis of images of

individual facial parts, herein referred to as basic morphological elements.

In a preferred embodiment, as shown in FIG. **1**, the system for generating a composite human face includes a general-purpose digital computer including a processor **100** linked to a machine-readable storage element **108** that may be in the form of a mass storage device such as a hard-drive, a CD-ROM or any other suitable storage medium. The system further includes a device for visualizing the facial image such as a computer monitor **110** or a printing device. The preferred embodiment also provides data input on which a user interface **112** is supported in order to allow the user to select through a touch screen, keyboard, pointing device or other input means, the individual basic morphological elements and to view the combined result on the display screen **110**. The latter is likely to be part of the data input. The computer readable medium **108** storing the composite picture system includes of a set of modules namely a library of basic morphological elements **104** and program instructions **102** interacting with the library of basic morphological elements to create a facial image. Optionally, the computer readable medium **108** may also include a library of element codes **106**.

In the preferred embodiment the composite picture system comprises an electronic library of basic morphological elements **104**. Each basic morphological element in the library is an image of a facial part or an accessory such as glasses, earrings or other. The basic morphological elements in the library **104** are organized into morphological classes, each class describing a part of the face. In a preferred embodiment, the following basic morphological classes are used: hairstyle, forehead, eyebrows, eyes, nose, mouth, chin, moustache, beard, wrinkles and glasses. Optionally, each basic morphological class may be further subdivided into subclasses to refine the description of the elements it contains. For example, as shown in FIG. **6**, the morphological class "MOUTH" **600** may be subdivided into "thick lips" **604**, "narrow lips" **602**, "thin lips" **606** and so on. Each subclass contains a set of basic morphological elements **608**, **610**, **612**, **614** and **616**. A given morphological element may belong to more than a single set. The data structure implementing the class hierarchy described may include a set of pointers indicating the memory locations where the images of the basic morphological elements are stored. The use of pointers is well known in the art to which this invention pertains. For the purpose of simplicity, the description below is given in terms of classes and elements. However, the processing described below may be applied to subclasses without detracting from the spirit of the invention. Other morphological classes may be used without detracting from the spirit of the invention. It is preferable that the classes are chosen in such as to obtain a gender neutral set. The most favorable results have been found by considering eyes and eyebrows as two distinct classes.

In the preferred embodiment, as shown in FIG. **4**, creating the library of basic morphological elements comprises a sequence of steps. The first step in the creating of the library, is the gathering of pictures of faces **400**. In a preferred embodiment, a database of approximately 2,000 (two thousand) pictures of faces has been found sufficient to build a library. The pictures may be taken with any suitable device for taking photographs, specifically for the purpose of the library such as mug shots and the likes, or may be taken from other photographs such as in magazines. The accessories such as beards, glasses and so on may be pictures or may be synthetically created with the use of graphing tools without detracting from the spirit of the invention. Other sources of pictures are possible and their use does not detract from the spirit of the invention. In the preferred embodiment, pictures of individuals are taken in black in white with the same lighting and the individuals in the same position. Preferably, the faces in the pictures are directed forward, eyes open looking into the camera lens and mouth closed. Color images as well as images taken in manners differing from the ones described above may be used without detracting from the spirit of the invention. In the preferred embodiment, images from both genders, images from a wide range of age groups and images from different races are collected in order to have a good representation of the various facial characteristics of humans. The exact proportions of the images with respect to race, gender and age are not crucial to the invention as additional images may readily be added to the library.

Once the images are collected they are digitized **402**. Alternatively, the images can be taken with a digital camera, thus avoiding the steps of developing films, crating hard copies and so on. Preferably the images are digitized from the negatives using a high resolution RGB digitization scheme. Other digitization schemes may be used here without detracting from the spirit of the invention. Grey scale images generally provide sufficient information on the facial characteristics and are more storage efficient and easier to manipulate than color images. The digitized images are stored on a computer readable medium such as a hard drive, disk, CDROM or other non-volatile storage medium.

Following the digitization step **402**, each image is processed in order to extract basic morphological elements which are substantially proportional one to the other and which are readily combinable to yield a coherent facial image. The basic morphological elements in the facial images are isolated **404** and grouped according the morphological class to which they belong. In the preferred embodiment, the basic morphological elements are isolated by applying a mask to eliminate the parts of the face that are not needed. For example, if the eyes in a facial image are to be isolated, a mask is applied to eliminate all other components of the face leaving two circles containing the eyes. Preferably, a small amount of skin is left around the basic elements being isolated in order to avoid abrupt edges.

Once the basic morphological elements have been isolated and grouped into their respective classes **404**, all skin components of the image are modified **406** so all the skin parts of the basic morphological elements have a common skin tone herein referred to as universal skin tone. The universal skin tone appearance may be a preset threshold. Preferably, the skin components are not "colored" by the universal skin tone but are rather processed and smoothed until the desired color is obtained in order to conserve the shadings of the skin. This operation may be performed through the use of filters selectively chosen to either darken or lighten the skin of the basic morphological elements in order to bring the skin tone closer to that of the universal skin tone. For example, a "burn tool" of an image processing software may be used to darken the image and a "dodge tool" may be used to lighten it. Preferably, the filters are configured to specify on which portion of the image to operate such as in the shadows, in the highlights or in the midtones. It may also bedesirable to fade parts of the image in order to eliminate edges, an operation commonly referred to as air brush. In the preferred embodiment, the facial image is created in gray scale. The universal skin tone is a predetermined shade of gray. Preferably, the shade of gray is chosen such that it is neither dark or pale such as to be able to represent a wide range of skin types. Once the skin tone of the skin components have been modified, the basic morphological element is pasted onto a background of the universal skin tone. The background preferably completely surrounds the basic morphological element.

Following the modification of skin components, each element is dimensionally calibrated **408** based on a set of

pre-determined criteria. The calibration operation is of particular importance since the volume of the head and the size of the facial features of different individuals is variable. The variation in volume often creates discontinuities around the facial edges when basic morphological elements from different individuals are assembled to create a composite image. The calibration step permits a reduction or elimination of these discontinuities. For each basic morphological element in each class, a series of calibration operations are performed as shown in FIG. **5**. First, the image size of each basic morphological element is modified to fit predetermined dimensions **500**. The predetermined dimensions are such that elements of the various basic morphological classes are substantially proportional one to the other. More specifically, the proportions of the elements are such that the elements may be combined in a facial image that resembles a human face in terms of facial element dimensions. This operation involves warping the image and modifying pixel positions either by contracting the image or by expanding it. Warping is well known in the art of computer graphics and imaging and there is no necessity to describe these techniques in a greater detail. Following this, a set of predetermined points in the image, herein designated as critical points, are displaced **502** to coincide with predetermined locations. A set of critical points is determined for each basic morphological class. As a concrete example, the morphological class "EYE" has two (2) critical points representing the position of the center of each eye. Therefore, each basic morphological elements in the "EYE" class has two (2) critical points which are displaced to coincide with predetermined positions. As another concrete example, the morphological class "NOSE" has a single critical point representing the position of the tip of the nose. Following this, the position of non-critical points is determined through an interpolation operation **504** based on the displacement of the critical points. Alternatively, all the points associated with an element are displaced in the same way as the critical point. The principles of interpolation and of critical points are well-known in the art to which this invention pertains. The calibration operation **408** may alternatively be performed using a drawing tool such as Microsoft Photoshop or other similar image editing tools.

Following the calibration step **408**, the gender specific features of the basic morphological elements are reduced **410**. By making the basic morphological elements non gender specific, the size of the library can be reduced while providing a large number of possible facial images. As mentioned previously in the specification, favorable results have been found by considering eyes and eyebrows as two distinct classes. Effectively, eyebrow shapes and the manner in which they were plucked in certain faces were found to contain a substantial amount of gender information. Therefore by separating the eyebrows and the eyes, male eyes can be used on a female face and vice versa. This separation of eyes and eyebrows was performed at the isolation of basic morphological elements step **404**. Another operation performed to make the basic morphological elements is the elimination of makeup and facial hair. Beards, mustaches and others may be added as separate basic morphological elements. In the preferred embodiment, elements of the morphological classes including gender specific characteristics are processed to remove the characteristics. The processing included applying filters to eliminate these characteristics. Items such as makeup are removed by varying the color of the region concerned such as the lips, the eyelids and the cheeks. In the preferred embodiment where the image is in gray scale, the image is darkened or lighten until the desired appearance is achieved. For example, Photoshop's "burn tool" and "dodge tool" can be used to edit the basic morphological elements. Alternatively, the pixels of the basic morphological element images may be individually corrected to yield the desired result.

Following the processing of each basic morphological element, a mask is used to cut the element in a shape suitable for its use in the composite picture system. A mask of the same configuration is applied to all components of a given class. Preferably, the masks shapes and sizes of the various morphological classes are chosen such that when elements of the classes are combined, the contour of the face is continuous. New components may be added to the library of basic morphological elements by performing the processing operations described above.

In the preferred embodiment, after the library of basic morphological elements is created, each facial component is identified with a unique identifier, herein referred to as a element code. The element codes are stored on a computer readable medium in the database of element codes **106**. Typically, the element code is a sequence of alphanumeric characters. In the preferred embodiment, the element code includes both information about the basic morphological element type and about its position in the facial image. For example, the portion of the element code referring to the element type may be a class number followed by the element number. For example, if the morphological class "EYE" is designated with the number 23, then all the basic morphological elements representing eyes would be given element codes beginning with 23 followed by an identifier specific to the element such as "2301", "2345" and so on. If the morphological classes contain subclasses, the element code may further contain an identifier describing the subclass. Other schemes are possible for identifying the basic morphological elements and methods other than the ones presented above do not deter from the spirit of the invention provided the element type portion of the element code is unique. The position portion of the element code reflects the X,Y coordinate of a predetermined point in the image. Preferably, all basic morphological elements in a given basic morphological class are given the same default coordinates and therefore the same position portion value. For example, if the default value for the elements of the "EYE" morphological class is coordinate (34, 123), then the element code for the components may be "2301x34y123", "2345x34y123" and so on. Alternatively, the position portion value may be expressed as an offset of the default value. Other schemes are possible for expressing the position of the elements and methods other than the ones presented above do not deter from the spirit of the invention. The coordinate values for the horizontal and vertical positions can be later modified using the vertical and horizontal controls of the user interface. Preferably, limit values for the X and Y positions are also stored in order to limits the motion of the elements such that the faces created from the combination of the elements are a substantially realistic representation of a human face. The table below shows a possible arrangement of the database of element codes for three morphological classes. In this arrangement the individual morphological elements are given a unique alphanumeric label within their class.

	"EYE"	"NOSE"	"MOUTH"
Code	23	45	52
X default position	34	34	34
Y default position	123	80	50
X range	32–36	32–36	30–38
Y range	117–130	70–90	45–55

A facial code for a facial image may be created by combining the element codes of the basic morphological elements constituting the facial image. The combination may be a concatenation or any other means of combining the

identifiers provided that the resulting facial code is unique to that set of basic morphological elements and their coordinates. The facial code allows each facial image to be described with a very small number of characters permitting the rapid transmission of the composite picture over data lines. For example, a police station A using the facial code can transmit the entire composite picture of a suspect to police station B by simply sending the code for that facial image either verbally or through an electronic communication means. At the reception, police station B enters the code into the composite picture system that displays the composite picture. The electronic communication between location A and location B may be a telephone line with a set of modems, and Ethernet connection or any other communication means suitable for the transfer of data.

