

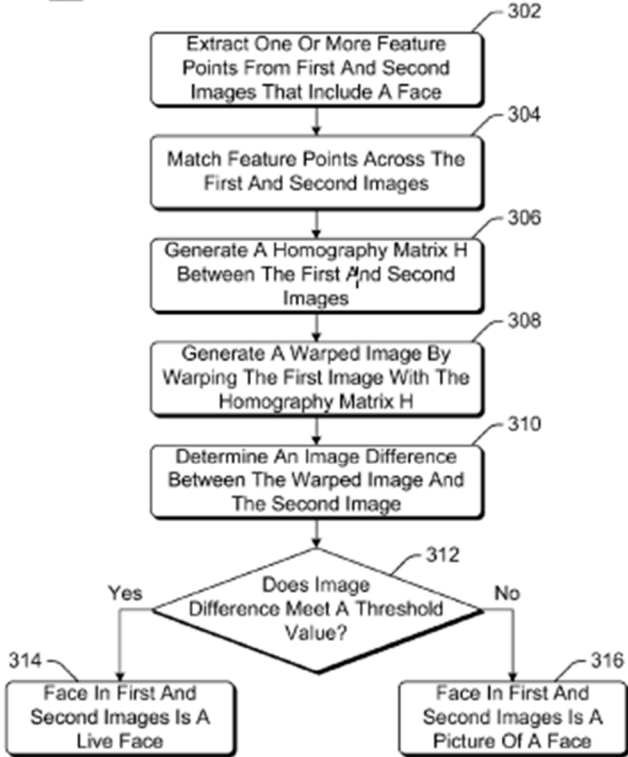
INVALIDITY CLAIM CHART
U.S. Patent 11,157,606

U.S. Patent Application Pub. No. 2011/0299741 A1 to Zhang et al. (“Zhang”) qualifies as prior art under at least 35 U.S.C. § 102(a)(1) because it is a printed publication that was publicly available before the effective filing date of U.S. Patent No. 11,157,606 (“the ’606 Patent”). Zhang also qualifies as prior art under at least 35 U.S.C. §§ 102(a)(2) because it is a published patent application that was filed before the effective filing date of ’606 Patent.

The asserted claims of the ’606 Patent are anticipated by Zhang. The asserted claims of the ’606 Patent are also invalid under 35 U.S.C. § 103 as obvious in view of Zhang alone or in combination with one or more other references identified in Defendants’ Invalidity Contentions.

Asserted Claims of the ’606 Patent	Prior Art
Claim 1	
<p>[606.1(p)] A method for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device, the method comprising:</p>	<p>To the extent the preamble is limiting, Zhang discloses a method for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device, the method comprising.</p> <p style="padding-left: 40px;">Multiple images including a face presented by a user are accessed. One or more determinations are made based on the multiple images, such as a determination of whether the face included in the multiple images is a 3-dimensional structure or a flat surface and/or a determination of whether motion is present in one or more face components (e.g., eyes or mouth). If it is determined that the face included in the multiple images is a 3-dimensional structure or that that motion is present in the one or more face components, then an indication is provided that the user can be authenticated. However, if it is determined that the face included in the multiple images is a flat surface or that motion is not present in the one or more face components, then an indication is provided that the user cannot be authenticated. [Abstract]</p>

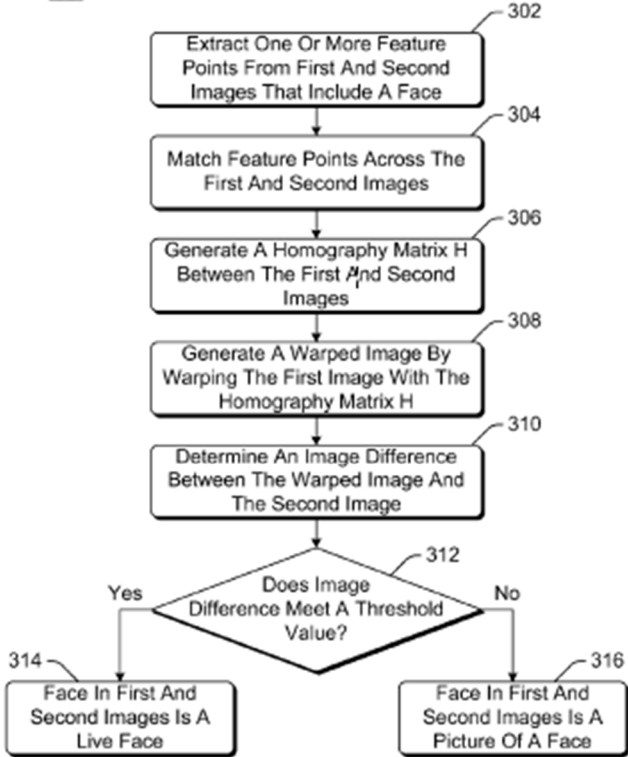
Asserted Claims of the '606 Patent	Prior Art
	<div data-bbox="613 321 995 786"><p style="text-align: center;">100</p><pre>graph TD 108((108)) -.-> 102[Image Capture Component 102] 102 --> 104[Live Face Detection Module 104] 104 --> 110[Live Face Indication 110]</pre></div> <p style="text-align: center;">Fig. 1</p> <p style="text-align: center;">[Fig. 1]</p>

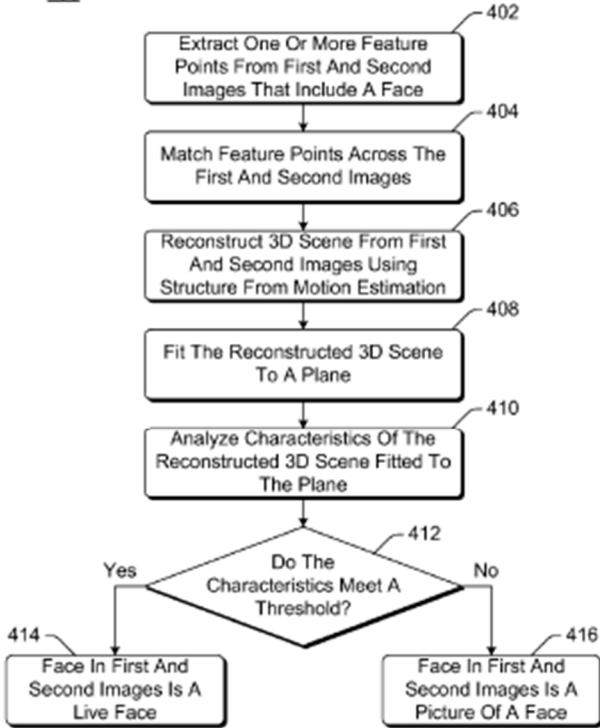
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	<p data-bbox="657 337 695 358">300</p>  <pre> graph TD 302[Extract One Or More Feature Points From First And Second Images That Include A Face] --> 304[Match Feature Points Across The First And Second Images] 304 --> 306[Generate A Homography Matrix H Between The First And Second Images] 306 --> 308[Generate A Warped Image By Warping The First Image With The Homography Matrix H] 308 --> 310[Determine An Image Difference Between The Warped Image And The Second Image] 310 --> 312{Does Image Difference Meet A Threshold Value?} 312 -- Yes --> 314[Face In First And Second Images Is A Live Face] 312 -- No --> 316[Face In First And Second Images Is A Picture Of A Face] </pre> <p data-bbox="863 1198 982 1247">Fig. 3</p> <p data-bbox="598 1325 695 1357">[Fig. 3]</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>In accordance with one or more aspects, multiple images including a face presented by a user are accessed. A determination is made, based on the multiple images, of whether the face included in the multiple images is a 3-dimensional (3D) structure or a flat surface. If it is determined that the face included in the multiple images is a 3-dimensional structure, then an indication is provided that the user can be authenticated. However, if it is determined that the face included in the multiple images is a flat surface, then an indication is provided that the user cannot be authenticated.</p> <p>In accordance with one or more aspects, multiple images including a face presented by a user are accessed. A determination is made, based on the multiple images, of whether motion is present in one or more components (e.g., eyes, mouth, etc.) of the face. If it is determined that motion is present in the one or more components of the face, then an indication is provided that the user can be authenticated. However, if it is determined that motion is not present in the one or more components of the face, then an indication is provided that the user cannot be authenticated. [0003]-[0004]</p> <p>Distinguishing live faces from flat surfaces is discussed herein. In order to authenticate a user for particular access (e.g., to a computer or network, to a building or other location, etc.), multiple images of a face presented by the user are captured and analyzed. The face presented by the user can be the user's actual face, or could be a picture of a face of the user that is presented by an imposter. An attempt is made to determine whether the images include a live face (e.g., the captured images are of a live human being) or a picture of a face. If it is determined that the images include a live face, then it is assumed that the face presented by the user is the face of the actual user that is requesting the particular access, and the user can be authenticated for access. However, if it is determined that the images include a picture, then it is assumed that the face presented by the user is the face of an imposter using a picture, and the user cannot be authenticated for access. [0012]</p> <p>Live face detection module 104 analyzes images 106 to determine whether images 106 include a live face or a picture of a face, and outputs an indication 110 of whether images 106 include a live face or a picture of a face. Indication 110 can be, for example, a first value to indicate</p>

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	<p>images 106 include a live face (e.g., “live”, “yes”, “authenticate”, etc.) and a second value to indicate images 106 include a picture of a face (e.g., “picture”, “no”, “do not authenticate”, etc.). A live face refers to the face of an actual human being (i.e., image capture component 102 captured images of an actual human being), rather than a picture of the face of a human being. If detection module 104 determines that images 106 include a live face, then live face indication 110 indicates that images 106 include a live face. In such situations, live face indication 110 indicates that user 108 can be authenticated for access (e.g., to whatever system, resource, location, etc. that user 108 is requesting access) because it is assumed that the actual human being that is user 108 is requesting particular access. The authentication of user 108 can be performed by another component or module (not shown) in a variety of different manners, such as by comparing one or more of images 106 to previously captured images of user 108. Alternatively, the authentication can be performed prior to the live face detection performed by module 104, in which case live face indication 110 indicates that any previous authentication of user 108 is valid. [0017]</p> <p>Live face detection module 104 can determine whether images 106 include a live face or a picture of a face in a variety of different manners. In one or more embodiments, live face detection module 104 includes one or both of a 3-dimensional (3D) structure determination module 112 and a face component movement determination module 114. Generally, 3D structure determination module 112 determines whether images 106 include a face that is a 3D structure (e.g., an actual human being) or a flat surface (e.g., a photograph), and face component movement determination module 114 determines whether motion is present in one or more components of the face in images 106. The manner in which these determinations are made by modules 112 and 114 is discussed in more detail below. [0019]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the CAMERA-BASED 3D AUTHENTICATION references (see cover document Section II.d.vii. for relevant disclosures in these references). A person</i></p>

