(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 August 2013 (22.08.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/120851 A1

(51) International Patent Classification:
G06T 7/00 (2006.01) *G06T 13/40* (2011.01)
G06T 17/00 (2006.01)

(21) International Application Number:
PCT/EP2013/052788

(22) International Filing Date:
12 February 2013 (12.02.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12155243.4 13 February 2012 (13.02.2012) EP

(71) Applicant: **MACH-3D SÀRL** [LU/LU]; Tudor Technoport, 66, rue de Luxembourg BP144, B-4002 Esch-sur-Alzette (BE).

(72) Inventors: **DE KEYSER, Chandra Olivier**; 38, Rue Antoine Meyer, L-2153 Luxembourg (LU). **TARQUINI, Massimiliano**; Via Sagunto 9/D, I-00174 Rome (IT). **LIGI, Alessandro**; V. Monte Caminetto 18, I-00060 Sacrofano (IT).

(74) Agents: **MACKETT, Margaret** et al.; Holidaystraat 5, B-1831 Diegem (BE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: METHOD FOR SHARING EMOTIONS THROUGH THE CREATION OF THREE-DIMENSIONAL AVATARS AND THEIR INTERACTION THROUGH A CLOUD-BASED PLATFORM

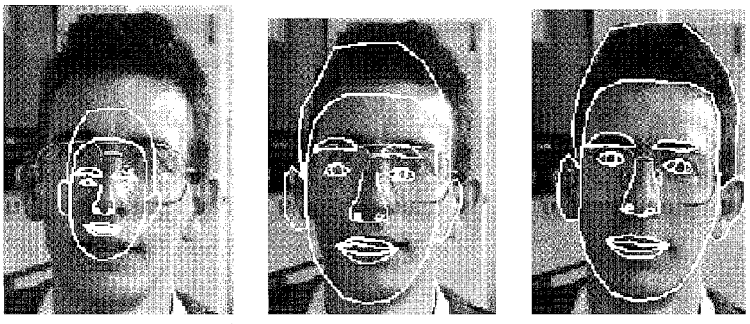


Fig. 13

(57) Abstract: Described herein is a method for creating a 3D avatar from a 2D photo for use on a mobile device. The method comprises acquiring an image (910), searching the image for a human face (920), and searching for facial characteristics (930) which are compared to a series of points to create a 3D mode! (940). To the 3D model, appropriate fitting (950), skinning (960) and texturing (970) are applied before the final reconstruction (980).

WO 2013/120851 A1

METHOD FOR SHARING EMOTIONS THROUGH THE CREATION OF THREE-DIMENSIONAL AVATARS AND THEIR INTERACTION THROUGH A CLOUD-BASED PLATFORM

Field of the Invention

The present invention relates to a method for the sharing of emotions through the creation of three-dimensional avatars and their interactions through a cloud–based platform, and is more particularly concerned with the creation of such avatars for use with mobile communication devices, for example smart phones, laptops, tablets etc; for their sharing through a cloud–based platform, integrated with social networks, which stores avatars and their mood; and for providing interactivity between avatars through the sending of virtual objects made available in a virtual store on that platform.

Background to the Invention

In the last few years, the development of powerful mobile devices and their diffusion worldwide has produced a global change in which people are moving away from using desktop computers to using a mobile equivalent, for example, smart phones, laptops, notebooks and other small portable electronic devices which can connect to the Internet.

The use of such mobile devices has allowed the phenomenon called "social networking" to become an important part in the day-to-day activities of many people's lives. Today, hundreds of millions of people use their virtual identities to communicate and interact

with other people over the Internet via social networking sites. In addition, these virtual identities are used to play games over the Internet.

Whilst this widespread phenomenon provides the ability for contact between people any time of day or night, it is difficult to determine exactly how people are feeling by looking at their virtual identity. It would be a development of the "social networking" phenomenon to be able to interact with people on social networking sites as if it were real life, so that a person's moods, feelings, sentiments etc. can be made available via the Internet.

Whilst this widespread phenomenon provides the ability for continuous contact between people any time of day or night, it is difficult to determine exactly how people are feeling by looking at their virtual identity. It would be a development of the "social networking" phenomenon to be able to interact with people on social networking sites as if it were real life, so that a person's moods, feelings, sentiments etc. can be made available via the internet.

In the last few years, the development of powerful mobile handsets and their diffusion is producing a new global change as most people are moving from desktop to mobile devices. However, a person's virtual identity is always with him/her as it becomes part of day-to-day life.

Summary of the Invention

It is therefore an object of the present invention to provide a method of creating a three-dimensional avatar which can provide a digital representation of feelings, sentiments, mood etc. when interacting with other people using mobile devices.

It is another object of the present invention to provide an innovative representation of a digital identity of a person which can be carried around and through which it is always possible to understand feelings of friends by simply looking at them as if it were real life, each

digital identity being provided by a 3D avatar representing feeling, sentiments, mood, etc. of a user.

In accordance with a first aspect of the present invention, there is provided a method for transforming a two-dimensional image of at least one portion of a human body into a three-dimensional model, the method comprising the steps of:-

a) acquiring an image including said at least one portion of the human body;

b) identifying said at least one portion within the image;

c) searching for features indicative of said at least one portion of the human body within said at least one portion;

d) identifying a set of landmarks corresponding to said features;

e) aligning a deformable mask including the set of landmarks, the deformable mask comprising a number of polygons that correspond to said at least one portion of the human body; and

f) applying a texture to each parameter forming said mask to provide said three-dimensional model.

In one embodiment, said polygons comprise triangles. At least some triangle vertices are arranged to correspond to the set of landmarks.

Said at least one portion of the human body preferably comprises at least a face and step c) comprises searching for facial features. In this case, the set of landmarks corresponds to facial features.

The method may further comprise step g) reconstructing non-visible parts of said face. Such non-visible parts include the inside of the mouth, the tongue, the throat and the teeth.

In another embodiment, the method may further comprise step h) animating the three-dimensional model. This may be achieved by at least one of: rotating said at least one portion about at least one of x-,

y- and z-axes within at least one predetermined range; and translating at least one portion within at least one predetermined range. In addition, an easing function may be applied to the model to smooth movements in the animated three-dimensional model. The amount of animation may be adjusted in accordance with contours applied to the two-dimensional image.

Step h) may further comprise moving points in the three-dimensional model according to at least one defined storyboard to create complex face animations, each defined storyboard simulating at least one of: a human emotion and feeling.

The three-dimensional model may be changed locally on a mobile device. It may also be stored locally on the mobile device.

In a preferred embodiment, the three-dimensional model is stored on a platform in a cloud environment. From this platform, the three-dimensional model can be shared via the platform with at least one social network. Optionally, the three-dimensional model is integrated with said at least one network. This means that a user, having created his/her three-dimensional model, can share it with his/her contacts on his/her social networks. Additionally, his/her contacts may also have three-dimensional models which are shared on their social networks via the platform.

In addition, the method further comprises the step of sharing emotion of a user on said at least one social network via the platform using the three-dimensional model. The three-dimensional model of a sender of a communication may be animated according to his/her feelings and/or mood. In this way, a recipient of the communication can be made aware of the feelings and/or mood of the sender as he/she receives the communication.

Virtual objects may be sent to a recipient via the platform connected to said at least one social network. A recipient, on receipt of the virtual object, may update his/her three-dimensional model in

accordance with the virtual object to display, in response to the type of virtual object, one or more of: simultaneous facial emotions; successive facial emotions; animations; graphical object displays; and text message displays. Such an update is achieved in accordance with a storyboard as described in more detail below.

In one embodiment, the virtual object can be selected from a plurality of virtual objects made available on the platform.

At least one application programming interface (API) is provided on the platform through which at least one of: the three-dimensional model is animated; and a user is targeted using advertising related to his/her mood. Naturally, it will be appreciated that the API in each case will be different, that is, one API for animating the three-dimensional model, and one API for allowing an advertiser to target a user according to his/her mood. The former API permits the three-dimensional model to be animated, for example, by the creation of a succession of animations, in the form of storyboards. Although two examples of API are given here, other API applications are also possible.

The ability to access three-dimensional models is provided by an API which allows any third party web and mobile application to replace two-dimensional images with three-dimensional models created in accordance with the present invention. By incorporating the technology underlying the present invention into their applications (web or mobile), application developers will be able to offer a more engaging and emotional user experience thereby resulting in more faithful and satisfied users.

In addition, three-dimensional models can be customised using accessories worn and/or displayed on and/or around a face. Packages of personalised accessories can be created and made available on the platform. In addition, packages of personalised moods may also be created and made available on the platform.

The three-dimensional models created in accordance with the present invention can be used to substitute for two-dimensional images in web and mobile applications. In addition, the three-dimensional models can be utilised in videogames or other applications using models of characters.

Moreover, the method of the present invention allows for the creation of an image wall including a plurality of facial images forming part of a patchwork, each image comprising a screenshot of a three-dimensional model.

Brief Description of the Drawings

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawings in which:-

Figure 1 illustrates a logical diagram of an infrastructure in accordance with the present invention;

Figure 2 illustrates a "life cycle" of a "living portrait" in accordance with the present invention;

Figure 3 illustrates high functionality built into a "cloud client" in accordance with the present invention;

Figure 4 illustrates options for a user playing with his "living portrait" in accordance with the present invention;

Figure 5 illustrates a "credit manager" subsystem of the present invention;

Figure 6 illustrates a "get credits" subsystem in accordance with the present invention;

Figure 7 illustrates a social networking activity diagram in accordance with the present invention;

Figure 8 illustrates cross-social network integration in accordance with the present invention;

Figure 9 illustrates the steps in creating a 3D face model in accordance with the present invention;

Figure 10 illustrates the steps needed in acquiring a source image for creating the 3D face model in Figure 9;

Figures 11 and 12 illustrate the recognition of an area including a human face;

Figure 13 illustrates the process of fitting a model to a face inside an image;

Figure 14 illustrates a grid comprising a plurality of triangles that is applied to a face;

Figure 15 illustrates the steps in creating a model texture;

Figure 16 illustrates the steps in an activity diagram;

Figure 17 illustrates 3DoM general architecture in accordance with the present invention;

Figure 18 illustrates 3DoM logical architecture; and

Figures 19 to 21 illustrate applications of an avatar created in accordance with the present invention.

Description of the Invention

The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes.

It will be understood that the terms "vertical" and "horizontal" are used herein refer to particular orientations of the Figures and these terms are not limitations to the specific embodiments described herein.

The present invention is based on a suite of applications and an application programming interface (API) that allows developers to build integrated applications. For example, mobile devices and desktop

platforms can be enhanced to implement a wide range of so-called "hi-tech" applications including: interactive three-dimensional (3D) games and virtual worlds; humanoid robotics and artificial intelligence (AI) interaction; performance-driven avatar animation; smart screens, billboards and kiosks; M-commerce; 3D displays; advanced and adaptive visualisations; and intelligent video conferencing.

The following terms with their definitions in the description of the invention to be described below:-

"Living Portrait" refers to a 3D deformable face model based on a photo of a human face. "Living Portrait" is a trademark of Mach 3D.

Java is a known programming language developed by Sun Microsystems, a subsidiary of Oracle Corporation. Much of its syntax is derived from C and C++ but has a simpler object model and fewer low-level facilities.

C is a general purpose computer programming language that is widely used for developing portable application software.

C++ is a popular programming language used for systems software, application software, device drivers, embedded software, high performance server and client application as well as entertainment software.

"OpenCV" refers to Open Source Computer Vision, a library of programming functions for real time computer vision.

"Cloud Computing" refers to the delivery of computing as a service rather than a product. Shared resources and information are provided to computers and other devices as a utility over a network, typically the Internet.

"Cloud Client" refers to computer hardware and/or software that rely on "cloud computing" for application delivery. This includes smart phones, tablets, other mobile devices, desktops and web applications that are connectable to the Cloud for Cloud Computing. It includes any programme that can interact with the platform, and in

particular, the 3DoM Platform described below, which is hosted in the Cloud.

"Cloud Application" refers to cloud application services or "software as a service" (SaaS) which deliver software over the Internet eliminating the need to install and run the application on a device.

"Cloud Platform" refers to a cloud platform services or "platform as a service" (PaaS) which deliver a computing platform and/or solution stack as a service, and facilitate the deployment of applications without the cost and complexity of obtaining and managing the underlying hardware and software layers.

"Cloud Infrastructure" refers to cloud infrastructure services or "infrastructure as a service" (IaaS) which deliver computer infrastructure as a service with raw block storage and networking.

"Server" refers to server layers that consist of computer hardware and/or software products specifically designed for the delivery of cloud services.

"Image histogram" refers to a graphical representation of tonal distribution in a digital image. It plots the number of pixels for each tonal value, and is used to judge and change tonal distribution of an entire image at a glance.

"App" refers to application, for example, web and smart phone applications.

"3me" or "MoodEe" is a virtual object that can be sent to the LP of a recipient to catch his/her attention. It can be considered to be like saying "hello" or winking. "3me" and "MoodEe" are trademarks of Mach-3D. 3me or MoodEe will be described in more detail below.

"3DoM Platform" refers to a particular Cloud Platform that is operated by Mach-3D and through which a user can be linked to his/her social networking site. "3DoM" is a trademark of Mach-3D.

At the highest level, the present invention allows people to communicate their feelings and mood through the Internet using their 3-

dimensional (3D) model created using a portrait of a human face. The present invention does not propose an alternative to social networks or networking sites, but works with them, and, with other communication tools, for example, Skype, MSN, *Yahoo!*, etc., to allow users to add a new degree of freedom to communicate through the Internet via a 3DoM Platform connectable to social networks or networking sites. Skype and MSN are trademarks of Microsoft Corporation, and *Yahoo!* is a trademark of Yahoo! Inc. The present invention is built upon a Cloud Infrastructure, and, as such, it is logically divided in three components: Cloud Server, Cloud Client, and Cloud Applications as defined above. For example, the Cloud Server includes the 3DoM platform, the Cloud Client includes any smart phone, tablet, other mobile device, desktop and web application connected to the 3DoM platform; and Cloud Applications include the applications provided by the 3DoM Platform.

Figure 1 represents a logical diagram of a Cloud Infrastructure 100 in accordance with the present invention. As shown, the Cloud 100 encompasses web applications 110, smart phones 120, 130, tablet applications 140, personal computer and/or laptops 150 and social networks 150, such as, *Twitter*. ("Twitter" is a trademark of Twitter Inc.). It will be appreciated that other social networks can be included in the cloud and *Twitter* has been given as a specific example. Therefore, every component forms part of the cloud which comprises servers, applications and clients as defined above.

A 3D representation of human face is called a "Living Portrait" or LP, which, as its name indicates, is alive and has the ability to change emotions or have a mood of its own. This LP therefore has the ability to become a new layer when representing people in the virtual world. It closes the gap between the real person and the personae that is the representation in the virtual world, in other words, the avatar. The change in emotions and moods of the LP can be controlled by the user or by a command which acts on the LP through its API. The change in

emotions and moods can be transmitted to his/her friends connected to his/her social network.

For a better understanding, Figure 2 illustrates a "life cycle" 200 of a LP. Using the 3DoM Cloud Client (which may be a smart phone app, a desktop application, a web app or a social network itself as described above), a user 'U' connects to 3DoM Platform using an existing account selected one from his social network accounts (*Facebook*, *Twitter*, *Google+*, etc.), step 210. "*Facebook*", "*Twitter*" and "*Google*" are trade marks of Facebook Inc., Twitter Inc., and Google Inc. respectively. Managing federated authentication, namely, where the user logs in only once and does not need to remember several login credentials, through existing social network accounts allows access to the user's social graph, and the LP application becomes part of the social network. When the user is authenticated to 3DoM, he/she is able to:

1. Create a LP (step 220) using a photo from a photo gallery, a photo taken by a camera in the user's mobile device, or a photo downloaded from the web or social network;
2. Change avatar characteristics (step 230): mood (step 232), expressions (step 234), dress up (step 236), make up (step 238); and
3. Share the LP through the Cloud (step 240).

Each time the user 'U' creates or modifies his/her LP, it is immediately shared through the 3DoM Platform hosted in the cloud (sometimes referred to as Cloud Server for simplicity). All the connected Cloud Clients, that is, friends of the user, receive notification about the changes and they can update the LP on their device from the 3DoM Platform (step 250). All users connected with the LP are immediately notified of a change of mood and dressing up of the LP (step 250). The connection between such users is defined by the social graph provided by the connected social network.

As part of the connection to the 3DoM Platform (step 210), a notification from the Cloud Server is received (step 260) which reloads the LP (step 270). The reloaded LP is stored locally (step 280). Similarly, when the LP is created for the first time in step 220, it is stored locally as shown in step 280.

Even if this is a simple scenario, the possible applications are many and some of these applications will be described in more detail below.

A 3DoM Cloud Client is represented by an application on each kind of mobile device that is connected to the 3DoM Cloud Server. A Client is an application with some features that can vary in numbers and characteristics depending on the target for the Client itself. For example, a *Facebook* Client may show only the LP on the *Facebook* user page (instead of the picture of the profile). This kind of Client does not have any other features than the visualisation of an LP given as parameter.