Once the basic morphological elements have been processed by the method described above in this specification, the images are stored on a computer readable medium. Preferably, the images are compressed in a format suitable for graphical storage such as a bitmap (BMP), GIF of JPEG file format. Other file formats may be used here without detracting from the spirit of the invention. The element codes are stored along with the elements or in a separate location. Alternatively, the basic morphological elements are printed on transparencies.

An example of a typical interaction will better illustrate the functionality of the image creation and modification module implemented by the program instructions **102** of composite picture system and using the data components **104** **106**.

In a typical interaction, as shown in FIG. **2**, once the composite picture system is activated **200**, the user selects a set of basic morphological elements **202** through a user interface. The interface to the composite picture system may be a keyboard, pointing device, touch screen or any other suitable input means. Once the system has received the request, it locates in the library of basic morphological elements, the entry corresponding with the received input. The received input may be an address of the memory location where the basic morphological element is located or some other way of identifying it. Preferably for a given facial image, a single basic morphological element is selected from a given morphological class. When an element is selected it is considered to be active. For example, for each facial image a single element from the "EYE" class will be active, a single element from the "MOUTH" class will be active and so on. In the event that more than one basic morphological element from the same morphological class is selected, only the one selected last is active. However, all morphological classes do not need to have an active element in a given facial image. For example, a facial image may not have any active elements from the "MOUSTACHE" class. Following this, the selected basic morphological elements are combined to form a facial image. The combination is performed by position each active basic morphological element in a same frame at its default location. Preferably, as previously described, all elements of a given morphological class have the same default position specified in the database of element codes. In the preferred embodiment, spaces in between basic morphological elements are uniformly filled by a predetermined tone, herein referred to as the universal skin tone. The system then displays the facial image to allow the user to view it **204**. Alternatively, after each selection of a basic morphological elements, the systems displays it to allow the user to view the image as it stands with the current selection of elements. If portions of the basic morphological elements overlap, the overlapping portion with the darkest color is displayed. At condition **206**, if the user is satisfied with the appearance of the facial image, the composite picture is complete **210** and the user may make use of it as he pleases. In the event that the user is not satisfied with the appearance of the facial image, condition **206** is answered in the negative and the user may modify the facial image **208**. The modification of the facial image may comprise different operations. For example, the user may replace a basic morphological element by another of the same class; he may remove an element all together; the element may be displaced in the vertical or horizontal direction; characterizing traits and accessories such as wrinkles, glasses and sun glasses may be added or removed. It is also desirable to allow the user to specify the universal skin tone he desires for a particular facial image. In the preferred embodiment the user can lighten or darken the current skin tone of the facial image. Once the facial image has been modified by selecting a revised set of basic morphological elements, the latter are combined to form a facial image. In the preferred embodiment, spaces in between basic morphological elements are uniformly filled by a predetermined tone, herein referred to as the universal skin tone. The system then displays the facial image to allow the user to view it at step **204**. Alternatively, after each selection of a basic morphological elements, the systems displays it to allow the user to view the image as it stands with the current selection of elements. The process continues until the user is satisfied with the image and condition **206** is answered in the affirmative the composite picture being done **210**.

In the preferred embodiment, the image creation and modification module includes a user interface allowing the user to view the facial image being created. The facial image is created in a gray shade and displayed in gray shade in the user interface. An example of an embodiment of the user interface is shown in FIG. **3**. Preferably, the user interface also allows a user to view various basic morphological elements in the library of basic morphological elements through a window **300**. Preferably, the user is permitted to select which morphological class **306** he wishes to look at and views a subset of the elements in the class. In FIG. **3**, the "EYE" morphological class was selected **306** and elements representing eye images are displayed **300**. Using an input device such as a keyboard, pointing device or other suitable means, the user may indicate the basic morphological element he wishes to add or replace in the facial image **304** by pointing to the image he desires. The facial image **304** is update to reflect the current status of the selection of basic morphological elements. Alternatively, the composite picture system may receive as input an alphanumeric representation of the facial image, herein designated as the facial code, describing the components and their position on the facial image. Using this facial code, the composite picture system reconstructs the facial image. Therefore, the user interface may also include a means for entering the element code and facial codes **302**. The facial code is a unique alphanumeric sequence describing the elements and their position in a facial image. The description of the facial code will be described later on in the specification. Optionally, the user interface includes a means, such as arrows in the user interface, for displacing the basic morphological elements **308** in the vertical and horizontal directions. The arrows are linked to active modules that modify the position of the selected image in the screen. When the element is displaced, the element code is also modified such as to reflect to current positioning of the element. In a typical interaction the user selects via a pointing device or other input means the element he wishes to displace in the facial image. The user then uses the displacement arrows **308** to position the element in the desired position in the facial image. Many variations in the user interface are possible and implementations different from the one presented above do not detract from the spirit of the invention.

In another preferred embodiment, the non-electronic system for generating a composite human face is implemented

using transparencies where the basic morphological elements are printed. The basic morphological element images are preferably processed by a general-purpose digital computer in the manner described above in this specification before being transposed onto transparencies. The complete facial image is composed by selecting transparencies from a library of transparencies containing the illustrations of the basic morphological elements and superposing them. Optionally, the system further includes a device for visualizing the facial image such as an overhead projector device.

The composite picture system may readily be used in law enforcement for witnesses to create their own depictions of suspects, in art school for students to understand how differences in facial features are manifested in overall appearance and in recreation for users to create faces that they find interesting or amusing. The composite system may also be a subsystem of some other system. The use of the composite system in situations other than the ones described above does not detract from the spirit of the invention.

Although the present invention has been described in considerable detail with reference to certain preferred versions thereof, other versions are possible. For example, the method and apparatus described may be used in a system to create images of cartoon characters. In this type of application the library of basic morphological elements would include the appropriate set of images. The construction and manipulation are similar to that presented above. System as the one presented above may also be used as educational tools or as a recreational or artistic tool to teach children how to create composite images. Artistic tools may require additional artifacts such as earrings, glasses and other articles that may be useful to complete the images. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

What is claimed is:

1. An apparatus for generating a composite facial image, said apparatus comprising:

a) a machine-readable storage medium storing graphical representations of basic morphological elements, said graphical representations being proportionate to one another and having respective boundaries, the graphical representations of basic morphological elements including skin components around their respective boundaries, the skin components having skin tones substantially similar to one another;

b) an input for receiving user data indicative of a set of data elements, each data element in said set of data elements being associated to a respective graphical representation of a basic morphological element in the machine-readable storage medium;

c) a processing unit in operative relationship with said machine-readable storage medium, said processing unit being operative for:

i. processing the set of data elements to locate in the machine-readable storage medium corresponding graphical representations of basic morphological elements, and

ii. combining the graphical representations of basic morphological elements located to generate a digital representation of a facial image, at least two graphical representations being combined such that their skin components having substantially similar skin tones meet at a boundary; and

d) a display unit in operative relationship with said processing unit for displaying the digital representation of the facial image.

2. The apparatus as defined in claim **1**, wherein said graphical representations of basic morphological elements are grouped in a plurality of morphological classes.

3. The apparatus as defined in claim **2**, wherein graphical representations of basic morphological elements belonging to a given morphological class have substantially similar dimensions.

4. The apparatus as defined in claim **3**, wherein the digital representation of the facial image includes a single graphical representation of a basic morphological element of a given morphological class.

5. The apparatus as defined in claim **1**, wherein said display means is a screen.

6. A method for generating a composite facial image, said method comprising the steps of:

a) providing a machine-readable storage medium for storing graphical representations of basic morphological elements, said graphical representations being proportionate to one another and having respective boundaries, the graphical representations of basic morphological elements including skin components around their respective boundaries, the skin components having skin tones substantially similar to one another;

b) receiving user data indicative of a set of data elements, each data element in said set of data elements being associated to a respective graphical representation of a basic morphological element in the machine-readable storage medium;

c) processing the set of data elements to locate in the machine-readable storage medium corresponding graphical representations of basic morphological elements;

d) combining the graphical representations of basic morphological elements located to generate a digital representation of a facial image, at least two graphical representations being combined such that their skin components having substantially similar skin tones meet at a boundary; and

e) displaying the digital representation of the facial image on display means.

7. The method as defined in claim **6**, wherein said graphical representations of basic morphological elements are grouped in a plurality of morphological classes.

8. The method as defined in claim **7**, wherein graphical representations of basic morphological elements belonging to a given morphological class have substantially similar dimensions.

9. The method as defined in claim **8**, wherein the digital representation of the facial image includes a single graphical representation of a basic morphological element of a given morphological class.

10. A computer-readable storage medium containing a program element for directing a computer to create a facial image, said computer including:

a) a memory unit including a set of graphical representations of basic morphological elements, said graphical representations being proportionate to one another and having respective boundaries, the graphical representations of basic morphological elements including skin components around their respective boundaries, the skin components having skin tones substantially similar to one another;

b) a processor unit in operative relationship with said memory unit, said program element instructing said processor unit for:

i. receiving user data indicative of a set of data elements, each data element in said set of data elements being associated to a respective graphical representation of a basic morphological element in the computer-readable storage medium,

ii. processing the set of data elements to locate in the computer-readable storage medium corresponding graphical representations of basic morphological elements, and

iii. combining the graphical representations of basic morphological elements located to generate a digital representation of a facial image, at least two graphical representations being combined such that their skin components having substantially similar skin tones meet at a boundary; and

c) a display unit in operative relationship with said processor unit for displaying the digital representation of the facial image.

11. The computer-readable storage medium as defined in claim **10**, wherein said graphical representations of basic morphological elements are grouped in a plurality of morphological classes.

12. The computer-readable storage medium as defined in claim **11**, wherein graphical representations of basic morphological elements belonging to a given morphological class have substantially similar dimensions.

13. The computer-readable storage medium as defined in claim **12**, wherein the digital representation of the facial image includes a single graphical representation of a basic morphological element of a given morphological class.

14. A computer-readable storage medium comprising a set of graphical representations of basic morphological elements, said graphical representations being proportionate to one another and having respective boundaries, the graphical representations of basic morphological elements including skin components around their respective boundaries, the skin components having skin tones substantially similar to one another, said graphical representations of basic morphological elements being grouped in a plurality of morphological classes, graphical representations of basic morphological elements belonging to a given morphological class having substantially similar dimensions.

15. A computer-readable medium comprising computer-executable instructions for directing a computer to implement a graphical user interface for creating a facial image, said computer including:

a) a memory unit for storing a plurality of graphical representations of basic morphological elements, said graphical representations being proportionate to one another and having respective boundaries, the graphical representations of basic morphological elements including skin components around their respective boundaries, the skin components having skin tones substantially similar to one another; and

b) a processor unit in operative relationship with said memory unit, said computer-executable instructions instructing said processor unit for generating a graphical user interface for:

i. displaying at least some of the plurality of graphical representations of basic morphological elements,

ii. providing means for enabling a user to select a set of graphical representations of basic morphological elements from the at least some of the plurality of graphical representations of basic morphological elements displayed in the user interface, and

iii. combining and displaying the graphical representation of basic morphological elements selected to generate a digital representation of a facial image, at least two graphical representations being combined such that their skin components having substantially similar skin tones meet at a boundary.

16. A method for generating an electronic library of basic morphological elements suitable for usage in a composite picture system, said method comprising the steps of:

a) providing a plurality of facial images;

b) digitizing the facial images;

c) processing the digitized facial images to create a plurality of graphical representations of basic morphological elements of a certain facial image, said graphical representations of basic morphological elements including skin components having different skin tones;

d) applying a filtering process to said graphical representations of basic morphological elements to derive modified graphical representations, the modified graphical representations including skin components having skin tones substantially similar to one another;

e) processing said modified graphical representations to generate calibrated graphical representations, said calibrated graphical representations being substantially proportional to one another; and

f) storing the calibrated graphical representations on a computer-readable storage medium.