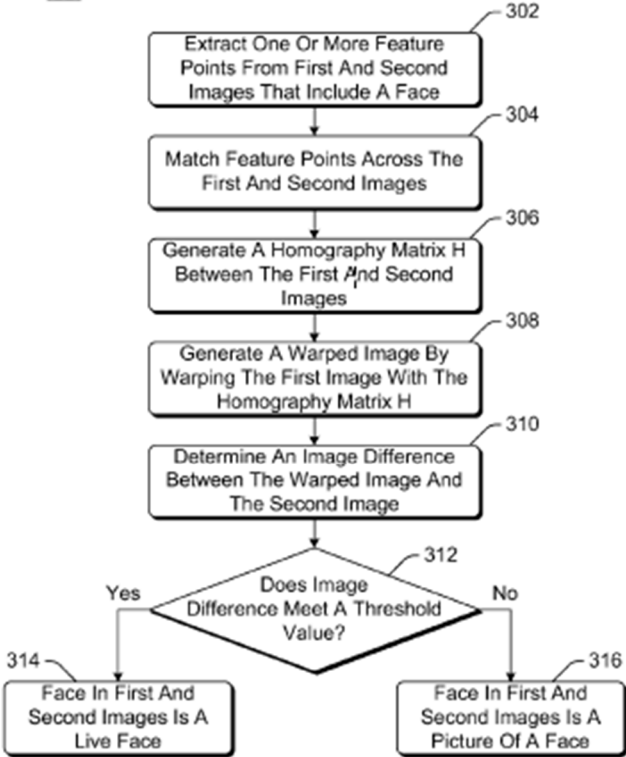
Asserted Claims of the '606 Patent	Prior Art
	<i>having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i>
[606.1(a)] capturing at least one first image of the user taken with the camera of the computing device at a first distance from the user;	<p>Zhang discloses capturing at least one first image of the user taken with the camera of the computing device at a first distance from the user.</p> <p>Multiple images including a face presented by a user are accessed. One or more determinations are made based on the multiple images, such as a determination of whether the face included in the multiple images is a 3-dimensional structure or a flat surface and/or a determination of whether motion is present in one or more face components (e.g., eyes or mouth). If it is determined that the face included in the multiple images is a 3-dimensional structure or that that motion is present in the one or more face components, then an indication is provided that the user can be authenticated. However, if it is determined that the face included in the multiple images is a flat surface or that motion is not present in the one or more face components, then an indication is provided that the user cannot be authenticated. [Abstract]</p>

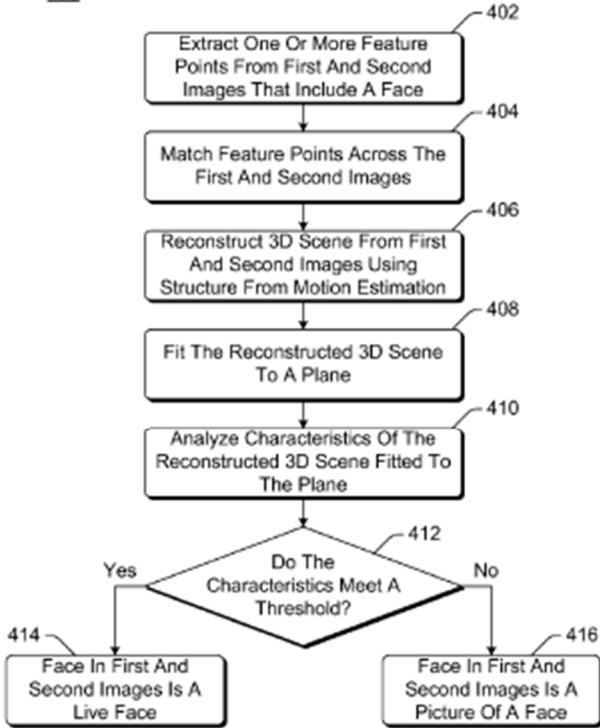
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	<p>In order to authenticate a user for particular access (e.g., to a computer or network, to a building or other location, etc.), multiple images of a face presented by the user are captured and analyzed. [0012]</p> <p>Image capture component 102 captures multiple images 106 each including a face presented by a user 108, and makes images 106 available to live face detection module 104. Image capture component 102 can capture images 106 in a variety of different manners, such as using various digital imaging technologies (e.g., charge-coupled devices (CCDs), complementary metal-oxide-semiconductor (CMOS) sensors, and so forth). [0016]</p> <p>These multiple images can be images including a live face or images including a picture of a face. The multiple images are images that have been captured by an image capture component (e.g., image capture component 102 of FIG. 1). [0021]</p> <p>In one or more embodiments, the first and second images in process 300 are adjacent images in a sequence of three or more images. For example, multiple images (such as 30 or 60 images) can be accessed by the 3D structure determination module implementing process 300. Assume the multiple images are, in their order of capture, image 1, image 2, image 3, image 4, . . . image z. The first and second images in process 300 can be adjacent or sequential images in the sequence of multiple images, such as image 1 and image 2, image 4 and image 5, and so forth. Alternatively, the first and second images in process 300 can be non-adjacent images, having one or more intervening images between them in the sequence of images. For example, the first and second images in process 300 can be image 1 and image 10, image 12 and image 37, and so forth.</p> <p>Additionally, even if the first and second images in process 300 are not adjacent or sequential images in the sequence, at least part of process 300 can be performed for each adjacent pair of images in the sequence. For example, the feature point extraction and feature point matching in acts 302 and 304 can be generated for each adjacent pair of images in the sequence, which can</p>

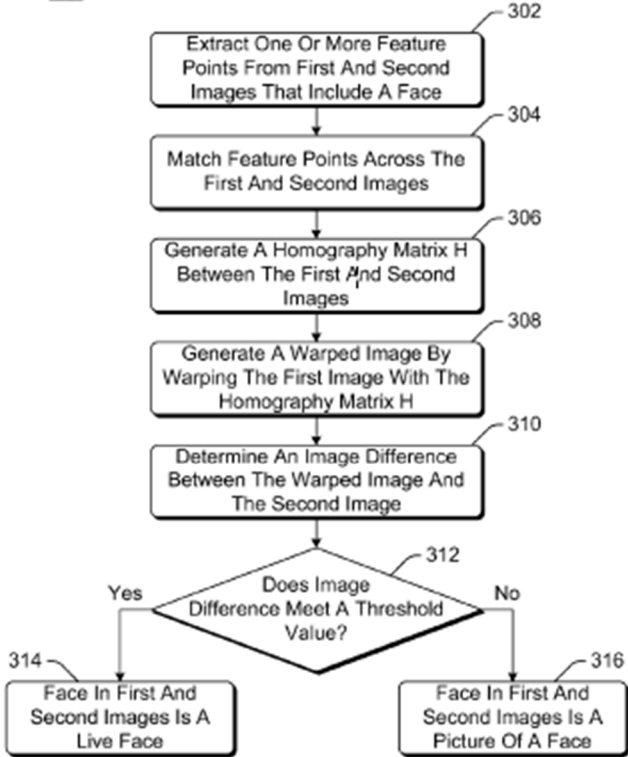
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	<p>facilitate the feature matching process when matching features across two images with one or more intervening images. [0035-0036]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the MULTIPLE IMAGES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
[606.1(b)] processing the at least one first image to obtain first biometric data from the at least one first image;	Zhang discloses processing the at least one first image to obtain first biometric data from the at least one first image.

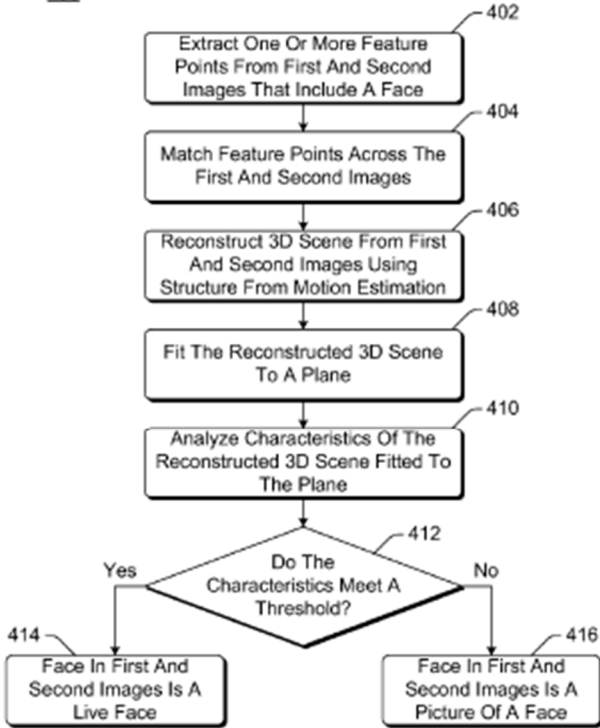
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	<p>Returning to FIG. 1, in one or more embodiments 3D structure determination module 112 uses a homography based technique for determining whether a face included in images 106 is a 3D structure or a flat surface. Alternatively, other techniques can be used, such as a structure from motion estimation technique.</p> <p>The homography based technique uses a 3×3 homography matrix, also referred to herein as matrix H. The homography based technique leverages the fact that two views of a flat (planar) surface are related based on a homography matrix H. Accordingly, in analyzing a first image and a second image, the first image can be warped or transformed using the homography matrix H to generate a warped image. The warped image is then compared to the second image. If the first and second images are views of a flat surface (e.g., a picture of a face), then the warped image will be similar to the second image. Thus, if the difference between the second image and the warped image is small (e.g., below a threshold value), then the first and second images include a face that is a flat surface rather than a live face. However, if the difference between the second image and the warped image is larger (e.g., at least a threshold value), then the first and second images include a facet that is a live face rather than a flat surface. [0024]-[0025]</p> <p>In process 300, one or more feature points are extracted from two images, referred to in process 300 as the first and second images (act 302). These first and second images each include a face of the same person, and can be, for example, images 106 of FIG. 1. The one or more feature points are feature points of the face in the first and second images. A variety of different feature points can be extracted, such as a corner of an eye, a corner of a mouth, a tip of a nose, and so forth. Each feature point is a single pixel or a region of multiple pixels. These feature points can be extracted in a variety of different conventional manners, such as using template matching algorithms, feature matching algorithms, and so forth. [0027]</p> <p>In process 400, one or more feature points are extracted from two images, referred to in process 400 as the first and second images (act 402). These first and second images each include a face of the same person, and can be, for example, images 106 of FIG. 1. The one or more feature points are feature points of the face in the first and second images. A variety of different feature</p>

