



(51) International Patent Classification:

G06F 18/214 (2023.01) G06F 21/32 (2013.01)
G06F 18/2413 (2023.01) G06V 40/16 (2022.01)

(21) International Application Number:

PCT/EP2024/073525

(22) International Filing Date:

22 August 2024 (22.08.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

23193997.6 29 August 2023 (29.08.2023) EP

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(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, CV, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG,
KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY,
MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA,
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RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,
TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, CV,
GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST,
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, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,
SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a
patent (Rule 4.17(ii))

Published:

— with international search report (Art. 21(3))
— in black and white; the international application as filed
contained color or greyscale and is available for download
from PATENTSCOPE

(54) Title: SECURE AUTHENTICATION

(57) Abstract: A method for authenticating an authorized user, the method comprising: receiving a request to access a resource, in response to receiving the request to access the resource triggering to illuminate the object by light, and triggering to generate an image of the object while the object is being illuminated by the light, receiving a template image of the authorized user, providing the image and the template image to a data-driven model for determining if the object associated with the image corresponds to the authorized user, wherein the data-driven model is trained with a plurality of training images obtained by generating a plurality of synthetic representations of a human generated from a representation of the human and augmenting the plurality of synthetic representations of a human to generate a plurality of training images, allowing the authorized user to access a resource in response determining that the object corresponds to the authorized user.



SECURE AUTHENTICATION

TECHNICAL FIELD

The disclosure relates to methods for authenticating an authorized user, methods for generating a plurality of training images for training a data-driven model suitable for determining if an object associated with an image corresponds to an authorized user, methods for training a data-driven model for determining if an object associated with an image corresponds to an authorized user, a non-transitory computer-readable storage medium, use of a plurality of training images, use of a data-driven model trained based on a plurality of training images, a device and/or system for authenticating an authorized user.

TECHNICAL BACKGROUND

Secure authentication of an authorized user requires large amount of training data. Collecting such large amounts of training data require a lot of resources but increases the reliability of authentication algorithms.

SUMMARY

Any disclosure, embodiments and examples described herein relate to the methods, the systems, apparatuses, chemical products and computer elements lined out above and below. Advantageously, the benefits provided by any of the embodiments and examples equally apply to all other embodiments and examples.

In an aspect, the disclosure relates to a method for authenticating an authorized user, the method comprising: receiving a request to access a resource, in response to receiving the request to access the resource triggering to illuminate the object by light, and triggering to generate an image of the object while the object is being illuminated by the light, receiving a template image of the authorized user, providing the image and the template image to a data-driven model for determining if the object associated with the image corresponds to the authorized user, wherein the data-driven model is trained based on a plurality of training images obtained by generating a plurality of synthetic representations of a human based on a representation of the human and augmenting the plurality of synthetic representations of a human to generate a plurality of training images, allowing the authorized user to access a resource based on determining that the object corresponds to the authorized user.

In another aspect, it relates to a device and/or system for authenticating an authorized user comprising: a processor; and a memory storing instructions that, when executed by the processor, configure the device and/or system to perform any one of the methods as described herein.

In another aspect, it relates to use of a data-driven model trained based on a plurality of training images as obtained by any one of the methods as described herein.

In another aspect, it relates to use of training images as obtained by any one of the methods as described herein for training a data-driven model for authenticating an authorized user.

In another aspect, it relates to an authentication system trained with training images obtained by a method according to any one of the methods as described herein and/or trained according to any one of the methods as described herein.

In another aspect, it relates to a method for authenticating an authorized user, the method comprising: receiving a request to access a resource, in response to receiving the request to access the resource triggering to generate an image of the object from the light received from the direction of the object, receiving a template image of the authorized user, determining if the object associated with the image corresponds to the authorized user by providing the image and the template image to a data-driven model, wherein the data-driven model is trained with a plurality of training images obtained by generating a plurality of synthetic representations of a human generated from a representation of the human and augmenting the plurality of synthetic representations of a human to generate a plurality of training images, allowing the authorized user to access a resource based on determining that the object corresponds to the authorized user.

In another aspect, it relates to a method for obtaining a plurality of training images for training a data-driven model for determining if an object associated with an image corresponds to an authorized user, the method comprising: providing a representation of a human, generating a plurality of synthetic representations of the human based on the representation of the human, generating a plurality of training images by augmenting the plurality of synthetic representations, providing the plurality of training images.

In another aspect, it relates to a method for authenticating an authorized user, the method comprising: receiving an image of an object, providing the image to a data-driven model for determining if the object associated with the image corresponds to an authorized user, wherein the data-driven model is trained based on a plurality of training images generated by generating a plurality of synthetic representations of a human based on a representation of the human and augmenting the plurality of synthetic representations of a human to generate a plurality of training images, allowing the authorized user to access a resource based on determining that the object correspond to the authorized user.

In another aspect, it relates to a method for training a data-driven model for determining if an object associated with an image corresponds to an authorized user, the method comprising: providing the plurality of training images

generated by any one of the methods described herein, training the data-driven model based on the plurality of training images, optionally, providing the trained data-driven model.

In another aspect, it relates to a device and/or system for authenticating an authorized user comprising: a processor; and a memory storing instructions that, when executed by the processor, configure the device and/or system to perform any one of the methods as described herein.

In another aspect, it relates to method for training a data-driven model for determining if an object associated with an image corresponds to an authorized user, the method comprising: receiving a request for training the data-driven model, providing a plurality of training images obtained by generating a plurality of synthetic representations of a human generated from a representation of the human and augmenting the plurality of synthetic representations of a human to generate a plurality of training images, training the data-driven model based on the plurality of training images, optionally providing the data-driven model.

In another aspect, it relates to a device, in particular a communication device for authenticating an authorized user, the device comprising: an illumination source for illuminating the object by light, a camera for generating an image of the object while the object is being illuminated by the light, a processor for receiving a template image of the authorized user, providing the image and the template image to a data-driven model for determining if the object associated with the image corresponds to the authorized user, wherein the data-driven model is trained based on a plurality of training images obtained by generating a plurality of synthetic representations of a human based on a representation of the human and augmenting the plurality of synthetic representations of a human to generate a plurality of training images, allowing the authorized user to access a resource based on determining that the object correspond to the authorized user.

EMBODIMENTS

In the following, terminology as used herein and/or the technical field of the present disclosure will be outlined by ways of definitions and/or examples. Where examples are given, it is to be understood that the present disclosure is not limited to said examples.

Secure authentication requires reliable user recognition. For this purpose, data-driven models are trained with thousands to hundreds of thousands of different images. Generating so many different images for training data-driven models requires a lot of time and resources. These images need to represent the overwhelming plurality of perspectives the user can be presented to the authentication device and/or system. Still, common authentication algorithms can fail at distinguishing similarly looking people such as siblings, in particular twins. Furthermore,

adapting current authentication algorithms to new scenarios takes a lot of time. Hence, there is a desire to increase the reliability of authentication algorithms while increasing the adaptiveness of authentication algorithms.

This can be achieved by training the data-driven model for authenticating an authorized user based on the plurality of training images generated as described herein. These training images can be generated based on readily available and easy to collect representations of a human. Based on the representation of the human a plurality of synthetic representations of the human can be created. This improves the number of different training images to be generated and thus, increases the reliability of the thereon trained data-driven model. The plurality of synthetic representations of the human can be associated with different perspectives onto the human, for example by changing the orientation of the head of the human between two of the plurality of synthetic representations of the human. This enables to distinguish robustly between similarly looking people. Thus, this feature corresponds to the aim of increasing the reliability of authentication algorithms. Furthermore, augmenting the plurality of synthetic representations to generate a plurality of training images enables to tailor the conditions of the training images such as background or lighting according to the already available training data. Hence, already available training data can be further used while enriching the training data by training images significantly improving the reliability of the authentication algorithm. Ultimately, training the data-driven model based on the training images as described herein allows for tailored and robust authentication algorithms.

These and other objects, which become apparent upon reading the following description, are solved by the subject matters of the independent claims. The dependent claims refer to embodiments of the disclosure.

In an embodiment, authentication may refer to face authentication. The training image may show at least a part of the human's face. The representation of the human may be a representation of a human's face.

In an embodiment, the light may be infrared light. Infrared light may comprise of near infrared light, midinfrared light and/or far-infrared light. Near infrared light may be in the range of 780 nm to 3000 nm excluding the value of 3000 nm as being comprised in the range. Mid infrared light may be in the range of 3 μm to 15 μm excluding the value of 15 μm as being comprised in the range. Far infrared light may be in the range of 15 μm to 1000 μm . The infrared light may be associated with a wavelength between 700 nm and 800 nm and/or between 1000 nm and 1200 nm.

In an embodiment, data-driven model may be an augmentation data-driven model and/or a liveness data-driven model. Data-driven model may refer to a model suitable for describing one or more non-linear relations between input data and output data. Input data may refer to data to be provided to the data-driven model and/or to data being received by the data-driven model. Output data may be data to be received from the data-driven model and/or to be provided by the data-driven model. Hence, the data-driven model may determine the output data

based on transforming the input data via one or more non-linear relations. In this context, input data may be for example an image and/or one or more representations of a human. Output data may be for example an indication whether the object associated with the image may be an authorized user and/or one or more training images.