* * * * *

EXHIBIT B

US007289647B2

(12) **United States Patent**
Côté

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(45) **Date of Patent: Oct. 30, 2007**

(54) **SYSTEM AND METHOD FOR CREATING AND DISPLAYING A COMPOSITE FACIAL IMAGE**

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(73) Assignee: **I. Q. Biometrix, Inc.**, Fremont, CA (US)

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(51) **Int. Cl.**
G06K 9/00 (2006.01)
G06K 9/54 (2006.01)
G06K 9/60 (2006.01)

(52) **U.S. Cl.** **382/118**; 382/305

(58) **Field of Classification Search** ..... 382/232, 382/243, 115, 118, 308, 305; 348/399.1; 345/473, 621, 530, 646, 676, 680, 581; 707/103 R, 707/103 Y; 715/968
See application file for complete search history.

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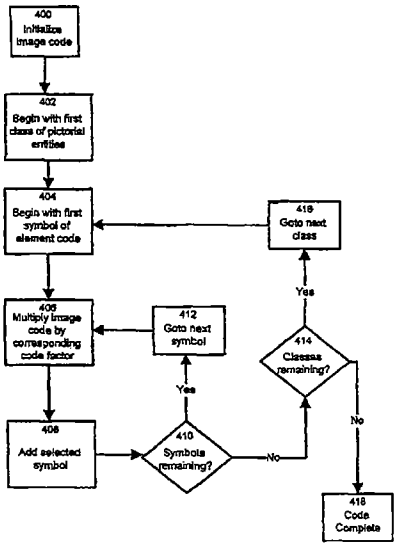
(57) **ABSTRACT**

The invention relates to a method and an apparatus for encoding images, more particularly to an encoding unit in conjunction with a library of pictorial entities and image qualifiers. The method and apparatus provide encoding an image by using a code factor table in conjunction with a set of element codes. The resulting image code allows the set pictorial elements of an image and their associated image qualifiers to be represented by a compact code uniquely representing a given configuration of pictorial elements. The use of the resulting image code facilitates the transmission and storage of images requiring only the code to be sent or stored. The invention further provides a computer readable medium comprising a program element that direct a computer to implement the encoding process.

44 Claims, 9 Drawing Sheets



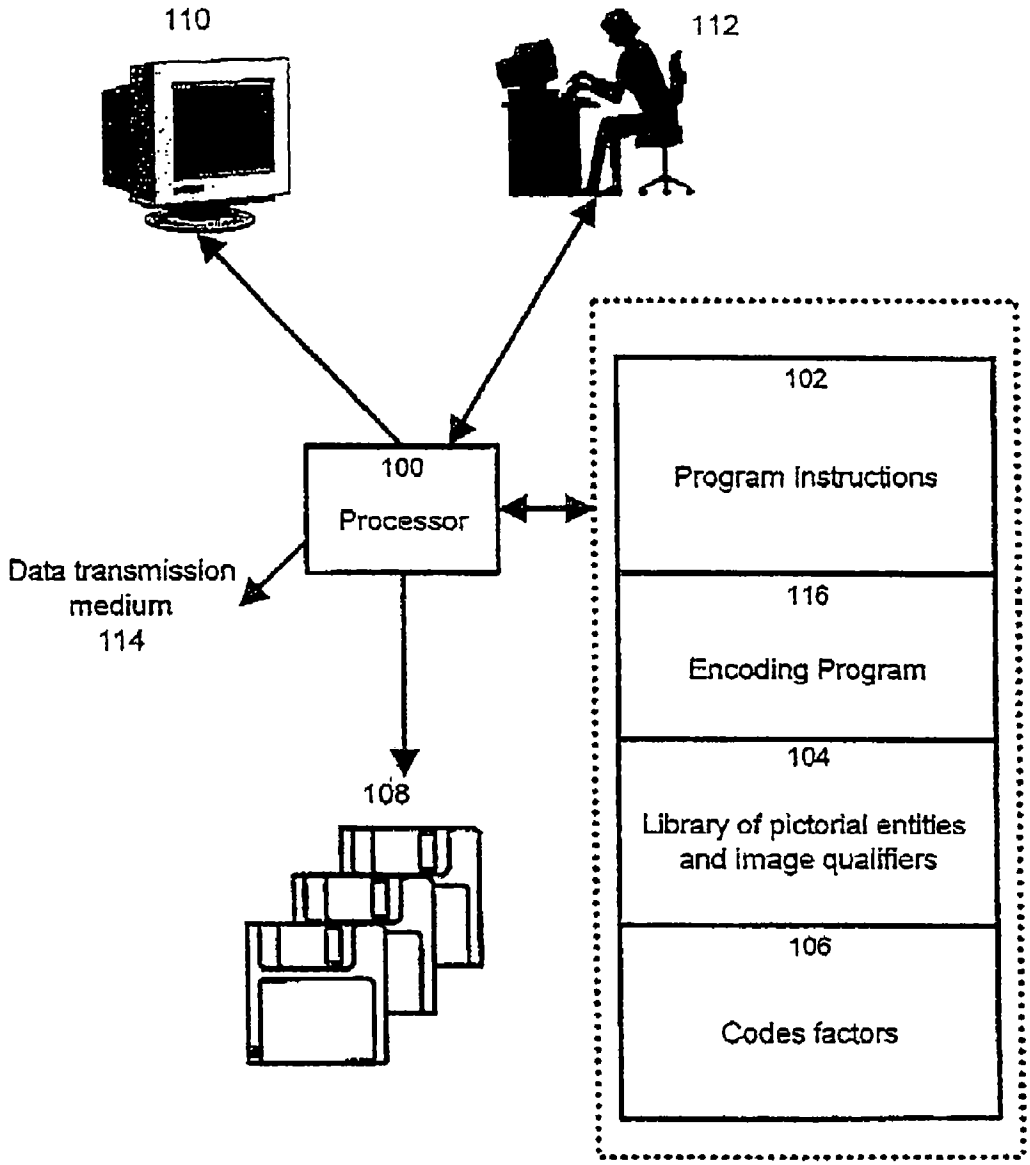

110
112
102
Program instructions
100
Processor
116
Encoding Program
Data transmission medium 114
104
Library of pictorial entities and image qualifiers
108
106
Codes factors

Figure 1

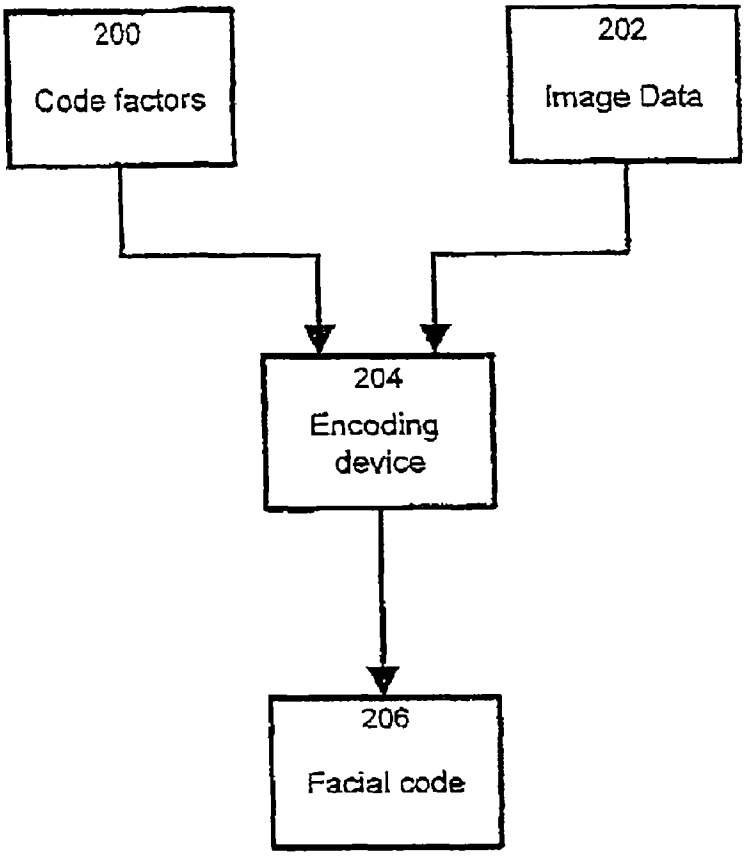

200
Code factors
202
Image Data
204
Encoding device
206
Facial code

Figure 2

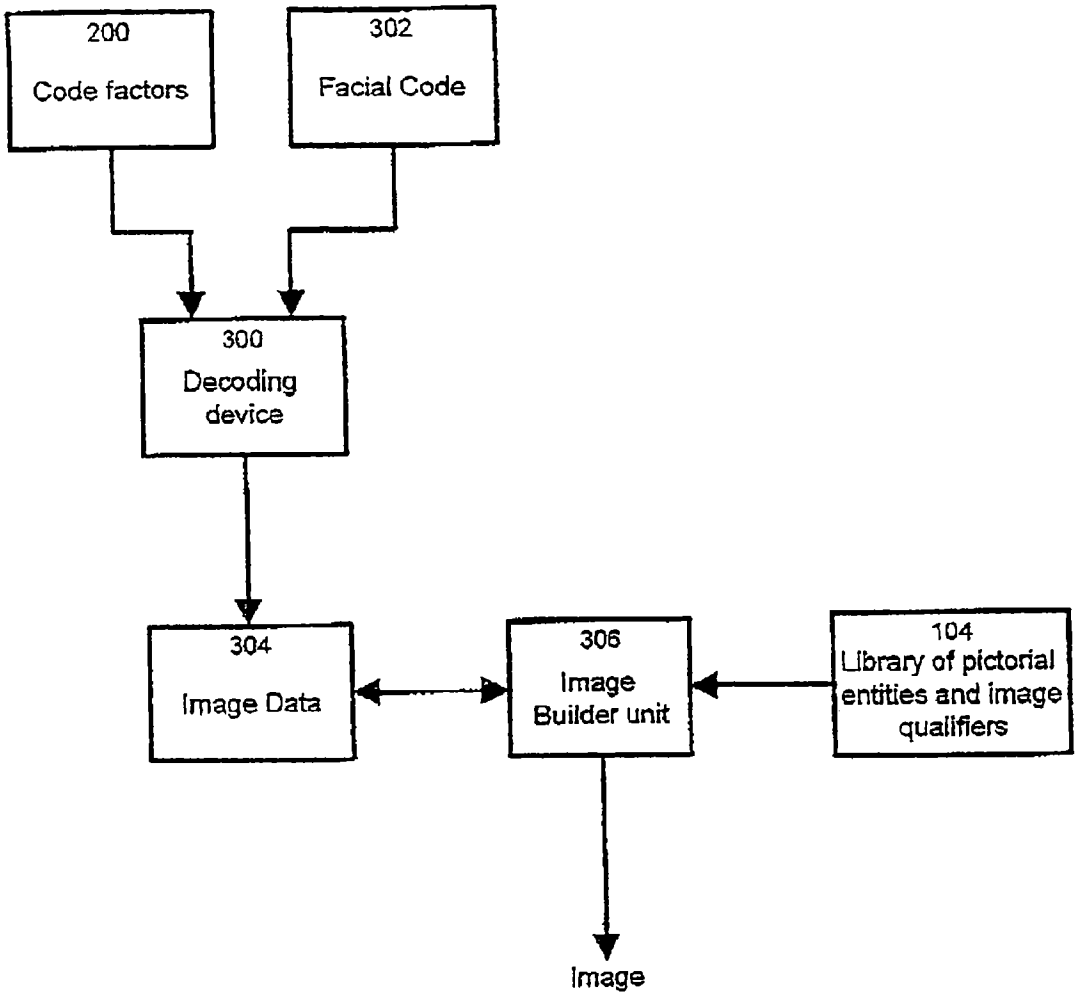

200
Code factors
302
Facial Code
300
Decoding device
304
Image Data
306
Image Builder unit
104
Library of pictorial entities and image qualifiers
Image