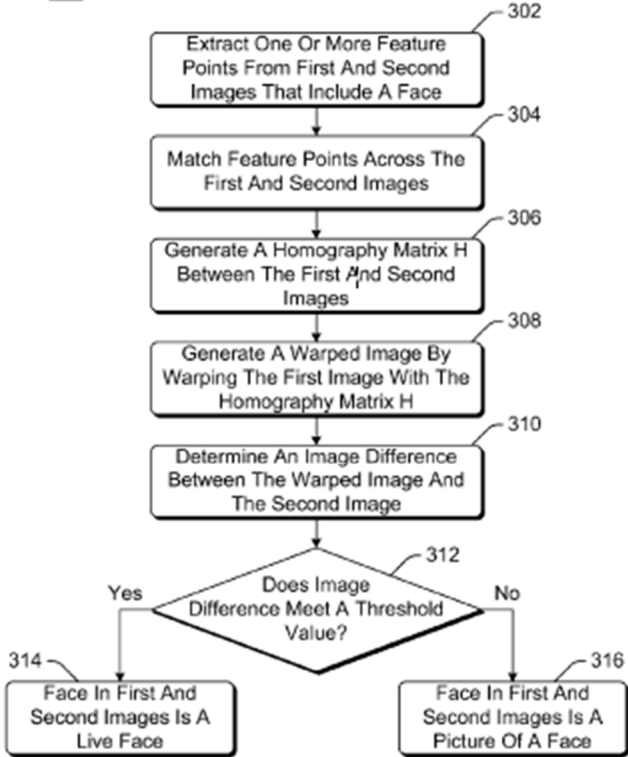
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	<p>points can be extracted, such as a corner of an eye, a corner of a mouth, a tip of a nose, and so forth. Each feature point is a single pixel or a region of multiple pixels. [0041]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the BIOMETRIC DATA references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.1(c)] capturing at least one second image of the user taken with the camera of the computing device at a second distance from the user, the second distance being different than the first distance;</p>	<p>Zhang discloses capturing at least one second image of the user taken with the camera of the computing device at a second distance from the user, the second distance being different than the first distance.</p> <p>Multiple images including a face presented by a user are accessed. One or more determinations are made based on the multiple images, such as a determination of whether the face included in the multiple images is a 3-dimensional structure or a flat surface and/or a determination of whether motion is present in one or more face components (e.g., eyes or mouth). If it is determined that the face included in the multiple images is a 3-dimensional structure or that that motion is present in the one or more face components, then an indication is provided that the user can be authenticated. However, if it is determined that the face included in the multiple images is a flat surface or that motion is not present in the one or more face components, then an indication is provided that the user cannot be authenticated. [Abstract]</p>

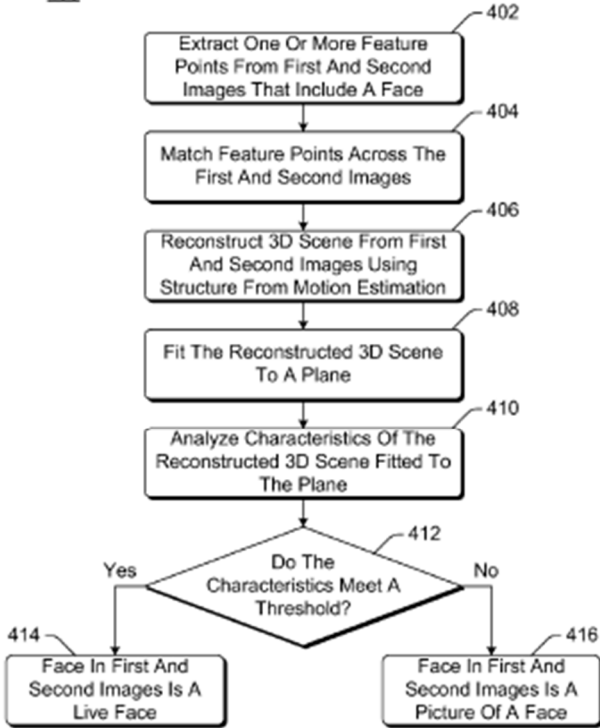
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	<p>Image capture component 102 captures multiple images 106 each including a face presented by a user 108, and makes images 106 available to live face detection module 104. Image capture component 102 can capture images 106 in a variety of different manners, such as using various digital imaging technologies (e.g., charge-coupled devices (CCDs), complementary metal-oxide-semiconductor (CMOS) sensors, and so forth). [0016]</p> <p>These multiple images can be images including a live face or images including a picture of a face. The multiple images are images that have been captured by an image capture component (e.g., image capture component 102 of FIG. 1). [0021]</p> <p>In one or more embodiments, the first and second images in process 300 are adjacent images in a sequence of three or more images. For example, multiple images (such as 30 or 60 images) can be accessed by the 3D structure determination module implementing process 300. Assume the multiple images are, in their order of capture, image 1, image 2, image 3, image 4, . . . image z. The first and second images in process 300 can be adjacent or sequential images in the sequence of multiple images, such as image 1 and image 2, image 4 and image 5, and so forth. Alternatively, the first and second images in process 300 can be non-adjacent images, having one or more intervening images between them in the sequence of images. For example, the first and second images in process 300 can be image 1 and image 10, image 12 and image 37, and so forth.</p> <p>Additionally, even if the first and second images in process 300 are not adjacent or sequential images in the sequence, at least part of process 300 can be performed for each adjacent pair of images in the sequence. For example, the feature point extraction and feature point matching in acts 302 and 304 can be generated for each adjacent pair of images in the sequence, which can facilitate the feature matching process when matching features across two images with one or more intervening images. [0035-0036]</p>

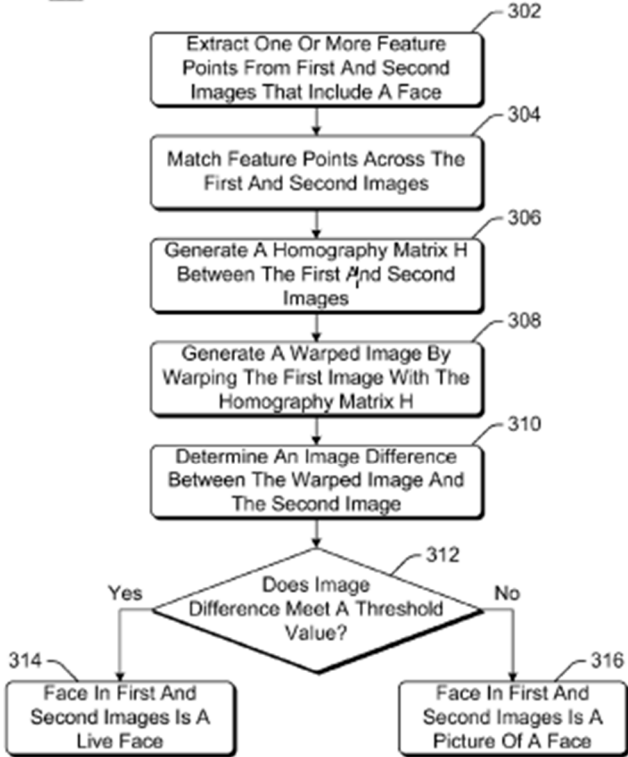
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<p>[606.1(d)] processing the at least one second image to obtain second biometric data based on the at least one second image;</p>	<p>Zhang discloses processing the at least one second image to obtain second biometric data based on the at least one second image.</p>

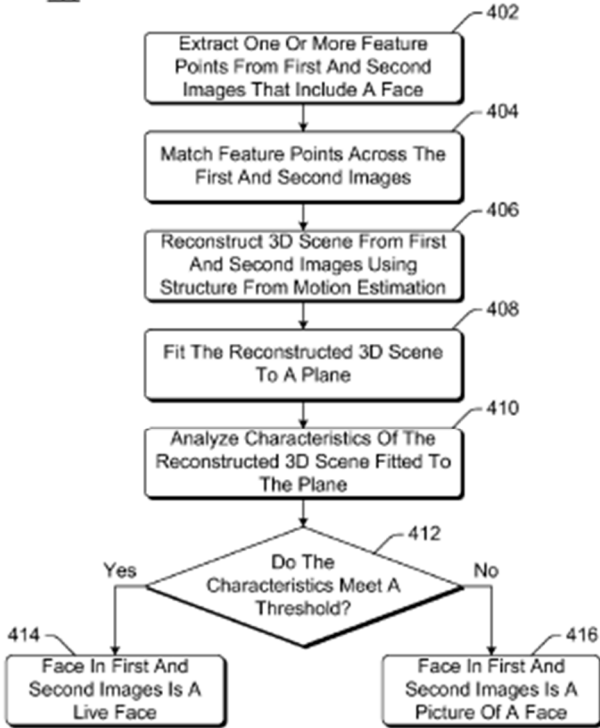
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	<p>forth. Each feature point is a single pixel or a region of multiple pixels. [0041]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the BIOMETRIC DATA references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.1(e)] comparing the first biometric data with the second biometric data to determine whether the first biometric data matches the second biometric data;</p>	<p>Zhang discloses comparing the first biometric data with the second biometric data to determine whether the first biometric data matches the second biometric data.</p>

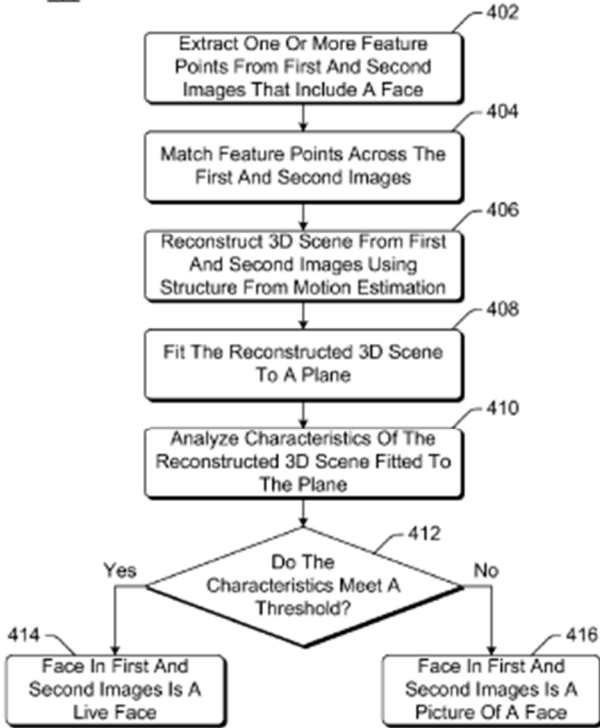
Asserted Claims of the '606 Patent	Prior Art
	<p data-bbox="657 337 695 358">300</p>  <pre> graph TD 302[Extract One Or More Feature Points From First And Second Images That Include A Face] --> 304[Match Feature Points Across The First And Second Images] 304 --> 306[Generate A Homography Matrix H Between The First And Second Images] 306 --> 308[Generate A Warped Image By Warping The First Image With The Homography Matrix H] 308 --> 310[Determine An Image Difference Between The Warped Image And The Second Image] 310 --> 312{Does Image Difference Meet A Threshold Value?} 312 -- Yes --> 314[Face In First And Second Images Is A Live Face] 312 -- No --> 316[Face In First And Second Images Is A Picture Of A Face] </pre> <p data-bbox="863 1198 982 1247">Fig. 3</p> <p data-bbox="598 1325 695 1357">[Fig. 3]</p>