Figure 3 illustrates high level functionality built into a 3DoM Cloud Client 300. The user 'U' has access to an activity browser module 310, access to a profile manager module 320, the ability to create a LP 330, the ability to play with his LP 340, access to a credit manager module 350, and access to social networking module 360. In addition, the user also has the ability to shop, block 370, and play games, block 380, and can access in app advertising, block 390. Access to an alerter, block 395, is also provided.

The activity browser module 310 allows the user to navigate through activities like: received messages, received/sent 3me, credit status and so on. The activity browser module 310 works like an interactive log under the responsibility of the user and only the user is capable of managing it. The profile manager module 320 provides a facility that allows the user to manage his/her 3DoM profile. Using the profile manager module 320, the user is able to enter the social network

accounts that he/she wants to use, manage his/her privacy settings, enter personal data and so on.

When creating a LP 330, the user can use an image containing his/her face. This module can connect to the Internet to look for a photo using Google image or to get photos from the social network user profile. This feature may vary from client to client depending on the target platform. If the target platform is an "in app LP engine", that is, the application is provided with the full set of APIs and is therefore self-sufficient, avatars can be created locally without connecting to the Internet. If the target platform is "LP engine as service", a connection to the server is needed to create a LP as the application is not capable of creating avatars on its own. The LP, once created, is sent to the 3DoM Cloud Server. This is described in more detail below.

In module 340, the user can play with his LP or with the LP of friends. This is shown in more detail in Figure 4 which corresponds to part of Figure 2. Elements that have been described with reference to Figure 2 are similarly numbered but bear the prefix '4' instead of '2'. In sub-module 436, the user can customise his/her LP by adding apparels like hats, wigs, glasses or other kind of gadgets. Clothing, 3me (or MoodEe) and gadgets can be downloaded from the 3DoM online shop. These may be charged to the user or may be free depending on the profile of the individual user. In sub-module 438, the user can change the make-up of the avatar.

In sub-module 434, the user can use expressions to create different moods. Here, the user can change the facial expression of his/her LP using a pre-compiled set of expressions. More precisely, a facial expression is defined as being a feature that shows an emotion and which lasts only a few seconds. For example, a smile appears almost instantly, but, in the next moment, the face is still smiling but not with the same intensity, and, a few seconds later, the face stops smiling. Changing the expression of the LP does not change its status on the

Cloud Server. This is because expressions are not uploaded to or modified through the Cloud in order to save resources and cost, for example, data bandwidth used and processing power. However, if sufficient data bandwidth and/or processing power can be made available at a reasonable cost to the user, expressions may also be uploaded to the 3DoM Platform for sharing through the Cloud.

Expressions can be triggered by an external event, for example, a missed call, low battery, etc.

In module 432, the mood of the LP can be changed. Moods are persistent and complex. They may be defined as a set of expressions, dress up, make up etc. This means that when the user changes his/her mood, his/her LP behaves accordingly. The mood is uploaded and then sent to all the connected Clients for that LP though the 3DoM Cloud Server. The new selected mood is then stored onto the Cloud Server until the next change. For example, some moods may be simple, for example, displaying happiness, tiredness, boredom, angriness etc. or may be more complex, for example, "I'm a pirate" and "I feel like a zombie". All the Clients are preloaded with a default set of moods but the user can create his/her own moods and upload them to the Cloud. This is described in more detail below.

Returning now to Figure 3, the credit manager module 350 allow a user to purchase apps etc. using a virtual currency, in this case, 3DoM dollars (3DoM$). However, this may be amended in cases, such as, iPhone applications, where the user can only use payment gateways through the Apple on-line store or other store associated with the mobile device. (Both iPhone and Apple are trademarks of the Apple Corporation.) Credit manager activities are shown in Figure 5.

In Figure 5, a credit manager system 500 is shown. As described above, the user connects to 3DoM using his/her social network account, step 510. From there, he/she can get credits (step 520),

manage credits (step 530), trade credits (step 540) and spend credits (step 550). Naturally, other options are also possible.

Figure 6 illustrates the way to get credits in more detail. Elements that have previously described with reference to Figure 5 have the same reference numerals. The user may get credits in many ways, but only two ways are shown as examples. Credits can be bought using real money (step 610), or can be awarded as rewards for activities conducted in the 3DoM world (step 620). Such activities include: inviting friends to join 3DoM, publishing invitation messages onto the social network, conducting advertising activities, etc. However, all activities conducted to get rewards follow predetermined rules and need to be verified. This means that all the rewarded activities are performed by the 3DoM Cloud Client and the user is guided to choose between the activities proposed by the system. A list of rewarded activities is provided by the system (step 630), the user selects one of the activities (step 640), and performs the activity (step 650) to get the rewards in step 620.

Returning to Figure 5, a facility, manage credits (step 530), is provided to enable the user to check his/her credits, and to access his/her log of activities (spent credits, rewards, etc. etc.). Through this interface, the user has the ability to report potential fraud and/or unauthorised access to his/her account and/or use of his/her credits.

Another facility, trade credits (step 540), provides a way for a user to earn credits by "selling" self-created gadgets or moods so that they are loaded onto the store hosted on the 3DoM Platform. Naturally, before such items are loaded onto the 3DoM Platform, they would need to be tested to determine their usefulness. This potentially has several advantages. For example, the most creative users are retained, the number of gadgets and moods available on the system are increased, and third party companies are rewarded for creating products for the 3DoM Platform.

Similarly, spend credits (step 550) allows the user to spend his/her credits by buying gadgets, 3me, new moods and so on.

As described above, the 3DoM Platform of the present invention does not substitute already existing social networks. The present invention integrates seamlessly with such networks through the user's social graph, which is accessible via an application programming interface (API) provided by the referenced platform. This has many advantages including: instant access to connected users, access to user data (in accordance with privacy rules set by the user), letting social networks manage their users' graphs, and the opportunity to be more effective during a marketing campaign. Moreover, using the social graph provided by the social networks means cost saving when storing user data onto the 3DoM Cloud Servers.

Figure 7 illustrates a social networking activity diagram 700 which illustrates the activities for which the social networking module is responsible. As before, the user 'U' connects to the 3DoM Platform using his/her social network account 720 and, after user authentication, step 715, has access to various activities as shown. User authentication, step 715, is responsible for performing user authentication for the 3DoM Platform through his/her social network accounts. This allows the user to connect to one or more social networks using account data he/she provides. All the user account data is stored on the 3DoM Cloud Server database to allow the 3DoM Platform to share all the authentication information between the user clients.

One critical module is cross social network integration as indicated by 730. Cross integration between social networks does not mean that the 3DoM Platform fuses different social graphs from different social networks, but provides high level interfaces to implement cross social networks functionality and to provide a set of functionalities that can be used by all client modules. A social graph for an individual on a social network or networking site refers to that individual and his/her

associated connections. The operation of this module is described in more detail below with reference to Figure 8.

Sharing of LP facility, block 740, is the core of the 3DoM Platform sharing of emotions as all the other functionality elements rely upon the possibility of sharing moods and emotions of the LP with connected friends through the 3DoM Cloud Server. This is described in more detail below.

In a "send 3me" module 750, a virtual object is sent to catch the attention of the LP of a recipient. 3me (or MoodEe) are complex objects which can be purchased from the store, and produce effects that are applied to the LPs. A 3me (or MoodEe) can be a kiss, a slap, a wasp bite, a glass of a drink, a flower bouquet, etc. In addition, a 3me (or MoodEe) can contain a text which is composed at the moment of sending the 3me (or MoodEe) or which is already available. When the user receives a 3me (or MoodEe), the client notifies him/her and asks the user if the 3me (or MoodEe) is accepted or not. If the 3me (or MoodEe) is accepted, a message is sent to the sender and the 3me is stored locally. 3me (or MoodEe) (always in singular, just like SMS) can be used to provide emotions to friends by animating their LP and delivering text messages to them.

Upon receipt of the 3me (or MoodEe), the LP of the recipient can display one or more of: a facial expression for example, a smile, surprise, sadness, etc.; skin textures, for example, stamping red lips on the face for a kiss; greening of the skin for a bite by a wasp; bruising the skin for a slap etc.; a graphical display of the object forming the 3me (or MoodEe); and a text message which is displayed on the screen. If the receiver accepts the 3me (or MoodEe), the user is offered the possibility of sending back a message with an included expression to notify the sender of his/her feelings on receipt of the accepted 3me (or MoodEe). If the 3me (or MoodEe) is refused, a message is sent to the sender and the 3me (or MoodEe) is deleted from the receiver client.

There is a module 760 that allows the user to get LPs of his/her friends. As described above, the 3DoM Platform introduces new ways to communicate with friends through the Cloud using social networks. A 3DoM user stays connected with his/her friends through their LP. This feature allows the user to be able to check the moods of his/her friends, to be notified about the change in the mood of a friend, to communicate with connected friends, and to play with the LP of friends as shown by module 765. This kind of connection can be done by navigating the "social graph" of the social network used to connect to the service.

In module 770, messages can be sent to friends. This provides the possibility to share moods and expressions with them and to introduce a new way to communicate with connected friends. Using the 3DoM Platform, the user can send a message to a friend as part of a 3me (or MoodEe) which includes his/her feelings when writing the content. In this way, an LP can now become an advanced version of an emoticon making the user able to "virtually" understand the mood of the message sender. The message being sent as part of a 3me (or MoodEe) may be displayed in an original way, such as, a bubble spoken by the LP like in comic books, or a text–to-speech conversion using a third party technology, etc. 3me (or MoodEe) with messages can be considered to be an evolution of the combination of SMS and emoticons.

3me (or MoodEe) objects may fall within one of three categories: those that are free; those that are charged; and those that are sponsored. Sponsored 3me (or MoodEe) will be freely available for the users sending them, as they will be sponsored by companies doing advertising campaigns, for example, a glass of vodka, sponsored by Smirnoff or a chocolate bar sponsored by Côte d'Or. Smirnoff is a trademark of the Diageo plc, and Côte d'Or is a trademark of Kraft Foods. The recipient of the 3me (or MoodEe) will see a fun animation of

expressions on his/her LP relating to the object and will be able to receive a real version of that object in a participating store or bar.

Through the 3DoM Client, the user can change his profile photo on his social network, module 780. As an example, a user can change the expression of his LP or the dressing of the LP, and then can substitute the social network profile photo with a new one representing a snapshot of the LP. At each moment, the user can share his mood by changing the social network profile photo according to his/her feelings at that moment.

Also through the 3DoM Client, the user can publish his/her LP directly on his/her social network page/wall with a comment, module 790. Depending on the construction of the social network page/wall, the 3D LP may be converted to a 2D representation thereof.

Figure 8 illustrates an interface module 800 for cross social network integration. The interface module 800 comprises a cross network platform 810 have a plurality of programming interfaces 820 which connect to respective ones of functions 830, 840, 850, 860, 870 on the platform 810. Such functions include authentication, sending messages, publishing photos, changing profile photo and various other functions. The network platform 810 also interfaces with the associated APIs 880, 885, 890 of the social networking sites, such as, *Facebook*, *Twitter*, *Google+* and *LinkedIn*. *LinkedIn* is a business-related social networking site.

Naturally, advertising is one of the sources of revenue for any social networking site and the 3DoM Platform is no exception. A dedicated module manages advertising inside the client. A dedicated library provides the ability to display advertising that takes advantage of all the user information so that the most relevant advertising can be selected for display. The mood of a user may significantly influence his/her receptiveness to an advertisement of a given product or service. Knowing that a user is happy, hungry, thirsty, hot or cold could be an

indication that he/she may well be disposed to receiving an appropriate advertising message. The 3DoM platform is aware of the mood of its users and of their changes in near real–time.

The 3DoM platform makes information relating to the mood of its users available to third parties such as advertisers and information providers through a dedicated library (API) which will offer a unique targeting system: ads and more generally information such as news will be selected based on people's mood. Users of 3DoM will also be able, through the setting of personal preferences, to opt in & out of different types of advertising and news, or of all information altogether.

The 3DoM platform has the knowledge of its users' social circles. Because of this, 3DoM allows the combination of the LP of a user with those of his/her friends in his social network and enables the development of games with a more personal, attractive and engaging experience: each user plays with his/her LP as the hero and the LPs of his/her friends as opponents or team members.

As described above, the creation of a LP is core to the 3DoM Platform, and requires the ability to transform a two-dimensional (2D) human portrait into a 3D deformable model.

Image interpretation is intended to convert raw image data into a meaningful interpretation. Automated methods that promise fast and objective image interpretation have therefore created much interest and have become a significant area of research activity. Such methods may be deterministic, that is, based upon physical properties of an object, or stochastic, that is, based upon statistical evaluation of classes of objects. There are many algorithms that can effectively be used for that purpose.

In accordance with one aspect of the present invention, a cross-platform technology, for use with tablets and smart phones etc., is provided which selects an effective algorithm with linear complexity. It is the selection of a linear complexity algorithm which makes it possible to

implement the invention on a device with limited computing capacity and power, such as, a smart phone.

A technique based upon statistical models called active shape models (ASM) is used. This technique was described in "Statistical Models of Appearance for Computer Vision" by T. F. Cootes and C. J. Taylor, Imaging Science and Biomedical Engineering Department of Manchester University, 8 March 2004. It attempts to learn the actual pattern of variability found in a class of objects, rather than making arbitrary assumptions. The idea is to estimate the population statistics from a set of examples instead of using a single prototype. The pattern of variation for a given class of objects is established from a training set and statistical analysis is used to give efficient parameterisations of this variability, providing a compact and efficient representation. Those characteristics of compactness and efficiency, together, make the algorithm capable of being deeply integrated with devices with limited performances like smart phone.

The exhaustive treatment of the ASM algorithm can be found at the following website (which is a reproduction of the article discussed above) – see in particular pages 37 to 43:-

http://personalpages.manchester.ac.uk/staff/timothy.f.cootes/Models/app_models.pdf.

In accordance with the present invention, the ASM model used is determined from a number of training sets, and the number of landmarks chosen is in accordance with the processing that is required to create the 3D model or avatar form a 2D photo. Starting from a 2D photo, 93 landmarks identifying face characteristics are utilised in an image interpretation phase. These landmarks are special points placed by ASM in correspondence to a typical characteristic and will be described in more detail below. A set of those landmarks is called ASHAPE. At the end of this step, the model is bi-dimensional and cannot

be animated, deformed, shaped. ASHAPE is the starting point for the next step.

In accordance with the present invention, ASMs are used with a high level of detail and the ASHAPE of 93 landmarks or points provides a compromise between fast response time of the application providing a better user experience, and resolution, that is, quality of the 3D model or avatar produced. It will be appreciated that the present invention is not limited to the use of 93 landmarks for the ASHAPE, but any suitable number can be used in accordance with the desired resolution and processing power required to provide the transformation from the 2D photo to the 3D model or avatar whilst providing a fast response time and hence good user experience.

Figure 9 illustrates a flow chart 900 of the steps required to create a 3D face model from a 2D image of a human face thereby creating a LP. The first step is image acquisition and digital elaboration, step 910. Here, the client acquires images from different sources. If needed, the algorithm applies image filters to enhance the image quality (not shown). The next step is to search for a human face inside the image, step 920, and the client restricts the operation of the next step of the algorithm by finding an area containing a human face. Once a human face has been identified, a search for facial characteristics is carried out, step 930. The search is restricted to the previously detected area which contains a human face. In particular, the algorithm looks for the following facial characteristics: front, eyes, eyebrows, eyelids, face oval, nose and mouth. Each characteristic is then marked using a set of points, or landmarks, each landmark being uniquely identified by a number as will be described in more detail below.

The next step is to create the 3D model, step 940. During this step, the client creates the LP using a "low-poly" 3D prototype. A "low-poly" 3D model is a model created using a small number of polygons to minimise hardware requirements, for example, triangles. This

prototype is called the LP general model (LPGM). Using the LPGM, face-tracked characteristics are fitted within the wireframe (step 950), that is, the 3D model without applied texture which appears to be made of wired frames, of the LPGM. This is done by matching some key points of the LPGM with points representing the facial characteristics (93 points), the ASHAPE. All the other points are interpolated. This is described in more detail below with reference to Figure 14.

Once the fitting has been carried out in step 950, the next step is to create a skin in a process called skinning, step 960. Skinning uses the initial image to create skin texturing for the 3D avatar, texturing the model using information from the original image. Once done, the texture is applied to the LP in step 970. The final step is reconstruction, step 980, where invisible parts of the face, for example, the interior of the mouth, tongue, throat, teeth etc., are created to produce the 3D model that comprises an LP as indicated at 990.

The reconstruction of the internal parts of the mouth can provide colours and lighting of the teeth depending on the face colours and lighting of the original LP so that a more aesthetic match can be provided.

The LP can now be animated or otherwise changed in shape or texture. Once the 3D model is created, the user is given the possibility to add elements to create surprising effects, such as, dressing up, adding hair, clothes, make-up, moods etc., as mentioned above. With the enhanced reconstruction of the internal parts of the mouth described above, teeth may be provided as an object which can be selected as an accessory, for example, vampire teeth. An API is provided which allows commands to be sent to modify the 3D model to simulate expressions, head movement (top, down, left, right, tilt, flip), facial muscle movement. This is done locally on the mobile device on which the application is operating.

The steps described above with reference to Figure 9 will be described in more detail below with reference to Figures 10 to 15.