Figure 3

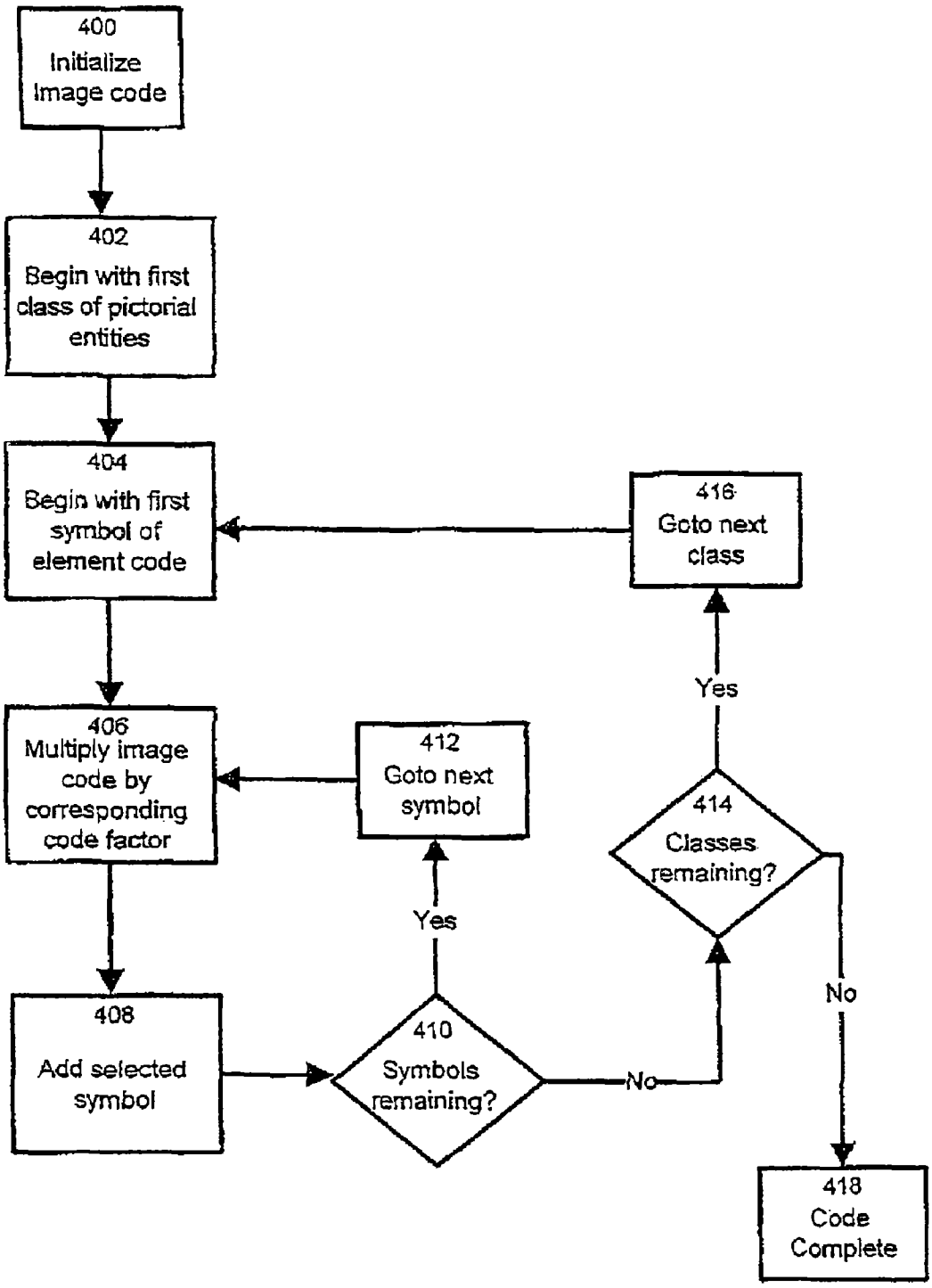

400
Initialize image code
402
Begin with first class of pictorial entities
404
Begin with first symbol of element code
406
Multiply image code by corresponding code factor
408
Add selected symbol
410
Symbols remaining?
412
Goto next symbol
414
Classes remaining?
416
Goto next class
418
Code Complete
Yes
No
Yes
No

Figure 4

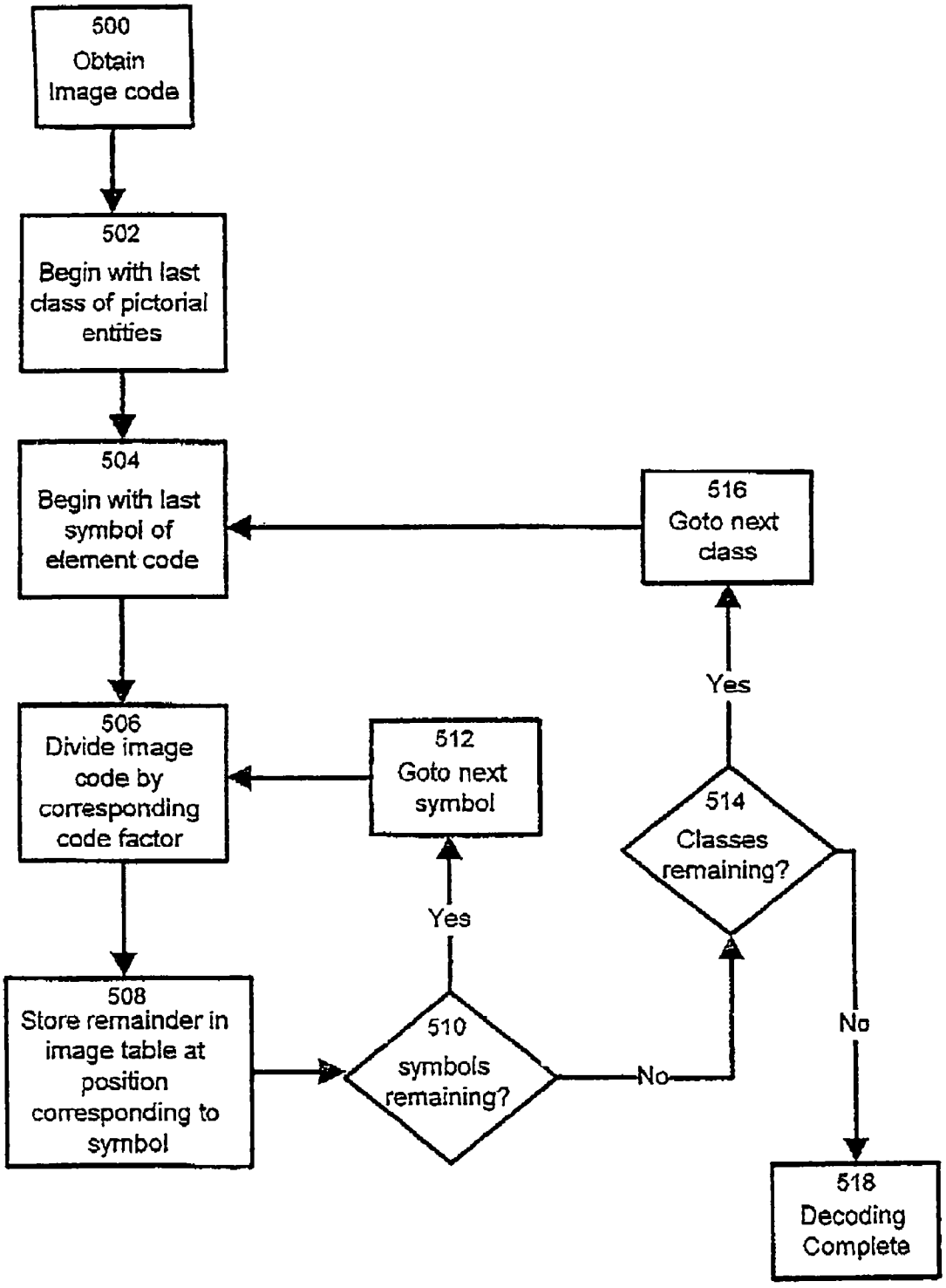

500
Obtain Image code
502
Begin with last class of pictorial entities
504
Begin with last symbol of element code
506
Divide image code by corresponding code factor
508
Store remainder in image table at position corresponding to symbol
510
symbols remaining?
512
Goto next symbol
514
Classes remaining?
516
Goto next class
518
Decoding Complete
Yes
No
Yes
No

Figure 5

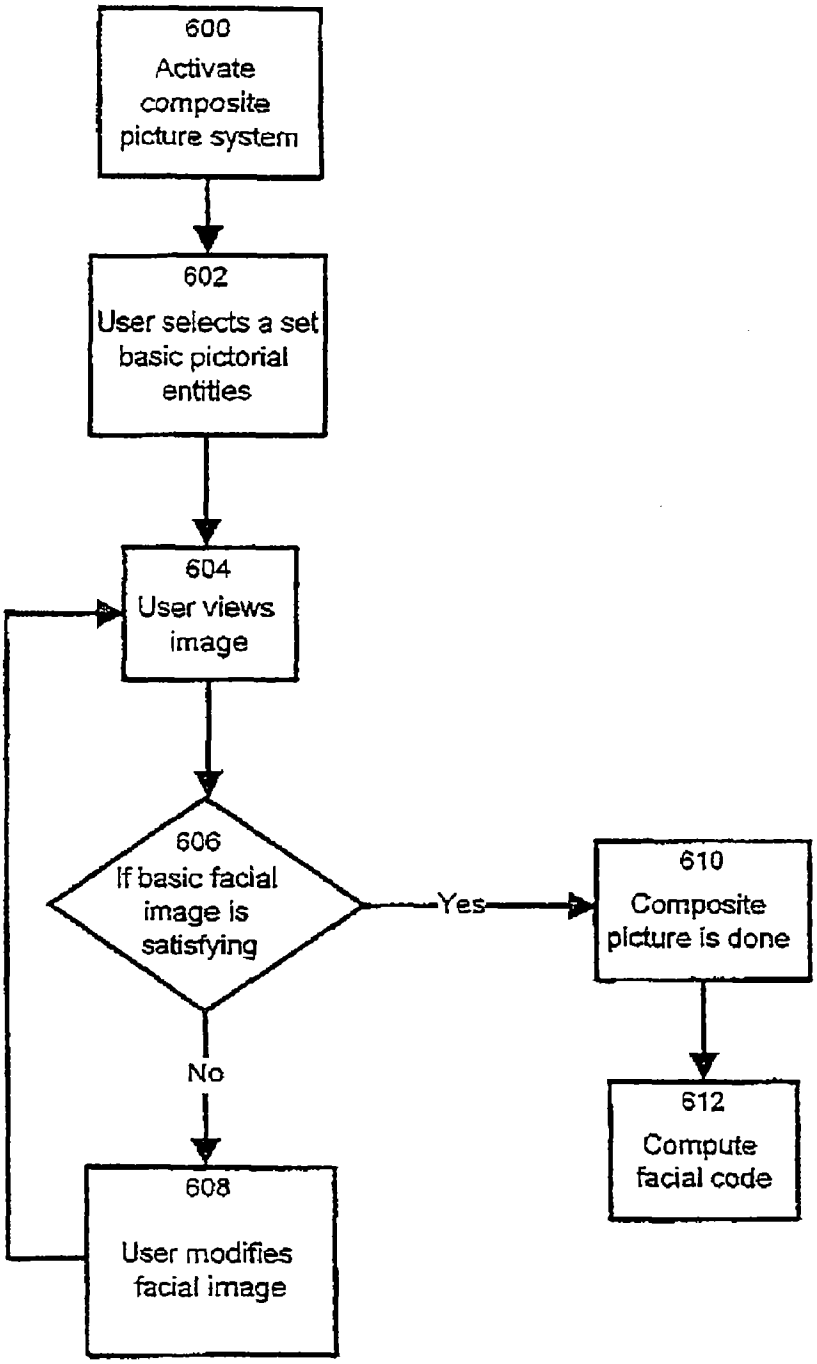

600
Activate composite picture system
602
User selects a set basic pictorial entities
604
User views image
606
If basic facial image is satisfying
Yes
610
Composite picture is done
612
Compute facial code
No
608
User modifies facial image