Asserted Claims of the '606 Patent	Prior Art
	<p data-bbox="661 337 695 358"><u>400</u></p>  <pre> graph TD 402[Extract One Or More Feature Points From First And Second Images That Include A Face] --> 404[Match Feature Points Across The First And Second Images] 404 --> 406[Reconstruct 3D Scene From First And Second Images Using Structure From Motion Estimation] 406 --> 408[Fit The Reconstructed 3D Scene To A Plane] 408 --> 410[Analyze Characteristics Of The Reconstructed 3D Scene Fitted To The Plane] 410 --> 412{Do The Characteristics Meet A Threshold?} 412 -- Yes --> 414[Face In First And Second Images Is A Live Face] 412 -- No --> 416[Face In First And Second Images Is A Picture Of A Face] </pre> <p data-bbox="856 1166 976 1214">Fig. 4</p> <p data-bbox="598 1295 695 1328">[Fig. 4]</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>Returning to FIG. 1, in one or more embodiments 3D structure determination module 112 uses a homography based technique for determining whether a face included in images 106 is a 3D structure or a flat surface. Alternatively, other techniques can be used, such as a structure from motion estimation technique.</p> <p>The homography based technique uses a 3×3 homography matrix, also referred to herein as matrix H. The homography based technique leverages the fact that two views of a flat (planar) surface are related based on a homography matrix H. Accordingly, in analyzing a first image and a second image, the first image can be warped or transformed using the homography matrix H to generate a warped image. The warped image is then compared to the second image. If the first and second images are views of a flat surface (e.g., a picture of a face), then the warped image will be similar to the second image. Thus, if the difference between the second image and the warped image is small (e.g., below a threshold value), then the first and second images include a face that is a flat surface rather than a live face. However, if the difference between the second image and the warped image is larger (e.g., at least a threshold value), then the first and second images include a facet that is a live face rather than a flat surface. [0024]-[0025]</p> <p>The feature points extracted in act 302 are matched across the first and second images (act 304). This matching of the feature points across the first and second images refers to identifying the locations of the same feature points in each of the two images. For example, the locations of the same corner of the same eye in the face in the first and second images are identified. The matching of feature points across the first and second images can be performed in a variety of different conventional manners, such as using template matching algorithms, feature matching algorithms, and so forth. After matching, matching feature points across the two images, and the corresponding pixels in the two images within those feature matching feature points, are known. [0028]</p> <p>In one or more embodiments, process 300 also determines whether the first and second images include the same face. This determination can be performed in a variety of different manners. For example, during the matching of feature points in act 304, if all (or at least a threshold number) of the feature points cannot be matched then it is determined that the first and second</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>images are of different faces. By way of another example, a variety of different conventional face recognition techniques can be used to recognize whether the faces in the first and second images are the same person. If it is determined that the first and second images do not include the same face, then various remedial measures can be taken, such as stopping process 300 for the first and second images (but optionally repeating process 300 for other images), indicating that the face in the first and second images is a picture of a face in act 316, and so forth. [0038]</p> <p>The feature points extracted in act 402 are matched across the first and second images (act 404). This matching of the feature points across the first and second images refers to identifying the locations of the same feature points in each of the two images. For example, the locations of the same corner of the same eye in the face in the first and second images are identified. [0042]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the COMPARING IMAGES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.1(f)] comparing the first biometric data to second biometric data to determine whether differences between the at least one first image and the at least one second image match</p>	<p>Zhang discloses comparing the first biometric data to second biometric data to determine whether differences between the at least one first image and the at least one second image match expected differences resulting from movement of the camera or the user which changed the distance between the user and camera from the first distance to the second distance.</p>

Asserted Claims of the '606 Patent	Prior Art
<p>expected differences resulting from movement of the camera or the user which changed the distance between the user and camera from the first distance to the second distance;</p>	<div data-bbox="611 332 1234 1110"> <p>300</p> <pre> graph TD 302[Extract One Or More Feature Points From First And Second Images That Include A Face] --> 304[Match Feature Points Across The First And Second Images] 304 --> 306[Generate A Homography Matrix H Between The First And Second Images] 306 --> 308[Generate A Warped Image By Warping The First Image With The Homography Matrix H] 308 --> 310[Determine An Image Difference Between The Warped Image And The Second Image] 310 --> 312{Does Image Difference Meet A Threshold Value?} 312 -- Yes --> 314[Face In First And Second Images Is A Live Face] 312 -- No --> 316[Face In First And Second Images Is A Picture Of A Face] </pre> </div> <p style="text-align: center;">Fig. 3</p> <p>[Fig. 3]</p>

Asserted Claims of the '606 Patent	Prior Art
	<p data-bbox="661 337 695 358"><u>400</u></p>  <pre> graph TD 402[Extract One Or More Feature Points From First And Second Images That Include A Face] --> 404[Match Feature Points Across The First And Second Images] 404 --> 406[Reconstruct 3D Scene From First And Second Images Using Structure From Motion Estimation] 406 --> 408[Fit The Reconstructed 3D Scene To A Plane] 408 --> 410[Analyze Characteristics Of The Reconstructed 3D Scene Fitted To The Plane] 410 --> 412{Do The Characteristics Meet A Threshold?} 412 -- Yes --> 414[Face In First And Second Images Is A Live Face] 412 -- No --> 416[Face In First And Second Images Is A Picture Of A Face] </pre> <p data-bbox="856 1166 976 1214">Fig. 4</p> <p data-bbox="598 1295 695 1328">[Fig. 4]</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>Returning to FIG. 1, in one or more embodiments 3D structure determination module 112 uses a homography based technique for determining whether a face included in images 106 is a 3D structure or a flat surface. Alternatively, other techniques can be used, such as a structure from motion estimation technique.</p> <p>The homography based technique uses a 3×3 homography matrix, also referred to herein as matrix H. The homography based technique leverages the fact that two views of a flat (planar) surface are related based on a homography matrix H. Accordingly, in analyzing a first image and a second image, the first image can be warped or transformed using the homography matrix H to generate a warped image. The warped image is then compared to the second image. If the first and second images are views of a flat surface (e.g., a picture of a face), then the warped image will be similar to the second image. Thus, if the difference between the second image and the warped image is small (e.g., below a threshold value), then the first and second images include a face that is a flat surface rather than a live face. However, if the difference between the second image and the warped image is larger (e.g., at least a threshold value), then the first and second images include a facet that is a live face rather than a flat surface. [0024]-[0025]</p>

[0029] A homography matrix H between the first and second images is generated (act 306). The first and second images are related by the homography matrix H as follows:

$$\tilde{x}' = \lambda H \tilde{x}$$

where $\tilde{x}$ refers to a location in the first image, $\tilde{x}'$ refers to a location in the second image, H refers to a homography matrix, and λ refers to a non-zero scalar value. A location in the first image is represented as $[u, v]^T$, where u and v are the coordinates of the location in the first image. A location in the second image is represented as $[u', v']^T$, where u' and v' are the coordinates of the location in the second image. When calculating the homography matrix H , $\tilde{x} = [u, v, 1]^T$ and $\tilde{x}' = [u', v', 1]^T$. Given two locations in the two images and with z being the location in the first of the two images, a homography matrix H is calculated by determining a homography matrix H for which the difference between $\tilde{x}'$ as calculated by $\tilde{x}' = \lambda H \tilde{x}$ and the actual location in the second image is small. This homography matrix can be determined in different manners, such as using any of a variety of conventional algorithms to determine that the difference between $\tilde{x}'$ as calculated by $\tilde{x}' = \lambda H \tilde{x}$ and the actual location in the second image is minimized, is below a threshold value, and so forth. In one or more embodiments, the homography matrix can be determined from 4 or more pairs of corresponding locations in the two images, as described below. Let $\{(x_i, x'_i) | i=1, \dots, N\}$ be the N pairs ($N \geq 4$). Each pair gives an equation $\tilde{x}'_i = \lambda_i H \tilde{x}_i$. Eliminating the unknown scalar factor λ_i yields two scalar equations:

$$\tilde{x}_i^T h_1 - u_i' \tilde{x}_i^T h_3 = 0$$

$$\tilde{x}_i^T h_2 - v_i' \tilde{x}_i^T h_3 = 0$$

Asserted Claims of the '606 Patent	Prior Art
	<p>where $h_j=[H_{j1},H_{j2},H_{j3}]^T$ is the j-th row vector of the homography matrix H. In matrix form: $B_i h=0$, where $h=[H_{11}, H_{12}, H_{13}, \dots, H_{33}]^T$ is a 9-D vector consisting of the unknown homography elements, and</p> $B_i = \begin{bmatrix} \tilde{x}_i^T & 0 & -u'_i \tilde{x}_i^T \\ 0 & \tilde{x}_i^T & -v'_i \tilde{x}_i^T \end{bmatrix}$ <p>is a 2×9 matrix. With N pairs, a $2N \times 9$ matrix B is formed by stacking all B_i's, and an equation $Bh=0$ is obtained. As h is defined up to a scale factor, the solution is well known to be the eigenvector of the 9×9 matrix $B^T B$ associated with the smallest eigenvalue. This solution includes the elements of homography matrix H (the eigenvector of the solution) to be used in warping the first image as discussed below.</p> <p>[0029]</p>

	<p>[0030] A warped image is then generated by warping the first image with the homography matrix H (act 308). This homography matrix H is the homography matrix H generated in act 306. The first image is warped based on the calculation $y = \lambda H \tilde{x}$ (which is the same as $\tilde{x}' = \lambda H \tilde{x}$, except that y refers to the warped image so y is being used instead of $\tilde{x}'$). Each pixel in the first image has a value $\tilde{x}$ that is used to calculate a value y using $y = H \tilde{x}$. The value y is a vector, and the first and second elements of y are each divided by the third element of y to obtain a location of a pixel in the warped image. In other words, for a value $y = [y_1, y_2, y_3]$, the location of the pixel in the warped image is</p>
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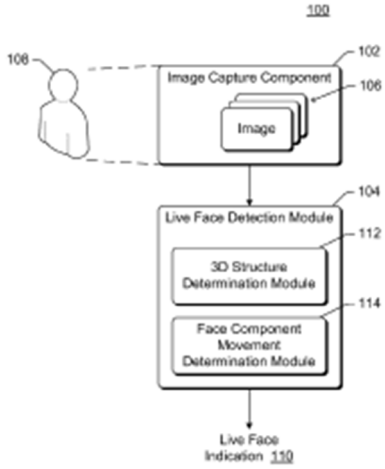
Asserted Claims of the '606 Patent	Prior Art
	$\left[\frac{y_1}{y_3}, \frac{y_2}{y_3} \right].$ <p>The intensity or color of the pixel in the first image (having the value $\tilde{x}$) is then applied to the pixel at the location</p> $\left[\frac{y_1}{y_3}, \frac{y_2}{y_3} \right]$ <p>in the warped image. These intensities or colors of pixels can be represented in a variety of different manners, such as using conventional RGB values, conventional CMYK values, and so forth.</p> <p>[0030]</p> <p>An image difference between the warped image (generated in act 308) and the second image is determined (act 310). The image difference can be computed in different manners. In one or more embodiments, the warped image and the second image are superimposed and the difference in color or intensity values at the same pixels (locations) in the two images is determined. In other words, for each location $[u,v]$ in the warped image, the difference between the color or intensity value at the location $[u,v]$ in the warped image and the location $[u,v]$ in</p>