The data-driven model may be trained based on a plurality of training images to determine a similarity score associated with at least two of the plurality of training images. The similarity score may indicate that the two training images show the same human if the similarity score may be within a predefined range. The predefined range may be a numerical range specified by at least one threshold value. The similarity score may indicate that the two training images show the same person if the similarity score exceeds a threshold value.

The data-driven model for determining if the object associated with the image corresponds to the authorized user may comprise one or more embedding layers. The one or more embedding layers may be configured for reducing the dimensionality of the image. The one or more embedding layers may transform the image and/or the template image into a dimensionality representation such as a tensor, in particular a two-dimensional tensor or a one dimensional tensor. The data-driven model for determining if the object associated with the image corresponds to the authorized user may be trained and/or parametrized to reduce the dimensionality of the image and/or the template image. The data-driven model may be trained and/or parametrized for generating a dimensionality-reduced representation associated with the image and/or the template image. Alternatively, receiving the template image may comprise receiving a tensor associated with the template image. The tensor associated with the template image may be obtained by providing the template image to one or more embedding layers, e.g. of a second data-driven model. The second data-driven model may comprise one or more encoders. Additionally or alternatively, the data-driven model for determining if the object associated with the image corresponds to the authorized user may comprise one or more classification layers. The one or more classification layers may be configured for receiving the tensor associated with the image and the tensor associated with the template image and/or classifying the tensor associated with the image and the tensor associated with the template image according to whether the image and the template image may be associated with the authorized user, preferably the same authorized user. Additionally or alternatively, the data-driven model for determining if the object associated with the image corresponds to the authorized user may comprise one or more mathematical relations for determining a distance between the tensor associated with the image and the tensor associated with the template image, in particular an Euclidean distance and/or a cosine similarity.

In an embodiment, the liveness data-driven model may be a liveness classification data-driven model. The liveness classification model may be suitable for classifying pattern images. By doing so, the liveness classification model may classify whether the object associated with the pattern image may be a living human. The liveness classification model may comprise an encoder and/or one or more classification layers. The liveness classification model may receive the pattern image, preferably a partial image generated from the pattern image,

at the encoder. The encoder may transform the pattern image, preferably a partial image generated from the pattern image, into a dimensionality-reduced representation associated with the pattern image. The dimensionality-reduced representation associated with the pattern image may be a tensor, in particular a one or two dimensional tensor, associated with the pattern image. For this purpose, the encoder may comprise one or more convolutional layers. The one or more classification layers of the liveness classification data-driven model may receive the dimensionality-reduced representation associated with the pattern image may map the dimensionality-reduced representation associated with the pattern image to an indication whether the object may be a living organism. The indication whether the object may be a living organism may be a numerical value. The numerical value may indicate a confidence level associated with determining whether the object may be a living organism.

Hence, the methods described herein may further comprise generating a partial image from the pattern image by cropping the pattern image. Providing the pattern image may refer to providing the partial image generated from the pattern image.

The encoder may be suitable for reducing the dimension of the image. Hence, the encoder may be suitable for generating a dimensionality-reduced representation of the image and/or the template image. In an embodiment, the encoder may comprise one or more convolutional layers. Hence, the data-driven model may comprise a convolutional neural network.

In an embodiment, training image may refer to an image suitable for training the data-driven model. The training image may show a human. Preferably, two or more training images of the plurality of training images may show the same human and one or more training images of the plurality of the training images may show a different human. Hence, the plurality of training images may be associated with two or more different humans. In an embodiment, the humans associated with the training images may be independent of existing humans and/or may be synthetically generated representations of humans and/or synthetic images of humans.

In an embodiment, representation may refer to a visual representation of an object. The object may be a living organism such as a human. Preferably, the representation of a human may be a representation of at least a part of a human, in particular at least a part of the face of the human. The visual representation may be suitable for recognizing an object and/or may indicate an object. The visual representation may comprise a feature associated with the object. The feature associated with the object may characterize the object. The visual representation of a first object may be different from the visual representation of a second object. Example for a representation may include a sketch, a text description of an object, an image, at least a part of a contour of an object or a combination thereof. In an embodiment, the humans associated with the representations of the human may be

independent of existing humans and/or may be synthetically generated representations of humans. The representation of a human may be a synthetic representation of the human.

In an embodiment, the user may be a user of a device. The method may be a computer-implemented method. The authorized user may be a user authorized to access a resource.

In an embodiment, allowing the authorized user to access a resource may include allowing the authorized user to perform at least one operation with a device, computing apparatus and/or system. Resource may be a device, a system, a computing apparatus, a function of a computing apparatus, a function of a device, a function of a system and/or an entity. Additionally and/or alternatively, allowing the authorized user to access a resource may include allowing the authorized user to access an entity. Entity may be physical entity and/or virtual entity. Virtual entity may be a database for example. Physical entity may be an area with restricted access. Area with restricted access may be one of the following: security areas, rooms, apartments, vehicles, parts of the before mentioned examples, or the like. Device and/or system may be locked. Device and/or system may be unlocked by the authorized user. The device and/or system may be unlocked by determining that the object associated with the image may correspond to the authorized user and optionally, by determining that the object associated with the pattern image may be a living organism.

Device and/or system may be suitable for comparing an image related to the object initiating the authentication process with a template image related to an authorized user. Template image related to an authorized user may be generated during an enrollment process. User undergoing an enrollment process may be referred to as enrolled user. Template image related to the authorized user generated in an enrollment process may be stored in a memory of the device and/or system. Storing the tensor associated with the template image may refer to storing a dimensionality-reduced representation associated with the template image. Dimensionality-reduced representation associated with the template image may be stored in a memory. Device and/or system may be suitable for performing at least one action. Dimensionality-reduced representation may comprise at least one tensor. Tensor may be indicative of a feature associated with the image.

In an embodiment, providing the image to a data-driven model for determining if the object associated with the image may correspond to an authorized user may comprise generating a dimensionality-reduced representation of the image of the object, in particular by the data-driven model. The dimensionality-reduced representation of the image may comprise less datapoints than the image. Preferably, the dimensionality-reduced representation of the image may be a feature vector. The feature vector may comprise a plurality of numerical values. The feature vector may be indicative of one or more features associated with the object. The one or more features may be associated with the image of the object. The one or more features may characterize the object and/or may be suitable for distinguishing the object from a second object. The data-driven model may determine if the object

associated with the image corresponds to an authorized user based on the dimensionality-reduced representation of the image and/or the dimensionality-reduced representation of the template image. For this purpose, the data-driven model may receive the dimensionality-reduced representation of the image and/or the dimensionality-reduced representation of the template image at the one or more classification layers of the data-driven model and the dimensionality-reduced representation of the image and the template image may be mapped to an indication whether the object corresponds to an authorized user. Allowing the object to access a resource based on determining that the object corresponds to the authorized user may comprise receiving an indication that the object may correspond to the authorized user, in particular from the one or more classification layers of the data-driven model.

In an embodiment, receiving the template image of the authorized user may refer to receiving a dimensionality-reduced representation of the template image. Providing the template image to the data-driven model may refer to providing the dimensionality-reduced representation of the template image to the data-driven model. The template image may be generated during an enrollment process of the authorized user.

The dimensionality-reduced representation of the template image may comprise less datapoints than the template image. The dimensionality-reduced representation of the template image may comprise a plurality of numerical values. The dimensionality-reduced representation of the template image may be indicative of one or more features associated with the authorized user. The one or more features may be associated with the template image of the authorized user. The one or more features may characterize the authorized user and/or may be suitable for distinguishing the authorized user from an unauthorized user such as a second object.

Using a dimensionality-reduced representation of the image and/or the template image allows for a resource-efficient authentication of the authorized user while maintaining the reliability as the size of the input data used for authenticating an object is reduced.

In an embodiment, the methods may further comprise receiving a template image, in particular a dimensionality-reduced representation of the template image. The template image may show the authorized user. The template image, in particular a dimensionality-reduced representation of the template image may be further provided to the data-driven model for determining if the object associated with the image corresponds to the authorized user.

In an embodiment, the user may be an authorized user.

In an embodiment, the device may be a smartphone, a smartwatch, a computer or the like.

In an embodiment, the method may further comprise triggering to illuminate the object by patterned light and generating a pattern image while the object may be illuminated by patterned light and providing the pattern image to a liveness data-driven model for determining if the object associated with the image may correspond to a living human, wherein the liveness data-driven model may be trained based on historical pattern images and corresponding indications whether the objects associated with the historical pattern images may correspond to a living humans and allowing the authorized user to access a resource further based on determining that the object correspond to the living human. The liveness data-driven model may be trained and/or parametrized to receive the pattern image and map the pattern image to an indication whether the object associated with the pattern image may be a living organism.

In an embodiment, the patterned coherent infrared light may comprise of less than 4000 light beams. In an embodiment, projecting the patterned coherent infrared light onto an object may result in projecting less than 4000 spots. In an embodiment, the patterned coherent infrared light may comprise of less than 3000 light beams, preferably less than 2000 light beams, most preferably less than 1000 light beams. In an embodiment, projecting the patterned coherent infrared light onto an object may result in projecting less than 3000 spots, preferably less than 2000 spots, most preferably less than 1000 spots.