Figure 6a

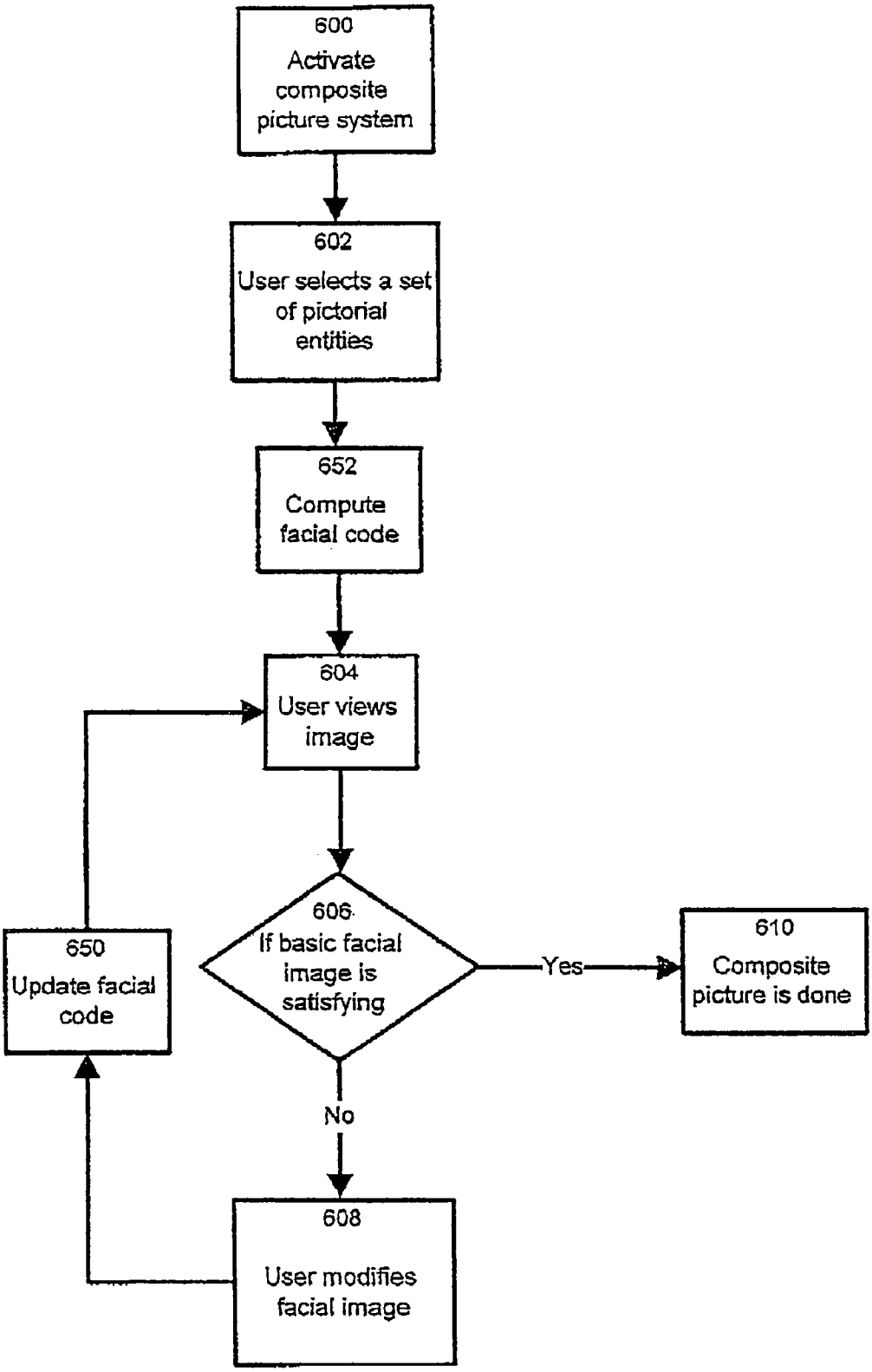

600
Activate composite picture system
602
User selects a set of pictorial entities
652
Compute facial code
604
User views image
606
If basic facial image is satisfying
Yes
610
Composite picture is done
No
608
User modifies facial image
650
Update facial code

Figure 6b

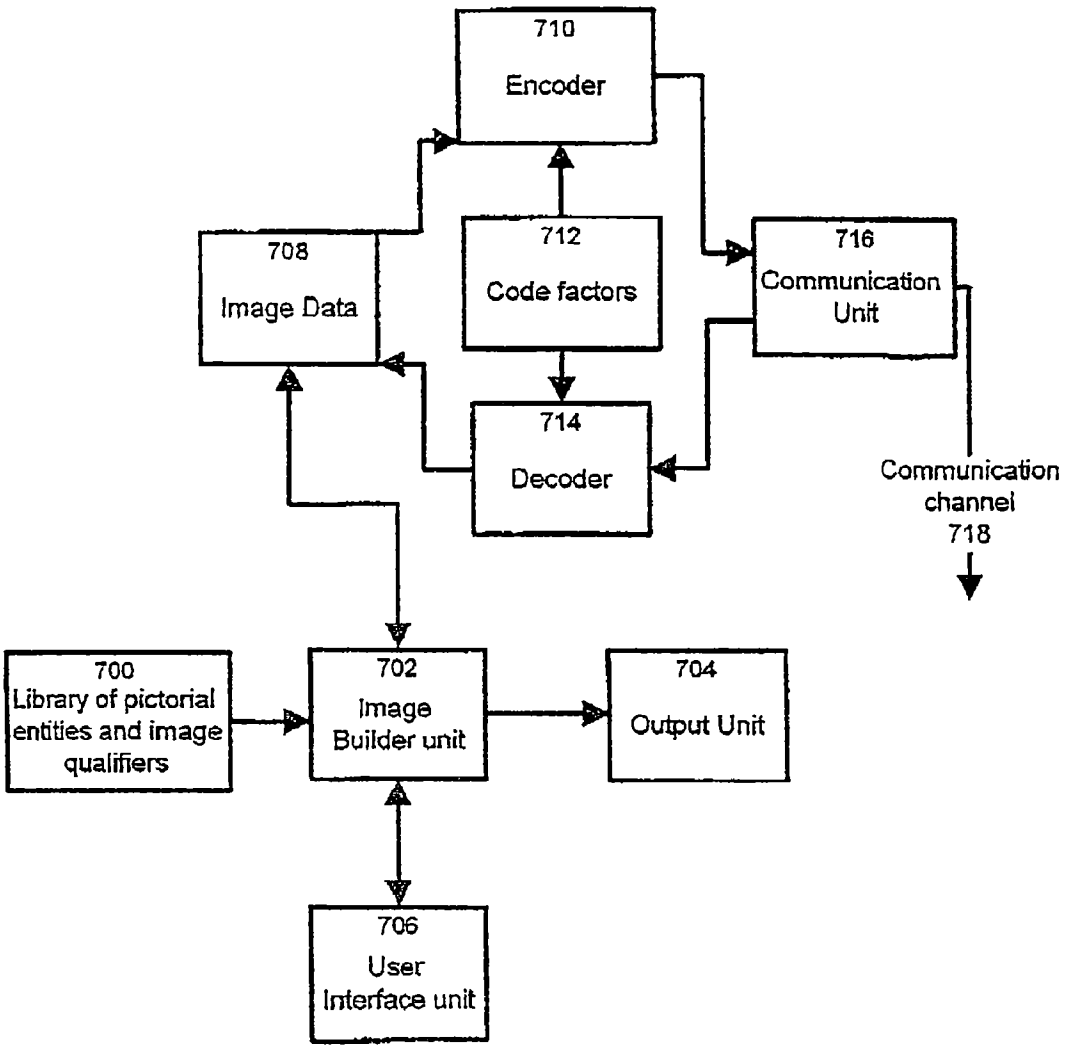

710
Encoder
712
Code factors
708
Image Data
716
Communication Unit
714
Decoder
Communication channel
718
700
Library of pictorial entities and image qualifiers
702
Image Builder unit
704
Output Unit
706
User Interface unit

Figure 7

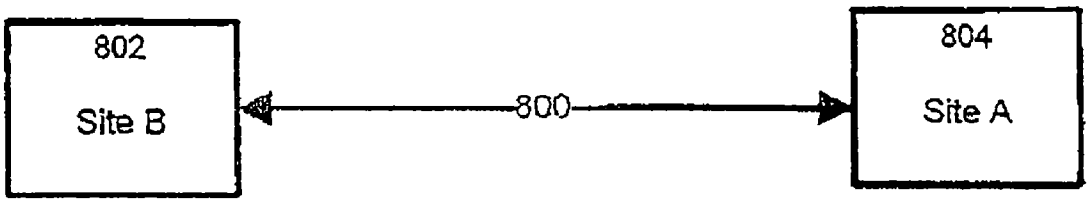


Figure 8

SYSTEM AND METHOD FOR CREATING AND DISPLAYING A COMPOSITE FACIAL IMAGE

This application is a Continuation of U.S. patent application Ser. No. 09/322,932, filed on May 28, 1999, now U.S. Pat. No. 6,690,830 the entire contents of which are incorporated by reference herein.

FIELD OF THE INVENTION

This invention relates to a method and apparatus for encoding/decoding image data. It is particularly applicable to the encoding/decoding of images that can be separated into their constituent parts as may be used in composite picture systems used in law enforcement, artistic creations, recreation and education

BACKGROUND

It is known in the art to create images on the basis of components that are assembled to form a complete image. For example, a common technique for synthesizing single images of faces involves horizontally dividing the image of a face into bands for different features of the face such as hair, eyes, nose, mouth, and chin, respectively. Paper strips containing exemplary features are then be combined to form a composite drawing of a face. Yet another example involves a program element running on a computing platform which allows a user to select individual components and combining them on a pre-selected face. In a typical interaction, the user first selects the shape of the face then eyes, nose, mouth and other components and combines them to form a facial image. Many variations on this theme can be used as described in Kakiyama et al. U.S. Pat. No. 5,600,767, Yoshino et al. U.S. Pat. No. 5,644,690, Sato et al. U.S. Pat. No. 5,537,662 and Belfer et al. U.S. Pat. No. 5,649,086 whose contents are hereby incorporated by reference. For example, the Sato et al. Patent, entitled Electronic Montage composing apparatus, describes a system for creating a montage image of a face using a plurality of basic parts stored in a library.