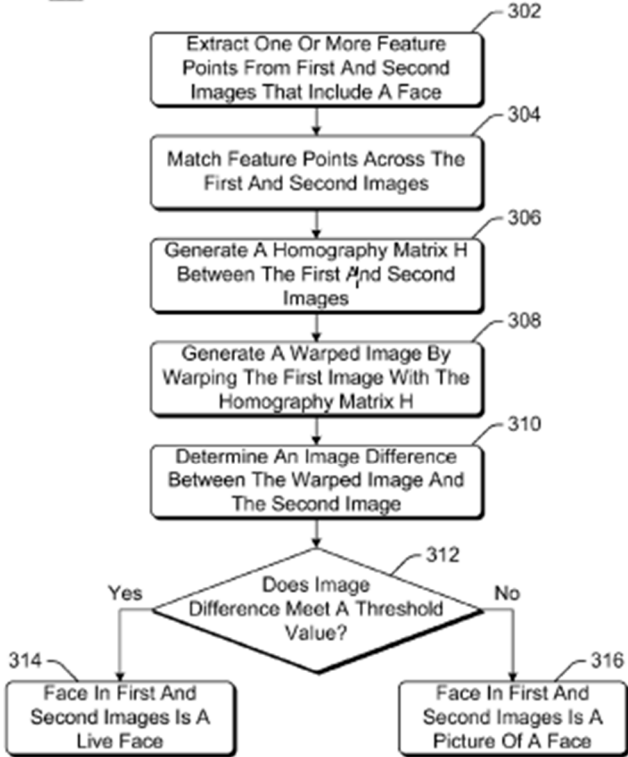
Asserted Claims of the '606 Patent	Prior Art
	<p>the second image is determined. The differences determined for these different locations are then combined to generate the image difference. [0031]</p> <p>A determination is then made as to whether the image difference determined in act 310 meets a threshold value (act 312). The image difference can meet the threshold value by, for example, being greater than the threshold value, being greater than or equal to the threshold value, and so forth. This threshold value can be, for example 10 in situations where the color values can be one of 256 gray levels. This threshold value can be a fixed value (e.g., 10 gray levels) or can be a relative value (e.g., 5% of the number of possible color or intensity values). [0033]</p> <p>If the image difference meets the threshold value, then the face in the first and second images is determined to be a live face (act 314). However, if the image difference does not meet the threshold value, then the face in the first and second images is determined to be a flat surface and thus a picture of a face (act 316). [0034]</p> <p>A 3D scene is reconstructed from the first and second images using structure from motion estimation (act 406). This reconstructed 3D scene is a 3-dimensional description of the scene represented by the first and second images based on estimated motion between the first and second images. The reconstructed 3D scene can be generated in a variety of different conventional manners using well-known structure from motion estimation and stereoscopic vision technology techniques. Such structure from motion estimation and stereoscopic vision technology techniques are based on the matching feature points in act 404. [0043]</p> <p>Characteristics of the reconstructed 3D scene fitted to the plane (generated in act 408) are analyzed (act 410). The characteristics can be analyzed in different manners, such as by comparing ratios of various facial components or feature points to one another. These various facial components or feature points can be, for example, eyes, corners of eyes, corners of mouths, noses, tips of noses, and so forth. For example, the characteristics can be analyzed by obtaining a first value that is a maximum distance from a particular feature (e.g., tip of a nose) in the reconstructed 3D scene to the plane, a second value that is the distance between two</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>facial components on the plane (e.g., the distance between the eyes or between the corners of the eyes), and calculating a ratio of the first value to a second value. [0045]</p> <p>A determination is then made as to whether the analyzed characteristics in act 410 meet a threshold (act 412). The characteristics can meet the threshold by, for example, being greater than a threshold value, being greater than or equal to a threshold value, and so forth. This threshold can be a fixed value (e.g., the ratio of the first value to the second value from act 410 is greater than 10%) or a relative value (e.g., the ratio of the first value to the second value from act 410 is greater than 5% of the second value).</p> <p>If the analyzed characteristics meet the threshold value, then the face in the first and second images is determined to be a live face (act 414). However, if the analyzed characteristics do not meet the threshold value, then the face in the first and second images is determined to be a flat surface and thus a picture of a face (act 416). [0046-0047]</p> <p>In process 500, a face component is extracted from multiple images that include a face (act 502). These first and second images include a face, and can be, for example, images 106 of FIG. 1. A face component can be a variety of different parts of a face, and typically is a part of a face that is expected to change over short durations of time. In one or more embodiments a face component is one or both eyes, which are typically expected to change over short durations of time, for example as the person blinks or looks at different objects. In other embodiments, a face component is a mouth, which is typically expected to change over short durations of time, for example as the person talks. Alternatively, other face components can be extracted in act 502. [0053]</p> <p>The face component extracted in act 502 is matched across the multiple images (act 504). This matching of the face component across the multiple images refers to identifying the locations of the same face component in each of the multiple images. For example, the locations of the same eye in the face in the multiple images are identified. The matching of a face component across the multiple images can be performed in a variety of different conventional manners, and in one</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>or more embodiments is performed using the same or similar techniques as are used to match feature points across images discussed above with respect to act 304 of FIG. 3. [0054]</p> <p>A check is then made as to whether motion is present in the face component (act 506). Whether motion is present in the face component can be determined in a variety of different manners. [0055]</p> <p>In one or more embodiments, a face component difference between the face components in two images is generated. The difference between the face components in two images can be determined by, for example, superimposing the face components of the two images and determining the difference in color or intensity values at the same pixels (locations) of the face components, analogous to the determination of the image difference discussed above with reference to act 310 in FIG. 3. [0056]</p> <p>In one or more embodiments, the determination of whether motion is present in the face component in act 506 is made by analyzing (e.g., and determining a face component difference between face components of) two adjacent images in a sequence of three or more images. For example, multiple images (such as 30 or 60 images) can be accessed by the face component movement determination module implementing process 500. Assume the multiple images are, in their order of capture, image 1, image 2, image 3, image 4, . . . image z. The two images that are analyzed (e.g., and for which the face component difference is determined) in act 506 can be adjacent or sequential images in the sequence of multiple images, such as image 1 and image 2, image 4 and image 5, and so forth. Alternatively, the two images that are analyzed (e.g., and for which the face component difference is determined in act 506) can be non-adjacent images, having one or more intervening images between them in the sequence of images. For example, the two images that are analyzed in act 506 can be image 1 and image 9, image 18 and image 39, and so forth. [0060]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with</i></p>

Asserted Claims of the '606 Patent	Prior Art
	<p><i>the disclosures contained in any one or more of the COMPARING IMAGES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.1(g)] determining that the user's face is three-dimensional when:</p>	<p>Zhang discloses determining that the user's face is three-dimensional.</p> <p>Multiple images including a face presented by a user are accessed. One or more determinations are made based on the multiple images, such as a determination of whether the face included in the multiple images is a 3-dimensional structure or a flat surface and/or a determination of whether motion is present in one or more face components (e.g., eyes or mouth). If it is determined that the face included in the multiple images is a 3-dimensional structure or that that motion is present in the one or more face components, then an indication is provided that the user can be authenticated. However, if it is determined that the face included in the multiple images is a flat surface or that motion is not present in the one or more face components, then an indication is provided that the user cannot be authenticated. [Abstract]</p>

Asserted Claims of the '606 Patent	Prior Art
	 <p style="text-align: center;">Fig. 1</p> <p style="text-align: center;">[Fig. 1]</p>