In Figure 10, the image acquisition and digital elaboration step 910 is shown in more detail. For the first step (step 1000), the user acquires a photo. This can be done using a webcam (step 1010), searching onto the Internet (step 1020) or simply navigating into the handset image gallery (step 1030). Alternatively, the photo can be uploaded from a local file system (step 1040).

When using the Internet as the photo source, the photo can be loaded from *Facebook* (step 1022), from a Google search (step 1024) or by inserting an image URL (step 1026). To support this phase, the application may select only photos that contain a human face seen substantially from the front, or "face-on". However, it may also be possible to select a photo from a slight angle to either side from the "face-on" position.

During loading of the photo, the application automatically applies some image filters (step 1050) to enhance the quality of the photo. Such filters usually regulate image contrast or expand colour gamma, that is, the range of the visible colours. The application of filters improves the result and enhances image quality, as well as precision, when creating an LP. This operation is really important especially when using images from local camera since many devices use low cost lenses and hardware that produces low quality images, especially in contrast and gamma.

Histogram equalisation is a method that is used in conventional image processing for adjusting image contrast of the original image. Gamma correction controls the overall brightness of an image. Images that are not properly corrected can look either bleached out or too dark. Trying to reproduce colours accurately also requires some knowledge of gamma. Varying the amount of gamma correction changes not only the brightness but also the ratios of red to green to blue. Note

that improving the quality of an image refers to working on the general parameters of brightness and contrast to enhance the image quality, and nothing can be done to create "information" if the image is low quality.

Before proceeding with the recognition of facial characteristics, step, 1060, the algorithm needs to determine an approximated area containing human face and estimate the starting pose alignment. Good pose estimation provides a good starting point and allows the software to minimise resources used in the creation of the 3D model, for example, battery usage for mobile devices. This image area is generally called a region of interest (ROI). In Figure 11, an image 1100 is shown in which the estimated area is represented by a rectangle 1110 which surrounds the points determined as facial characteristics 1120.

The ROI may be automatically executed by the software using Haar like classifiers, a tool to determine if a determinate pattern may be found inside an image-squared region, or manually by the user. If done manually, as shown in Figure 12, the user then moves, scales, and rotates the image using the icons on the toolbar 1130 until the face is aligned to a white shape 1140 used as guideline. A rectangle (not shown) containing the white shape 1140 becomes the ROI for the image.

Returning to Figure 9, facial characteristics are determined in step 930 as described above. This step represents the core of the whole process of transforming a 2D image into a 3D model. The higher the accuracy achieved at this stage, the better the end result. As mentioned above, ASMs, which are based on statistical models of shapes of objects, are used to fit an example of an object to a new image. The process of fitting of a model to a face inside an image is shown in Figure 13.

In Figure 13, three stages of fitting the model to a face inside an image are shown in (a), (b) and (c). As mentioned above, the purpose of ASM is the fitting of 93 landmarks to the image. To speed-up this process, the algorithm uses the ROI detected in the previous step to

restrict the area on which the search for the face is carried out. The ASM algorithm uses a training set of previously defined shapes, the training set comprising images of faces of people of different gender, skin colour, morphological characteristics and shapes. Each shape is made of points (called landmarks) manually placed into the image.

As mentioned above, the shape used to create an LP is made of 93 landmarks which are grouped together to represent human facial characteristics. In particular, landmarks 0 to 4 represent the front, landmarks 5 to 19 the face oval, landmarks 20 to 25 the right eyebrow, landmarks 26 to 31 the left eyebrow, landmarks 32 to 39 the left eye, landmarks 40 to 42 the bottom left eyelid, landmarks 43 to 45 the left eyelid, landmarks 46 to 53 the right eye, landmarks 54 to 56 the bottom right eyelid, landmarks 57 to 59 the right eyelid, landmarks 60 to 70 the nose, and landmarks 71 to 92 the mouth. The landmarks are not numbered in the Figures for reasons of clarity.

An additional series of landmarks can be applied to the critical parts of the face, for example, the eyes and the mouth, which has more points than those described above so that an enhanced representation of the features of the eyes and mouth can be provided.

During this step, ASM is applied to the input image and the client finds all the 93 landmarks to identify the face characteristics of the user. As shown in Figure 13, this step is represented in the image by the points connected by the lines. At (a), the ASM is applied to the image and then manipulated as shown as (b) until the ASM substantially matches the face as shown at (c). The line 1120 (Figure 11) shows another example of the ASM.

The shape does not find a 3D model, but a 2D model made of points, P_i, for each point in the shape, with coordinates (x_i, y_i) on the plane as defined by:

$$P_i = (x_i, y_i)$$

As mentioned above, ASHAPE is defined as the set of 93 points or landmarks, which result from the ASM algorithm. Each point is represented by coordinates P(x, y) having origin in the top left side of the related image. To complete the process of creating an LP, one more step is needed where all 93 landmarks are used to fit a previously generated 3D model to the face.

In order to switch from a 2D model to the desired 3D model, a generic 3D deformable model is needed. Such a model is then modified to fit the face by moving some points of the 3D model to match with the points of the 2D model. As the 3D model contains many more points of two-dimensional positions, the positions of the remaining points are determined by linear interpolation.

In order to create a 3D deformable model of the human face, a wireframe generic 3D model of human face is created using a 3D graphics technique specific to the present invention. The 3D model is created such that it has: portability and can be used on all platforms with 3D graphics capability; precision so that movements of the face can be as close as possible to reality; quality so that it is acceptable to the user both on a mobile device and on desktop computers; a good performance in terms of low battery consumption; and a data size that can easily be transmitted via email or via an Internet connection without adversely affecting the minimum acceptable quality level.

Figure 14 illustrates a low poly parameterised face mask specifically developed for model-based coding of human faces adaptable to the 2D face model made of 93 landmarks which describe human facial characteristics. For simplicity not all the points and vertex are shown in the Figure.

As shown in Figure 14, the model comprises a number of points or vertices. These points or vertices are either anchor points (AP) or simple points (SP). Anchor points are a set of special points in a 1-to-1 relation with points within the 2D model. All anchor points define a set

called APS. Simple points are necessary to animate the model and enhance the quality of the 3D model. All simple points define a set called SPS. As a consequence, an LPGM is the set of all the AP and SP and can be represented by:

$$LPGM = APS \cup SPS$$

The points in the LPGM can be represented as coordinates in space as $P_i = (X_i, Y_i, Z_i)$, and these coordinates may be represented by their homogeneous form where:

$$P1_i = (X_i, Y_i, Z_i, w) = (X_i/w, Y_i/w, Z_i/w, 1) = (X1_i, Y1_i, Z1_i, 1)$$

The LPGM is made of three sections which describe respectively, the list of vertices, the list of faces and a list of forming units (FU).

The list of vertices is used to define the corners of surfaces, typically triangles, in 3D models where each such point is given as a vector. In the present invention, the vertices are represented using a vector R^3, which can be expressed as (vx, vy, vz). A single vertex can be represented in XML format as:

```
<LPVERTEXLIST>
    <LPVERTEX ID = "FRONTE_1">
        <X>0.174</X>
        <Y>0.98</Y>
        <Z>-0.024</Z>
    </LPVERTEX>
    ..............
</LPVERTEXLIST>
```

All the vertices represent a generic face model centred in the origin of axes. In the model shown in Figure 14, there are 150 vertices where 93 vertices correspond to the landmarks determined previously.

The list of faces represents polygons that are used for texturing and shading in the 3D model. In the present invention, these polygons are triangles, and each face is represented by three vertices and is listed by its ID as it appears in the list of vertices. Each triangle is

used to create textures from the shades to render the 3D model. Vertices are listed using their ID as it appears in the vertex list. For a single face:

```
<LPFACELIST>
    <LPFACE ID = "T_BOCCA_LABBRO_INFERIORE_1">
        <V1>BOCCA_1</V1>
        <V2>BOCCA_2</V2>
        <V3>BOCCA_3</V3>
    </LPFACE>
    .....
</LPFACELIST>
```

The list of forming units represents the core for model animation and expression representation. The name of each item represents the action when applied to the model; an index (INDX) represents the index of the vertex or vertices affected by this FU; and convolution values (COV) are values that need to be applied to the coordinates (x, y, z) of the vertex during the affine transform. Whilst the LP has z coordinates, these are not used when skinning or texturing as these only need features defined by a 2D surface.

An affine transform or map is a transformation which preserves straight lines and ratios of distances. In particular, all points initially lying on a line still lie on the line after transformation and the midpoint of a line segment remains the midpoint after transformation. It is to be noted that an affine transform does not necessarily preserve angles or lengths.

After ASHAPE has been found using the ASM algorithm, the next step is fitting the LPGM to conform to the ASHAPE. At the end of this operation, some points in LPGM, namely, points in APS, are aligned to the points of ASHAPE. All the other points in LPGM, namely, points in SPS, are manually evaluated or interpolated to find their correct position, for example, by matching some key points of the LPGM with points representing the facial characteristics (93 points as described above), the ASHAPE.

Because the ASHAPE is a 2-dimensional model and the LPGM is a 3D model, points in LPGM are translated, that is, moved from one position to another one, only along the X- and Y-axes. Because the original image does not contain information about depth of the face, the Z-axis is evaluated empirically on the basis of information from the ASHAPE. The master model is now aligned to the ASHAPE.

In the next step, a skin needs be created that will be applied to the model. Here, the model skin is created using the information from the original image. To do this, simple texturing is used – a basic method for mapping a texture onto an object. This is done using open graphic libraries (OpenGL) API which is a reference graphic sub-system for all the smart phone and desktop computers. The method of creating textures is described below with reference to Figure 15.

Referring now to Figure 15, a flow chart 1500 of steps needed for creating a model texture is shown. In order to create the skin of the LP, the base image points are used, step 1510. For each point in the LP, the corresponding point projected on the x, y plane is determined as follows (step 1520):

$$\forall P = (x, y, z) \in LP \Rightarrow Pxy = (x, y, 0)$$

For each face in the list of faces, an image area corresponding to the related triangle strip is created (step 1530), and the set of the triangular image strips represent the skin of the LP. These triangular strips are then cut in step 1540 before reconstruction in step 1550. The third step is the application of the textures to the model of the face. Each triangle generated is then applied to the corresponding face portion and is controlled by the graphic engine.

In the last step of LP creation, it is necessary to reconstruct the non-visible parts of the face, namely, the interior of the mouth, the tongue, the throat, the teeth etc. as described above.

The final LP can be shown as facing a source of light. However, the light source can be moved sideways, up or down, so that

shadows appear on the face of the LP providing a more realistic 3D appearance. Movement of the head of the LP causes the shadows to be adapted with the movement in accordance with the direction of the source of light.

The final LP can be defined as a triple combination of the base image (the image used to generate the ASHAPE), the ASHAPE (the 2D model of the face) and metadata (a list of metadata describing the LP).

Now the model is ready to be animated. There are two different types of animation, namely, automatic animation and user-induced animation. Automatic animation gives "life" to the model and is independent of user interaction, whilst user-induced interaction provides animation due to the interaction of a user with the model to give feelings and facial expressions. In addition, these two types of animation can be coupled to obtain a third kind of animation which is the mood of the LP.

As stated previously, the model is a 3D model comprising vertices and faces with a texture mapped onto them. After the model has been fitted to the human face, it can be represented by a 3N-dimensional vector where N is the number of vertices as represented following:

$$\Phi = (x1, y1, z1, x2, y2, z2, \ldots, \ldots, .xn, yn, zn)$$

where (xi, yi, zi) represents the coordinates of the i-th vertex.

Animating the 3D model consists of re-shaping the model by translating, rotating, scaling vertices. For example, a user input of touching the screen makes the head of the LP look towards the point of contact on the touch screen. In the absence of a manual input, the head can be swung around its point of rotation using a simulation of natural movements. This simulation is based on rotation about the X-, the Y- and the Z-axes.

Rotation about the X-axis relates to movement around the axis passing through a pivot point (as defined below) and which is parallel to the X-axis. The angle of rotation may be predetermined and when

reached, a new value is set, or, alternatively, the angle of rotation is not predetermined. The new angle of rotation, Axi, can be randomly chosen in a range of values defined by intersections of sets. Ax1 can be defined as the set of angles between ±15°; Ax2 can be defined as the set of angles having a distance from the current angle of rotation in the range between 7.5° and 30° with 0° set as a default for the first time; and Ax3 can be defined as the set of angles having a sign that is opposite to that of the current rotation angle with 0° set as a default for the first time. A new angle of rotation, Axr, can be defined as the function, R(Ax):

$$Axr = R(Ax1 \cap Ax2 \cap Ax3)$$

Similarly, rotation duration, Txr, can be associated with the new angle of rotation, Axr, along the X-axis. The rotation duration can be expressed in ms: Where Axr1 is the next chosen rotation and Axr0 is the current completed rotation, a minimum rotation duration, Min(Txr), and a maximum rotation duration, Max(Txr), can be expressed respectively as follows:

Min(Txr) = 100ms x distance between Axr0 and Axr1 (in °)

Max(Txr) = 200ms x distance between Axr0 and Axr1 (in °)

In addition, Txr can be defined as the value, randomly chosen from the set of values in the range defined by the previously defined functions:

$$R(Min(Txr) \leq Txr \leq Max(Txr))$$

Together with the angle and the time of rotation, a function is used to ease the movement. Five different easing functions have been defined, namely: LINEAR, QUAD, CUBIC, QUART, QUINT. The algorithm selects randomly from the set of all easing functions as follows:

EFxr =Random({LINEAR, QUAD, CUBIC, QUART, QUINT})

Having defined Axr, Txr, and the easing function, until the new limit is reached, that is, before choosing another angle and time of rotation, part of the movement is done applying EFxr, and rotation, ROTx, about the X-axis can be defined as:

$$ROTx = (Axr, Txr, EFxr)$$

Similarly for rotation around the Y-axis, Ay1 can be defined as the set of angles between ±12°; Ay2 can be defined as the set of angles having a distance from the current angle of rotation in the range between 4.8° and 24° with 0° set as a default for the first time; and Ay3 can be defined as the set of angles having a sign that is opposite to that of the current rotation angle with 0° set as a default for the first time. A new angle of rotation, Ayr, can be defined as the function, R(Ay):

$$Ayr = R(Ay1 \cap Ay2 \cap Ay3)$$

As before, rotation duration, Txy, can be associated with the new angle of rotation, Ayr, along the Y-axis. The rotation duration can be expressed in ms: Where Ayr1 is the next chosen rotation and Ayr0 is the current completed rotation, a minimum rotation duration, Min(Tyr), and a maximum rotation duration, Max(Tyr), can be expressed respectively as follows:

$$Min(Tyr) = 100ms \times \text{distance between Ayr0 and Ayr1 (in °)}$$

$$Max(Tyr) = 300ms \times \text{distance between Ayr0 and Ayr1 (in °)}$$

In addition, Tyr can be defined as the value, randomly chosen from the set of values in the range defined by the previously defined functions:

$$R(Min(Tyr) \leq Tyr \leq Max(Tyr))$$

Together with the angle and the time of rotation, a function is used to ease the movement. Five different easing functions have been defined, namely: LINEAR, QUAD, CUBIC, QUART, QUINT. The algorithm selects randomly from the set of all easing functions as follows:

$$EFyr = Random(\{LINEAR, QUAD, CUBIC, QUART, QUINT\})$$

Having defined Ayr, Tyr, and the easing function, until the new limit is reached, that is, before choosing another angle and time of rotation, part of the movement is done applying EFyr, and rotation, ROTy, about the Y-axis can be defined as:

$$ROTy = (Ayr, Tyr, EFyr)$$

Similarly for rotation around the Z-axis, Az1 can be defined as the set of angles between ±2.2°; Az2 can be defined as the set of angles having a distance from the current angle of rotation in the range between 4.8° and 24° with 0° set as a default for the first time; and Az3 can be defined as the set of angles having a sign that is opposite to that of the current rotation angle with 0° set as a default for the first time. A new angle of rotation, Azr, can be defined as the function, R(Az):

$$Azr = R(Az1 \cap Az2 \cap Az3)$$

As before, rotation duration, Tzr, can be associated with the new angle of rotation, Azr, along the Z-axis. The rotation duration can be expressed in ms: Where Azr1 is the next chosen rotation and Azr0 is the current completed rotation, a minimum rotation duration, Min(Tzr), and a maximum rotation duration, Max(Tzr), can be expressed respectively as follows:

Min(Tzr) = 100ms x distance between Azr0 and Azr1 (in °)

Max(Tzr) = 500ms x distance between Azr0 and Azr1 (in °)

In addition, Tzr can be defined as the value, randomly chosen from the set of values in the range defined by the previously defined functions:

$$R(Min(Tzr) \leq Tzr \leq Max(Tzr))$$

Together with the angle and the time of rotation, a function is used to ease the movement. Five different easing functions have been defined, namely: LINEAR, QUAD, CUBIC, QUART, QUINT. The algorithm selects randomly from the set of all easing functions as follows:

EFzr =Random({LINEAR, QUAD, CUBIC, QUART, QUINT})

Having defined Azr, Tzr, and the easing function, until the new limit is reached, that is, before choosing another angle and time of rotation, part of the movement is done applying EFzr, and rotation, ROTz, about the Z-axis can be defined as:

$$ROTz = (Azr, Tzr, EFzr)$$

Pivot point:

The origin of the three axes of rotation, the so–called pivot point, is automatically determined after the fitting of LPGM on ASHAPE. This point is obtained using the X- and Y-coordinates of the sixty-sixth landmark of the model LPGM. The Z value of the required point is equal to the 11/10 of the depth of the model.

