

FACE LIVENESS DETECTION SYSTEM, DEVICE AND METHOD

TECHNICAL FIELD

[001] The present specification relates broadly, but not exclusively, to face liveness detection system, device and method.

BACKGROUND

[002] Electronic-Know Your Customer (eKYC) is a digital due diligence process performed by an entity to verify identities of its users and to assess potential risks of illegal intentions. In an eKYC process, face recognition is sometimes used to verify the identity of a user based on face biometrics. In a face recognition process, face liveness detection is a critical anti-spoofing procedure to determine whether a selfie face image taken for face recognition is from a live person or from a photo.

[003] Among existing face liveness detection methods, photinus liveness detection (also known as photonics/optical liveness detection) is one that projects a light flow with a sequence of colours onto a user's face and collects corresponding light reflections from the user's face to perform liveness analysis.

[004] However, as only specific colours are required for face liveness detection, current photinus liveness detection methods project only those required colours in the light flow without transition in-between. The fast changing of discrete colours in the light flow may cause dizziness to users.

[005] Furthermore, although the colours in the light flow seem random to users, the sequence of colours is actually picked from a fixed pool of colour sequences. By repetitively projecting the light flow for many times, a possible attacker is able to collect all the colour sequences in the fixe pool of colour sequences, and perform attacks with the known color sequences. Thus, the current photinus liveness detection methods are prone to attacks as the color sequences are exposed to front-end users.

[006] A need therefore exists to provide methods and devices that seek to overcome or at least minimize the above mentioned problems.

SUMMARY

[007] According to an embodiment, there is provided a face liveness detection system. The system comprises a light emitting device configured to project a light flow having a sequence of colours to a face; a camera device configured to capture a plurality of images of the face whilst a plurality of selected colours in the sequence of colours are being projected onto the face; a detection device configured to: rearrange the plurality of images in accordance with a pre-determined order of colours; and detect liveness of the face based on the rearranged plurality of images.

[008] According to another embodiment, there is provided a face liveness detection device. The device comprises at least one processor; and a memory including computer program code for execution by the at least one processor, the computer program code instructs the at least one processor to: project a light flow having a sequence of colours to a face; capture a plurality of images of the face whilst a plurality of selected colours in the sequence of colours are being projected onto the face; rearrange the plurality of images in accordance with a pre-determined order of colours; and detect liveness of the face based on the rearranged plurality of images.

[009] According to yet another embodiment, there is provided a method for face liveness detection. The method comprises: projecting a light flow having a sequence of colours to a face; capturing a plurality of images of the face whilst a plurality of selected colours in the sequence of colours are being projected onto the face; rearranging the plurality of images in accordance with a pre-determined order of colours; and detecting liveness of the face based on the rearranged plurality of images.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Embodiments and implementations are provided by way of example only, and will be better understood and readily apparent to one of ordinary skill in the art from the following written description, read in conjunction with the drawings, in which:

[0011] Figure 1 is a schematic diagram of a face liveness detection system 100, according to an embodiment.

[0012] Figure 2 is a schematic diagram of a face liveness detection device 200, according to an embodiment.

[0013] Figure 3 is a flow chart illustrating a method 300 for face liveness detection, according to an embodiment.

[0014] Figure 4 shows a diagram 400 depicting an embodiment of light flow having a sequence of colours 402 projected to a face. The sequence of colours includes a plurality of selected colours 418 selected from a pool of colours. In this embodiment, the plurality of selected colours 418 includes grey 404, yellow 406, green 408, blue 410, white 412, yellow 414, and grey 416.

[0015] Figure 5 shows a diagram 500 depicting an embodiment of rearranged plurality of images 502. The rearranged plurality of images 502 includes an image 504 of a user's face captured whilst the colour grey 404 in the sequence of colours 402 is projected onto the face, an image 506 of the face captured whilst the colour blue 410 in the sequence of colours 402 is projected onto the face, an image 508 of the face captured whilst the colour yellow 406 in the sequence of colours 402 is projected onto the face, an image 510 of the face captured whilst the colour white 412 in the sequence of colours 402 is projected onto the face, an image 512 of the face captured whilst the colour yellow 414 in the sequence of colours 402 is projected onto the face, an image 514 of the face captured whilst the colour green 408 in the sequence of colours 402 is projected onto the face, and an image 516 of the face captured whilst the colour grey 416 in the sequence of colours 402 is projected onto the face.