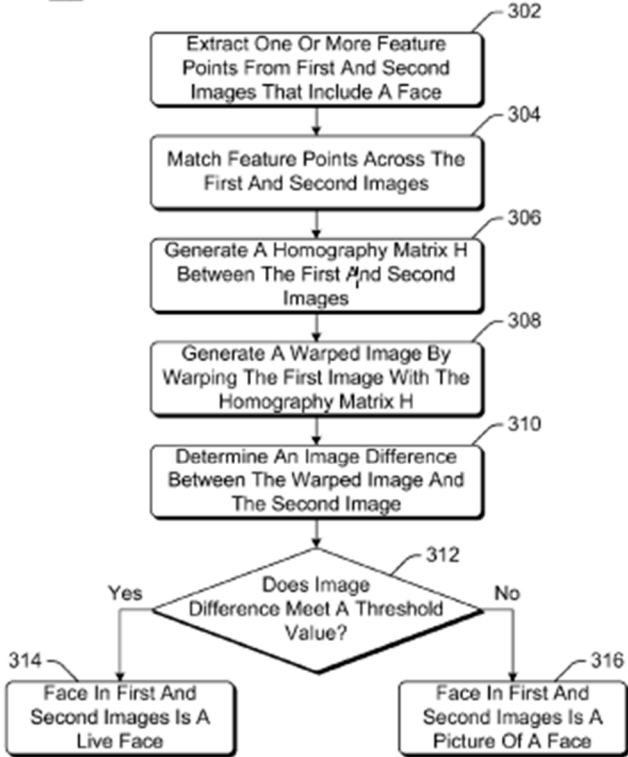
Asserted Claims of the '606 Patent	Prior Art
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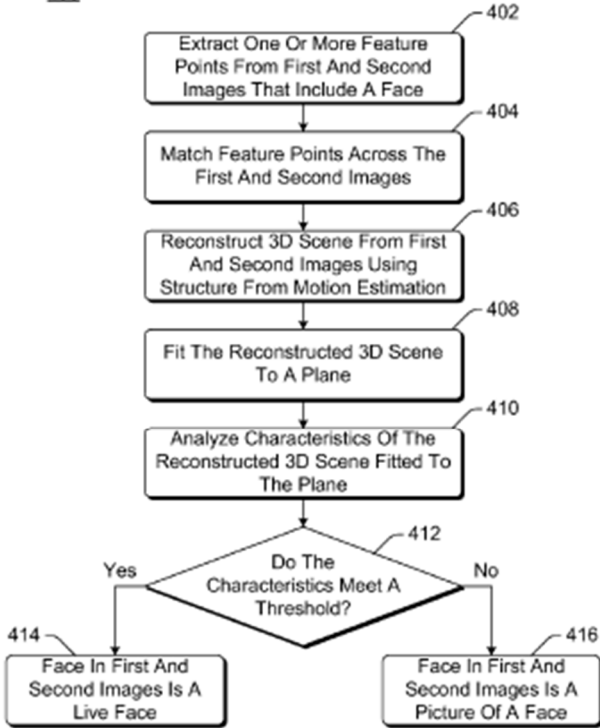
Asserted Claims of the '606 Patent	Prior Art
	<p>In accordance with one or more aspects, multiple images including a face presented by a user are accessed. A determination is made, based on the multiple images, of whether the face included in the multiple images is a 3-dimensional (3D) structure or a flat surface. If it is determined that the face included in the multiple images is a 3-dimensional structure, then an indication is provided that the user can be authenticated. However, if it is determined that the face included in the multiple images is a flat surface, then an indication is provided that the user cannot be authenticated.</p> <p>In accordance with one or more aspects, multiple images including a face presented by a user are accessed. A determination is made, based on the multiple images, of whether motion is present in one or more components (e.g., eyes, mouth, etc.) of the face. If it is determined that motion is present in the one or more components of the face, then an indication is provided that the user can be authenticated. However, if it is determined that motion is not present in the one or more components of the face, then an indication is provided that the user cannot be authenticated. [0003]-[0004]</p> <p>Distinguishing live faces from flat surfaces is discussed herein. In order to authenticate a user for particular access (e.g., to a computer or network, to a building or other location, etc.), multiple images of a face presented by the user are captured and analyzed. The face presented by the user can be the user's actual face, or could be a picture of a face of the user that is presented by an imposter. An attempt is made to determine whether the images include a live face (e.g., the captured images are of a live human being) or a picture of a face. If it is determined that the images include a live face, then it is assumed that the face presented by the user is the face of the actual user that is requesting the particular access, and the user can be authenticated for access. However, if it is determined that the images include a picture, then it is assumed that the face presented by the user is the face of an imposter using a picture, and the user cannot be authenticated for access. [0012]</p> <p>Live face detection module 104 analyzes images 106 to determine whether images 106 include a live face or a picture of a face, and outputs an indication 110 of whether images 106 include a live face or a picture of a face. Indication 110 can be, for example, a first value to indicate</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>images 106 include a live face (e.g., “live”, “yes”, “authenticate”, etc.) and a second value to indicate images 106 include a picture of a face (e.g., “picture”, “no”, “do not authenticate”, etc.). A live face refers to the face of an actual human being (i.e., image capture component 102 captured images of an actual human being), rather than a picture of the face of a human being. If detection module 104 determines that images 106 include a live face, then live face indication 110 indicates that images 106 include a live face. In such situations, live face indication 110 indicates that user 108 can be authenticated for access (e.g., to whatever system, resource, location, etc. that user 108 is requesting access) because it is assumed that the actual human being that is user 108 is requesting particular access. The authentication of user 108 can be performed by another component or module (not shown) in a variety of different manners, such as by comparing one or more of images 106 to previously captured images of user 108. Alternatively, the authentication can be performed prior to the live face detection performed by module 104, in which case live face indication 110 indicates that any previous authentication of user 108 is valid. [0017]</p> <p>Live face detection module 104 can determine whether images 106 include a live face or a picture of a face in a variety of different manners. In one or more embodiments, live face detection module 104 includes one or both of a 3-dimensional (3D) structure determination module 112 and a face component movement determination module 114. Generally, 3D structure determination module 112 determines whether images 106 include a face that is a 3D structure (e.g., an actual human being) or a flat surface (e.g., a photograph), and face component movement determination module 114 determines whether motion is present in one or more components of the face in images 106. The manner in which these determinations are made by modules 112 and 114 is discussed in more detail below. [0019]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the AUTHENTICATION BASED ON IMAGE DIFFERENCES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these</i></p>

FACETEC, INC. v. IPROOV LTD
CASE No. 2:21-02252-ART-BNW
EXHIBIT 606-C

Asserted Claims of the '606 Patent	Prior Art
	<i>combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i>
[606.1(g)(i)] the first biometric data does not match the second biometric data; and	Zhang discloses the first biometric data does not match the second biometric data.

Asserted Claims of the '606 Patent	Prior Art
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Asserted Claims of the '606 Patent	Prior Art
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[0029] A homography matrix H between the first and second images is generated (act 306). The first and second images are related by the homography matrix H as follows:

$$\tilde{x}' = \lambda H \tilde{x}$$

where $\tilde{x}$ refers to a location in the first image, $\tilde{x}'$ refers to a location in the second image, H refers to a homography matrix, and λ refers to a non-zero scalar value. A location in the first image is represented as $[u, v]^T$, where u and v are the coordinates of the location in the first image. A location in the second image is represented as $[u', v']^T$, where u' and v' are the coordinates of the location in the second image. When calculating the homography matrix H , $\tilde{x} = [u, v, 1]^T$ and $\tilde{x}' = [u', v', 1]^T$. Given two locations in the two images and with z being the location in the first of the two images, a homography matrix H is calculated by determining a homography matrix H for which the difference between $\tilde{x}'$ as calculated by $\tilde{x}' = \lambda H \tilde{x}$ and the actual location in the second image is small. This homography matrix can be determined in different manners, such as using any of a variety of conventional algorithms to determine that the difference between $\tilde{x}'$ as calculated by $\tilde{x}' = \lambda H \tilde{x}$ and the actual location in the second image is minimized, is below a threshold value, and so forth. In one or more embodiments, the homography matrix can be determined from 4 or more pairs of corresponding locations in the two images, as described below. Let $\{(x_i, x'_i) | i=1, \dots, N\}$ be the N pairs ($N \geq 4$). Each pair gives an equation $\tilde{x}'_i = \lambda_i H \tilde{x}_i$. Eliminating the unknown scalar factor λ_i yields two scalar equations:

$$\tilde{x}_i^T h_1 - u_i' \tilde{x}_i^T h_3 = 0$$

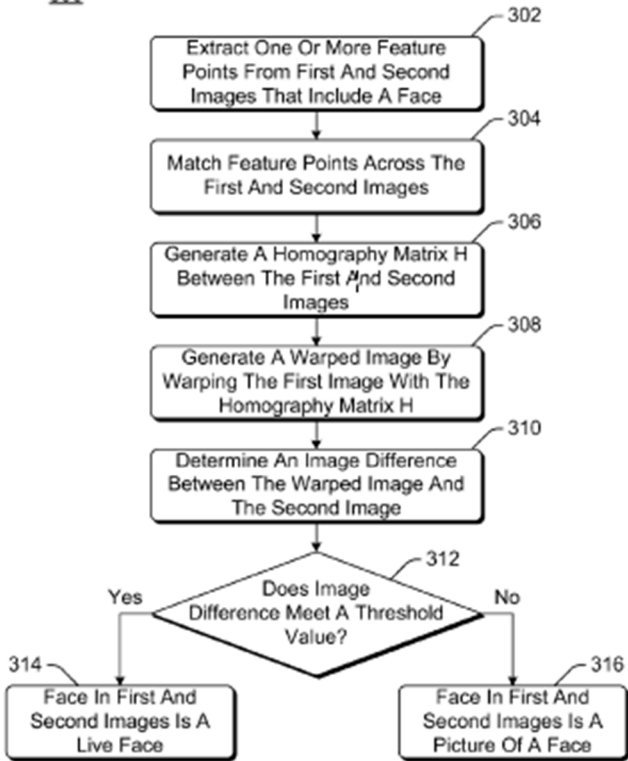
$$\tilde{x}_i^T h_2 - v_i' \tilde{x}_i^T h_3 = 0$$

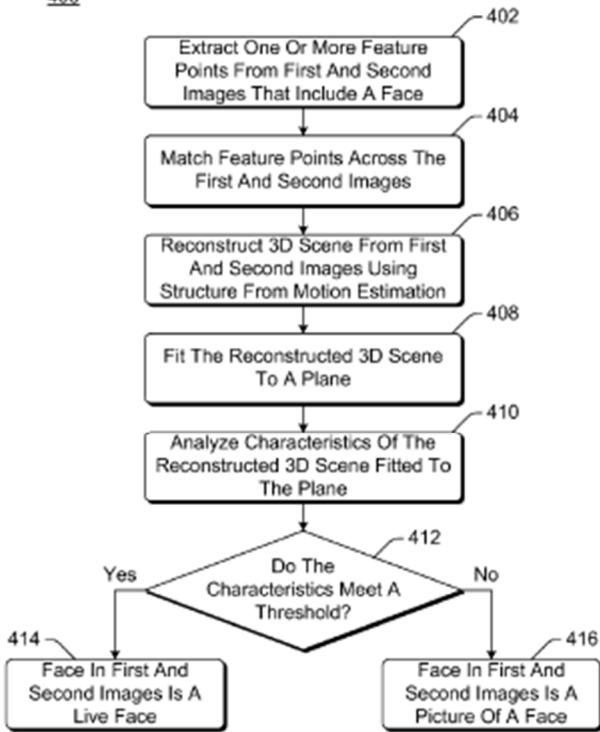
Asserted Claims of the '606 Patent	Prior Art
	<p>where $h_j = [H_{j1}, H_{j2}, H_{j3}]^T$ is the j-th row vector of the homography matrix H. In matrix form: $B_i h = 0$, where $h = [H_{11}, H_{12}, H_{13}, \dots, H_{33}]^T$ is a 9-D vector consisting of the unknown homography elements, and</p> $B_i = \begin{bmatrix} \tilde{x}_i^T & 0 & -u'_i \tilde{x}_i^T \\ 0 & \tilde{x}_i^T & -v'_i \tilde{x}_i^T \end{bmatrix}$ <p>is a 2×9 matrix. With N pairs, a $2N \times 9$ matrix B is formed by stacking all B_i's, and an equation $Bh = 0$ is obtained. As h is defined up to a scale factor, the solution is well known to be the eigenvector of the 9×9 matrix $B^T B$ associated with the smallest eigenvalue. This solution includes the elements of homography matrix H (the eigenvector of the solution) to be used in warping the first image as discussed below.</p> <p>[0029]</p>