The pattern image may show the object while the object may be illuminated by patterned light. Patterned light may comprise to two or more light beams. Projecting the patterned light onto the object may result in projecting a pattern onto the object. Determining if the object is a living human is advantageous since it increases the security of the authentication. For example, liveness detection can determine whether the authorized user or a spoofing object representing the authorized user is presented during the authentication process. Hence, this feature contributes to a reliable authentication and enables the detection of spoofing objects. The patterned light may be patterned infrared light, in particular associated with the wavelength of infrared light as described herein. Using infrared light is advantageous since the light may not be visible to humans. Hence, the detection of spoofing masks may be carried out without the object, in particular an imposter to notice.

In an embodiment, the infrared light may be coherent infrared light, coherent patterned infrared light. Projecting coherent light may result on projecting an infrared light pattern onto the object, wherein the pattern comprises of two or more light spots and wherein the light spots comprise a plurality of speckles. Hence, illuminating the user with coherent patterned infrared light may result in the formation of a plurality of speckles. The formation of speckles may be related to the material associated with the object. The speckles may be indicative whether the object may be a living human. Therefore, using coherent patterned infrared light increases the reliability of the authentication process.

In an embodiment, the representation of the human may be received via a user interface. By doing so, the training of the data-driven model may be controlled enabling a tailored and reliable authentication process.

In an embodiment, the representation of the human may comprise an image of the human, a sketch of the human, a text description of the human, at least a part of a contour of the human or a combination thereof. By doing so, readily available data can be used for generating training images. Hence, resources and time for capturing training images can be saved while the training images can be tailored for the application area of the data-driven model for authentication.

In an embodiment, generating the plurality of synthetic representations of the human from the representation of the human may comprise generating a 3-dimensional model of the human based on representation of the human. Generating a 3-dimensional model of the human may include identifying one or more features of the human associated with the representation of the human and mapping the one or more features to the one or more features of a topology map of a human, in particular a user's face. The one or more features of the human may be landmarks of a user's face. Additionally or alternatively, generating the 3-dimensional model of the human may comprise providing the representation of the human to a 3D data-driven model. The 3D data-driven model may be parametrized and/or trained to receive a representation of the human and generate a 3-dimensional model from the representation of the human. The 3D data-driven model may be parametrized and/or trained to generate depth information related to the representation of the human. The 3D data-driven model may comprise an encoder configured for reducing the dimensionality of the representation of the human and/or transforming the representation of the human into a machine-processable representation of the human such as a tensor, in particular a two or one dimensional tensor.

The plurality of synthetic representations may be generated from the 3-dimensional model of the human by selecting one or more orientations of the 3-dimensional model and/or selecting one or more point of views onto the 3-dimensional model of the human.

Further, generating the plurality of synthetic representations of the human based on the representation of the human may comprise generating a first representation of the human, changing the orientation of the 3-dimensional representation of the human, in particular after having generated the first representation of the human, and generating a second representation of the human. The plurality of synthetic representations of the human may comprise the first representation of the human and the second representation of the human. Changing the orientation of the 3-dimensional representation of the human may refer to rotating the 3-dimensional representation of the human and/or shifting the 3-dimensional representation of the human. By doing so, training images associated with the human in different perspectives and/or different orientations of the human may be obtained. This enables a reliable authentication of the authorized user.

In an embodiment, the plurality of synthetic representations of the human may differ in a perspective onto the human within the representation of the human, the location of at least a part of the human within the representation of the human or a combination thereof.

Differ in a perspective onto the human may refer to differ in an orientation of the human in relation to a point of view associated with the representation of the human, the synthetic representation of the human, the training image, the image or the like.

In an embodiment, the plurality of training images may show one or more humans. At least a part of the plurality of training images associated with one human may differ in a perspective onto the human within the representation of the human, the location of at least a part of the human within the representation of the human, a brightness of the training images, a background within the training images or a combination thereof. By doing so, the generated training images can be tailored to the needs of the authentication process. Hence, these features contribute to a robust and tailored authentication of the authorized user.

In an embodiment, background may comprise a scenery and/or one or more object independent of the object associated with the image. Background may be defined dependent on the object. Background may comprise at least a part of a surrounding of the object.

In an embodiment, generating the plurality of training images may comprise providing the plurality of synthetic representations of the human to an augmentation data-driven model and receiving the plurality of training images from the augmentation data-driven model. The augmentation data-driven model may be trained based on historical representations of humans and corresponding training images. The augmentation data-driven model may be trained to generate the plurality of training images associated with visual variations of the human and/or positional variations of the human within the image and/or in relation to the surrounding of the human such as the background. Positional variations may include for example changing the point of view onto the human, size of the human, in particular in relation to the surrounding of the human such as the background, changing a brightness, a contrast, a hue, a saturation value associated with synthetic representations of the human or the like. Visual variations of the human may include changing a face expression of the human, changing an item of clothing associated with the human, changing a feature of the human including for example hair, nails, lips of the like. Preferably, the augmentation data-driven model may be trained to change the perspective onto the human within the representation of the human, the location of at least a part of the human within the representation of the human, a brightness of the training images, a surrounding of the human such as the background within the training images or a combination thereof. The augmentation data-driven model may be trained to generate the plurality training images comprising a number of features associated with the human larger than the number of

features associated with the human comprised in the representation of the human. Hence, the augmentation data-driven model may be trained to increase the number of features associated with the object. The augmentation data-driven model may be trained for adding one or more features associated with the human and/or a background to generate the plurality of training images. The augmentation data-driven model may be configured to map the plurality of synthetic representations of the human to the plurality of training images.

In an embodiment, the method may further comprise preprocessing the plurality of synthetic representations prior to providing the plurality of synthetic representations of the human to the augmentation data-driven model. Preprocessing the plurality of synthetic representations may comprise applying at least one image augmentation technique, in particular to at least one of the plurality of synthetic representations of the human. Additionally or alternatively, preprocessing the plurality of synthetic representations may comprise generating a representation of the contours associated the human. Further, providing the representations of the human to the augmentation data-driven model may comprise providing the representations of the contours associated with the human to the augmentation data-driven model. The augmentation data-driven model may be trained and/or parametrized to receive representations of contours associated with a plurality of humans and providing a plurality of training images generated from the representations of contours associated with a plurality of humans. In an embodiment, the methods may further comprise generating a representation of the contour of the human and wherein providing the representations of the human to the augmentation data-driven model comprises providing the representations of the contours of the human to the augmentation data-driven model.

By doing so, the training images can be generated tailored to the needs of the authentication process to enable a tailored and reliable authentication of the authorized user.

In an embodiment, augmenting the plurality of synthetic representations of a human to generate a plurality of training images may refer to augmenting the plurality of synthetic representations of a human to generate a plurality of training images by adding one or more features associated with the human to one or more of the plurality of synthetic representations of the human to generate the plurality of training images. The training image may be associated with a number of different pixel values higher than a number of different pixel values associated with the representations of the human. Hence, adding the one or more features associated with the human may result in increasing the number of different pixel values. Furthermore, augmenting the plurality of synthetic representations of a human to generate a plurality of training images may refer to augmenting the plurality of synthetic representations of a human to generate a plurality of training images by adding one or more features associated with a background.

In an embodiment, feature associated with the human may be a part of the human, in particular the human's face. The feature associated with the human may be suitable for characterizing and/or identifying at least a part of the

human. One or more of the plurality of training images may comprise the one or more features associated with the human. Examples for features may include eye, nose, cheek, eyebrow, lip, chin, wrinkle, mole, liver spot, beauty spot, shadow generated by the parts of the human's face, one or more hairs, at least a part of a bone structure associated with the human, in particular the human's face or the like. Feature associated with the background may be a part of a background scenery, preferably an item of the background such as an object associated with the background.

In an embodiment, image augmentation technique may comprise at least one of scaling, cutting, rotating, blurring, warping, shearing, resizing, folding, changing the contrast, changing the brightness, adding noise, multiply at least a part of the pixel values, drop out, adjusting colors, applying a convolution, embossing, sharpening, flipping, averaging pixel values or a combination thereof.

In an embodiment, the augmentation data-driven model may be trained to add noise to the representations of the human for obtaining noisy representations of the human, in particular by the one or more encoder blocks, and removing noise from the noisy representations of the human for obtaining the plurality of training images, in particular by the one or more decoder blocks. The augmentation data-driven model may comprise a plurality of encoder blocks and/or decoder blocks. The encoder blocks may be suitable for reducing the dimensionality of the representation of the human. The decoder blocks may be suitable for increasing the dimensionality of the representation of the human. The method may further comprise passing the representation of the human through the encoder blocks of the augmentation data-driven model and/or passing the representation of the human, in particular the noisy representation of the human, through the decoder blocks of the augmentation data-driven model. Passing the representation of the human through the encoder blocks may be referred to a backward diffusion. Passing the representation of the human through the decoder blocks may be referred to as forward diffusion.

In an embodiment, synthetic representation of a human may be a representation of a human generated synthetically. Hence, synthetic representation of the human may be a representation generated by processing the representation of the human digitally. Synthetic representation of the human may be generated independent of an image generation unit such as a camera. Synthetic representation may comprise image data suitable for visually representing a human.