[0016] Figure 6 shows a block diagram of a computer system 600 suitable for use as a face liveness detection system 100 as exemplified in Figure 1, or as a face liveness detection device 200 as exemplified in Figure 2, or for implementing one or more steps in a method 300 for face liveness detection as exemplified in Figure 3.

[0017] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale. For example, the dimensions of some of the elements in the illustrations, block diagrams or

flowcharts may be exaggerated in respect to other elements to help to improve understanding of the present embodiments.

DETAILED DESCRIPTION

[0018] Embodiments will be described, by way of example only, with reference to the drawings. Like reference numerals and characters in the drawings refer to like elements or equivalents.

[0019] Some portions of the description which follows are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within a computer memory. These algorithmic descriptions and functional or symbolic representations are the means used by those skilled in the data processing arts to convey most effectively the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

[0020] Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as “projecting”, “capturing”, “rearranging”, “detection”, “selecting”, “initiating”, or the like, refer to the action and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

[0021] The present specification also discloses apparatus for performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various machines may be used with programs in accordance with the teachings herein. Alternatively, the construction of more specialized apparatus to perform the required method steps may be appropriate. The structure of a computer suitable for executing the various methods / processes described herein will appear from the description below.

[0022] In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described herein may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the specification contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the spirit or scope of the invention.

[0023] Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the GSM mobile telephone system. The computer program when loaded and executed on such a computer effectively results in an apparatus that implements the steps of the preferred method.

[0024] This specification uses the term “configured to” in connection with systems, devices, and computer program components. For a system of one or more computers to be configured to perform particular operations or actions means that the system has installed on it software, firmware, hardware, or a combination of them that in operation cause the system to perform the operations or actions. For one or more computer programs to be configured to perform particular operations or actions means that the one or more programs include instructions that, when executed by data processing apparatus, cause the apparatus to perform the operations or actions. For special-purpose logic circuitry to be configured to perform particular operations or actions means that the circuitry has electronic logic that performs the operations or actions.

[0025] Embodiments of the present application provide a face liveness detection approach that utilises a light flow with a sequence of colours having both face liveness detection relevant colours and irrelevant colours for projecting onto a user's

face and captures a plurality of images of the face whilst the face liveness detection relevant colours (referred to as a plurality of selected colours in the present application) are projected onto the face, which increases difficulty for attackers to recognise which colours are real useful colours for face liveness detection. In this manner, security of face liveness detection can be enhanced by the present application.

[0026] Furthermore, the face liveness detection approach of the present application rearranges the order of the captured plurality of images of the face and uses the rearranged plurality of images for face liveness detection. In this manner, even if attackers manage to crack the plurality of selected colours (whilst whose projection the plurality of images are captured) by observing shutter actions in view of the sequence of colours being projected, it is still unknown to the attackers based on which order will the captured plurality of images be rearranged for face liveness detection. In this manner, security of face liveness detection is further enhanced by the present application.

[0027] In addition, the face liveness detection approach of the present application include transitional colour band between every two adjacent colours in a pool of colours in the sequence of colours, which gives minimal visual impact to users and can alleviate dizziness caused by abrupt change of discrete colours in conventional photinus liveness detection. In this manner, user experience of the face liveness detection can be improved by the present application.

[0028] Figure 1 illustrates a schematic diagram of a face liveness detection system 100 according to an embodiment of the present application. The face liveness detection system 100 at least includes a light emitting device 102, a camera device 104 and a detection device 106. The light emitting device 102, the camera device 104 and the detection device 106 can be interconnected and coupled for intercommunication.

[0029] The light emitting device 102, the camera device 104 and the detection device 106 are configured to cause the face liveness detection system 100 to perform the steps for face live detection as described in the present application. Details of the steps will be described below with reference to Figure 3, which depicts

a flow chart illustrating a method 300 for face liveness detection according to an embodiment.

