illegitimate access to the device. Such replay attacks can be easily carried out with videos obtained from publicly available sources (e.g. social networking services).

[0001] Therefore, authentication methods relying on existing face recognition technology can be easily circumvented and are often vulnerable to attacks by adversaries, particularly if it takes little effort for adversaries to acquire and reproduce images and/or videos of the targeted person (e.g. a public figure). Nevertheless, authentication methods relying on face recognition technology can still provide a higher degree of convenience and better security compared to conventional forms of authentication, such as the use of passwords or personal identification numbers. Authentication methods relying on face recognition technology are also increasingly used in more ways on the mobile devices (e.g. as means to authorise payments facilitated by the devices or as an authentication means to gain access sensitive data, applications and/or services).

[0002] Accordingly, what is needed is system and method for adaptively constructing a three-dimensional facial model based on two or more inputs of a two-dimensional facial image that seek to address one or more of the above-mentioned problems. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

## Summary

[0003] An aspect provides a server for adaptively constructing a three-dimensional (3D) facial model based on two or more inputs of a two-dimensional (2D) facial image. The server includes a single image capturing device, at least one processor and at least one memory including computer program code. The at least one memory and the computer program code are configured to, with the at least one processor, cause the server at least to display a plurality of user interfaces indicating a camera shutter aperture with an aperture size different from each other, receive, from the single image capturing device, the two or more inputs of the 2D facial image, the two or more inputs being captured at different distances from the single image capturing device, determine depth information relating to at least a point of each of the two or more inputs of the 2D facial image, and construct the 3D facial model in response to the determination of the depth information.

[0004] Another aspect provides a method for adaptively constructing a three-dimensional (3D) facial model based on two or more inputs of a two-dimensional (2D) facial image. The method includes displaying a plurality of user interfaces indicating a camera shutter aperture with an aperture size different from each other, receiving, from a single image capturing device, the two or more inputs of the 2D facial image, the two or more inputs being captured at different distances from the single image capturing device, determining depth information relating to at least a point of each of the two

# Claims

1. A server for adaptively constructing a three-dimensional (3D) facial model based on two or more inputs of a two-dimensional (2D) facial image, the server comprising:

a single image capturing device;

at least one processor; and

at least one memory including computer program code;

the at least one memory and the computer program code configured to, with the at least one processor, cause the server at least to:

display a plurality of user interfaces indicating a camera shutter aperture with an aperture size different from each other;

receive, from the single image capturing device, the two or more inputs of the 2D facial image, the two or more inputs being captured at different distances from the single image capturing device;

determine depth information relating to at least a point of each of the two or more inputs of the 2D facial image; and

construct the 3D facial model in response to the determination of the depth information.

2. The server according to claim 1, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the server to:

determine a first x-axis and a first y-axis distance between two reference points in a first of the two or more inputs, the first x-axis distance and the first y-axis distance representing the distance between the two reference points in a x-axis direction and a y-axis direction, respectively; and

determine a second x-axis and a second y-axis distance between the two reference points in a second of the two or more inputs, the second x-axis distance and the second y-axis distance representing the distance between the two reference points in a x-axis direction and a y-axis direction, respectively.

3. The server according to claim 2, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the server to:

determine a difference between at least one of (i) the first x-axis distance and the second x-axis distance and (ii) the first y-axis distance and the second y-axis distance so as to determine the depth information.

4. The server according to claim 1, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the server to further:

control the single image capturing device to capture the two or more inputs at different distances and angles relative to the single image capturing device.

5. The server according to claim 1, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the server to further:

determine a facial attribute of the 2D facial image, wherein the 3D facial model is constructed in response to the determination of the facial attribute.

6. The server according to claim 1, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the server to further:

determine rotational information of the 2D facial image, wherein the 3D facial model is constructed in response to the determination of the rotational information.

7. The server according to claim 1, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the server to further:

control the single image capturing device in response to a difference between at least one of (i) a first x-axis distance and a second x-axis distance and (ii) a first y-axis distance and a second y-axis distance.

8. The server according to claim 7, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the server to further:

control the single image capturing device to cease taking a further input of the 2D facial image.

9. The server according to claim 1, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the server to:

determine at least one parameter to detect authenticity of the facial image.

10. A method for adaptively constructing a three-dimensional (3D) facial model based on two or more inputs of a two-dimensional (2D) facial image, the method comprising:

displaying a plurality of user interfaces indicating a camera shutter aperture with an aperture size different from each other;

receiving, from a single image capturing device, the two or more inputs of the 2D facial image, the two or more inputs being captured at different distances from the single image capturing device;

determining depth information relating to at least a point of each of the two or more inputs of the 2D facial image; and

constructing the 3D facial model in response to the determination of the depth information.

11. The method according to claim 10, wherein the step of determining depth information relating to at least a point of each of the two or more inputs of the 2D facial image comprises:

determining a first x-axis and a first y-axis distance between two reference points in a first of the two or more inputs, the first x-axis distance and the first y-axis distance representing the distance between the two reference points in a x-axis direction and a y-axis direction, respectively; and

determining a second x-axis and a second y-axis distance between the two reference points in a second of the two or more inputs, the second x-axis distance and the second y-axis distance representing the distance between the two reference points in a x-axis direction and a y-axis direction, respectively.

12. The method according to claim 11, wherein the step of determining depth information relating to at least a point of each of the two or more inputs of the 2D facial image further comprises:

determining a difference between at least one of (i) the first x-axis distance and the second x-axis distance and (ii) the first y-axis distance and the second y-axis distance so as to determine the depth information.

13. The method according to claim 10, wherein the two or more inputs are captured at different distance and angles relative to the single image capturing device.

14. The method according to claim 10, further comprising:

determining a facial attribute of the 2D facial image, wherein the 3D facial model is constructed in response to the determination of the facial attribute.

15. The method according to claim 10, further comprising:

determining rotational information of the 2D facial image, wherein the 3D facial model is constructed in response to the determination of the rotational information.

16. The method according to claim 10, further comprising:

controlling the single image capturing device in response to a difference between at least one of (i) a first x-axis distance and a second x-axis distance and (ii) a first y-axis distance and a second y-axis distance so as to capture the two or more inputs of the 2D facial image.

17. The method according to claim 16, further comprising:

controlling the single image capturing device to cease taking a further input of the 2D facial image.

18. The method according to claim 10, where the step of constructing the 3D facial model comprises:

determining at least one parameter to detect authenticity of the facial image.