In constructing an image, pictorial entities are selected from a library of pictorial entities as assembled into images. These images may then be stored on a computer readable medium commonly referred to as a database or repository. Often, the storage of an image requires significant amounts of memory, often necessitating large repositories. For example, a composite picture system used in a police department often requires maintaining records of thousands of individuals. The images are typically stored in files in some graphical format such as a "bitmap", "gif" or "jpeg" are other format. Although such encoding schemes provide a compressed representation of the image, the memory required for storing the image remains significant. In addition, compression methods of the type described above generally degrade the quality of the image. The size and quality of images is also particularly significant when the images are transmitted from one site to another via a digital link. For example, a given police station may transmit a composite picture to another police station in order to share information about a given suspect.

Thus, there exists a need in the industry to refine the process of encoding images such as to reduce the memory requirements for storage and the bandwidth required for the transmission of the image.

SUMMARY OF THE INVENTION

The invention provides a novel method and an apparatus for encoding images.

For the purpose of the specification, the expression "basic elements" is used to describe a part of a specific image. In the preferred embodiment, a basic element is comprised of a pictorial entity conditioned by a set of image qualifiers. Examples of pictorial entities in a facial image are noses, eyes, mouths and eyebrows. In the preferred embodiment, pictorial entities are grouped into classes. For example, in composite picture system, all nose pictorial entities are grouped into the "NOSE" class and all the eye pictorial entities are grouped in the "EYE" class. Each class of pictorial entities is associated to a set of image qualifiers that are used to condition the pictorial entities in the associated class. The image qualifiers may include position qualifiers, zoom qualifiers, color qualifier and the likes.

For the purpose of this specification, the basic elements used in the special case of a facial image are referred to as "basic morphological elements".

For the purpose of this specification, the word "symbol" is used to designate a representation of an object, image, qualifier or the likes. In a specific example, a symbol may be an index mapped to a memory location storing data elements such as a pictorial entity or image qualifier.

According to a broad aspect, the invention provides, a computer readable storage medium comprising a program element suitable for use on a computer having a memory. The program element is operative to create a first input to receive a set of element codes. The element codes characterized a portion of an image and included at least one symbol. A given symbol is a representation of a certain characteristic of the portion of the element code. A given symbol can acquire a set of possible values indicative of variations of the certain characteristic with which it is associated. The program element is also operative to create a second input to receive code factors associated to respective symbols of the set of element codes. A given code factor is assigned a value that exceeds the highest value that the symbol with which it is associated can acquire. The program element is operative to process the set of element codes to derive an image code. The image code is a compressed digital representation of the image, and is derived at least in part on the basis of the plurality of code factors. The image code can then be released as the output.

In a preferred embodiment, the image code is a number in a given base. Preferably, a large base is used in order to obtain a reduced number of characters in the image code.

In a preferred embodiment of the invention, the encoding method and apparatus is integrated into a picture system. The picture system creates images on the basis of images of basic individual parts, herein referred to as basic elements. In the preferred embodiment, the picture system includes a library of pictorial entities and qualifiers, an image builder unit, an encoding unit, a decoding unit and a factor table.

Each basic element in an image is assigned a unique identifier, herein referred to as element code. The element code contains information data elements, herein referred to as symbols. In a specific embodiment, the element code for each basic element includes a symbol that characterizes the pictorial element. In a preferred embodiment, the element code includes a plurality if symbols. In a specific example two (2) symbols are used namely an pictorial entity symbol and a position qualifier symbol. The element code may contain additional symbols without detracting from the spirit of the invention. For example symbols representative of

other image qualifiers may be used such as color, zoom and other image effects may be used. An image is constructed by a set of basic elements. The basic elements present in a given facial image are said be "active" in the given image. The set of active elements is stored in a data structure suitable for that purpose. In a specific example this data structure is an image data table. The image data table stores for each class a record, each record containing a set of fields, each field describing the active pictorial entity and qualifiers.

The number variations in each of the symbols for each of the classes is stored in a table, herein referred to as a code factor table. The code factor table provides information about the number of possible variations in an image. For each class, the code factor table stores a record, each record containing a set of fields, each field describing a maximum factor. The maximum factor in the code factor table is the largest identifier used for the given factor. Each symbol in the image data table is mapped to a factor in the code factor table.

According to another broad aspect, the invention provides an apparatus for encoding an image, the image comprising a set of basic elements, each basic element of the set of basic elements being associated to an element code. An encoding unit receiving as input the code factors and the element codes. The encoding unit processes the set of element codes to derive an image code, the image code being a compressed digital representation of the image derived at least in part on the basis of said plurality of code factors. The encoding unit then outputs the image code.

According to another broad aspect, the invention provides a method for encoding an image, the image comprising a set of basic elements, each basic element of the set of basic elements being associated to an element code. A processing step receives as input the code factors and the element codes to derive an image code. The image code is a compressed digital representation of the image derived at least in part on the basis of said plurality of code factors. The image code is the released.

In a preferred embodiment, the image code can be used to reproduce the image described by the image code. Image data may be obtained by combining the code factors and the image code with a decoding device. The image data is obtained by applying the inverse operations in the reverse order than those applied in the encoding process to the image code.

The image code allows each image to be described with a very small number of characters permitting the rapid transmission of the image over a data transmission medium. The receiving device has a decoding unit that is capable of extracting data information from the image code.

According to another broad aspect, the invention provides a method, apparatus and computer readable medium for decoding an image, the image comprising a set of basic elements, each basic element of the set of basic elements being associated to an element code. A processing step receives as input the code factors and the image code to derive the element codes. The element codes are then released.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the present invention will become apparent from the following detailed description considered in connection with the accompanying drawings. It is to be understood, however, that the drawings are designed for purposes of illustration only and not as a definition of the limits of the invention for which reference should be made to the appending claims.

FIG. **1** shows an apparatus including an embodiment of the invention;

FIG. **2** shows a high-level block diagram of functional units of the image system including an image encoder in accordance with the spirit of the invention;

FIG. **3** shows a high-level block diagram of functional units of the image system including an image decoder in accordance with the spirit of the invention;

FIG. **4** shows a detailed block diagram of the encoding process in accordance with the spirit of the invention;

FIG. **5** shows a detailed block diagram of the decoding process in accordance with the spirit of the invention;

FIGS. **6***a* and **6***b* show flow diagrams for the creation of an image and the facial code in accordance with an embodiment of the invention;

FIG. **7** shows an alternative apparatus including an embodiment of the invention;

FIG. **8** shows apparatuses including an embodiment of the invention connected by a data transmission medium.

DETAILED DESCRIPTION

In the preferred embodiment, the encoding method and apparatus in accordance with the invention is integrated into a picture system for creating images on the basis of images of individual parts, herein referred to as basic elements. For the sake of simplicity, the specification will describe an embodiment of the invention integrated into a composite picture system. It is to be understood that the encoding method and apparatus may be used in systems for creating images on the basis of individual constituent parts other than a composite picture system without detracting from the spirit of the invention.

In a preferred embodiment, as shown in FIG. **1**, the composite picture system includes a general-purpose digital computer including a processor **100** linked to a machine-readable storage element **108** that may be in the form of a mass storage device such as a hard-drive, a CD-ROM or any other suitable storage medium. The system further includes a device for visualizing the facial image such as a computer monitor **110** or a printing device. The preferred embodiment also provides data input on which a user interface **112** is supported in order to allow the user to select through a touch screen, keyboard, pointing device or other input means, the individual basic morphological elements and to view the combined result on the display screen **110**. The latter **110** is likely to be part of the data input. Optionally, the system further provides a data transmission medium **114** such as a telephone line, LAN, digital cable, optical cable, wireless transmission device or any other suitable means for transmitting an image from the general purpose digital computer to a receiving device. The computer readable medium **108** storing the composite picture system includes of a set of modules namely a library of pictorial entities and image qualifiers **104** and program instructions **102** interacting with the library of pictorial entities and image qualifiers to create a facial image. The computer readable medium **108** may also include symbols where each symbol is associated to a respective one of the pictorial entities and image qualifiers in the library of pictorial entities and image qualifiers **104**. The computer readable medium further comprising a set of code factors, each code factor being associated to a set of symbols, a given code factor being larger that the largest symbol in the set with which it is associated The computer

readable medium further comprises an encoding program element **116** to encode a facial image.

In the preferred embodiment the composite picture system comprises an electronic library of pictorial entities and image qualifiers **104**. Each pictorial entity in the library is an image of a facial part or an accessory such as glasses, earrings or other. The pictorial entities in the library **104** are organized into morphological classes, each class describing a part of the face. In a preferred embodiment, the following basic morphological classes are used: hairstyle, forehead, eyebrows, eyes, nose, mouth, chin, moustache, beard, wrinkles and glasses. The pictorial entities are stored on a computer readable medium. The images may be compressed in a format suitable for graphical storage such as a bitmap (BMP), GIF of JPEG file format. Other file formats may be used here without detracting from the spirit of the invention.

In the preferred embodiment, each pictorial entity is identified with a pictorial entity symbol. Typically, the pictorial entity symbol is a sequence of alphanumeric characters. The pictorial entity symbols are stored on a computer readable medium in the database of symbols. Each image qualifier in the library is a characteristic of a corresponding class. The image qualifiers in the library **104** may be organized into qualifier types, each qualifier type describing a certain characteristic of the pictorial entity. In a preferred embodiment, the following qualifier types are used: position and color. Other image qualifiers such as zoom and the likes may be used without detracting from the spirit of the invention. The image qualifiers are stored on a computer readable medium. In the preferred embodiment, each image qualifier is identified with an image qualifier symbol. Typically, the image qualifier symbol is a sequence of alphanumeric characters. The image qualifier symbols are stored on a computer readable medium in the database of symbols.

In a preferred embodiment, a basic morphological element includes a pictorial entity and a set of image qualifiers. The image qualifiers condition the pictorial entity to alter the visual effect of the latter. For example the image qualifier may modify the position, color zoom or any other visual effect of the pictorial entity. The purpose of the specification, the expression "basic morphological element" is used to refer to the pictorial entity conditioned by the image qualifiers. Each basic morphological element is associated to an element code. The element code contains a set of symbols. In a specific example, the element code for each basic morphological element includes two (2) symbols namely a pictorial entity symbol and a position qualifier symbol. The pictorial entity symbol identifies the pictorial entity within a given class in the library of pictorial entities and image qualifiers. Preferably, the pictorial entities of a given class are each assigned a unique symbol. The symbols need not be consecutive provided they can be ordered and the largest symbol assigned to a pictorial entity of a given class can be determined. The position qualifier symbol provides information on the position of the pictorial entity in the facial image. Preferably, the number of possible positions for a pictorial entity of a given class is predetermined. In a specific example, there may be 5 possible positions for the eyes in a facial image. Each position is assigned a position qualifier symbol such as a number from 1 to 5 and each position qualifier symbol corresponds to a position the pictorial entity with which it is associated can acquire. The element code may contain additional symbols without detracting from the spirit of the invention. For example, the element code may contain a "zoom" qualifier indicating the zoom level of the pictorial entity.

A facial image is constructed by a set of basic morphological elements. The basic morphological element present in a given facial image is said be "active" in the given image. The set of active basic morphological elements is stored in a data structure suitable for that purpose. In a specific example this data structure is an image data table. The image data table stores for each class a record. Each records describes an element code, each record containing a set of fields, each field describing the pictorial entity symbol, position qualifier symbol and any other symbol. The entries in the image data table are referred to as active element symbols. The table below shows a specific example of an image data table.

Class	Pictorial entity symbol	Position qualifier symbol
EYES	34	2
LIPS	2	1
GLASSES	111	17

As shown above, a basic morphological element of class "EYES" with a pictorial entity symbol "34" which is positioned at position "2" is active in the facial image.