The easing function is used to vary the speed of the rotation during the execution of the movement. All easing functions (LINEAR, QUAD, CUBIC, QUART, QUINT) are based on 3 arguments, namely: D, the duration of the animation in seconds; C, the final absolute size of the movement; and T, the time in seconds spent to go from 0 to D on which the value C is evaluated. Therefore, the LINEAR easing function can be defined as LINEAR(D, C, T) = (C*T)/D; the QUAD easing function as:

$QUAD(D, C, T) = C/2*T^2$ (if $(T = D/2)<1$)

$QUAD(D, C, T) = -C/2*(T_1*(T_1 - 2) - 1)$ (where $T_1 = T-1$)

Similarly, the CUBIC, QUART AND QUINT easing functions can be defined as:

$CUBIC (D, C, T) = C/2*T^3$ (if $(T = D/2)< 1$)

$CUBIC (D, C, T) = -C/2*(T^3 + 2)$ (where $T_1 = T - 2$)

$QUART (D, C, T) = C/2*T^4$ (if $(T = D/2) < 1$)

$QUART (D, C, T) = -C/2*(T^4 - 2)$ (where $T_1 = T – 2$)

$QUINT (D, C, T) = C/2*T^5$ (if $(T = D/2) < 1$)

$QUINT (D, C, T) = -C/2*(T^5 + 2)$ (where $T_1 = T – 2$)

Not all the vertices in an LP are moved according to the defined rules. To make the LP animation as realistic as possible, the LPGM has been structured to cover not only the face oval but also an area containing the image background. From the animation point of view, LPGM is divided in many areas; Contour 3, the outer edge, far from the head oval, including large portions of the background; Contour 2, the area between Contour 3 and the face oval, including hair and small portions of the background; Upper Contour, an upper portion of Contour

2, including all points on the upper side of the brow; and Lower Contour, a lower portion of Contour 2, including all points on the lower side of the chin.

To evaluate X-, Y- and Z-axis rotation to be applied to each vertex of the LP, the following rules are applied:

(1) if a vertex belongs to Contour 3, no rotation is applied thereby anchoring all points in Contour 3 to the image background;

(2) if a vertex belongs to Lower Contour, X- and Y-rotations are reduced by 50% of their value with the Z-axis rotation being reduced to 10% of the original value;

(3) if a vertex belongs to Upper Contour, X-, Y- and Z-axis rotations are reduced to 60% of their original value;

(4) if a vertex belongs to Contour 2, X-, Y- and Z-axis rotations are reduced to 30% of their original value; and

(5) all other vertices are moved according to the defined rules.

This kind of movement, especially between Contour 2 and Contour 3, introduces very noticeable deformations. Because Contour 3 is fixed, all the textures are stretched with a disturbing effect. To reduce this effect, a gradient is applied, which gradually makes textures completely opaque in the area next to the centre of the LP, and almost totally transparent in the area next to the top of Contour 3.

Expressions:

Expressions are little animations induced by the user or automatically generated by the application that represent human facial expressions. Each expression is made of small actions that concur to create a complex animation. The simplest action in facial expression is moving a simple vertex by applying the affine transform to translate the vertex from one position to another.

Applying the following LP Forming Unit (LPFU), the movement of the raising of the 10th vertex of the LP by a factor defined by the vector (COV1, COV2, COV3):

```
<LPACTIVEVERTEX >
        <INDX>BOCCA_10</INDX>
        <COV1>0.0</COV1>
        <COV2>0.086957</COV2>
        <COV3>0.021739</COV3>
</LPACTIVEVERTEX >
```

Complex animations groups the movement of different vertices logically grouped to form meaningful movement. Those groups of movements are called LP Forming Unit (LPFU). LPFU defines a movement of one or more vertex of the LP to form an expression. As an example, applying the following LPFU, the upper lips of the model can be raised. These movements have been developed in the course of complex and iterative trial and errors exercises and are all documented in tables.

However, applying one or more LPFUs is not sufficient to create an expression. This is because each LPFU statically changes the position of one or more points from point A to point B without a transition between A and B. In order to create a particular expression, a storyboard is created for that expression. Such a storyboard 1600 is shown in Figure 16.

To animate the model, each LPFU must be applied following a storyboard that takes into account the LPFUs, their order, the duration of each LPFU, the easing functions, and the reverse mode to take the model back to the main expression. In Figure 16, the LPFU is loaded from the LP model, step 1610. In order to complete the animation of an expression, animation handlers are used that group one ore more LPFUs, that is, all the information necessary to animate the LPFU as well as their sequence, step 1620, and the expression is executed over a time period (of the order of a second) by playing the storyboard, step 1630.

The LPFUs are grouped into "Animation Bundles" that represent the animation of a single LPFU (a single event into a storyboard).

Each "Animation Bundle" is preferably provided to the user on the screen of his/her mobile device so that he/she can make an appropriate selection to animate his/her 3D model or any other 3D model to which he/she has access.

In the following example, the method for the "Lip Stretcher" creates an animation bundle, adds the "Lip Stretcher" LPFU to it and then inserts the Animation Bundles inside the expression storyboard.

```
PUBLIC VOID LIPSTRETCHER() {
   ANIMATIONBUNDLE BUNDLE = NEW ANIMATIONBUNDLE();

BUNDLE.ANIMATIONS.ADD(PREPAREANIMATIONFORACTIONUNIT("LIP STRETCHER", 0, -110F, 0,
1000, FALSE, PICKRANDOMEASING()));

BUNDLE.ANIMATIONS.ADD(PREPAREANIMATIONFORACTIONUNIT("LIP STRETCHER", 0, -110F,
2000, 1000, TRUE, PICKRANDOMEASING()));

SYNCHRONIZED (ANIMATIONBUNDLES) {
      ANIMATIONBUNDLES.ADD(BUNDLE);
   }
 }
```

Sentiments can be extracted from textual data using natural language processing, text analytics and semantic technologies identifying positive and negative opinions, emotions, and evaluations, and taking the context into consideration to disambiguate interpretations.

Extracting indicators about opinions and emotional reactions of the writer or speaker mean that it can then be expressed with the display of emotions on the LP of the user. In accordance with the present invention, the technology covers techniques and approaches that promise to enable directly opinion-oriented information-seeking systems allowing the programmer to get into user opinion using dedicated sets of API.

As part of the invention, there is a functionally of sharing LPs, moods and emotions through the Cloud. Naturally, network usage

needs to be minimised as well as the amount of data stored on the 3DoM Cloud Server. The 3DoM Platform has typical Cloud Architecture: all the components communicate exchanging messages that represent the way to implements computing and application as a service. Data is shared through the Cloud using the Internet as the communication channel.

Each of the facial expressions, emotions, moods and accessories of the LP may be associated to events. The LP publishes those events so that they can be captured by an external program. This capability (among others) is used to create animated scenarios composed of one or more objects, either in 2D or 3D, in motion combined with a LP. In one example, the eyes of the LP are capable of following a moving object close to its face.

Figure 17 illustrates 3DoM general architecture 1700. Architecture 1700 comprises 3DoM Cloud Clients 1710, 3DoM Cloud Server 1720, and a back end infrastructure 1730. The 3DoM Cloud Clients 1710 are represented in a layer containing all 3DoM clients, including web browsers on desktops, smart phones, tablets etc. The back end infrastructure 1730 supports the entire architecture but, in particular, data storage servers.

A synchronous message-oriented communication schema is used to allow communication between all the layers in the 3DoM architecture. Message-oriented communication is a way of communicating between processes. Messages, which correspond to events, are the basic units of data delivered. In synchronous communication, the sender blocks waiting for the receiver to engage in the exchange. Message-oriented communication can be implemented in many ways and do not impose a way to implement the content of the message. In one embodiment, to preserve the size of messages, Google Protocol Buffer technology can be used.

Protocol buffers provide a flexible, efficient, automated mechanism for serialising structured data which is similar to XML, but

smaller, faster, and simpler. Once the data structure has been defined, special generated source code can be used to write and read the structured data to and from a variety of data streams using a variety of programming languages. The data structure can be updated without breaking deployed programs that are compiled against the "old" format.

Figure 18 illustrates the 3DoM logical architecture 1800. Front end 1810 represents the main entrance door to the 3DoM Platform, and it tunnels messages coming into the system from users 1820 routing them to the 3DoM Platform. It is responsible of handling secure connections via HTTPS via firewall 1830. An information bus 1840 represents the collection of technologies used to replicate data and make the 3DoM Platform scalable, and it is responsible for load balancing and data replication as well as scalability. Connected to the information bus 1840 is a number of 3DoM Servers 1850, 1860, 1870 and two database servers 1880, 1890. Each 3DoM Server 1850, 1860, 1870 implements the 3DoM Platform and each database server 1880, 1890 stores data.

The sharing of data between platforms through the mobile Internet and the storing of data on handsets of different data storage capacities needs to be handled in the most efficient manner in order to have fast transmissions and low storage requirements. For small amounts of data to be stored and transferred, XML is overloaded by XML-specific keywords and headers. Moreover, parsing XML using a mobile handset is time and battery consuming. In order to fix all those problems, even if XML remains the reference language to create and edit models, specific data formats are implemented, one for each object to be stored. This means that, from a programmer point of view, to simplify editing and programming operations, XML can be used. However, from a system point of view, XML files are parsed and transformed into specific data files containing only relevant data. Those data files are compressed and cyphered before they are used by the 3DoM system.

The LP file format is called F3D. It is designed to contain all the necessary data to describe an LP minimising the size of the document without losing the possibility of extending the content with metadata. The F3D file format is a binary format and uses GZIP algorithm to compress data. GZIP is a UNIX compression utility using its own compression algorithm. A dedicated file format, D3D, is also used for dress up objects. In addition, an LPGM distributable file format is used to store the LPGM, that is, the 3D reconstruction of the human face, its contours and basic movements. This file comprises a sequence of GZIP compressed binary and is divided into a list of vertices, a list of triangles and as list of active vertices (AV). Other dedicated file formats may be used for moods and 3me (or MoodEe).

As mentioned above, the present invention is built around "shape core libraries", a complete set of libraries for the development of 3D apps. All the core functionalities in the libraries are available in either JAVA version or C/C++ native version so that the needs of different target platforms can be met. Shape4J is the Java version of the API and has been developed to meet the expanded requirements of portability. Shape API is the native version of the API and uses OpenCV.

Whilst the present invention has been described with reference to faces and their recognition, tracking and transformation from 2D to 3D, it will readily be understood that the underlying principles and technology can be applied to other known shapes of the human body as well as to other living beings.

The present invention can be implemented as a personal assistant to create a user-friendly original alerting and/or assistance tool as shown in Figures 19 to 21. In Figures 19 to 21 respectively, the personal assistant can be configured to notify the user: of the name of an incoming caller; of the availability of new apps; news; events; weather; and that the battery is too low etc. The personal assistant can also be used with incoming messages (SMS) and email. The personal assistant

can be created as described above by mapping a chosen face over an existing polygonal model without the need for a dedicated server to process images with all the processing being done on the smart phone.

3D avatars can be integrated with the user's phone contact list. Such avatars can automatically be created by tracking a suitable picture associated with a contact name, either taken by the camera on the phone or one downloaded from a social network, and turning the picture into a realistic and animated 3D model as described above.

It will be appreciated that the present invention is not limited to social applications and the LP can also be used in other domains, for example, e-commerce and in store retail.

The present invention can allow people to try merchandise in a much more engaging and practical way offering benefits such as: being able to see themselves with glasses, different make-up, hats etc. It would also be possible to try products or articles not present in a store thereby reducing stock and shipping the product directly to the user's home. In addition, there is no need to wait for a sales person, and it is possible to store favourite times for a final decision, getting the opinion of contacts via social networking connections. For example, "snapshots" of the LP wearing the item can be posted on the user's social network for feedback of his/her friends.

In addition, a virtual store forming part of the 3DoM Platform can be made available to third parties so that these parties can create virtual objects, such as, 3me (or MoodEe), together with associated animation of the LP through an API hosted by the 3DoM Platform. The virtual store offers virtual objects for sale, displays them, groups them by category to facilitate selection, and features search functions along with other features common to e-commerce stores.

Third parties can be offered the possibility of proposing 3me (or MoodEe) to the 3DoM Platform, which, after validation, will be

displayed in the virtual store, and upon selling these 3me, will provide a share of the generated revenue to the third party originator.

The LP provides a high level of realism in terms of facial features and skin texture. The LP can interact with virtual objects received from friends to change expression etc.

Applications in which the LP in accordance with the present invention can be used include, but are not limited to: enriching chat or group chat applications, such as, MSN, SKYPE, eBuddy, Whatsapp, etc.; and to add more emotion and to replace automatically the emoticons with a facial expression corresponding to that emoticon, for example, the :-) emoticon would be replaced by the user's LP smiling, and likewise for all other emoticons.

In addition, the LP can be used to synchronise lip movement with spoken text to offer hearing impaired users a better interface. Similarly, a virtual reader can be created for reading aloud a web page, a news article or any text information using text-to-speech conversion technology provided by third parties. The virtual reader could be customised to speak with a given accent and voice, the lip movements being synchronised with the spoken text with the LP showing expressions and animations to make the reading more lifelike.

Electronic greetings cards could also be created using an LP, and, by attaching a message to it, a virtual or a recorded voice could present the message of the sender while showing facial animations.

LPs can be incorporated into organiser applications where the application reminds the user that he/she needs to do a task. If he/she does not do the task, the LP could take a disappointed or angry look, for example. If the task is completed, the LP could show a congratulating face. Likewise, the LP can be used on high end gym equipment to give positive feedback when the user is performing well, for example, better than last he/she did the same exercise, and to provide encouragement if

he/she is struggling with the exercise. Naturally, the LP could also give negative feedback if necessary.

The 3DoM platform allows the integration with social networks through their API and with web sites as described above. One possible application of the 3DoM platform is to provide the functionality of creating a large image wall composed of a large number of small facial images, each providing a piece of a sort of patchwork. The image wall is in effect composed of small (thumbnail) images which are screenshots of LPs.

The user can put his/her face on the image wall by purchasing a special type of 3me (or MoodEe) which will offer the following possibilities: take a screenshot of his/her LP as it was at its last update; give the user the possibility of inserting a text message; and upload the screenshot to the image wall. The image wall can be implemented either within the social network making use of the APIs of that social network, on the 3DoM platform or in a web site.

One way to implement the construction of the image wall is for charitable purposes. Initially, the wall comprises a plurality of grey images on a white background. By sending a specific 3me (or MoodEe), the face of the user is posted in one of the grey images which become coloured showing that a contribution to the charitable cause has been made at some point. A user can repeatedly send such 3me (or MoodEe) to have his/her picture posted several times. When a user looks at the wall from far, he/she can visualize groups of coloured pixels in various spots, which correspond to where a user has sent a 3me (or MoodEe). The more users send 3me (or MoodEe), in effect, in this instance, making a donation, the more coloured groups of pixels start replacing grey points of the image wall.

Although the image wall has been described with respect to donating to charity, it could be used for other collections and populated by the sending of specific 3me (or MoodEe).

As described above, 3me (or MoodEe) are complex objects which produce effect that are applied to LPs. However, some 3me (or MoodEe) objects may degrade after a predetermined period of time if not utilised. Users having unused 3me (or MoodEe) objects will be notified if these objects are about to suffer degradation. This gives the user the opportunity to use the object thereby reactivating them for a further predetermined period of time. A user has the option of opting in or out for such notifications.

Further uses of LPs may include the setting of a mode such as "do not disturb" mood or similar. When a call is placed to a user who has selected the "do not disturb" mood, the LP of that user with a facial expression corresponding to this mood will appear. In addition, a message may also be set by the user to indicate more details, for example, "in a meeting" or "sorry I can't take your call". For this to be implemented, the caller needs to check with the 3DoM platform to obtain the user mood information.

The 3DoM platform allows users to specify their mood associated with a communication, and may store the mood of users together with the history of mood changes. This information can be analysed to provide crowd sentiment analysis.

For users who do not wish to reveal their social networking ID, a unique 3DoM ID may be provided to protect the user's confidentiality. In this case, the user may use his/her 3DoM ID rather than his social network ID to send 3me (or MoodEe) objects to others via the 3DoM platform and to react when receiving a 3me (or MoodEe) object.

LPs may also be enriched with characteristics which are "Tamagotchi-like" (Tamagotchi is a handheld digital pet, Tamagotchi is a trademark of Bandai Co. Ltd., a subsidiary of Namco Bandai of Taitō, Tokyo, Japan.) Users will need to conduct activities, for example, feeding, playing, accessorising, etc., to keep their LP in good shape and

to ensure that he/she grows up healthy. Such activities can be obtained from the 3DoM platform. The embodied character in the Tamagotchi may be a character based on the LP of a friend, a celebrity, a comic book character, etc.

Although emotions and moods have been described above as being set by the user, they may be automatically detected and uploaded onto the 3DoM platform. For example, a camera or other device built into a television may capture the emotions and/or mood of one of more persons watching a television show, the captured data being uploaded to the 3DoM platform via an internet link. From the 3DoM platform, this captured information may be used to animate accordingly the LP of the user. This captured information may also be used for sentiment analysis, mood-based commercials and audience satisfaction.