[0030] At step 302, the light emitting device 102 is configured to project a light flow having a sequence of colours to a user's face 101 (interchangeable referred as a face 101 in the present application). The light emitting device 102 can be a light emitting diode (LED) that is configured to emit light of various colours. For example, the light emitting device 102 can be a colour changing LED which includes three diodes that produce respectively red, green and blue lights and generates various colours by varying the duty cycle on each of the three diodes.

[0031] Alternatively or additionally, the light emitting device 102 can be a display screen of the user's electronic device (e.g. a mobile phone). The display screen is made up of pixels, and each pixel includes three colours: red, green, and blue. By varying brightness of each colour within each pixel of the display screen, various colours can be emitted by the display screen. In some embodiments, the sequence of colours projected to the face 101 can be emitted in the format of a colour-changing user interface shown on the display screen. It is appreciable to those skilled in the art that the light emitting device 102 and the emission of the sequence of colours can be in other forms.

[0032] An embodiment of a light flow projected onto the face 101 as at step 302 is depicted in Figure 4. As shown in Figure 4, the light flow 400 includes a sequence 402 of colours that are sequentially projected onto the face 101. The sequence 402 of colours include a pool of colours, which can be colours of visible lights, such as red, orange, yellow, green, cyan, blue, purple, black, grey, white, etc. Based on practical needs, the sequence 402 of colours can include one or more cycles (T) of the pool of colours. In the embodiment of Figure 4, the sequence 402 of colours include more than 2 cycles of the pool of colours in order for sufficient number of images to be captured. It is appreciable to those skilled in the art that the number of cycle can be decided based on the practical needs and requirements.

[0033] Based on practical needs, the sequence 402 of colours can stop at any point in the cycle. In the present embodiment, the sequence 402 begins with beginning colours white and grey, and ends with ending colours grey and white. Between the beginning colours and ending colours, two cycles T1 and T2 of the pool of colours are repeated in

an order of "red, orange, yellow, green, cyan, blue, purple, black, grey, white". It can be seen in Figure 4 that the sequence 402 further includes a portion of a third cycle which stops at colour red before the ending colours grey and white.

[0034] As shown in Figure 4, every two adjacent colours in the pool of colours have a transitional colour band therebetween. By virtue of the transitional colour band in the sequence of colours, the light flow 400 gives minimal visual impact to users, and the dizziness caused by the abrupt change of discrete colours in conventional photinus liveness detection can be alleviated. In this manner, user experience of the face liveness detection is improved.

[0035] The sequence 402 of colours includes a subset of specific colours that are specifically used for face liveness detection. The subset of specific colours are selected from the pool of colours, and are referred to as a plurality of selected colours 418. In other words, not all the colours in the sequence of colours projected to the face 101 are used for face liveness detection, only the plurality of selected colours are captured by the camera device 104 in step 304 for subsequent face liveness detection.

[0036] In the embodiment as shown in Figure 4, the plurality of selected colours 418 include grey 404, yellow 406, green 408, blue 410, white 412, yellow 414 and grey 416. In this embodiment, the colour grey 404 is from the beginning colours, the colour yellow 406, the colour green 408, the colour blue 410 and the colour white 410 are from the first cycle T1, the colour yellow 414 is from the second cycle T2, and the colour grey 416 is from the ending colours. It is appreciable that the selected colours can be from different points in the sequence of colours in accordance to various embodiments. For example, in an alternative embodiment, the colour grey 416 can be replaced with a colour grey 416' from the second cycle T2. Each of these selected colours is projected at a respective timing in the sequence of colours. The projection timing can be predetermined based on practical needs and requirements. For example, upon initiation of the projection of the light flow 400, the colour grey 404 is projected at 0.2nd second, the colour yellow 406 is projected at 5th second, the colour green 408 is projected at 6th second, the colour blue 410 is projected at 10th second, the colour white 412 is projected at 14th second, the colour yellow 414 is projected at 19th second, and the colour grey 416 is projected at 30th second. It is appreciable that the timing of each colour can vary based on practical needs. If a fast process is desired, the transition between two colours can be short; if a slow process is desired, the transition between

two colours can be long. In the present embodiment, the colour grey 404 is projected at 0.2nd second, the colour yellow 406 is projected at 5th second. In between, the colours between grey and yellow are also projected. To a front end user, at step 302 he/she will see the whole sequence 402 of colours as shown in Figure 4, without knowing which colours are selected by the backend system (e.g. the face liveness detection system 100) and captured by the camera device 104 in step 304 for subsequent face liveness detection.