The number variations in each of the symbols for each of the classes is stored in a table, herein referred to as a code factor table The code factor table provides information about the number of possible variations in a facial image. For each class, the code factor table stores a record, each record containing a set of fields, each field describing a maximum factor. The maximum factor in the code factor table is the largest symbol assigned to an image qualifier or pictorial entity for a given class. Alternatively, the maximum factor is larger that the largest symbol assigned to an image qualifier or pictorial entity for a given class. This will best be understood in conjunction with a specific example. The table below shows an example of a code factor table.

Class	Maximum pictorial entity factor	Maximum position qualifier factor
EYES	900	5
LIPS	600	26
GLASSES	200	23

In the above table, there are three classes namely "EYES", "LIPS" and "GLASSES" having "900", "600" and "200" pictorial entities respectively as their maximum factor. In this specific example, the pictorial entities are assigned numerical symbols no larger that the maximum factor for each respective class. In the case where pictorial entities are not assigned consecutive numerical symbols, the second column would contain the largest pictorial entity symbol assigned to the pictorial entities of the respective class. The third column includes the maximum position qualifier factor. Class "LIPS" for example has "26" as is maximum position qualifier factor. In this specific example, positions for the individual pictorial entities are pre-determined. Each pre-determined position is given a numerical position symbol that is between 1 and the maximum position qualifier factor in the code factor table.

As shown in FIG. **2**, a facial code **206** for a given facial image may be created by combining the code factors **200** and the image data **202** with an encoding device **204**. In a

preferred embodiment, the encoding device **204** derives the facial code in accordance with the process described in FIG. **4**.

The facial code is first initialized at a based value **400**. Preferably, this base value is zero (0). Following this, the encoding method begins with the first class of the pictorial entities **402** and the first symbol of the element code of the class **404**. The facial code is first multiplied **406** by the corresponding factor value in the code factor table. An example in conjunction with the factor table below will better illustrate this step **406**.

Class	Maximum pictorial entity factor	Maximum position qualifier factor
EYES	900	5
LIPS	600	26
GLASSES	200	23

If class "EYES" for the pictorial entity is being considered, then the facial code is multiplied by the pictorial entity factor "900". Following this, the pictorial entity symbol from the image data table is added **408** to the facial code. An example in conjunction with the image data table below will better illustrate this step **408**.

Class	Pictorial entity symbol	Position qualifier symbol
EYES	34	2
LIPS	2	1
GLASSES	111	17

If class "EYES" for pictorial entity is being considered, then the pictorial entity symbol "34" is added to the facial code. The system then proceeds to step **410** that checks if there are any symbols remaining for the current class. In the affirmative, the system proceeds to step **412** that determines which symbol to consider next. In the example above, the following symbol to consider is the position qualifier symbol. The system then restarts at step **406**. In the event that all symbols for the current class have been processed, step **410** is answered in the negative and the system proceeds to step **414**. Step **414** checks if there are any classes remaining. In the affirmative the system proceeds to step **416** that determines which class to consider next. In the example above, the next class to consider is the "LIPS" class. The system then restarts at step **404** with the first symbol of the element code of the new class. In the event that all classes have been processed, step **414** is answered in the negative and the system proceeds to step **418** with the complete facial code

As a variant, the facial code may be further comprise version number information for the purpose of differentiating between different version numbers of the composite picture system. This in turn permits to insure that a composite picture system using the facial code produced by the process described above is not induced in error if its version is not the same than that of the composite picture system that created the image. In a specific example, the version number information is integrated to the facial code by multiplying the code by a specific number.

In the preferred embodiment, the facial code is a number in a given base. Preferably, a large base is used in order to obtain a reduced number of characters in the facial code. In a specific example, the facial code is a number in base "62" with characters {0-9, a-z, A-Z}. Other bases may be used without detracting from the spirit of the invention. It is to be noted that the computations in steps **406** and **408** of the encoding process may result in very large numbers in the order of 10E+66 or bigger for large systems. It may therefore be preferable to provide some specialized functions for the computation of the multiplication and addition operations for these numbers in order to avoid the possibility of overflow. The implementation of such computations will be readily available to the person skilled in the art to which this invention pertains.

As a variant, characters in the facial code that may be visually confusing are replaced by non-alphanumeric characters. For instance the letter "O" and the number "0" are similar in appearance as are the letter "I", the letter "l" and the digit "1". In a specific example, the characters in the facial code that may be visually confusing are replaced by non-alphanumeric characters such as "+", "=", "@" and so once the code is computed.

In a preferred embodiment, the facial code can be used to reproduce the facial image described by the facial code. As shown in FIG. **3**, facial image data **304** may be obtained by combining the code factors **200** and the facial code **302** with a decoding device **300**. The facial image data **304** is obtained by applying the inverse operations in the reverse order than those applied in the encoding process to the facial code. In a preferred embodiment, the decoding device **300** derives the facial image data **804** in accordance with the process described in FIG. **5**.

The facial code is first obtained **500**. Following this, the decoding process begins with the last class of the pictorial entities **502** and the last symbol of the element code of that class **504**. The facial code is first divided **506** by the factor value in the code factor table associated to the symbol being considered. An example in conjunction with the factor table below will better illustrate this step **506**.

Class	Maximum pictorial entity factor	Maximum position qualifier factor
EYES	900	5
LIPS	600	26
GLASSES	200	23

If class "GLASSES" for the position qualifier is being considered, then the facial code is divided by the factor "23". Following this, the remainder of the division performed in step **506** is stored as the corresponding position qualifier symbol in the image data table **508**. The system then proceeds to step **510** that checks if there are any symbols remaining for the current class. In the affirmative, the system proceeds to step **512** that determines which symbol to consider next. In the example above, the following symbol to consider is the pictorial entity symbol. The system then restarts at step **506**. In the event that all symbols for the current class have been processed, step **510** is answered in the negative and the system proceeds to step **514**. Step **514** checks if there are any classes remaining. In the affirmative the system proceeds to step **516** that determines which class to consider next. In the example above, the next class to consider is the "LIPS" class. The system then restarts at step **504** with the last symbol of the element code of the new class. In the event that all classes have been processed, step **514** is answered in the negative and the system proceeds to

step **518** with the image data table including the complete description of the image described by the facial code. The image data table can then be used by the composite picture system to access the library of pictorial entities and image qualifiers **104** and produce a facial image.

As shown in FIG. **3**, the image data **304** is stored in an image data table that can be accessed by an image builder unit **306**. The image builder unit **306** accesses the library of pictorial entities and image qualifiers **104** of the composite picture system to extract the pictorial entities specified by the image data. The image builder also extracts the image qualifiers specified by the image data and is operative to condition the pictorial entities on the basis of the these extracted image qualifiers. Following this the builder unit **300** outputs an image which may be displayed to the user of the composite picture system. Extracting data elements from a database on the basis of symbols is well known in the art to which this invention pertains.

In the event that the facial code comprises version number information, the reverse operation used to imbed the version number in the facial code is applied to the facial code during the decoding process. In a specific example where the version number information is integrated in the facial code by multiplying the code by a specific number, the decoding process involves dividing the facial code by that number.

In the event that characters in the facial code that may be visually confusing were replaced by non-alphanumeric characters, the reverse operation is performed on the facial code.

An example of a typical interaction will better illustrate the functionality of the encoding module implemented by the program instructions **102** of composite picture system and using the data components **104** **106**.

In a typical interaction, as shown in FIG. **6***a*, once the composite picture system is activated **600**, the user selects a set of pictorial entities **602** through a user interface. The interface to the composite picture system may be a keyboard, pointing device, touch screen or any other suitable input means. The received input may be an address or the memory location where a given pictorial entity is located or some other way of identifying it. The selection is entered in the image data table in association with corresponding qualifier symbols. Preferably, the pictorial entities in a given class as assigned default qualifier symbols. Once the system has received the request, the entries in the image data table are used to locate in the library of pictorial entities and image qualifiers, the entries corresponding with the received input. When pictorial entity or image qualifier is selected it is considered to be active. Following this, the selected pictorial entities and image qualifiers are combined to form a facial image. The combination is performed by positioning each active pictorial entity in a same frame at the location specified by the position qualifier in the image data table. The system then displays the facial image to allow the user to view it **604**. Alternatively, after each selection of a pictorial entity, the systems displays it to allow the user to view the image as it stands with the current selection of pictorial entities. At condition **606**, if the user is satisfied with the appearance of the facial image, the composite picture is complete **610**. The completeness of the image may be indicated by a user inputting a command indicative that the image is complete. The image data table is then processed by the encoding process to compute the facial code **612**. The user of the system may then make use of the facial image and facial code as he pleases. For example, the user may print the resulting facial image, he may store the image by storing the facial code computed at step **612** or he may transmit the image to an external site by transmitting the facial code. In the event that the user is not satisfied with the appearance of the facial image, condition **606** is answered in the negative and the user may modify the facial image **608**. The modification of the facial image may comprise different operations. For example, the user may replace a pictorial entity by another of the same class; he may remove a pictorial entity all together; the element may be displaced in the vertical or horizontal direction. In a specific example, the user interface may include a means, such as arrows in the user interface, for displacing the pictorial entities in the vertical and horizontal directions. The arrows may be linked to functional modules that modify the position of the selected image in the screen. When the pictorial entity is displaced, the corresponding position qualifier symbol in the image table is also modified such as to reflect to current positioning of the pictorial entity. The user may select via a pointing device or other input means the element he wishes to displace in the facial image. The user then uses the displacement arrows to position the pictorial entity in the desired position in the facial image. Many variations in the user interface are possible and implementations different from the one presented above do not detract from the spirit of the invention. For every modification performed in step **608**, the image data table is updated accordingly. Once the facial image has been modified by selecting a revised set of pictorial entities and image qualifiers, the latter are combined to form a facial image. The system then displays the facial image as described in the image data table to allow the user to view it at step **604**. Alternatively, after each selection of a pictorial entity or and image qualifier, the systems displays it to allow the user to view the updated image as it stands with the current selection. The process continues until the user is satisfied with the image and condition **606** is answered in the affirmative the system proceeds to step **610**.

As a variant, as shown in FIG. **6***b*, the facial code may be computed incrementally as the user selects pictorial entities and image qualifiers and modifies the facial image. Following step **602**, the image data table is processed **652** by the encoding unit to compute the facial code corresponding to the data in the image data table. The facial image may then be modified in accordance with steps **604** **606** and **608** described previously. Following step **608**, the image data table is reprocessed by the encoding unit **650** to compute the facial code corresponding to the updated data in the image data table. In this variant, the facial code for the image being created is computed as the user creates the image. Once the use stops entering new modifications, the code is readily computed without the need for the user to input a command indicative that the image is complete.

In another typical interaction, the composite picture system may receive as input the facial code describing a facial image. Using this facial code, the composite picture system reconstructs the facial image. Therefore; the user interface may also include a means for entering the facial codes. The facial code is first decoded by the process described in connection with FIG. **5**. The decoding process produces an image data table containing information for generating the facial image. The system accesses the library of pictorial entities and image qualifiers and extracts the pictorial entities and image qualifiers corresponding to the data contained in the image data table. The image is then displayed to the user which may make use of it as he please by modifying it, storing it, printing it or transmitting it.