In an embodiment, training the data-driven model may refer to retraining the data-driven model. The request may be a request for retraining the data-driven model. The data-driven model may be trained based on a plurality of historical training images. Training the data-driven model may refer to retraining the data-driven model. Receiving the request for retraining the data-driven model is triggered and/or initiated by an enrollment process associated with a user. An enrollment process may be a process for generating a template image of the authorized user.

Additionally or alternatively, receiving the request for retraining the data-driven model is triggered and/or initiated by determining that an object associated with a test image is a spoofing object by providing the test image to the data-driven model while the test image is associated with an authorized user. By doing so, an already trained model can be improved. This saves time and resources for training a model from scratch. Further, an already trained model can be tailored to the needs of a specific use case and reliability of the data-driven model is increased.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

In the following, the present disclosure is further described with reference to the enclosed figures. The same reference numbers in the drawings and this disclosure are intended to refer to the same or like elements, components, and/or parts.

FIG. 1A illustrates an embodiment of a device for authenticating a user 102.

FIG. 1B illustrates an embodiment of a system for authenticating a user.

FIG. 2 illustrates an embodiment of a method for authenticating a user.

FIG. 3 illustrates an embodiment of obtaining a plurality of training images.

FIG. 4 illustrates an embodiment of generating a training image by augmenting the representation of the human.

FIG. 5 illustrates an embodiment of generating a 3-dimensional model of the human 514 from the representation of the representation of a human 516.

FIG. 6 illustrates an embodiment of obtaining a plurality of training images.

DETAILED DESCRIPTION

The following embodiments are mere examples for implementing the method, the system or application device disclosed herein and shall not be considered limiting.

FIG. 1A illustrates an embodiment of a device for authenticating a user 102.

The device 102 may comprise an illumination source 110, a camera 112 comprising a sensor 114, a processor 104 and/or a memory 116. The illumination source 110 may emit light towards the object 106, preferably infrared light. Infrared light may be unrecognizable to the object 106. The sensor 114 of the camera 112 may be sensitive towards the light emitted by the illumination source 110. Hence, the sensor 114 may be suitable for generating an image of the object 106 while the user may be illuminated by the light emitted from the illumination source 110. The processor 104 may receive the image of the object 106. The processor 104 may process the image of the object 106. By doing so, the processor 104 may determine if the object 106 corresponds to an authorized user. This may include determining if the image of the object corresponds to a representation of a visual feature associated with the authorized user. The representation of a visual feature associated with the authorized user may be a template image and/or a dimensionality-reduced representation of the template image. For this purpose, the processor may execute instructions stored in a memory 116. In FIG. 2, an embodiment of authenticating a user is described.

Alternatively, the illumination source 110 and/or the camera 112 may be comprised in a second device and/or a third device. In this example, the processor 104 may be communicatively coupled to the second and/or third device for triggering the illumination source 110 to emit the light and triggering the sensor 114 to generate an image of the object 106 while the object is illuminated by the light.

The processor may receive a request to access resource such as unlocking the device. For this purpose, the device may comprise a user interface. The object 106 may request to access a resource by the user interface. For example, the device may be a phone. The object 106 may desire to control the phone. For this purpose, the object 106 may need to authenticate. The object 106 may request to access the resource and/or the authentication by using the touch display of the device. This may trigger to provide a signal to the processor 104 of the device. Based on receiving the signal, the processor 104 triggers the illumination source 110 to emit the light.

FIG. 1B illustrates an embodiment of a system for authenticating a user.

The system may comprise a first device 120 and a second device 118. In an embodiment, a first device 120 may comprise the processor 104 and the memory 116. The first device 120 may be communicatively connected to a second device 118 comprising the illumination source 110 and the camera 112 comprising the sensor 114. For example, the first device 120 may be connected to the second device 118 by means of a cloud service. In particular, the processor 104 and/or the memory 116 may be part of a cloud service. The second device 118 may be configured for providing the image generated by the sensor 114 to the first device 120. Receiving a request to access a resource may refer to receiving a signal triggering the illumination source 110 to emit light at the illumination source 110. In response to receiving the signal, the illumination source 110 may be triggered to

illuminate the object 106 by light. Further, the camera 112 may receive a signal triggering to generate an image of the object 106. Receiving a request to access a resource may further comprise receiving the signal at the camera 112.

The processor 104 may determine if the object associated with the image corresponds to an authorized user by providing the image to a data-driven model and/or operating a data-driven model with the image as input data for determining an indication whether the object associated with the image corresponds to an authorized user. Based on the indication whether the object associated with the image corresponds to an authorized user, the processor may provide a signal for providing access to the authorized user. Providing the signal for providing access to the authorized user may be referred to as allowing an authorized user to access a resource.

FIG. 2 illustrates an embodiment of a method for authenticating a user.

An image of an object may be provided 204. Providing the image of the object may comprise receiving a request to access a resource, in response to receiving the request to access the resource triggering to illuminate the object by light, and triggering to generate an image of the object while the object is being illuminated by the light. The image may be generated by a sensor 114 while the object may be illuminated by light emitted from an illumination source 110 as described within the context of FIG. 1A and FIG. 1B. The image may be provided to a data-driven model for determining if the object associated with the image corresponds to an authorized user. The data-driven model may be trained based on a plurality of training images. Training images may be generated as described in the context of FIG. 3 and FIG. 4. The data-driven model may be trained to determine if the object associated with the image may correspond to an authorized user. The authorized user may be authorized to access a resource. Hence, the data-driven model may be trained to determine if the object associated with the image may be authorized to access the resource.

For this purpose, the data-driven model may receive the image e.g. at an input layer of the data-driven model. The data-driven model may comprise an encoder. The encoder may be suitable for reducing the dimension of the image. Hence, the encoder may be suitable for generating a dimensionality-reduced representation of the image. In an example, the dimensionality-reduced representation may be a feature vector. The data-driven model may be trained to determine if the object associated with the image corresponds to an authorized user by determining a similarity score associated with the image, in particular the dimensionality-reduced representation of the image, and a template image, in particular a dimensionality-reduced representation of the template image. Hence, the data-driven model may receive the template image, in particular the dimensionality-reduced representation of the template image. The similarity score may be a distance between the dimensionality-reduced representation of the image and the dimensionality-reduced representation of the template image, in particular in a feature space. In an example, the data-driven model may determine the distance between the feature vector and the template vector. If

the distance between the feature vector and the template vector may be within a predefined range, the data-driven model may provide an indication that the object may be the authorized user. If the distance between the feature vector and the template vector may be outside of a predefined range, the data-driven model may provide an indication that the object may be an unauthorized user. Providing an indication that the object may be the authorized user may result in allowing the authorized user to access the resource. Hence, allowing an authorized user to access a resource based on determining that the object correspond to the authorized user may comprise receiving an indication that the object may be the authorized user from the data-driven model and allowing the authorized user to access the resource.

FIG. 3 illustrates an embodiment of obtaining a plurality of training images 312, 314, 316.

For obtaining a plurality of training images 312, 314, 316 a representation of a human 304 may be provided and/or received. The representation of a human 304 may be a sketch and/or an image of the human e.g. generated by a camera. Based on the representation of a human 304 a plurality of synthetic representations of the human 306, 308, 310 may be generated. The plurality of synthetic representations of the human 306, 308, 310 may be associated with different perspectives of the human, different locations of the human within the representation, different backgrounds or the like. Further, the plurality of training images 312, 314, 316 may be associated with different perspectives of the human, different locations of the human within the representation, different backgrounds or the like.

Generating a plurality of synthetic representations of the human 306, 308, 310 may comprise generating a 3-dimensional representation of the human based on the representation of the human. If not stated otherwise, the representation of the human may be 2-dimensional. The 3-dimensional representation of the human may be indicative of the topology associated with the human. Generating the 3-dimensional representation of the human 302 may comprise adding depth information to the representation of the human. The 3-dimensional representation of the human 302 may be generated by projecting the representation of the human onto a 3-dimensional model of human topology. The 3-dimensional model of human topology may be indicative of depth information associated with humans based on the human anatomy. The 3-dimensional model of human topology may specify one or more features associated with a plurality of human. Generating 3-dimensional representation of the human 302 may comprise projecting the representation of the human onto the 3-dimensional model of human topology. For this purpose, features of the human associated with the representation of a human 304 may be detected. The representation of a human 304 may be projected onto the 3-dimensional model of human topology by matching the features of the human associated with the representation of the human with the features of the 3-dimensional model of human topology.

Additionally or alternatively, generating the 3-dimensional representation of the human 302 may comprise generating depth information based on the representation of a human 304. Generating depth information based on the representation of a human 304 may comprise determining a distance between two or more features of the human associated with the representation of a human 304 and determining based on the distance depth information. For example, the distance between the eyes and the nose and the distance between the eyes may correlate with the distance of the nose and the eyes from a point of view associated with the representation of a human 304. Hence, the depth information may be obtained based on a correlation between the representation of a human 304 and the depth information. The correlation may be obtained based on historical representations of a human 304 and corresponding depth information. For example, the 3-dimensional model of the human topology may be obtained from the distance between two or more features of the human.