[0037] Based on the predetermined projection timings of the plurality of selected colours, synchronization between light flow projection at the light emitting device 102 and image capturing at the camera device 104 can be controlled. For example, based on the predetermined projection timings, the light emitting device 102 can project the plurality of selected colours 418 to the face 101 at predetermined time intervals, such as the colour grey 404 by 0.2 second, the colour yellow 406 by 5 seconds, the colour green 408 by 6 seconds, the colour blue 410 by 10 seconds, the colour white 412 by 14 seconds, the colour yellow 414 by 19 seconds, and the colour grey 416 by 30 seconds, whereas the camera device 104 captures the plurality of images of the face 101 at the predetermined time intervals, i.e. at 0.2nd second, 5th second, 6th second, 10th second, 14th second, 19th second, and 30th second, in response to initiation of the projection of the light flow 400. In this manner, at step 304, the camera device 104 is able to capture a plurality of images of the face 101 whilst the plurality of selected colours in the sequence of colours are being projected onto the face 101. Pixels of the face 101 with light reflections of the respective selected colours in the captured plurality of images can then be used for subsequent face liveness detection.

[0038] Alternative to grey 404, yellow 406, green 408, blue 410, white 412, yellow 414 and grey 416, it is appreciable to those skilled in the art that the plurality of selected colours can be other colours projected at other respective timings based on various practical needs and requirements.

[0039] It is also appreciable to those skilled in the art that the synchronization between light flow projection at the light emitting device 102 and image capturing at the camera device 104 can be controlled in other alternative manners, which can also allow the camera device 104 to capture a plurality of images of the face 101 whilst the plurality of selected colours in the sequence of colours are being projected onto the face 101 at step 304.

[0040] In steps 302 and 304, instead of projecting a light flow with only the plurality of selected colours 418 to the face 101, the present application projects the light flow 400 having the sequence 402 of colours that include the pool of colours. In this manner, a “masked”/ “camouflaged” light flow having both face liveness detection relevant colours and irrelevant colours is shown to front end users, which increases difficulty for attackers to recognise which colours are real useful colours for face liveness detection. In this manner, security of face liveness detection is enhanced by the present application.

[0041] In addition, as the pool of colours in the present application include colours of visible lights, which are almost all the colours that people can perceive, the sequence 402 of colours of the present application thus can cover almost all sorts of specific colours that can be specifically used for face liveness detection. In this manner, whenever the plurality of selected colours are changed to a new plurality of selected colours for security purposes, a light flow having a sequence of colours projected from the light emitting device 102 after the change will still be the same as the light flow 400 having the sequence 402 of colours. Therefore, the change of the plurality of selected colours for face liveness detection is not recognisable to front end users, especially attackers. In this manner, security of face liveness detection can be further improved by intermittently changing the plurality of selected colours for face liveness detection.

[0042] The captured plurality of images are transmitted from the camera device 104 to the detection device 106 for face liveness detection. As a further measure to enhance security of face liveness detection, the captured plurality of images need to be “decoded” by being rearranged in accordance with a pre-determined order of colours at step 306 before face liveness detection at step 308.

[0043] Prior to step 306, as described in the above embodiment, the camera device 104 captures the plurality of images in chronological order at 0.2nd second, 5th second, 6th second, 10th second, 14th second, 19th second, and 30th in step 304. The captured plurality of images reflect the face 101 with light reflections of the selected colours in an order of grey 404, yellow 406, green 408, blue 410, white 412, yellow 414, and grey 416. That is, the captured plurality of images include an image of the face 101 captured whilst the colour grey 404 in the sequence of colours 402 is projected onto the face 101, an image of the face 101 captured whilst the colour yellow 406 in the sequence of colours 402 is projected onto the face 101, an image of the face 101 captured

whilst the colour green 408 in the sequence of colours 402 is projected onto the face 101, an image of the face 101 captured whilst the colour blue 410 in the sequence of colours 402 is projected onto the face 101, an image of the face 101 captured whilst the colour white 412 in the sequence of colours 402 is projected onto the face 101, an image of the face 101 captured whilst the colour yellow 414 in the sequence of colours 402 is projected onto the face 101, and an image of the face 101 captured whilst the colour grey 416 in the sequence of colours 402 is projected onto the face 101.