FIG. **7** shows an alternative embodiment of an apparatus including an embodiment of the invention. Such an apparatus comprises a user interface **706** such as a touch screen, mouse, keyboard are any other suitable input means for

communicating with the user of the image system. The user interface communicates with an image builder unit **702** operative to generate graphical data on the basis of a given set of input data elements. The image builder unit may be implements on a general purpose computing platform running an application software of may be a dedicated CPU unit programmed specifically for the purpose of generating images. The Image builder unit **702** communicates with an output unit **704** such as a display unit or a printer unit to send the generated graphical data for output to the user. The image builder unit also communicates with a library of pictorial entities and image qualifiers **700**. The library of pictorial entities and image qualifiers **700** may be implemented on a computer readable medium such as a hard disk, CD-ROM, non-volatile RAM or any other suitable device. The image builder unit **708** also communicates with a computer readable medium including image data **708**. The image data specifies the pictorial entities that are active in the given image as well as any other relevant image qualifier such as position and zooming. The image data **708** may also be modified by the image builder unit **702** to update its entries on the basis of inputs received by the image builder unit **702** from the user through the user interface **706**. The image data **708** can be accessed by and encoder **710** operative to encode the image data according to the process described in this specification. The encoder may be implemented on a general purpose computing platform running an application software in accordance with the process described or may be a dedicated CPU unit programmed specifically for the purpose of encoding image data. The encoder **710** outputs the image code. The encoder may further communicate with a communication unit **716** such as a modem, network card or any other suitable communication devices suitable for transmitting data information over a communication channel **718**. The image data **708** can be accessed by a decoder **714** operative to decode an image code according to the process described in this specification. The decoder **714** may be implemented on a general purpose computing platform running an application software in accordance with the process described or may be a dedicated CPU unit programmed specifically for the purpose of decoding image codes. The decoder **714** outputs the image data that is inputted to the computer readable medium containing image data. The decoder may further communicate with the communication unit **716** in order to receive image codes. The encoder **710** and decoder **714** also communicate with a computer readable medium including element code factors **712**.

The facial code produced by the process described above allows each facial image to be described with a very small number of characters compared to a graphical representation permitting the rapid transmission of the composite picture over data transmission medium. For example, as shown in FIG. **8**, a police station at site A **804** using an embodiment of the invention can transmit the entire composite picture of a suspect to police station at site B **802** by simply sending the facial code for that facial image either verbally or through an electronic communication means **800**. At the reception, police station at site B **800** enters the code into the composite picture system that displays the composite picture. The data transmission medium **800** between site A **802** and site B **804** may be a telephone line with a set of modems, and Ethernet connection, the Internet or any other communication medium suitable for the transfer of data. In the above example, site A **804** and site B **802** have on their local site a composite picture system of the type described in FIG. **1** or FIG. **7** of the drawings. A copy of the library of pictorial entities and image qualifiers is stored at each site and only the code needs to be transferred. Advantageously, the invention further allows the storage of a facial image by storing the facial code only on a computer readable medium. This may result in substantial savings in terms of memory requirements for storing the images since only a single instance of each pictorial entity and image qualifier needs be stored, the instance being in the library of pictorial entities and image qualifiers.

Although the present invention has been described in considerable detail with reference to certain preferred versions thereof, other versions are possible. For example, the method and apparatus described may be used in a system to encode a given image provided the image is build on the basis of constituent parts. In these types of application the library of pictorial entities and image qualifiers would include the appropriate set of pictorial entities and image qualifiers. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

What is claimed:

1. A method, comprising:

receiving a number of facial feature designations;

generating element codes corresponding to the facial feature designations, each element code based on:

(a) a symbol representative of a facial feature, the symbol having one of a plurality of values indicative of variations of the facial feature, and

(b) a first code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the facial feature; and

displaying a composite image based on the element codes corresponding to the facial feature designations.

2. The method of claim **1**, wherein the receiving step includes:

displaying a plurality of facial feature images; and

receiving user signals selecting facial feature images included in the composite image.

3. The method of claim **2**, wherein displaying the composite image includes:

displaying the facial feature images in the composite image as the images are selected by the user signals, the images corresponding to respective ones of the element codes.

4. The method of claim **3**, wherein the facial feature images in the composite image are displayed at predetermined positions relative to one another when selected.

5. The method of claim **2**, further comprising:

receiving user modification signals for changing at least one of a size, shape, or position of at least one of the facial feature images in the composite image.

6. The method of claim **2**, wherein the user signals are generated by an input device.

7. The method of claim **6**, wherein the input device includes one of a touch screen, a mouse, a pointing device, and a keyboard.

8. The method of claim **2**, wherein the plurality of facial feature images are displayed in separate classes.

9. The method of claim **1**, wherein the receiving step includes:

displaying information corresponding to a plurality of classes of facial features; and

receiving user signals designating facial features in the composite image, each user signal designating a facial feature from a respective one of the classes.

10. The method of claim **9**, wherein said information includes a plurality of groups of facial feature images, each group corresponding to a respective one of the classes.

11. The method of claim **9**, wherein the classes of facial features are selected from the group comprising eyes, nose, mouth, jaw line, hair, beard, mustache, lips, skin pigment, face shape, and identifying features.

12. The method of claim **11**, wherein the identifying features include at least one of a scar, tattoo, birth mark, glasses, and jewelry.

13. A method, comprising:

displaying facial feature images on a first area of a screen; and

displaying a composite facial image on a second area of the screen, said composite image including facial feature images selected from the first screen area, wherein selection of each facial feature image automatically generates a corresponding element code based on:

(a) a symbol representative of a facial feature, the symbol having one of a plurality of values indicative of variations of the facial feature, and

(b) a first code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the facial feature, wherein the composite facial image is displayed based on a combination of element codes corresponding to the selected facial feature images.

14. The method of claim **13**, wherein the images are displayed in classes in the first screen area, each class corresponding to a different type of facial feature.

15. The method of claim **14**, wherein each class of images is separately displayed in the first screen area in response to a user signal selecting the class.

16. The method of claim **14**, wherein the classes of images are selected from the group comprising eyes, nose, mouth, jaw line, hair, beard, mustache, lips, skin pigment, face shape, and identifying features.

17. The method of claim **13**, wherein selecting a facial feature image in the first screen area causes the facial feature image to be displayed in the second screen area.

18. The method of claim **17**, wherein the selected facial feature is displayed at a predetermined position in the second screen area relative to other facial feature images in the composite image.

19. The method of claim **13**, wherein selecting a facial feature in the first screen area causes the facial feature to appear in the second screen area.

20. A method, comprising:

displaying a composite facial image in a first screen area;

displaying a group of facial feature images in a second screen area; and

automatically modifying the composite facial image in the first screen area based on a selection of a facial feature image in the second screen area, each of the facial feature images corresponding to an element code based on:

(a) a symbol representative of a facial feature, the symbol having one of a plurality of values indicative of variations of the facial feature, and

(b) a first code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the facial feature, wherein the composite facial image is based on a combination of element codes including an element code corresponding to the selected facial feature image.

21. The method of claim **20**, wherein the group includes more than one facial feature image.

22. A system, comprising:

a processor which generates a composite image based on user signals designating a number of facial features, the processor automatically generating element codes corresponding to the designated facial features, each element code based on:

(a) a symbol representative of a facial feature, the symbol having one of a plurality of values indicative of variations of the facial feature, and

(b) a first code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the facial feature; and

a screen which displays the composite image based on the element codes corresponding to the designated facial features.

23. The system of claim **22**, wherein the screen displays a plurality of facial feature images based on the element codes and the processor generates the composite image based on facial feature images selected by the user signals.

24. The system of claim **23**, wherein the screen displays the facial feature images in the composite image as the images are selected by the user signals.

25. The system of claim **24**, wherein the processor controls display of the facial feature images at predetermined positions on the screen.

26. The system of claim **24**, wherein the processor modifies at least one of a size, shape, or position of the facial feature images in the composite image based on user modification signals.

27. The system of claim **22**, further comprising:

an input device which generates the user signals.

28. The system of claim **27**, wherein the input device includes one of a touch screen, a mouse, a pointing device, and a keyboard.

29. The system of claim **23**, wherein the screen displays the plurality of facial feature images in separate classes.

30. The system of claim **22**, wherein the screen displays information corresponding to a plurality of classes of facial features, and wherein each user signal designates a facial feature from a respective one of the classes.

31. The system of claim **30**, wherein said information includes a plurality of groups of facial feature images, each group corresponding to a respective one of the classes.

32. The system of claim **31**, wherein the classes of facial features are selected from the group comprising eyes, nose, mouth, jaw line, hair, beard, mustache, lips, skin pigment, face shape, and identifying features.

33. The system of claim **32**, wherein the identifying features include at least one of a scar, tattoo, birth mark, glasses, and jewelry.

34. A system, comprising:

a screen; and

a processor for controlling the screen to display a number of facial feature images on a first area of a screen and to display a composite facial image on a second area of the screen, said composite image including facial feature images selected from the first screen area, the processor automatically generating element codes corresponding to the selected facial feature images, each element code based on:

(a) a symbol representative of a facial feature, the symbol having one of a plurality of values indicative of variations of the facial feature, and

(b) a first code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the facial feature, the composite image based on element codes corresponding to the selected facial feature images.

35. The system of claim **34**, wherein the images are displayed in classes in the first screen area, each class corresponding to a different type of facial feature.

36. The system of claim **35**, wherein each class of images is separately displayed in the first screen area in response to a user signal selecting the class.

37. The system of claim **35**, wherein the classes of images are selected from the group comprising eyes, nose, mouth, jaw line, hair, beard, mustache, lips, skin pigment, face shape, and identifying features.

38. The system of claim **34**, wherein selecting a facial feature image in the first screen area causes the facial feature image to be displayed in the second screen area.

39. The system of claim **38**, wherein the selected facial feature is displayed at a predetermined position in the second screen area relative to other facial feature images in the composite image.

40. A computer-readable medium storing a program comprising:

a first code section which causes a processor to recognize a number of facial feature designations;

a second code section which generates element codes corresponding to the facial feature designations, each element code based on:

(a) a symbol representative of a facial feature, the symbol having one of a plurality of values indicative of variations of the facial feature, and

(b) a first code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the facial feature; and

a third code section which causes a screen to display a composite image based on element codes corresponding to the facial feature designations.

41. A computer-readable medium storing a program comprising:

a first code section which causes a screen to display facial feature images on a first area; and

a second code section which causes the screen to display a composite facial image on a second area, said composite image including facial feature images selected from the first screen area, wherein selection of each facial feature image causes the second code section to automatically generate a corresponding element code based on:

(a) a symbol representative of a facial feature, the symbol having one of a plurality of values indicative of variations of the facial feature, and

(b) a first code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the facial feature, wherein the composite facial image is displayed based on a combination of element codes corresponding to the selected facial feature images.

42. A computer-readable medium storing a program comprising:

a first code section which displays a composite facial image in a first screen area;

a second code section which displays a group of facial feature images in a second screen area; and

a third code section which modifies the composite facial image in the first screen area based on a selection of a facial feature image in the second screen area, wherein the composite facial image is formed from a plurality of facial feature images including the selected facial feature image, each facial feature image represented by an element code based on:

(a) a symbol representative of a facial feature, the symbol having one of a plurality of values indicative of variations of the facial feature, and

(b) a first code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the facial feature.

43. The method of claim **1**, wherein each of the element codes further includes:

an image qualifier having one of a plurality of values indicative of variations of a position of the facial feature in the composite image; and

a second code factor having a value that equals or exceeds a maximum value of the plurality of values indicative of the variations of the position of the facial feature in the composite image.

44. A method, comprising:

displaying activatable facial feature images of first area of a screen;

concurrently displaying a composite facial image on a second area of the screen;

selecting at least one of said facial feature images using a user interface to yield at least one activated facial feature image;

incorporating said activated facial feature into said composite facial image to yield a modified composite facial image; and

displaying said modified composite facial image on said second area of the screen.

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