From the 3-dimensional representation of the human 302 a plurality of synthetic representations of the human 306, 308, 310 may be generated. As stated above, the plurality of synthetic representations of the human 306, 308, 310 may differ in orientation of the human within the representation of a human 304. Hence, the plurality of synthetic representations of the human 306, 308, 310 may be generated by rotating and/or mirroring the 3-dimensional representation of the human 302.

Based on the plurality of synthetic representations of the human 306, 308, 310 the plurality of training images may be generated as describe within the context of FIG. 4.

FIG. 4 illustrates an embodiment of generating a training image by augmenting the representation of the human 408.

The representation of the human 408 may one of the plurality of synthetic representations of a human 306, 308, 310. Obtaining the representation of the human 408 being one of the plurality of synthetic representations 306, 308, 310 may be described in the context of FIG. 3.

The representation 408 may be preprocessed 422. Preprocessing of a representation of a human 422 may include generating a representation of the contours of the human associated with the representation of the human. The representation of the human may comprise information on the colors associated with a part of the human. The representation of the contours of the human may comprise the outline of at least a part of the human. The representation of the contours of the human may be indicative of and/or may be suitable for defining the contour of the human associated with the training image, in particular the training image generated based on the representation of the human.

The representation of the human may be provided to an augmentation data-driven model. The augmentation data-driven model may be suitable for augmenting the input data to generate output data. In this context, the augmentation data-driven model may generate the training image by augmenting the representation of the human. Hence, the augmentation data-driven model may be provided with the representation of the human. The representation of the human may be processed by the augmentation data-driven model, in particular by passing the representation of the human through one or more layers of the augmentation data-driven model. The augmentation data-driven model may be provided with the representation of the human for changing at least a part of the representation of the human. Changing at least a part of the representation of the human may result in a training image.

In an embodiment, providing the representation of the human to the augmentation data-driven model may comprise preprocessing the representation of the human to generate the representation of the contours of the human and providing the representation of the contours of the human to the augmentation data-driven model. The augmentation data-driven model may process the representation of the contours of the human to the training image, in particular by augmenting the representation of the contour of the human. For this purpose, an algorithm such as the canny edge detection algorithm may be applied.

In an embodiment, providing the representation of the human to the augmentation data-driven model for generating the training image may comprise passing the representation of the human through a plurality of encoder blocks comprising encoder block 1 with dimension x 412 and encoder block n with dimension x_n 414. Passing the representation of the human through the plurality of encoder blocks 412, 414 may add noise to the representation of the human and/or may result in a noisy representation of the human. This may be referred to as backward diffusion. Preferably, the noise may be gaussian noise. The first encoder block 412 may be associated with a dimension x being larger than the dimension x_n of the n th encoder block 414. Hence, the plurality of encoder blocks may be suitable for reducing the dimension of the representation of the human and/or adding noise to the representation of the human.

Additionally or alternatively, providing the representation of the human to the augmentation data-driven model for generating the training image may comprise passing the representation of the human through a plurality of decoder blocks comprising decoder block 1 with dimension x_n 416 and decoder block m with dimension x 418. The dimension of the m -th decoder block 416 may correspond to the dimension of the first encoder block 412. Further, the dimension of the n -th encoder 414 block may correspond to the dimension of the first decoder block 416. Passing the representation of the human through the plurality of decoder blocks 416, 418 may remove noise of the representation of the human, in particular the noisy representation of the human received from an encoder block, preferably the last encoder block of the augmentation data-driven model and/or may result in a training image. This may be referred to as forward diffusion. Preferably, the noise may be gaussian noise. The m -th

decoder block 418 may be associated with a dimension x being larger than the dimension x_n of the first block 416. Hence, the plurality of decoder blocks may be suitable for increasing the dimension of the representation of the human, in particular the noisy representation of the human, and/or removing noise to the representation of the human, in particular the noisy representation of the human.

By doing so, the training image may comprise more features associated with the human than the representation of the human. The training image may correspond to an image generated of the human. Hence, the training image may be more realistic than the representation of the human. Feature associated with the human may be parts of the human, in particular the human's face such as eye, nose, cheek, eyebrow, lip, chin, wrinkle, shadow generated by the parts of the human's face.

Additionally or alternatively, augmenting the representation of the human may comprise applying least one image augmentation technique to the representation of the human. The image augmentation technique may be suitable for increasing the number of features associated with the human. The image augmentation technique may add one or more features associated with the human to the representation of the human and/or may sharpen the representation of the human, in particular to generate the training image.

Examples for available augmentation data-driven models may include stable diffusion model, preferably ControlNet. ControlNet may be a machine-learning architecture derived from the stable diffusion model.

FIG. 5 illustrates an embodiment of generating a 3-dimensional model of the human 514 from the representation of the representation of a human 516.

The 3D data-driven model may comprise an encoder 502 and a decoder 512. The 3D data-driven model may be a generative model. The 3D data-driven model may be for example trained in an adversarial manner. Hence, the generative model may be and/or may comprise at least a part of a generative adversarial network. This may include training the 3D data-driven model to generate 3-dimensional models of humans while a detector model may be trained to distinguish the 3-dimensional models of humans generated by the 3D data-driven model from real or realistic 3-dimensional models of humans.

The representation of a human 516 may be received at an encoder 502 of the 3D data-driven model in an image format, text format or the like. For processing the representation of a human 516 in an image format the encoder 502 is configured to receive image data, in particular 2-dimensional image data and reduce the dimensionality of the image data to a tensor associated with the representation of the human 510. For processing the representation of a human 516 in a text format the encoder 502 is configured to receive text data and transform the dimensionality of the text data into a tensor associated with the representation of the human 510. This may

allow the 3D data-driven model to efficiently process a machine-processable format associated with the representation of a human 516. In other words, the encoder 502 may transform the representation of a human 516 into a latent space. For this purpose, the encoder 502 may comprise one or more convolutional layers configured for reducing the dimensionality of the representation of a human 516. The tensor associated with the representation of the human 510 may be received by the decoder 512 of the 3D data-driven model. The decoder 512 may comprise one or more deconvolutional layers. The deconvolutional layers may be configured for increasing the dimensionality of the tensor associated with the representation of the human 510, preferably to result in a 3-dimensional model of the human 514. The 3-dimensional model of the human 514 may comprise a plurality of voxels.

FIG. 6 illustrates an embodiment of obtaining a plurality of training images.

The 3-dimensional model of the human 514 may specify depth information associated with the human. The plurality of synthetic representations 624 may specify a 2-dimensional view onto the human from a predefined point of view. Hence, the plurality of synthetic representations 624 may comprise a view onto the 3-dimensional model of the human 602 from one or more predefined point of views, in particular a plurality of different point of views.

The present disclosure has been described in conjunction with preferred embodiments and examples as well. However, other variations can be understood and effected by those persons skilled in the art and practicing the claimed subject-matter, from the studies of the drawings, this disclosure and the claims. Notably, in particular, the any steps presented can be performed in any order, i.e. the present disclosure is not limited to a specific order of these steps. Moreover, it is also not required that the different steps are performed at a certain place or at one node of a distributed system, i.e. each of the steps may be performed at different nodes using different equipment/data processing.

As used herein „determining“ also includes „initiating or causing to determine“, „generating“ also includes „initiating and/or causing to generate“ and „providing“ also includes „initiating or causing to determine, generate, select, send and/or receive“. „Initiating or causing to perform an action“ includes any processing signal that triggers a computing node or device to perform the respective action.

In the claims as well as in the description the word „comprising“ or „including“ or similar wording does not exclude other elements or steps and shall not be construed limiting to the elements or steps lined out. The indefinite article „a“ or „an“ does not exclude a plurality. A single element or other unit may fulfill the functions of several entities or items recited in the claims. The mere fact that certain measures are recited in the mutual different dependent claims does not indicate that a combination of these measures cannot be used in an advantageous implementation or further elements may be included.

Providing in the scope of this disclosure may include any interface configured to provide data. This may include an application programming interface, a human-machine interface such as a display and/or a software module interface. Providing may include communication of data or submission of data to the interface, in particular display to a user or use of the data by the receiving entity.

Any disclosure and embodiments described herein relate to the methods, the systems, devices, the computer program element lined out above and vice versa. Advantageously, the benefits provided by any of the embodiments and examples equally apply to all other embodiments and examples and vice versa.