[0044] At step 306, the detection device 106 rearranges the plurality of the images in accordance with a pre-determined order of colours. In an embodiment, the pre-determined order of colours includes an order of grey, blue, yellow, white, yellow, green and grey. Such an embodiment of pre-determined order 500 of colours and a accordingly rearranged plurality of images 502 are shown in Figure 5. It is appreciable to those skilled in the art that the pre-determined order of colours can include other orders in which the plurality of the selected colours are rearranged/reshuffled.

[0045] As shown in Figure 5, the rearranged plurality of images 502 include an image 504, an image 506, an image 508, an image 510, an image 512, an image 514, and an image 516. The image 504 is the image of the face 101 captured whilst the colour grey 404 in the sequence of colours 402 is projected onto the face. The image 506 is the image of the face 101 captured whilst the colour blue 410 in the sequence of colours 402 is projected onto the face. The image 508 is the image of the face 101 captured whilst the colour yellow 406 in the sequence of colours 402 is projected onto the face 101. The image 510 is the image of the face 101 captured whilst the colour white 412 in the sequence of colours 402 is projected onto the face 101. The image 512 is the image of the face 101 captured whilst the colour yellow 414 in the sequence of colours 402 is projected onto the face 101. The image 514 is the image of the face 101 captured whilst the colour green 408 in the sequence of colours 402 is projected onto the face 101. The image 516 is the image of the face captured whilst the colour grey 412 in the sequence of colours 402 is projected onto the face.

[0046] Subsequently, the detection device 106 detects liveness of the face based on the rearranged plurality of images as shown at step 308. For example, the detection device 106 can utilise a convolutional neural network to determine whether the

rearranged plurality of images captured from the face 101 are from a live person or a spoofing attack. In some embodiments, the convolutional neural network is implemented in a classifier (not shown) in the detection device 106. Alternatively or additionally, the classifier can be implemented as a separate device external to the detection device 106. It is appreciable to those skilled in the art that alternative or in addition to a convolutional neural network, the detection device 106 can detect liveness of the face 101 in other manners based on the rearranged plurality of images.

[0047] By virtue of rearrangement of the captured plurality of images in step 306 and the face liveness detection based on the rearranged plurality of images in step 308, another fold of security enhancement is provided by the present application. This is because, even if attackers manage to crack the plurality of selected colours (whilst whose projection the plurality of images are captured) by observing shutter actions taken by the camera device 104 in view of the sequence of colours being projected, it is still unknown to the attackers based on which order will the captured plurality of images be rearranged for face liveness detection. In this manner, the present application provides two-fold advantages in security enhancement.

[0048] In the embodiment 100 shown in Figure 1, the face liveness detection system 100 can further include an output device 108. In some embodiments, the output device 108 can form a face liveness detection device 110 together with the light emitting device 102, the camera device 104 and the detection device 106. In some embodiments, the face liveness detection device 110 can be a component device in an electronic device 110 of the user 101. Other parts of the electronic device 110 of the user 101 are not depicted for the sake of simplicity.

[0049] In some embodiments, the detection device 106 can be implemented as a component device 106' in a face liveness detection server 112 that is separate from and communicable with the electronic device 110 of the user 101. Other parts of the face liveness detection server 112 are not depicted for the sake of simplicity. The face liveness detection server 112 can be run by face liveness detection service providers or entities that need to run eKYC processes.

[0050] Once the detection device 106, 106' has produced a result for the face liveness detection, the detection device 106, 106' can transmit the result to the output device 108, which can then output the result to the user.

[0051] Figure 2 illustrates a schematic diagram of a device 200 for face liveness detection according to an embodiment. The device 200 at least includes one or more processor 202 and a memory 204. The at least one processor 202 and the memory 204 are interconnected. The memory 204 includes computer program code (not shown in Figure 2) for execution by the at least one processor 202. The computer program code instructs the at least one processor 202 to perform the steps for face liveness detection as shown in Figure 3 and described in the present application.