Alternatively or additionally, biorhythms of the user may be used. However, this requires the use of sensors which can detect changes in heart rate, body temperature etc. to provide information associated with different emotions.

If a video image of a user is obtained, for example, using a webcam connected to the internet, the emotions of the user may be detected using facial recognition from the video data. This data can be used to develop an emotional chat by remotely activating an LP showing the emotion detected corresponding to the user and displaying it on his/her LP to his/her remote audience. However, if the user does not want to be filmed or recorded and would prefer to represent himself/herself as a character, this character would then be animated accordingly.

In competitions, debates or other events, a LP can be used to represent the user. Where the results (which can be partial, during the event or final, after the event) can be determined by a vote through information technology tools, the results can be displayed using 3D animated LP with the capability to express human emotions. An

automated information system records the votes which can come from a variety of sources, such as social networks and formatted messages. The votes are counted and awarded to the different participants to the event according to the rules defined for the event. Each participant to the competition is represented graphically by his/her LP. As votes are collected, the LP is animated with a facial expression which reflects the vote count, for example, when victory gets closer, the LP will express a happy emotion; when a defeat looms, the LP will express a sad or unhappy emotion; if the vote count is tight, the LP can express a nervous emotion (with drops of sweat, for instance); and in general, in the case where are many candidates, the emotion which best corresponds to the situation will be displayed by each LP.

The information tools supporting this representation of the participants to an event as LPs will display the information visually through the various media channel available, such as: TV channels (SD, HD, Ultra HD, Interactive, Simulcast and other format for broadcast networks); paid or free channels; internet (web site); mobile applications; desktop applications; and social networks etc.

A server controlling the event may interact with social networks, RSS feeds, databases, as well as, video information, information received from computers, mobile devices and the web.

An extension of this event scenario is to provide a mobile application which allows users to vote and broadcast their emotions on a television show. The television channel (or particular show or programme) requests that viewers of the programme to download a suitable application or app from an application store so that they can create their own LP, set their mood, vote for one of the participants, and, optionally add a short text message. Each viewer's vote is sent either directly to the 3DoM platform or to 3DoM enabled software made available to the television channel or show. The vote may be free or may

be a paid purchase. In this latter case, the price can be fixed or variable, and can be set by a real-time auction.

The television programme will broadcast a selection of the votes in a manner such as a stock market, for example, like a ticker tape scrolling horizontally at the bottom of the television screen overlaying the programme image. The ticker tape may include the LP of the voter showing a living facial expression expressing a mood set by the voter, a short text message, and the name of the voter. The selection may be random, for example, the voter being chosen like in a lottery, based on the price paid by the viewer, or based on any other business rule set by the 3DoM platform. Viewers may be charged only in the event that their LP is broadcast or may be charged regardless of whether the relevant LP has been broadcasted. In the latter case, the charge may be for use of the 3DoM platform for viewers not having a 3DoM platform ID.

The 3DoM platform will enable the following additional services: an in application notification informing a viewer that his/her vote has been accepted and that they will be broadcast live in a few minutes; users will in turn be able to share this event with their friends via their social networks with a simple operation in a few clicks, passing the link of the television show or programme if it is being broadcast on the web or another link or information allowing people to tune in and watch the show; and selling the footage of a short video sequence containing the broadcast of the LP ticker tape at the bottom of the screen.

The present invention is not limited to humans and it may be possible to create LPs of other creatures, for example, pets. Such LPs can be used in "online competitions" or in interactive games.

CLAIMS

1. A method for transforming a two-dimensional image of at least one portion of a human body into a three-dimensional model, the method comprising the steps of:-

   a) acquiring an image including said at least one portion of the human body;

   b) identifying said at least one portion within the image;

   c) searching for features indicative of said at least one portion of the human body within said at least one portion;

   d) identifying a set of landmarks corresponding to said features;

   e) aligning a deformable mask including the set of landmarks, the deformable mask comprising a number of polygons that correspond to said at least one portion of the human body; and

   f) applying a texture to each parameter forming said mask to provide said three-dimensional model.

2. A method according to claim 1, wherein said polygons comprise triangles, at least some triangle vertices corresponding to the set of landmarks.

3. A method according to claim 1 or 2, wherein said at least one portion of the human body comprises at least a face and step c) comprises searching for facial features, said set of landmarks corresponding to facial features.

4. A method according claim 3, further comprising step g) reconstructing non-visible parts of said face.

5. A method according to claim 3 or 4, further comprising step h) animating the three-dimensional model.

6. A method according to claim 5, wherein step h) comprises at least one of: rotating said at least one portion about at least one of x-, y- and z-axes within at least one predetermined range; and translating at least one portion within at least one predetermined range.

7. A method according to claim 6, wherein step h) further comprises applying an easing function to smooth movements in the animated three-dimensional model.

8. A method according to claim 6 or 7, wherein step h) further comprises adjusting the amount of animation in accordance with contours applied to the two-dimensional image.

9. A method according to any one of claims 5 to 8, wherein step h) further comprises moving points in the three-dimensional model according to at least one defined storyboard to create complex face animations, each defined storyboard simulating at least one of: a human emotion.

10. A method according to any one of claims 3 to 9, further comprising the step of changing the three-dimensional model locally on a mobile device.

11. A method according to any one of claims 3 to 10, further comprising the step of storing the three-dimensional model on a platform in a cloud environment.

12. A method according to claim 11, further comprising the step of sharing the three-dimensional model via the platform on at least one social network, the three-dimensional model being optionally integrated with said at least one social network.

13. A method according to claim 12, further comprising the step of sharing emotion of a user on said at least one social network via the platform using the three-dimensional model.

14. A method according to claim 12 or 13, further comprising the step of sending a virtual object via the platform to a recipient connected to said at least one social network.

15. A method according to claim 14, further comprising the step of responding to receipt of the virtual object by updating the three-dimensional model in accordance with the virtual object to display, in response to the type of virtual object, one or more of: simultaneous facial emotions; successive facial emotions; animations; graphical object displays; and text message displays.

16. A method according to any one of claims 11 to 15, further comprising the step of providing at least one application programming interface on the platform through which at least one of: the three-dimensional model is animated; and a user is targeted using advertising related to his/her mood.

17. A method according to any one of claims 3 to 16, further comprising the step of substituting two-dimensional images with three-dimensional models in web and mobile applications.

18. A method according to any one of claims 11 to 17, further comprising the step of exchanging text messages between connected users and animating the three-dimensional model according to the sentiment of the message.

19. A method according to any one of claims 11 to 18, further comprising the step of creating of an image wall including a plurality of facial images forming part of a patchwork, each image comprising a screenshot of a three-dimensional model.

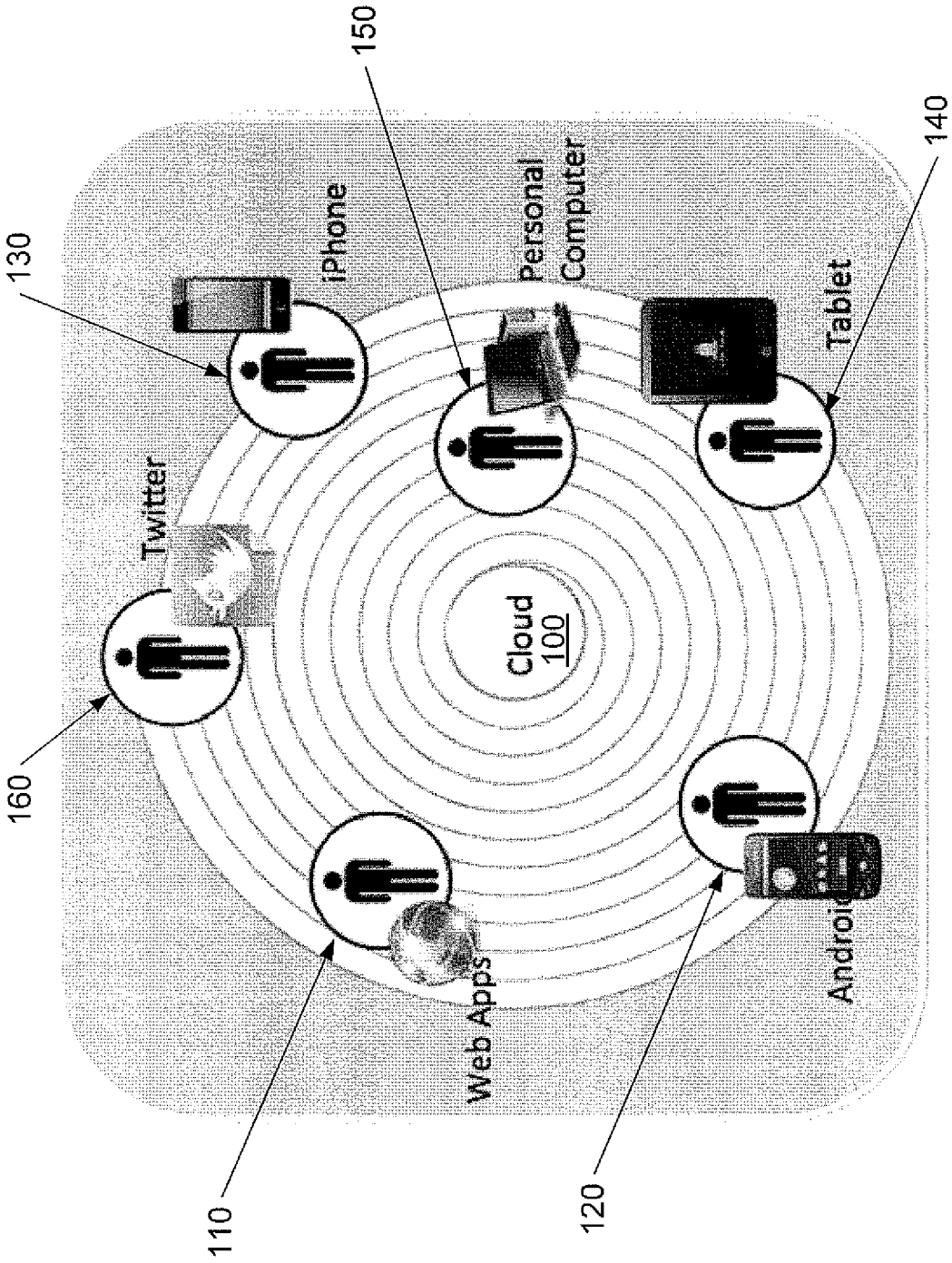

150
140
130
iPhone
Personal Computer
Tablet
Twitter
Cloud
100
160
Web Apps
Android
110
120