CLAIMS

What is claimed is:

1. A method for authenticating an authorized user, the method comprising:
 - receiving a request to access a resource,
 - in response to receiving the request to access the resource triggering to illuminate the object by light, and
 - triggering to generate an image of the object while the object is being illuminated by the light,
 - receiving a template image of the authorized user,
 - determining if the object associated with the image corresponds to the authorized user by providing the image and the template image to a data-driven model, wherein the data-driven model is trained with a plurality of training images obtained by generating a plurality of synthetic representations of a human generated from a representation of the human and augmenting the plurality of synthetic representations of a human to generate a plurality of training images,
 - allowing the authorized user to access a resource in response to determining that the object corresponds to the authorized user.
2. The method of claim 1, wherein receiving the template image of the authorized user refers to receiving a dimensionality-reduced representation of the template image and wherein providing the template image to the data-driven model refers to providing the dimensionality-reduced representation of the template image to the data-driven model.
3. The method of claim 1 or 2, further comprising triggering to illuminate the object by patterned light and generating a pattern image while the object is illuminated by patterned light and providing the pattern image to a liveness data-driven model for determining if the object associated with the image corresponds to a living human, wherein the liveness data-driven model is trained with historical pattern images and corresponding indications whether the objects associated with the historical pattern images corresponds to a living humans and allowing the authorized user to access a resource further in response to determining that the object correspond to the living human.
4. A method for obtaining a plurality of training images for training a data-driven model for determining if an object associated with an image corresponds to an authorized user, the method comprising:
 - providing a representation of a human,
 - generating a plurality of synthetic representation of the human from the representation of the human,

generating a plurality of training images by augmenting the plurality of synthetic representations, receiving the plurality of training images.

5. A method for training a data-driven model for determining if an object associated with an image corresponds to an authorized user, the method comprising:
 - receiving a request for training the data-driven model,
 - providing a plurality of training images obtained by generating a plurality of synthetic representations of a human generated from a representation of the human and augmenting the plurality of synthetic representations of a human to generate a plurality of training images,
 - training the data-driven model with the plurality of training images,
 - optionally providing the data-driven model.
6. The method of claim 5, wherein the representation of the human comprises an image of the human, a sketch of the human, a text description of the human, at least a part of a contour of the human or a combination thereof.
7. The method of claim 5 or 6, wherein training the data-driven model refers to retraining the data-driven model and wherein the request is a request for retraining the data-driven model and wherein the data-driven model is trained with a plurality of historical training images and wherein training the data-driven model refers to retraining the data-driven model and wherein receiving the request for retraining the data-driven model is triggered and/or initiated by an enrollment process associated with a user and/or wherein receiving the request for retraining the data-driven model is triggered and/or initiated by determining that an object associated with a test image is a spoofing object by providing the test image to the data-driven model while the test image is associated with an authorized user.
8. The method according to any one of claims 1 to 7, wherein generating the plurality of synthetic representations of the human from the representation of the human comprises generating a 3-dimensional representation of the human from the representation of the human.
9. The method according to any one of claims 1 to 8, wherein the plurality of training images show one or more humans and wherein at least a part of the plurality of training images associated with one human differ in a perspective onto the human within the representation of the human, the location of at least a part of the human within the representation of the human, a brightness of the training images, a background within the training images or a combination thereof.

10. The method according to any one of claims 1 to 9, wherein generating the plurality of training images comprises providing the plurality of synthetic representations of the human to an augmentation data-driven model and receiving the plurality of training images from the augmentation data-driven model, wherein the augmentation data-driven model is trained with historical representations of humans and corresponding training images.
11. The method according to any one of claims 1 to 10, further comprising generating a representation of the contour of the human and wherein providing the representations of the human to the augmentation data-driven model comprises providing the representations of the contours of the human to the augmentation data-driven model.
12. The method according to any one of claims 1-5 or 7-11, wherein the representation of human is an enrollment image generated during an enrollment process of the human, in particular the authorized user.
13. Use of training images as obtained by any one of claims 4 or 6-11 for training a data-driven model for authenticating an authorized user.
14. A device and/or system for authenticating an authorized user comprising:
 - a processor; and
 - a memory storing instructions that, when executed by the processor, configure the device and/or system to perform the method according to any one of claims 1 to 11.
15. An authentication system trained with training images obtained by a method according to any one of claims 4 or 7-12 and/or trained according to a method of any one of claims 6-12.