[0052] At step 302, the computer program code instructs the at least one processor 202 to project a light flow having a sequence of colours to a face.

[0053] Thereafter, at step 304, the computer program code instructs the at least one processor 202 to capture a plurality of images of the face whilst a plurality of selected colours in the sequence of colours are being projected onto the face.

[0054] Thereafter, at step 306, the computer program code instructs the at least one processor 202 to rearrange the plurality of images in accordance with a pre-determined order of colours.

[0055] Subsequently, at step 308, the computer program code instructs the at least one processor 202 to detect liveness of the face based on the rearranged plurality of images.

[0056] Figure 6 shows a block diagram of a computer system 600 suitable for use as a face liveness detection system 100 as exemplified in Figure 1, or as a face liveness detection device 200 as exemplified in Figure 2, or for implementing one or more steps in a method 300 for face liveness detection as exemplified in Figure 3.

[0057] The following description of the computer system / computing device 600 is provided by way of example only and is not intended to be limiting.

[0058] As shown in Figure 6, the example computing device 600 includes a processor 604 for executing software routines. Although a single processor is shown for the sake of clarity, the computing device 600 may also include a multi-processor system. The processor 604 is connected to a communication infrastructure 606 for communication

with other components of the computing device 600. The communication infrastructure 606 may include, for example, a communications bus, cross-bar, or network.

[0059] The computing device 600 further includes a main memory 608, such as a random access memory (RAM), and a secondary memory 610. The secondary memory 610 may include, for example, a hard disk drive 612 and/or a removable storage drive 614, which may include a magnetic tape drive, an optical disk drive, or the like. The removable storage drive 614 reads from and/or writes to a removable storage unit 618 in a well-known manner. The removable storage unit 618 may include a magnetic tape, optical disk, or the like, which is read by and written to by removable storage drive 614. As will be appreciated by persons skilled in the relevant art(s), the removable storage unit 618 includes a computer readable storage medium having stored therein computer executable program code instructions and/or data.

[0060] In an alternative implementation, the secondary memory 610 may additionally or alternatively include other similar means for allowing computer programs or other instructions to be loaded into the computing device 600. Such means can include, for example, a removable storage unit 622 and an interface 620. Examples of a removable storage unit 622 and interface 620 include a removable memory chip (such as an EPROM or PROM) and associated socket, and other removable storage units 622 and interfaces 620 which allow software and data to be transferred from the removable storage unit 622 to the computer system 600.

[0061] The computing device 600 also includes at least one communication interface 624. The communication interface 624 allows software and data to be transferred between computing device 600 and external devices via a communication path 626. In various embodiments, the communication interface 624 permits data to be transferred between the computing device 600 and a data communication network, such as a public data or private data communication network. The communication interface 624 may be used to exchange data between different computing devices 600 which such computing devices 600 form part an interconnected computer network. Examples of a communication interface 624 can include a modem, a network interface (such as an Ethernet card), a communication port, an antenna with associated circuitry and the like. The communication interface 624 may be wired or may be wireless. Software and data transferred via the communication interface 624 are in the form of signals which can be electronic, electromagnetic, optical or other signals capable of being received by

communication interface 624. These signals are provided to the communication interface via the communication path 626.

[0062] Optionally, the computing device 600 further includes a display interface 602 which performs operations for rendering images to an associated display 630 and an audio interface 632 for performing operations for playing audio content via associated speaker(s) 634.

[0063] As used herein, the term "computer program product" may refer, in part, to removable storage unit 618, removable storage unit 622, a hard disk installed in hard disk drive 612, or a carrier wave carrying software over communication path 626 (wireless link or cable) to communication interface 624. Computer readable storage media refers to any non-transitory tangible storage medium that provides recorded instructions and/or data to the computing device 600 for execution and/or processing. Examples of such storage media include floppy disks, magnetic tape, CD-ROM, DVD, Blu-ray™ Disc, a hard disk drive, a ROM or integrated circuit, USB memory, a magneto-optical disk, or a computer readable card such as a PCMCIA card and the like, whether or not such devices are internal or external of the computing device 600. Examples of transitory or non-tangible computer readable transmission media that may also participate in the provision of software, application programs, instructions and/or data to the computing device 600 include radio or infra-red transmission channels as well as a network connection to another computer or networked device, and the Internet or Intranets including e-mail transmissions and information recorded on Websites and the like.