Fig. 1

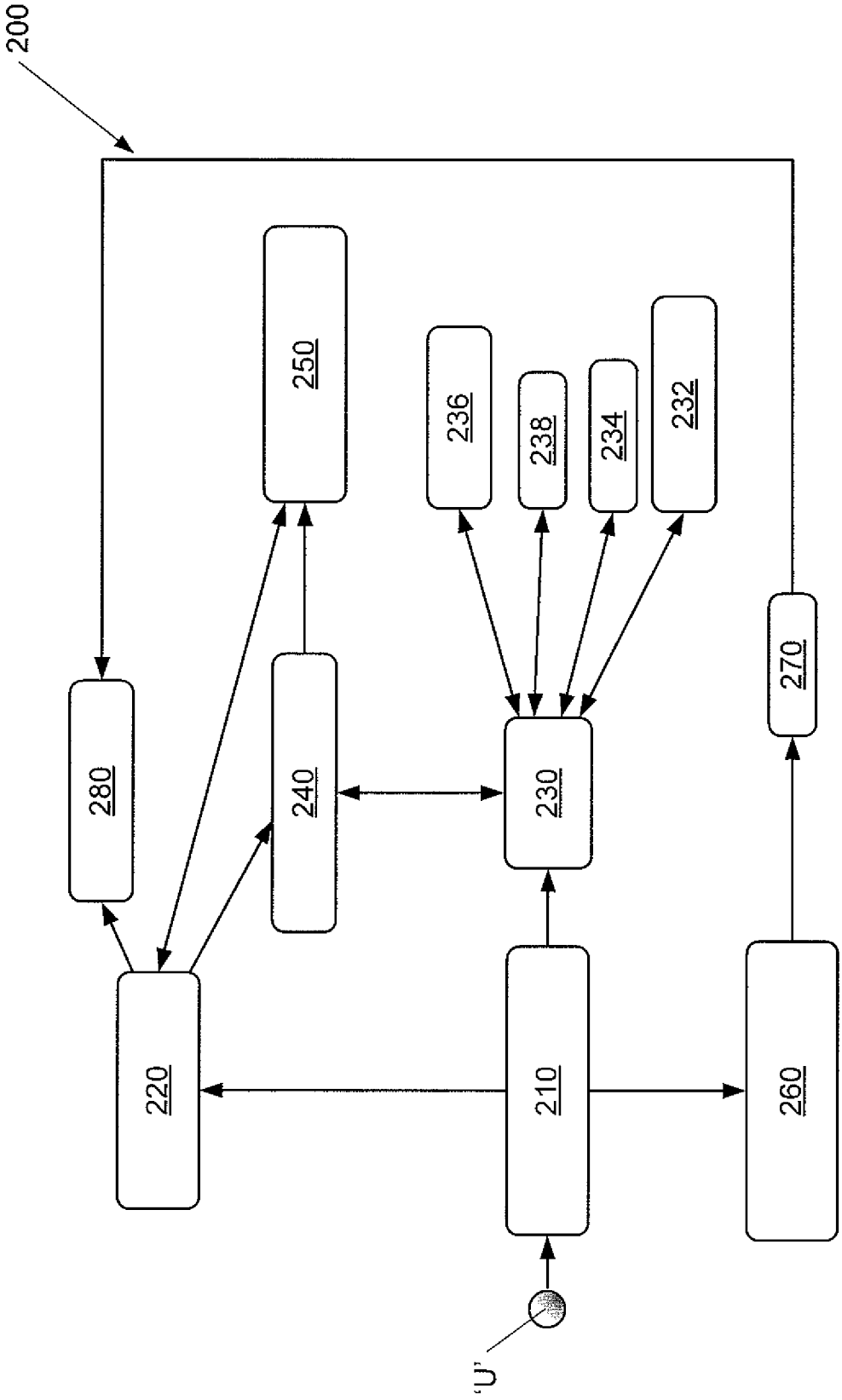


Fig. 2

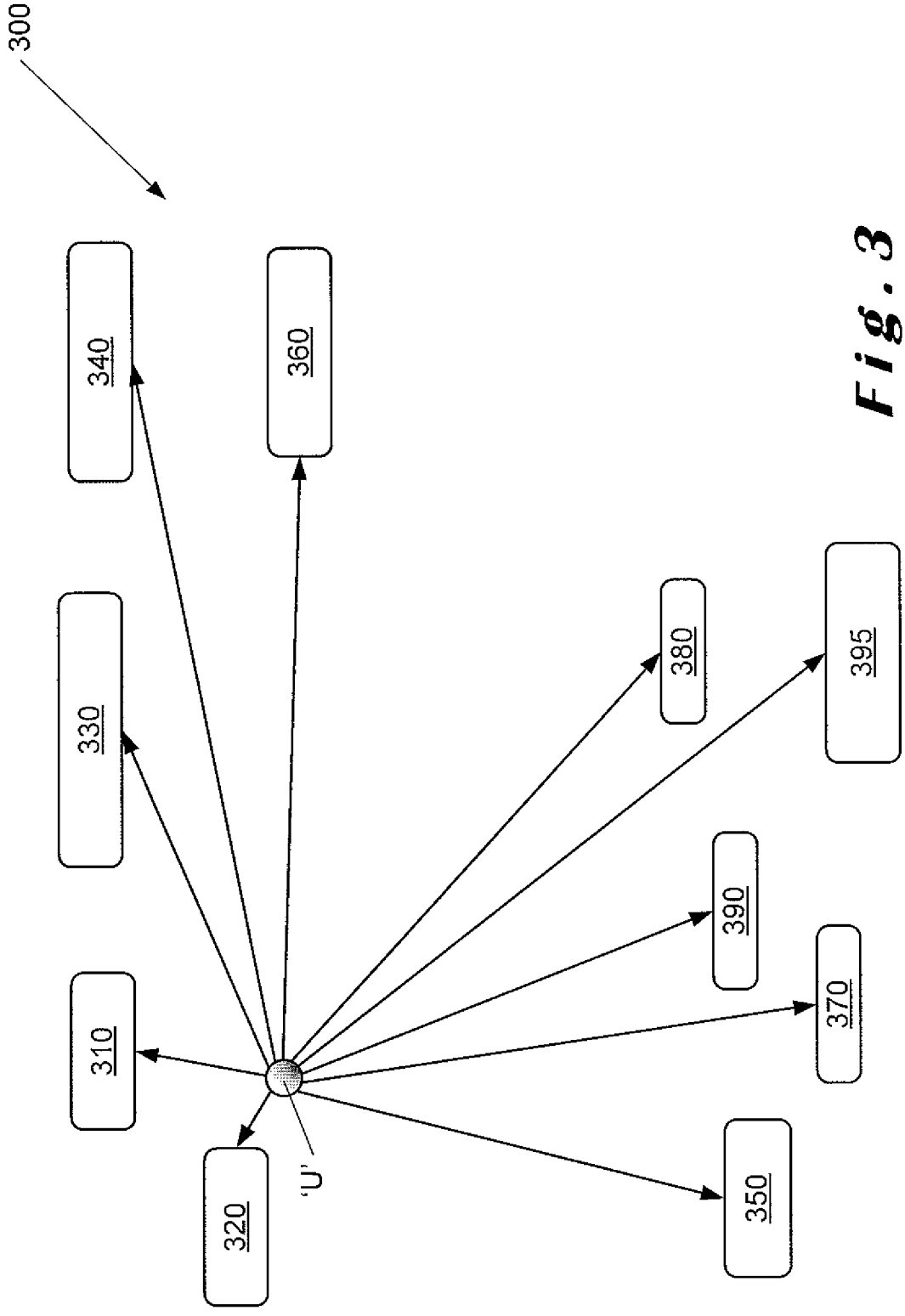


Fig. 3

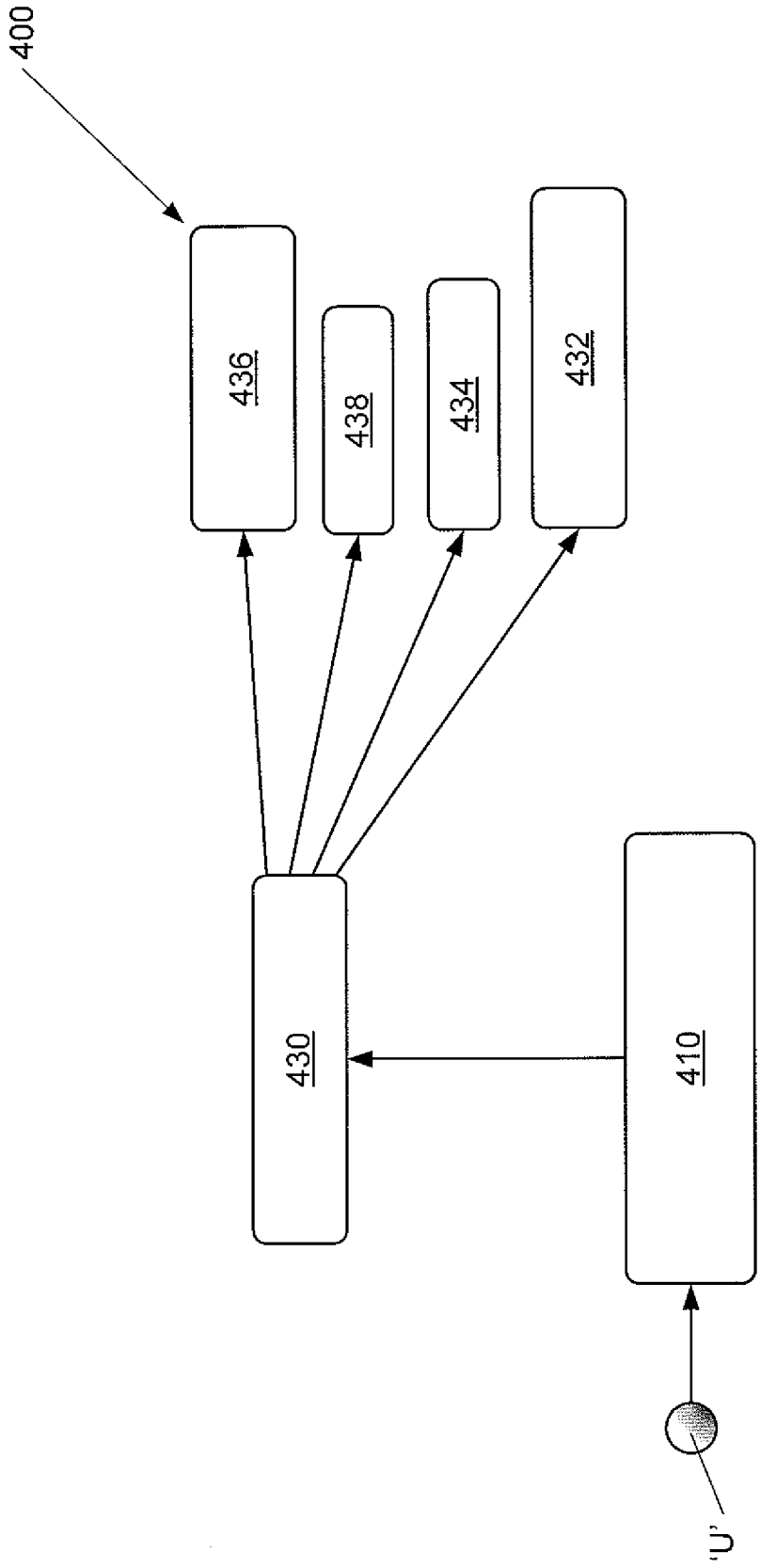


Fig. 4

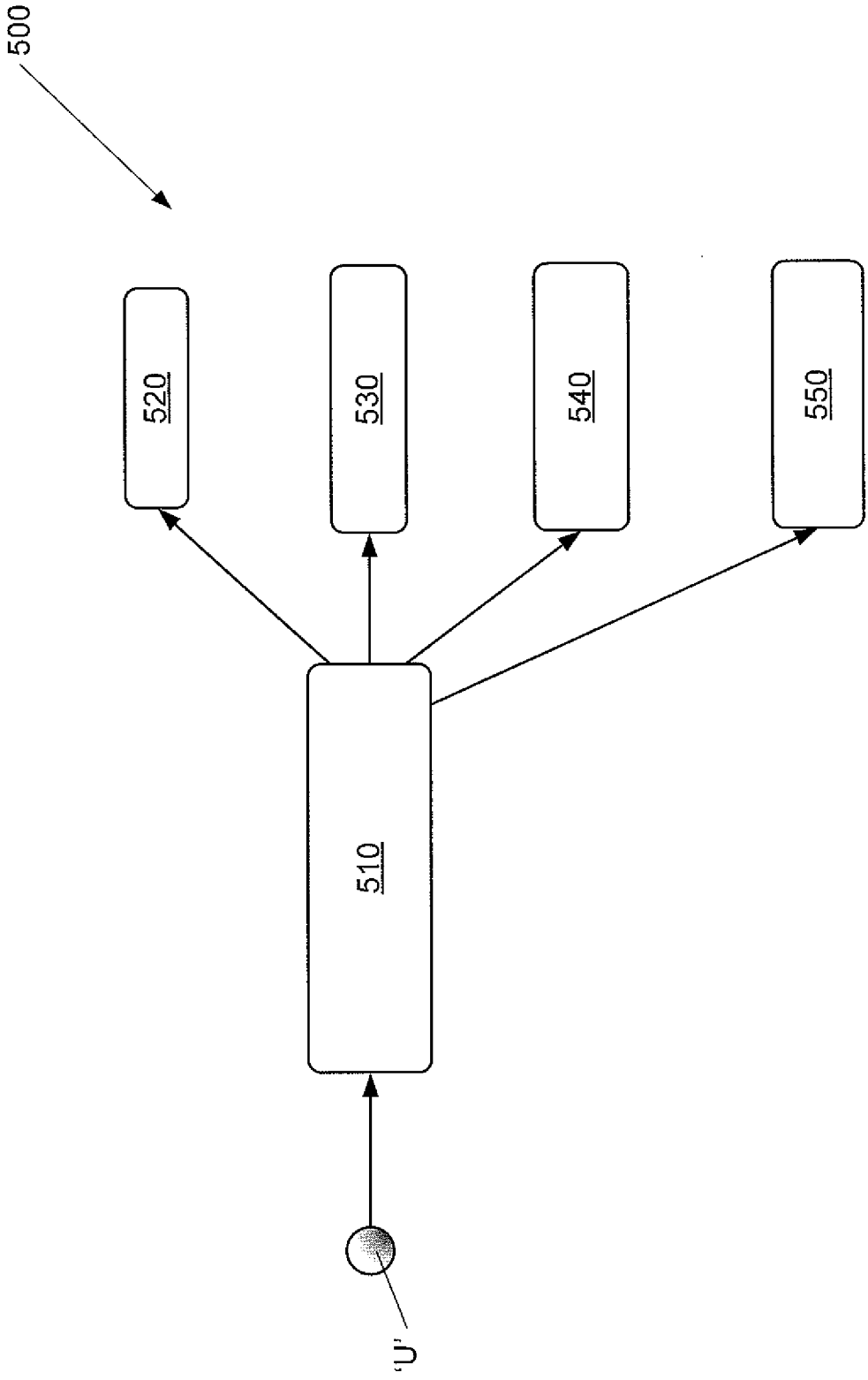


Fig. 5

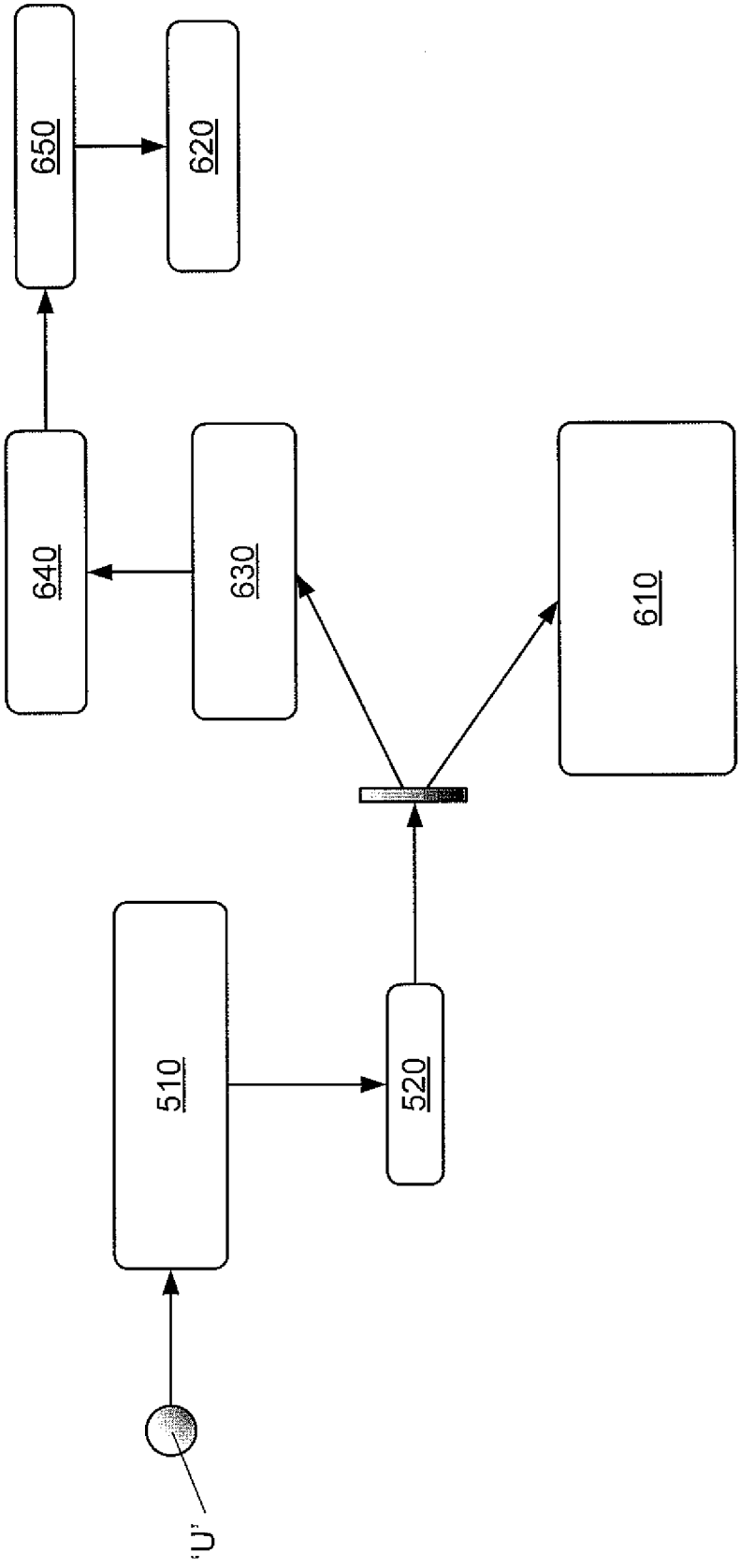


Fig. 6

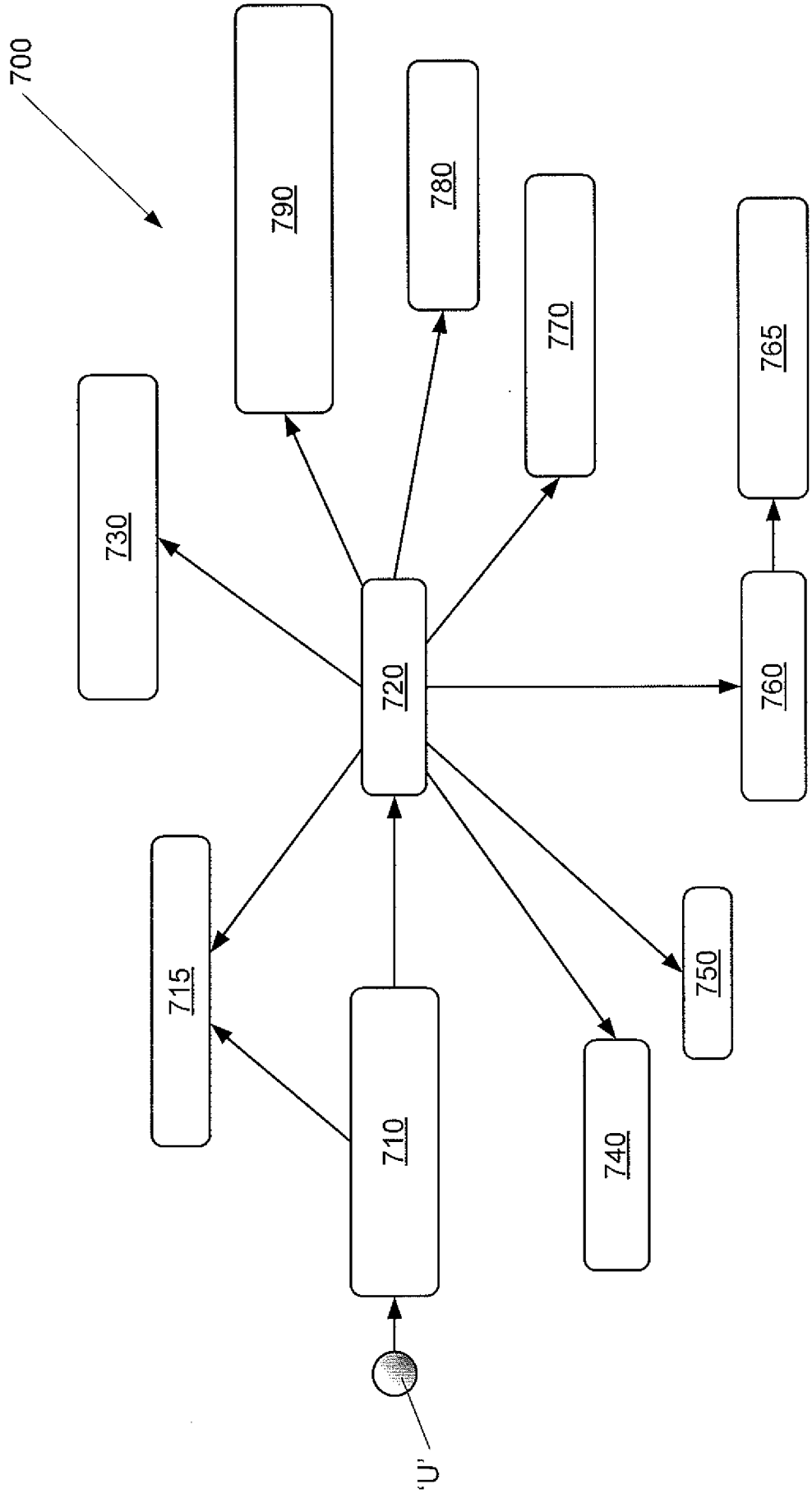


Fig. 7

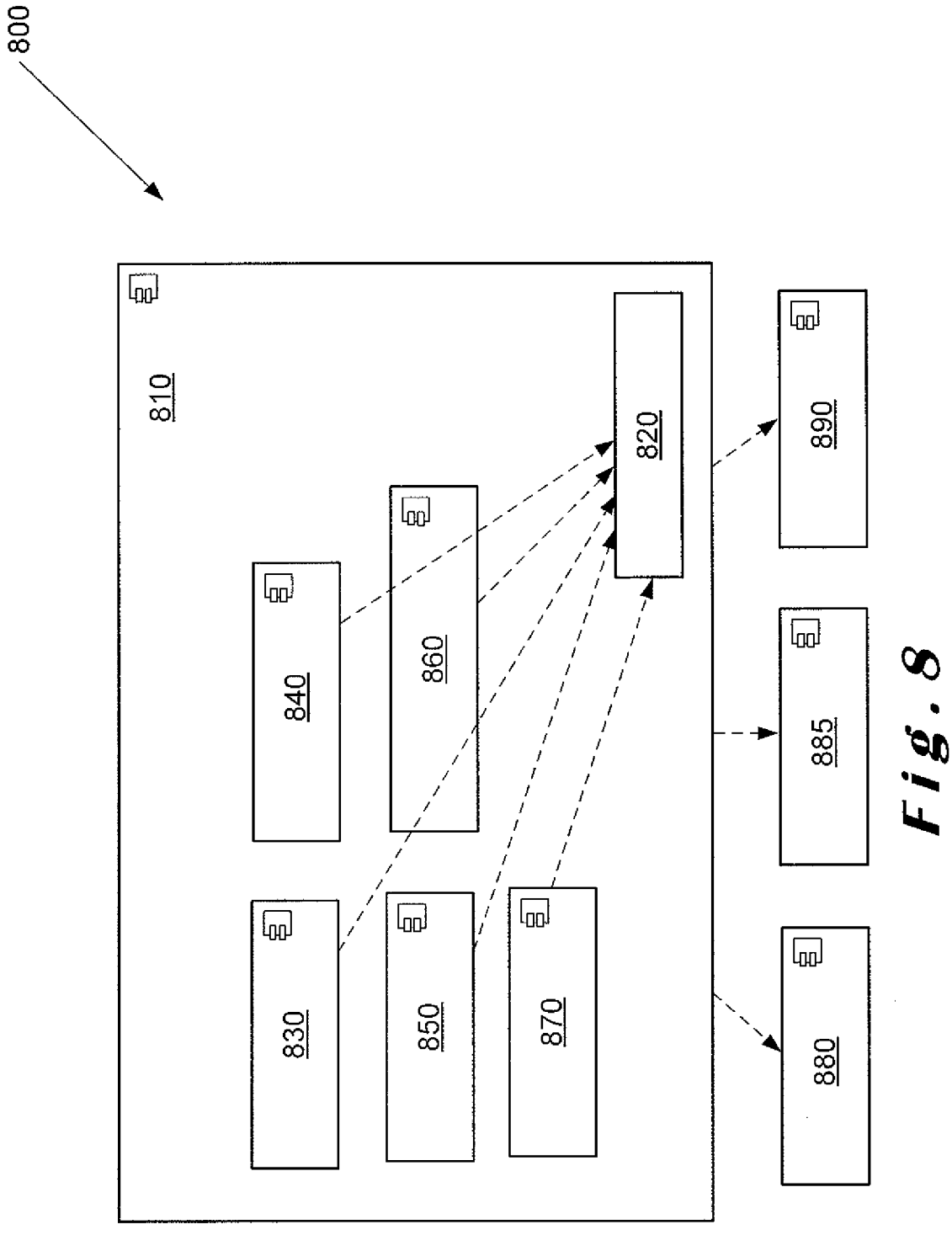


Fig. 8

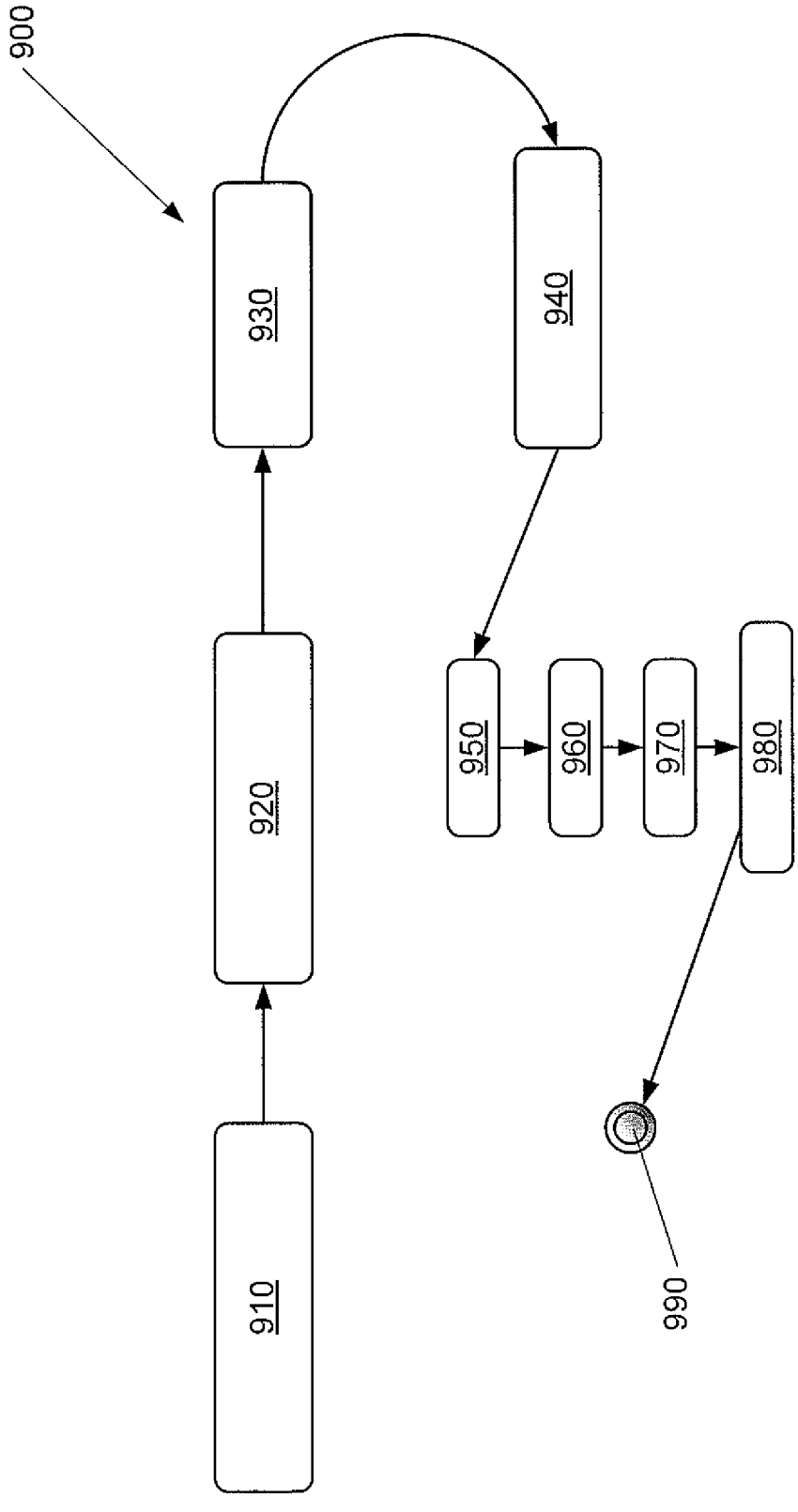


Fig. 9

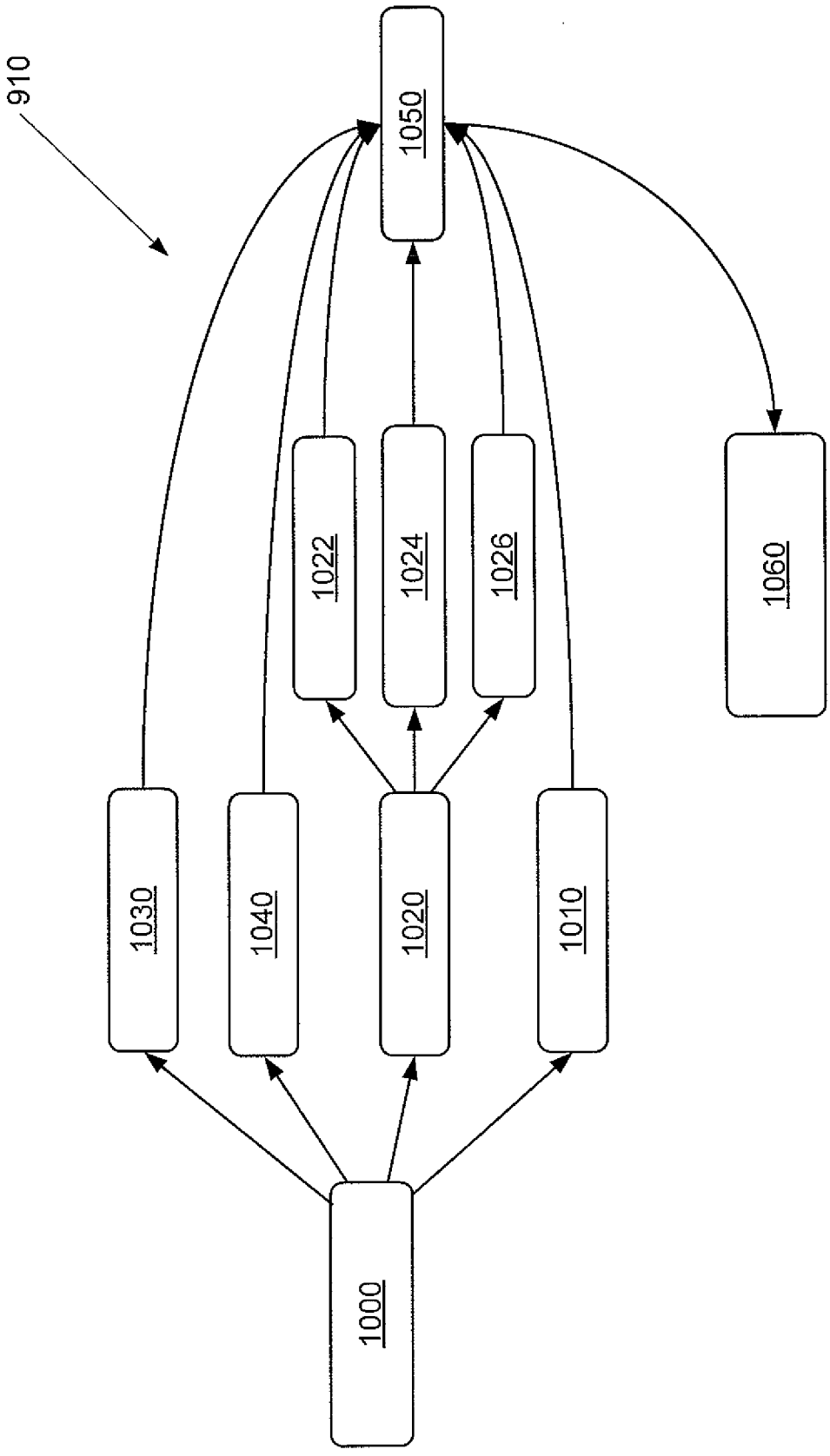


Fig. 10

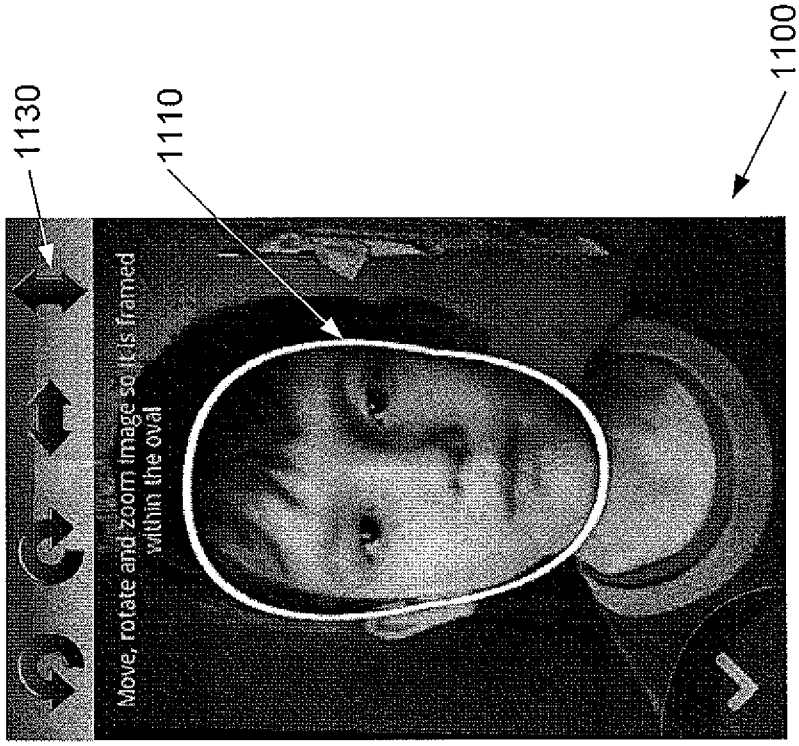

1130
1110
1100
Move, rotate and zoom image so it is framed within the oval

Fig. 12

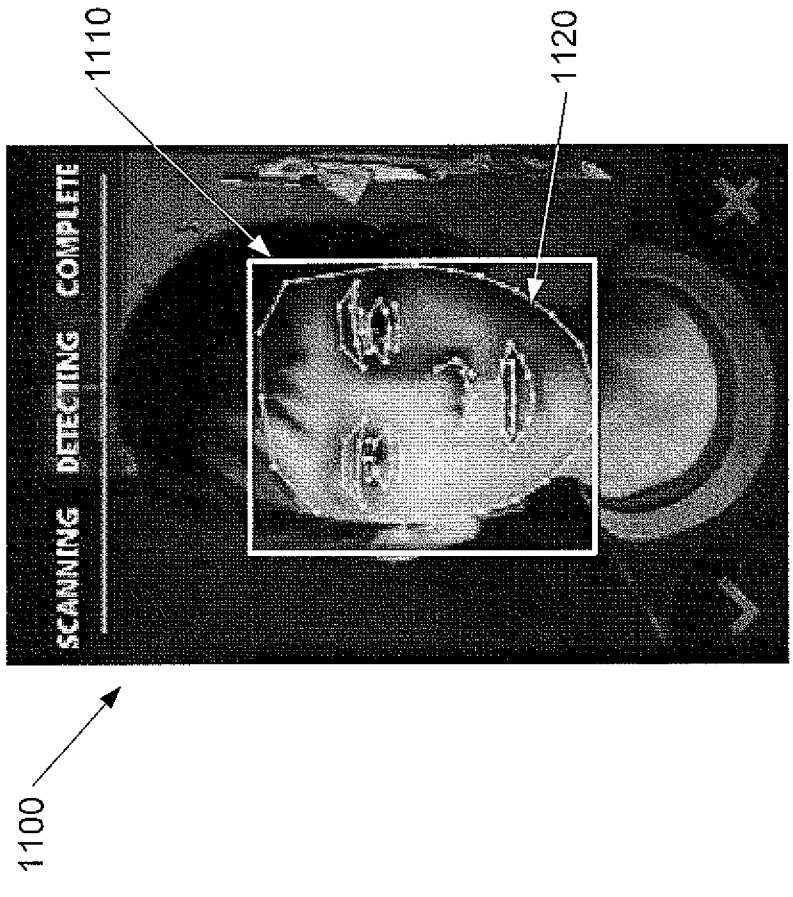

1110
1120
1100
SCANNING
DETECTING
COMPLETE

Fig. 11

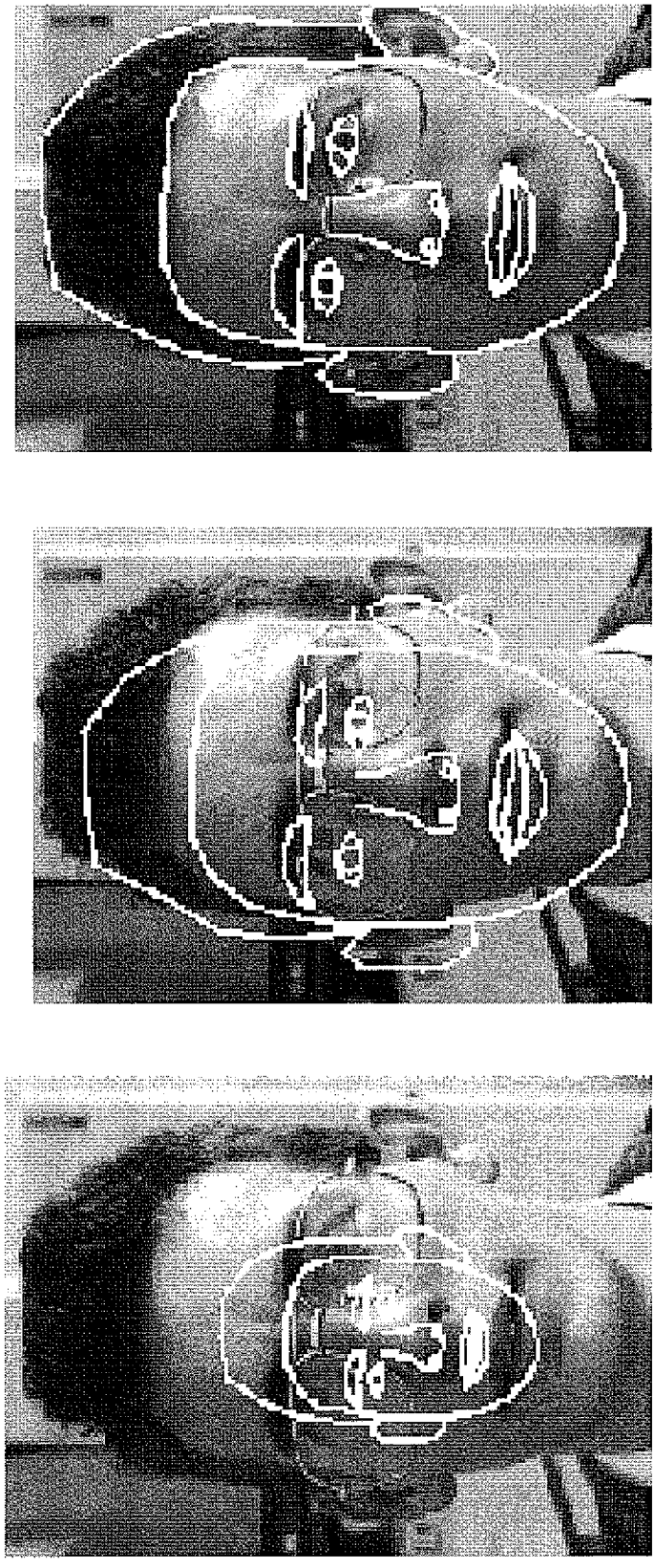


Fig. 13

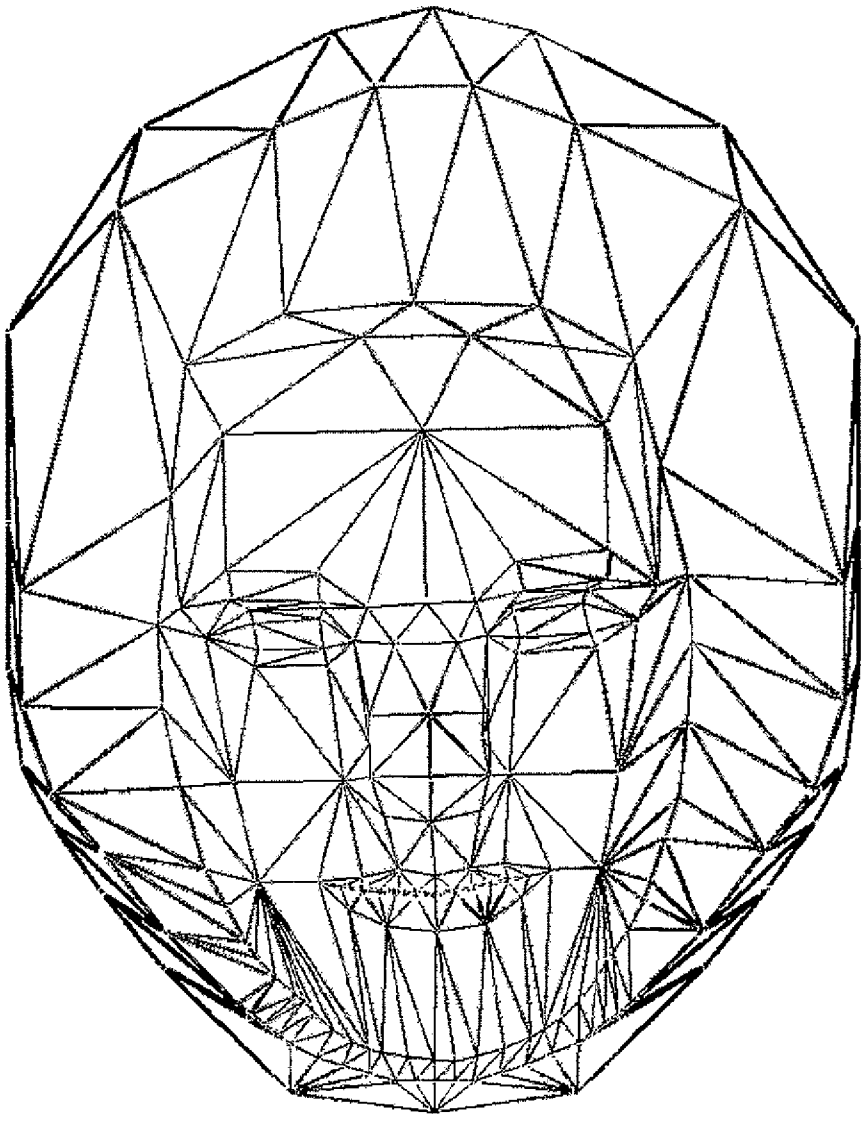


Fig. 14

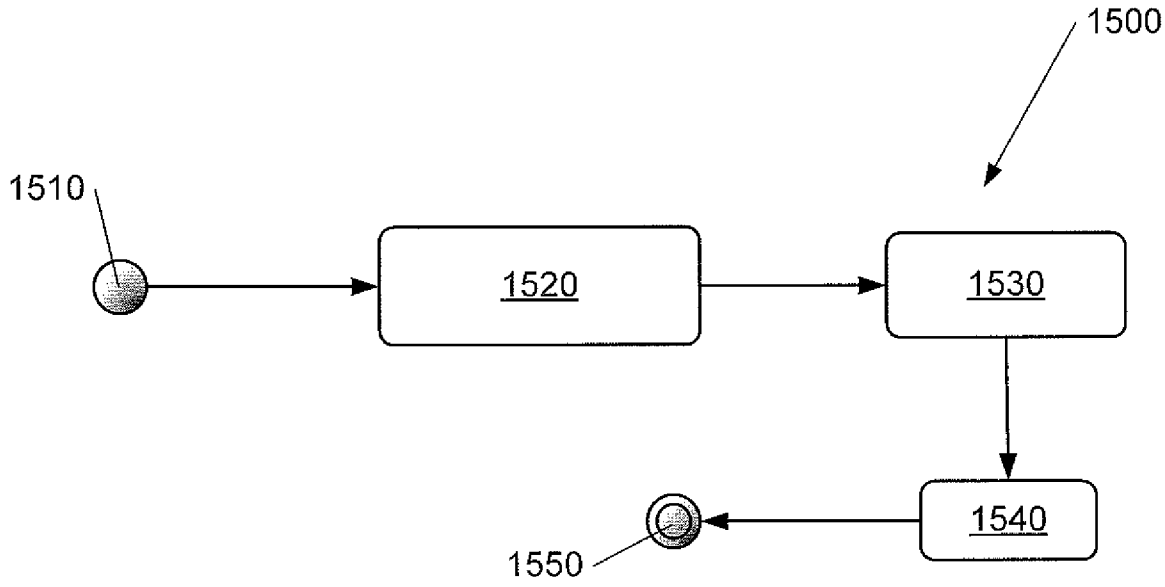


Fig. 15

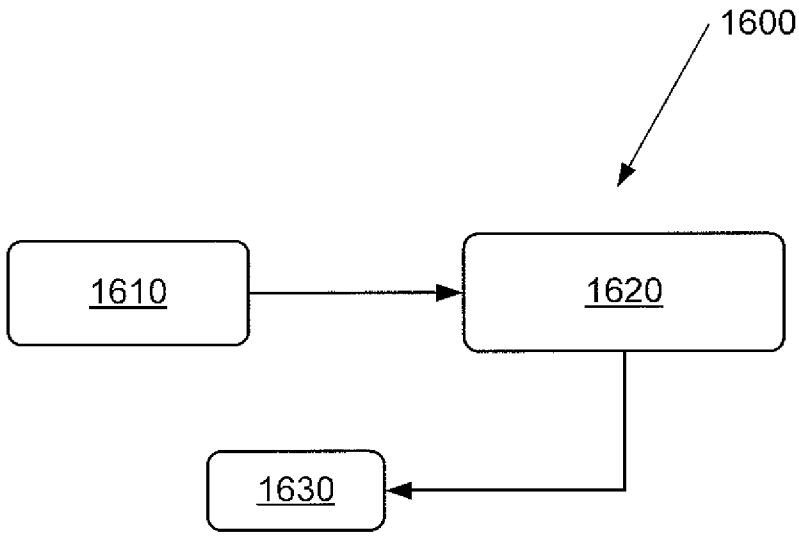


Fig. 16

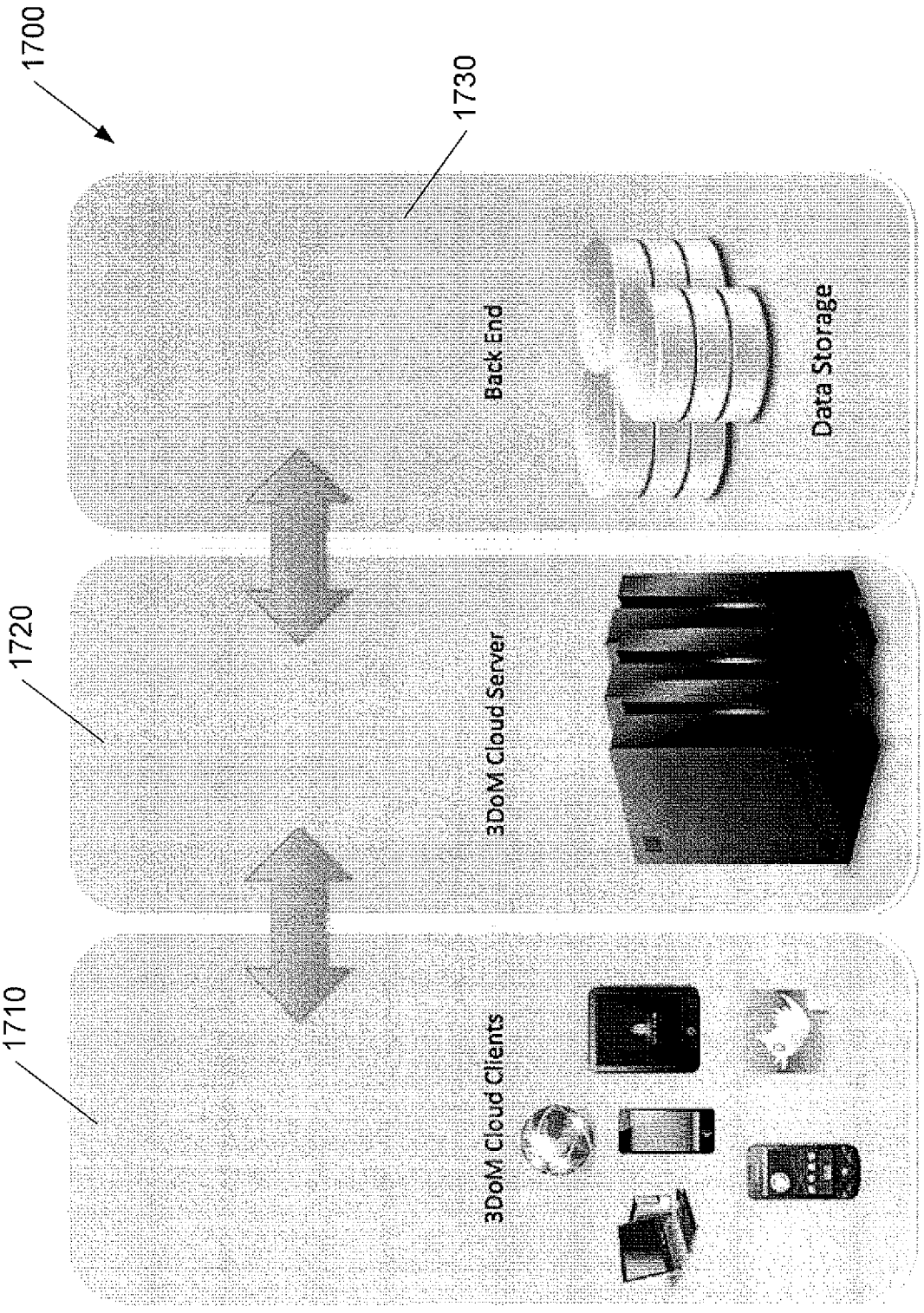

1700
1730
Back End
Data Storage
1720