1/7

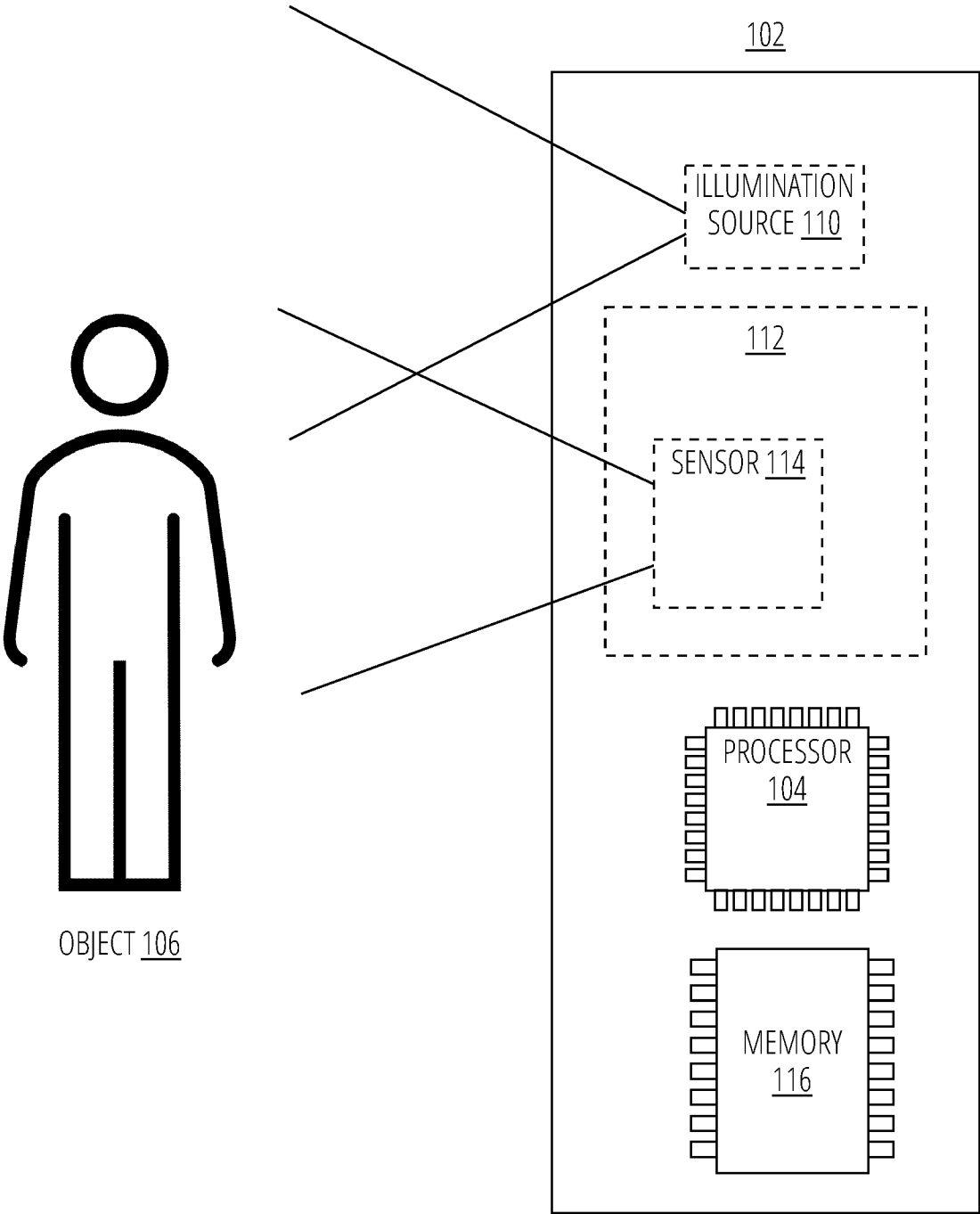


FIG. 1A

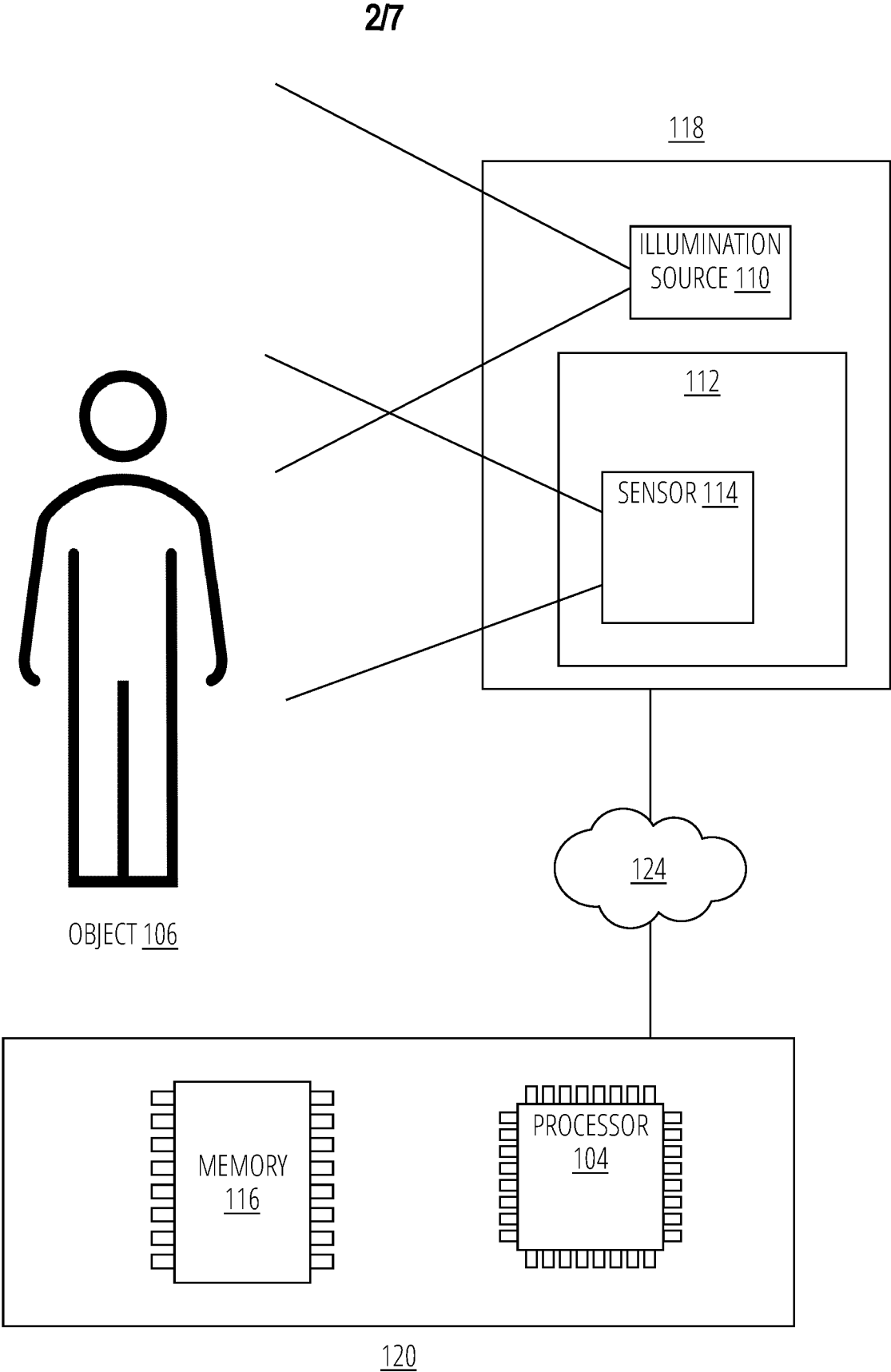


FIG. 1B

3/7

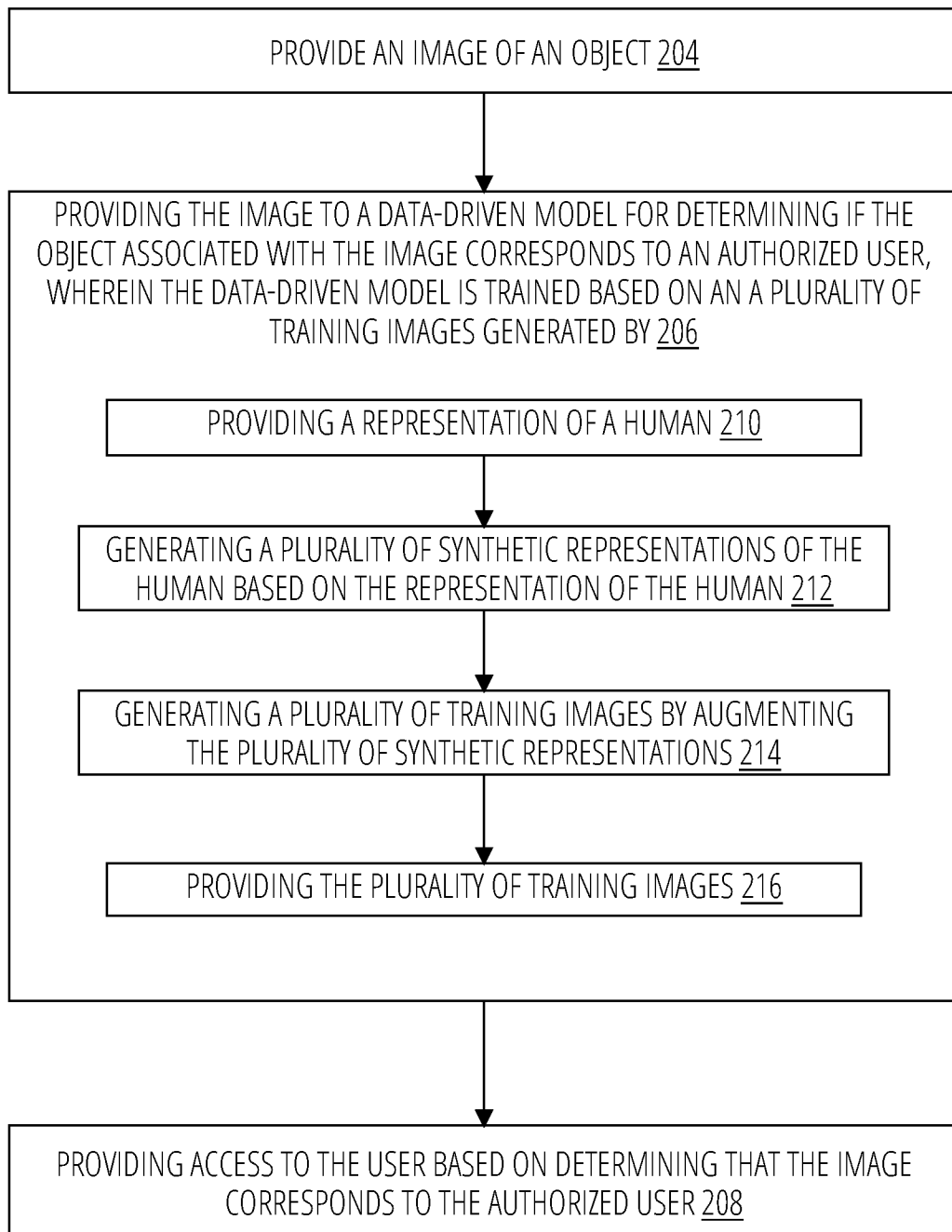


FIG. 2

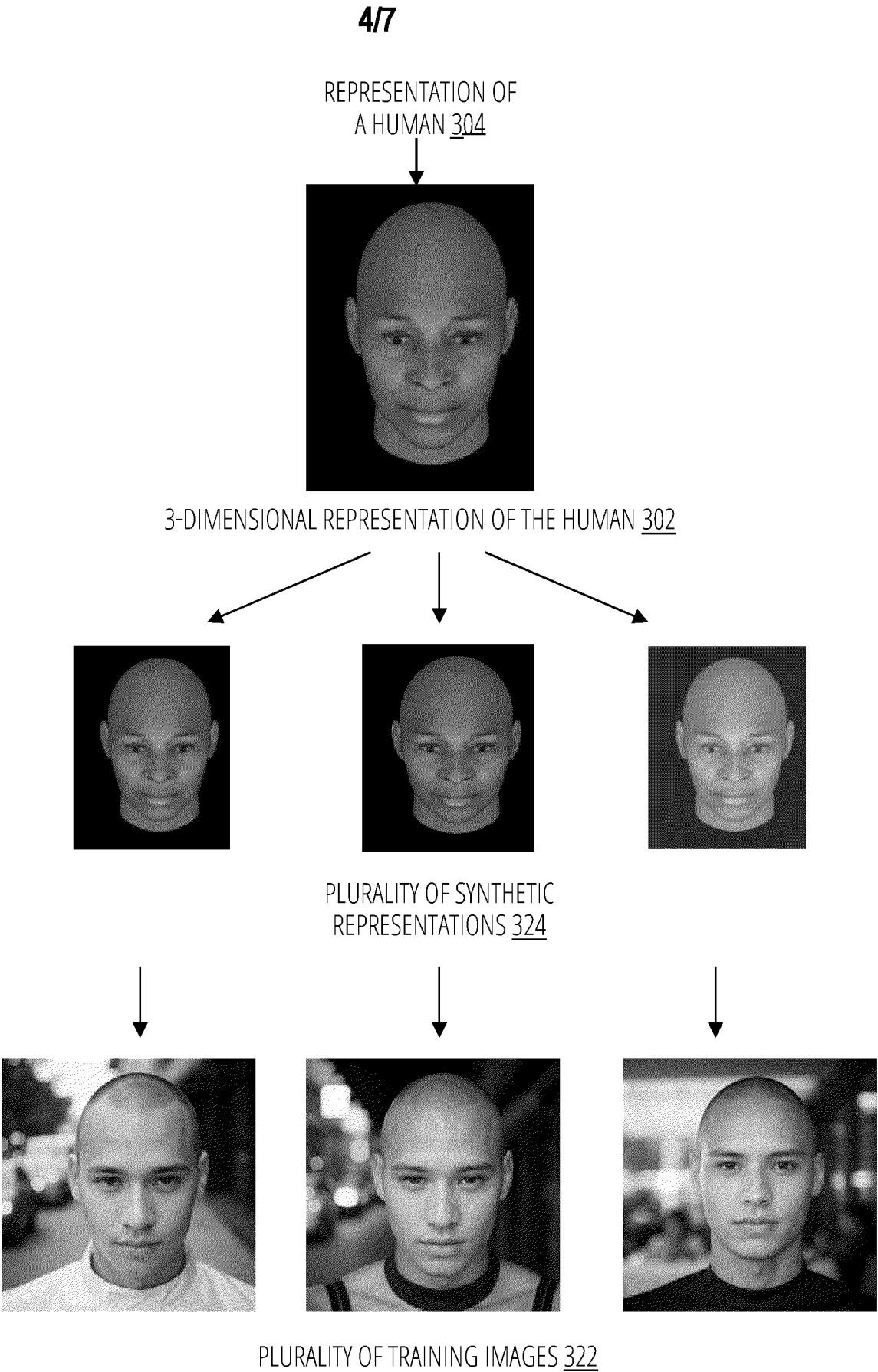


FIG. 3

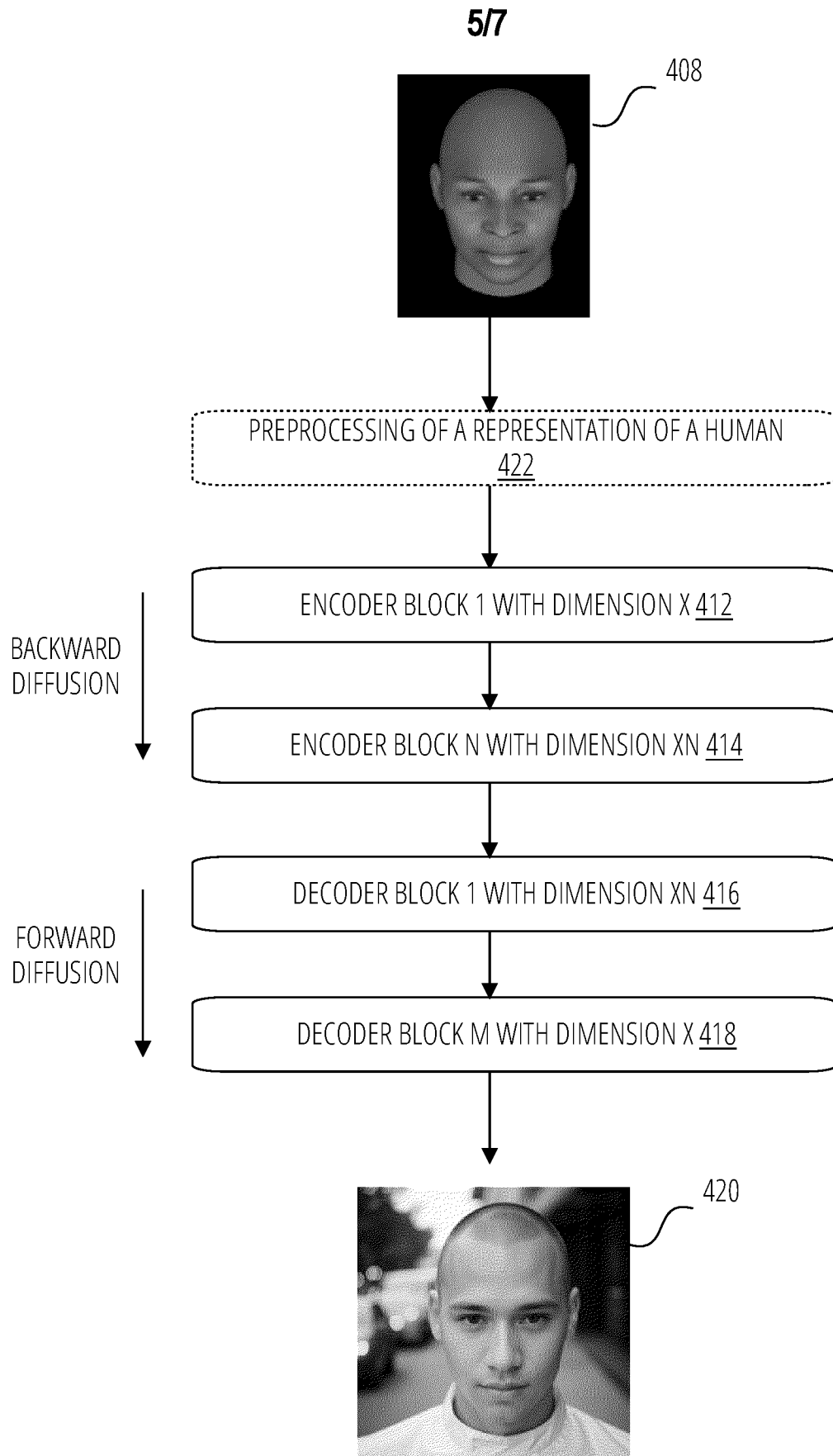
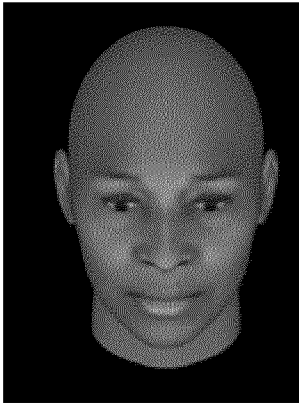
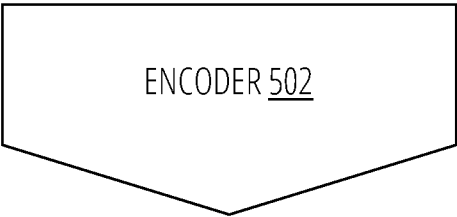


FIG. 4

6/7

REPRESENTATION OF
A HUMAN 516



3-DIMENSIONAL MODEL OF THE HUMAN 514

FIG. 5

7/7

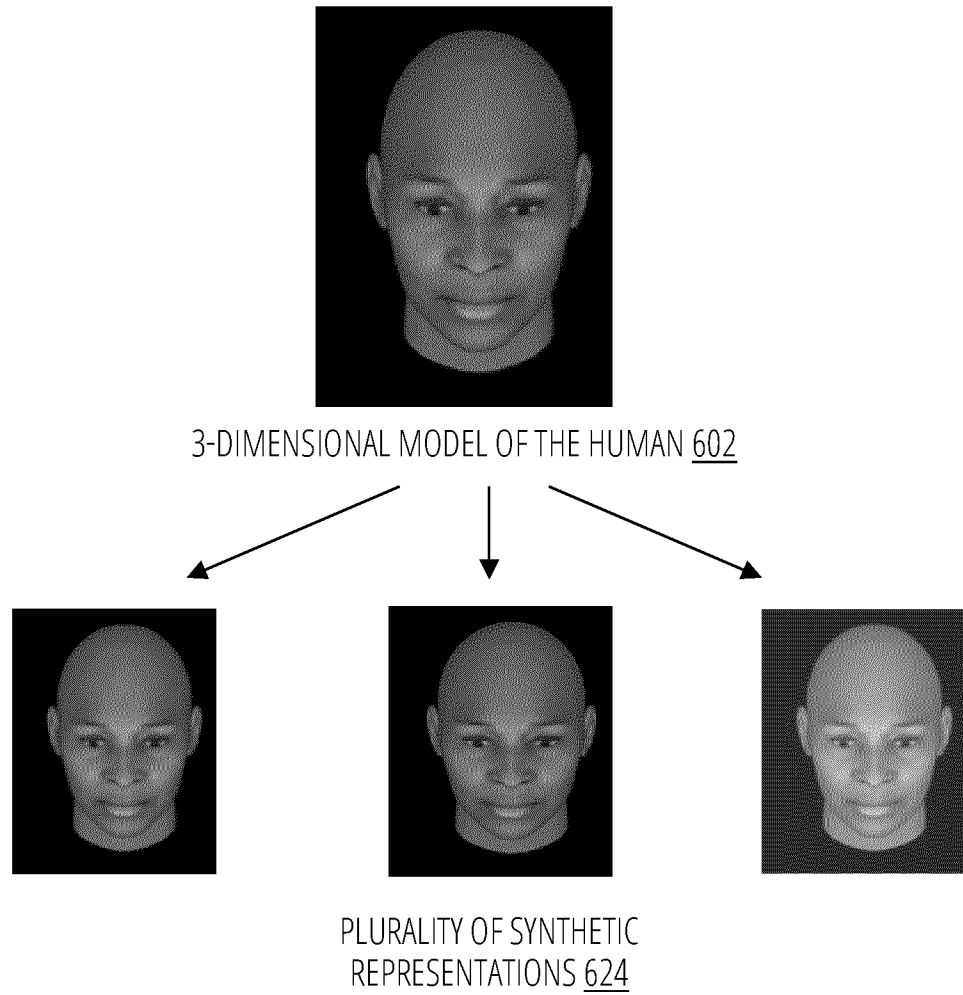


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2024/073525

A. CLASSIFICATION OF SUBJECT MATTER

INV. G06F18/214 G06F18/2413 G06F21/32 G06V40/16
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)

G06F H04L G06V

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2023/156313 A1 (TRINAMIX GMBH [DE])	1 - 10,
	24 August 2023 (2023-08-24)	13 - 15
Y	page 1, lines 5-9	11, 12
	page 11, line 37	
	page 12, lines 5-19	
	page 12, lines 31-33	
	page 13, lines 21-39	
	page 13, line 41 - page 14, line 13	
	page 18, lines 8-11	

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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

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"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

13 October 2024

Date of mailing of the international search report

25/10/2024

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2

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Authorized officer

Mukasa, Oliver

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/073525

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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