	<p>[0030] A warped image is then generated by warping the first image with the homography matrix H (act 308). This homography matrix H is the homography matrix H generated in act 306. The first image is warped based on the calculation $y = \lambda H \tilde{x}$ (which is the same as $\tilde{x}' = \lambda H \tilde{x}$, except that y refers to the warped image so y is being used instead of $\tilde{x}'$). Each pixel in the first image has a value $\tilde{x}$ that is used to calculate a value y using $y = H \tilde{x}$. The value y is a vector, and the first and second elements of y are each divided by the third element of y to obtain a location of a pixel in the warped image. In other words, for a value $y = [y_1, y_2, y_3]$, the location of the pixel in the warped image is</p>
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Asserted Claims of the '606 Patent	Prior Art
	$\left[\frac{y_1}{y_3}, \frac{y_2}{y_3} \right].$ <p>The intensity or color of the pixel in the first image (having the value $\tilde{x}$) is then applied to the pixel at the location</p> $\left[\frac{y_1}{y_3}, \frac{y_2}{y_3} \right]$ <p>in the warped image. These intensities or colors of pixels can be represented in a variety of different manners, such as using conventional RGB values, conventional CMYK values, and so forth.</p> <p>[0030]</p> <p>An image difference between the warped image (generated in act 308) and the second image is determined (act 310). The image difference can be computed in different manners. In one or more embodiments, the warped image and the second image are superimposed and the difference in color or intensity values at the same pixels (locations) in the two images is determined. In other words, for each location $[u,v]$ in the warped image, the difference between the color or intensity value at the location $[u,v]$ in the warped image and the location $[u,v]$ in</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>the second image is determined. The differences determined for these different locations are then combined to generate the image difference. [0031]</p> <p>If the image difference meets the threshold value, then the face in the first and second images is determined to be a live face (act 314). However, if the image difference does not meet the threshold value, then the face in the first and second images is determined to be a flat surface and thus a picture of a face (act 316). [0034]</p> <p>If it is determined that the first and second images do not include the same face, then various remedial measures can be taken, such as stopping process 300 for the first and second images (but optionally repeating process 300 for other images), indicating that the face in the first and second images is a picture of a face in act 316, and so forth. [0038]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the AUTHENTICATION BASED ON IMAGE DIFFERENCES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
[606.1(g)(ii)] the second biometric data has the expected differences as compared to the first biometric data resulting from the change in distance	Zhang discloses the second biometric data has the expected differences as compared to the first biometric data resulting from the change in distance between the user and the camera when capturing the at least one first image and the at least one second image.

Asserted Claims of the '606 Patent	Prior Art
<p>between the user and the camera when capturing the at least one first image and the at least one second image.</p>	<p>300</p>  <pre> graph TD 302[Extract One Or More Feature Points From First And Second Images That Include A Face] --> 304[Match Feature Points Across The First And Second Images] 304 --> 306[Generate A Homography Matrix H Between The First And Second Images] 306 --> 308[Generate A Warped Image By Warping The First Image With The Homography Matrix H] 308 --> 310[Determine An Image Difference Between The Warped Image And The Second Image] 310 --> 312{Does Image Difference Meet A Threshold Value?} 312 -- Yes --> 314[Face In First And Second Images Is A Live Face] 312 -- No --> 316[Face In First And Second Images Is A Picture Of A Face] </pre> <p>Fig. 3</p> <p>[Fig. 3]</p>

Asserted Claims of the '606 Patent	Prior Art
	<p style="text-align: center;">400</p>  <pre> graph TD 402[Extract One Or More Feature Points From First And Second Images That Include A Face] --> 404[Match Feature Points Across The First And Second Images] 404 --> 406[Reconstruct 3D Scene From First And Second Images Using Structure From Motion Estimation] 406 --> 408[Fit The Reconstructed 3D Scene To A Plane] 408 --> 410[Analyze Characteristics Of The Reconstructed 3D Scene Fitted To The Plane] 410 --> 412{Do The Characteristics Meet A Threshold?} 412 -- Yes --> 414[Face In First And Second Images Is A Live Face] 412 -- No --> 416[Face In First And Second Images Is A Picture Of A Face] </pre> <p style="text-align: center;">Fig. 4</p> <p style="text-align: center;">[Fig. 4]</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>Returning to FIG. 1, in one or more embodiments 3D structure determination module 112 uses a homography based technique for determining whether a face included in images 106 is a 3D structure or a flat surface. Alternatively, other techniques can be used, such as a structure from motion estimation technique.</p> <p>The homography based technique uses a 3×3 homography matrix, also referred to herein as matrix H. The homography based technique leverages the fact that two views of a flat (planar) surface are related based on a homography matrix H. Accordingly, in analyzing a first image and a second image, the first image can be warped or transformed using the homography matrix H to generate a warped image. The warped image is then compared to the second image. If the first and second images are views of a flat surface (e.g., a picture of a face), then the warped image will be similar to the second image. Thus, if the difference between the second image and the warped image is small (e.g., below a threshold value), then the first and second images include a face that is a flat surface rather than a live face. However, if the difference between the second image and the warped image is larger (e.g., at least a threshold value), then the first and second images include a facet that is a live face rather than a flat surface. [0024]-[0025]</p>

[0029] A homography matrix H between the first and second images is generated (act 306). The first and second images are related by the homography matrix H as follows:

$$\tilde{x}' = \lambda H \tilde{x}$$

where $\tilde{x}$ refers to a location in the first image, $\tilde{x}'$ refers to a location in the second image, H refers to a homography matrix, and λ refers to a non-zero scalar value. A location in the first image is represented as $[u, v]^T$, where u and v are the coordinates of the location in the first image. A location in the second image is represented as $[u', v']^T$, where u' and v' are the coordinates of the location in the second image. When calculating the homography matrix H , $\tilde{x} = [u, v, 1]^T$ and $\tilde{x}' = [u', v', 1]^T$. Given two locations in the two images and with z being the location in the first of the two images, a homography matrix H is calculated by determining a homography matrix H for which the difference between $\tilde{x}'$ as calculated by $\tilde{x}' = \lambda H \tilde{x}$ and the actual location in the second image is small. This homography matrix can be determined in different manners, such as using any of a variety of conventional algorithms to determine that the difference between $\tilde{x}'$ as calculated by $\tilde{x}' = \lambda H \tilde{x}$ and the actual location in the second image is minimized, is below a threshold value, and so forth. In one or more embodiments, the homography matrix can be determined from 4 or more pairs of corresponding locations in the two images, as described below. Let $\{(x_i, x'_i) | i=1, \dots, N\}$ be the N pairs ($N \geq 4$). Each pair gives an equation $\tilde{x}'_i = \lambda_i H \tilde{x}_i$. Eliminating the unknown scalar factor λ_i yields two scalar equations:

$$\tilde{x}_i^T h_1 - u_i' \tilde{x}_i^T h_3 = 0$$

$$\tilde{x}_i^T h_2 - v_i' \tilde{x}_i^T h_3 = 0$$

Asserted Claims of the '606 Patent	Prior Art
	<p>where $h_j = [H_{j1}, H_{j2}, H_{j3}]^T$ is the j-th row vector of the homography matrix H. In matrix form: $B_i h = 0$, where $h = [H_{11}, H_{12}, H_{13}, \dots, H_{33}]^T$ is a 9-D vector consisting of the unknown homography elements, and</p> $B_i = \begin{bmatrix} \tilde{x}_i^T & 0 & -u'_i \tilde{x}_i^T \\ 0 & \tilde{x}_i^T & -v'_i \tilde{x}_i^T \end{bmatrix}$ <p>is a 2×9 matrix. With N pairs, a $2N \times 9$ matrix B is formed by stacking all B_i's, and an equation $Bh = 0$ is obtained. As h is defined up to a scale factor, the solution is well known to be the eigenvector of the 9×9 matrix $B^T B$ associated with the smallest eigenvalue. This solution includes the elements of homography matrix H (the eigenvector of the solution) to be used in warping the first image as discussed below.</p> <p>[0029]</p>

	<p>[0030] A warped image is then generated by warping the first image with the homography matrix H (act 308). This homography matrix H is the homography matrix H generated in act 306. The first image is warped based on the calculation $y = \lambda H \tilde{x}$ (which is the same as $\tilde{x}' = \lambda H \tilde{x}$, except that y refers to the warped image so y is being used instead of $\tilde{x}'$). Each pixel in the first image has a value $\tilde{x}$ that is used to calculate a value y using $y = H \tilde{x}$. The value y is a vector, and the first and second elements of y are each divided by the third element of y to obtain a location of a pixel in the warped image. In other words, for a value $y = [y_1, y_2, y_3]$, the location of the pixel in the warped image is</p>
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Asserted Claims of the '606 Patent	Prior Art
	$\left[\frac{y_1}{y_3}, \frac{y_2}{y_3} \right].$ <p>The intensity or color of the pixel in the first image (having the value $\tilde{x}$) is then applied to the pixel at the location</p> $\left[\frac{y_1}{y_3}, \frac{y_2}{y_3} \right]$ <p>in the warped image. These intensities or colors of pixels can be represented in a variety of different manners, such as using conventional RGB values, conventional CMYK values, and so forth.</p> <p>[0030]</p> <p>An image difference between the warped image (generated in act 308) and the second image is determined (act 310). The image difference can be computed in different manners. In one or more embodiments, the warped image and the second image are superimposed and the difference in color or intensity values at the same pixels (locations) in the two images is determined. In other words, for each location $[u,v]$ in the warped image, the difference between the color or intensity value at the location $[u,v]$ in the warped image and the location $[u,v]$ in</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>the second image is determined. The differences determined for these different locations are then combined to generate the image difference. [0031]</p> <p>If the image difference meets the threshold value, then the face in the first and second images is determined to be a live face (act 314). However, if the image difference does not meet the threshold value, then the face in the first and second images is determined to be a flat surface and thus a picture of a face (act 316). [0034]</p> <p>A 3D scene is reconstructed from the first and second images using structure from motion estimation (act 406). This reconstructed 3D scene is a 3-dimensional description of the scene represented by the first and second images based on estimated motion between the first and second images. The reconstructed 3D scene can be generated in a variety of different conventional manners using well-known structure from motion estimation and stereoscopic vision technology techniques. Such structure from motion estimation and stereoscopic vision technology techniques are based on the matching feature points in act 404. [0043]</p> <p>Characteristics of the reconstructed 3D scene fitted to the plane (generated in act 408) are analyzed (act 410). The characteristics can be analyzed in different manners, such as by comparing ratios of various facial components or feature points to one another. These various facial components or feature points can be, for example, eyes, corners of eyes, corners of mouths, noses, tips of noses, and so forth. For example, the characteristics can be analyzed by obtaining a first value that is a maximum distance from a particular feature (e.g., tip of a nose) in the reconstructed 3D scene to the plane, a second value that is the distance between two facial components on the plane (e.g., the distance between the eyes or between the corners of the eyes), and calculating a ratio of the first value to a second value. [0045]</p> <p>In process 500, a face component is extracted from multiple images that include a face (act 502). These first and second images include a face, and can be, for example, images 106 of FIG. 1. A face component can be a variety of different parts of a face, and typically is a part of a face that is expected to change over short durations of time. In one or more embodiments a</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>face component is one or both eyes, which are typically expected to change over short durations of time, for example as the person blinks or looks at different objects. In other embodiments, a face component is a mouth, which is typically expected to change over short durations of time, for example as the person talks. Alternatively, other face components can be extracted in act 502. [0053]</p> <p>The face component extracted in act 502 is matched across the multiple images (act 504). This matching of the face component across the multiple images refers to identifying the locations of the same face component in each of the multiple images. For example, the locations of the same eye in the face in the multiple images are identified. The matching of a face component across the multiple images can be performed in a variety of different conventional manners, and in one or more embodiments is performed using the same or similar techniques as are used to match feature points across images discussed above with respect to act 304 of FIG. 3. [0054]</p> <p>A check is then made as to whether motion is present in the face component (act 506). Whether motion is present in the face component can be determined in a variety of different manners. [0055]</p> <p>In one or more embodiments, a face component difference between the face components in two images is generated. The difference between the face components in two images can be determined by, for example, superimposing the face components of the two images and determining the difference in color or intensity values at the same pixels (locations) of the face components, analogous to the determination of the image difference discussed above with reference to act 310 in FIG. 3. [0056]</p> <p>In one or more embodiments, the determination of whether motion is present in the face component in act 506 is made by analyzing (e.g., and determining a face component difference between face components of) two adjacent images in a sequence of three or more images. For example, multiple images (such as 30 or 60 images) can be accessed by the face component movement determination module implementing process 500. Assume the multiple images are,</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>in their order of capture, image 1, image 2, image 3, image 4, . . . image z. The two images that are analyzed (e.g., and for which the face component difference is determined) in act 506 can be adjacent or sequential images in the sequence of multiple images, such as image 1 and image 2, image 4 and image 5, and so forth. Alternatively, the two images that are analyzed (e.g., and for which the face component difference is determined in act 506) can be non-adjacent images, having one or more intervening images between them in the sequence of images. For example, the two images that are analyzed in act 506 can be image 1 and image 9, image 18 and image 39, and so forth. [0060]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the AUTHENTICATION BASED ON IMAGE DIFFERENCES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.4] The method according to claim 1, wherein the computing device is configured to display one or more prompts on a screen of the computing device to guide the user to capture the at least one first image at the first distance</p>	<p>Zhang discloses the method of claim 1.</p> <p><i>See disclosures for claims 606.1 above.</i></p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the USER PROMPTS references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>