3DoM Cloud Server
1710
3DoM Cloud Clients

Fig. 17

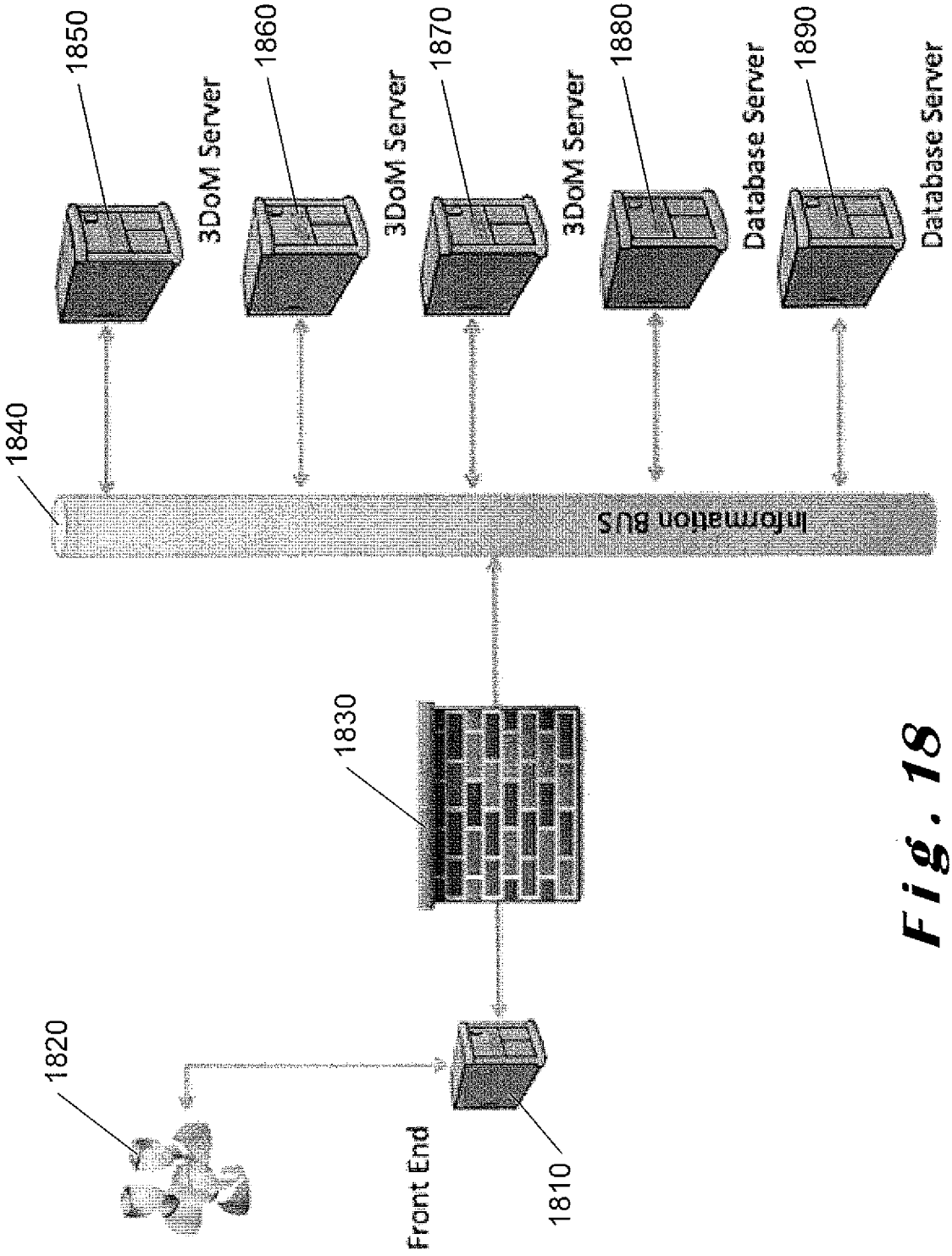

1850
3DoM Server
1860
3DoM Server
1870
3DoM Server
1880
Database Server
1890
Database Server
1840
Information BUS
1830
1820
Front End
1810

Fig. 18



Fig. 21



Fig. 20



Fig. 19

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/052788

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T7/00 G06T17/00 G06T13/40
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JUNCHUL CHUN ET AL: "Real-Time Face Pose Tracking and Facial Expression Synthesizing for the Animation of 3D Avatar", TECHNOLOGIES FOR E-LEARNING AND DIGITAL ENTERTAINMENT; [LECTURE NOTES IN COMPUTER SCIENCE;;LNCS], SPRINGER BERLIN HEIDELBERG, BERLIN, HEIDELBERG, vol. 4469, 11 June 2007 (2007-06-11), pages 191-201, XP019061659, ISBN: 978-3-540-73010-1 abstract; sections 2 and 3 ----- -/--	1-19

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 March 2013	15/03/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bouchaâla, Nicolas

2

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JUNFA LIU ET AL: "AAML Based Avatar Animation with Personalized Expression for Online Chatting System", ADVANCES IN MULTIMEDIA INFORMATION PROCESSING - PCM 2008, SPRINGER BERLIN HEIDELBERG, BERLIN, HEIDELBERG, vol. 5353, 9 December 2008 (2008-12-09), pages 643-652, XP019112882, ISBN: 978-3-540-89795-8 the whole document	1-19
A	LOIZIDES A ET AL: "Visualisation Tool for Representing Synthetic Facial Emotional Expressions", VISUALISATION, 2008 INTERNATIONAL CONFERENCE, IEEE, PISCATAWAY, NJ, USA, 9 July 2008 (2008-07-09), pages 135-140, XP031288405, ISBN: 978-0-7695-3271-4 the whole document	1-19
A	TRESADERN P A ET AL: "Real-Time Facial Feature Tracking on a Mobile Device", INTERNATIONAL JOURNAL OF COMPUTER VISION, KLUWER ACADEMIC PUBLISHERS, BO, vol. 96, no. 3, 28 May 2011 (2011-05-28), pages 280-289, XP035008614, ISSN: 1573-1405, DOI: 10.1007/S11263-011-0464-9 the whole document	1-19

2