Asserted Claims of the '606 Patent	Prior Art
and the at least on second image at the second distance.	
[606.5] The method according to claim 4, wherein the one or more prompts are ovals sized on the screen within which the face of the user is placed to capture the at least one first image and the at least one second image at the first and second distances.;	<p>Zhang discloses the method of claim 4.</p> <p><i>See disclosures for claims 606.4 above.</i></p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the OVAL PROMPTS references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
[606.6] The method according to claim 4, wherein the computing device is a hand-held device, and the user holds the computing device at the first distance and the second distance to capture the at least one first image and the at least one second image.	<p>Zhang discloses the method of claim 4.</p> <p><i>See disclosures for claim 606.4 above.</i></p> <p>Zhang further discloses the computing device is a hand-held device, and the user holds the computing device at the first distance and the second distance to capture the at least one first image and the at least one second image.</p> <p>A variety of different types of computing devices can be used to implement image capture component 102 and live face detection module 104, such as a desktop computer, a laptop or notebook computer, a notepad computer, a mobile station, an entertainment appliance, a set-top box communicatively coupled to a display device, a television, a cellular or other wireless</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>phone, a digital camera or video camera, a game console, an automotive computer, and so forth. [0013]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the HAND-HELD DEVICES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.7] The method according to claim 6, wherein the computing device comprises a laptop or desktop computer and, with the computing device stationary, the user moves from the first distance to the second distance to capture the at least one first image and the at least one second image.</p>	<p>Zhang discloses the method of claim 6.</p> <p><i>See disclosures for claim 606.6 above.</i></p> <p>Zhang further the computing device comprises a laptop or desktop computer and, with the computing device stationary, the user moves from the first distance to the second distance to capture the at least one first image and the at least one second image.</p> <p>A variety of different types of computing devices can be used to implement image capture component 102 and live face detection module 104, such as a desktop computer, a laptop or notebook computer, a notepad computer, a mobile station, an entertainment appliance, a set-top box communicatively coupled to a display device, a television, a cellular or other wireless phone, a digital camera or video camera, a game console, an automotive computer, and so forth. [0013]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the LAPTOP OR DESKTOP COMPUTER DEVICES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person</i></p>

Asserted Claims of the '606 Patent	Prior Art
	<i>having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i>
[606.8] The method according to claim 1, further comprising displaying an image on a screen of the computing device while capturing the at least one first and/or the at least one second image.	<p>Zhang discloses the method of claim 1.</p> <p><i>See disclosures for claim 606.1 above.</i></p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the USER IMAGE references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
[606.9] The method according to claim 1, wherein the first biometric data and the second biometric data are transmitted over a network to a server.	<p>Zhang discloses the method of claim 1.</p> <p><i>See disclosures for claim 606.1 above.</i></p> <p>Zhang further discloses the first biometric data and the second biometric data are transmitted over a network to a server.</p> <p>Image capture component 102 and live face detection module 104 can be implemented as part of the same computing device or alternatively can be implemented as separate devices. When implemented as separate devices, the devices implementing image capture component 102 and live face detection module 104 can communicate with one another via any of a variety of different networks, such as the Internet, a local area network (LAN), a public telephone network, an intranet, other public and/or proprietary networks, combinations thereof, and so forth. Alternatively, when implemented as separate devices, the devices implementing image</p>

Asserted Claims of the '606 Patent	Prior Art
	<p>capture component 102 and live face detection module 104 can communicate with one another via other wired and/or wireless connection mechanisms, such as a universal serial bus (USB), wireless USB, Bluetooth, radio frequency, and so forth. [0014]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the SERVER-BASED SOLUTIONS references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.19(p)] A method for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device, the method comprising:</p>	<p>To the extent the preamble is limiting, Zhang discloses a method for verifying three-dimensionality of a user's face using images of the user's face captured using a camera equipped computing device.</p> <p><i>See disclosures for claim limitations 606.1(p) above.</i></p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the CAMERA-BASED 3D AUTHENTICATION references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.19(a)] receiving first biometric data generated from at least one first image</p>	<p>Zhang discloses receiving first biometric data generated from at least one first image of the user taken with the camera of the computing device located at a first distance from the user;</p> <p><i>See disclosures for claim limitations 606.1(a) and 606.1(b) above.</i></p>

Asserted Claims of the '606 Patent	Prior Art
of the user taken with the camera of the computing device located at a first distance from the user;	<i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the BIOMETRIC DATA references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i>
[606.19(b)] receiving second biometric data generated from at least one second image of the user taken with the camera of the computing device located at a second distance from the user, the second distance being different than the first distance;	<p>Zhang discloses receiving second biometric data generated from at least one second image of the user taken with the camera of the computing device located at a second distance from the user, the second distance being different than the first distance.</p> <p>See disclosures for claim limitations 606.1(c) and 606.1(d) above.</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the BIOMETRIC DATA references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
[606.19(c)] comparing the first biometric data with the second biometric data to determine whether the first biometric data	<p>Zhang discloses comparing the first biometric data with the second biometric data to determine whether the first biometric data matches the second biometric data.</p> <p>See disclosures for claim limitations 606.1(e) above.</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with</i></p>

Asserted Claims of the '606 Patent	Prior Art
matches the second biometric data; and	<i>the disclosures contained in any one or more of the COMPARING IMAGES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i>
[606.19(d)] comparing the first biometric data with second biometric data to determine whether differences between the at least one first image and the at least one second image match expected differences resulting from movement of the camera or the user which changes the distance between the user and camera for capture of the one or more first images at the first distance and capture of the one or more second images at the second distance;	<p>Zhang discloses comparing the first biometric data with second biometric data to determine whether differences between the at least one first image and the at least one second image match expected differences resulting from movement of the camera or the user which changes the distance between the user and camera for capture of the one or more first images at the first distance and capture of the one or more second images at the second distance.</p> <p><i>See disclosures for claim limitations 606.1(f) above.</i></p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the COMPARING IMAGES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>

Asserted Claims of the '606 Patent	Prior Art
<p>[606.19(e)] determining that the user's face is three-dimensional when:</p>	<p>Zhang discloses the determining that the user's face is three-dimensional.</p> <p><i>See disclosures for claim limitations 606.1(g) above.</i></p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the AUTHENTICATION BASED ON IMAGE DIFFERENCES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.19(e)(i)] the first biometric data is not identical to the second biometric data; and</p>	<p>Zhang discloses the first biometric data is not identical to the second biometric data.</p> <p><i>See disclosures for claim limitations 606.1(g)(i) above.</i></p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the AUTHENTICATION BASED ON IMAGE DIFFERENCES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.19(e)(ii)] the second biometric data has expected differences as</p>	<p>Zhang discloses the second biometric data has expected differences as compared to the first biometric data, the expected differences resulting from the change in distance between the user and the camera</p>

Asserted Claims of the '606 Patent	Prior Art
<p>compared to the first biometric data, the expected differences resulting from the change in distance between the user and the camera when the at least one first image was captured at the first distance and the at least one second image was captured at the second distance.</p>	<p>when the at least one first image was captured at the first distance and the at least one second image was captured at the second distance.</p> <p><i>See disclosures for claim limitations 606.1(g)(ii) above.</i></p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the AUTHENTICATION BASED ON IMAGE DIFFERENCES references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>
<p>[606.20] The method of claim 19, wherein the receiving of the first biometric data and the second biometric data occurs at a server and the first biometric data and the second biometric data are received over one or more of a LAN, WAN, or Internet type network.</p>	<p>Zhang discloses the method of claim 19.</p> <p><i>See disclosures for claim 606.9 above.</i></p> <p>Zhang further discloses receiving of the first biometric data and the second biometric data occurs at a server and the first biometric data and the second biometric data are received over one or more of a LAN, WAN, or Internet type network.</p> <p>Image capture component 102 and live face detection module 104 can be implemented as part of the same computing device or alternatively can be implemented as separate devices. When implemented as separate devices, the devices implementing image capture component 102 and live face detection module 104 can communicate with one another via any of a variety of different networks, such as the Internet, a local area network (LAN), a public telephone network, an intranet, other public and/or proprietary networks, combinations thereof, and so forth. Alternatively, when implemented as separate devices, the devices implementing image capture component 102 and live face detection module 104 can communicate with one another</p>

FACETEC, INC. v. IPROOV LTD
CASE No. 2:21-02252-ART-BNW
EXHIBIT 606-C

Asserted Claims of the '606 Patent	Prior Art
	<p>via other wired and/or wireless connection mechanisms, such as a universal serial bus (USB), wireless USB, Bluetooth, radio frequency, and so forth. [0014]</p> <p><i>To the extent this element is not disclosed, it would be obvious to combine the disclosures of the reference charted herein with the knowledge of a person having ordinary skill in the art alone, or with the disclosures contained in any one or more of the SERVER-BASED SOLUTIONS references (see cover document Section II.d.vii. for relevant disclosures in these references). A person having ordinary skill in the art would have been motivated to make these combinations for the reasons set forth in Section II.d. of the cover document to Defendant's Invalidity Contentions.</i></p>