[0064] The computer programs (also called computer program code) are stored in main memory 608 and/or secondary memory 610. Computer programs can also be received via the communication interface 624. Such computer programs, when executed, enable the computing device 600 to perform one or more features of embodiments discussed herein. In various embodiments, the computer programs, when executed, enable the processor 604 to perform features of the above-described embodiments. Accordingly, such computer programs represent controllers of the computer system 600.

[0065] Software may be stored in a computer program product and loaded into the computing device 600 using the removable storage drive 614, the hard disk drive 612, or the interface 620. Alternatively, the computer program product may be downloaded to

the computer system 600 over the communications path 626. The software, when executed by the processor 604, causes the computing device 600 to perform functions of embodiments described herein.

[0066] It is to be understood that the embodiment of Figure 8 is presented merely by way of example. Therefore, in some embodiments one or more features of the computing device 600 may be omitted. Also, in some embodiments, one or more features of the computing device 600 may be combined together. Additionally, in some embodiments, one or more features of the computing device 600 may be split into one or more component parts.

[0067] The techniques described in this specification produce one or more technical effects. As mentioned above, embodiments of the present application provide a face liveness detection approach that utilises a light flow with a sequence of colours having both face liveness detection relevant colours and irrelevant colours for projecting onto a user's face and captures a plurality of images of the face whilst the face liveness detection relevant colours (referred to as a plurality of selected colours in the present application) are projected onto the face, which increases difficulty for attackers to recognise which colours are real useful colours for face liveness detection. In this manner, security of face liveness detection can be enhanced by the present application.

[0068] Furthermore, the face liveness detection approach of the present application rearranges the order of the captured plurality of images of the face and uses the rearranged plurality of images for face liveness detection. In this manner, even if attackers manage to crack the plurality of selected colours (whilst whose projection the plurality of images are captured) by observing shutter actions in view of the sequence of colours being projected, it is still unknown to the attackers based on which order will the captured plurality of images be rearranged for face liveness detection. In this manner, security of face liveness detection is further enhanced by the present application.

[0069] In addition, the face liveness detection approach of the present application include transitional colour band between every two adjacent colours in a pool of colours in the sequence of colours, which gives minimal visual impact to users and can alleviate dizziness caused by abrupt change of discrete colours in conventional photinus liveness detection. In this manner, user experience of the face liveness detection can be improved by the present application.

[0070] It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

What is claimed is:

1. A face liveness detection system, the system comprising:
 - a light emitting device configured to project a light flow having a sequence of colours to a face;
 - a camera device configured to capture a plurality of images of the face whilst a plurality of selected colours in the sequence of colours are being projected onto the face;
 - a detection device configured to:
 - rearrange the plurality of images in accordance with a pre-determined order of colours; and
 - detect liveness of the face based on the rearranged plurality of images.
2. The system according to claim 1, wherein the sequence of colours includes a pool of colours, wherein the plurality of selected colours are selected from the pool of colours, and wherein every two adjacent colours in the pool of colours have a transitional colour band therebetween.
3. The system according to claim 2, wherein the pool of colours include red, orange, yellow, green, cyan, blue, purple, black, grey and white.
4. The system according to any one of claims 1 to 3, wherein the pre-determined order of colours includes an order of grey, blue, yellow, white, yellow, green and grey.
5. The system according to any one of claims 1 to 4, wherein the light emitting device is configured to project the plurality of selected colours to the face at predetermined time intervals, and wherein the camera device is configured to capture the plurality of images of the face at the predetermined time intervals in response to initiation of the projection of the light flow.
6. The system according to any one of claims 1 to 5, wherein when detecting liveness of the face, the detection device is configured to utilise a convolutional neural network to determine whether the rearranged plurality of images are from a live person.
7. A face liveness detection device, the device comprising:
 - at least one processor; and
 - a memory including computer program code for execution by the at least one processor, the computer program code instructs the at least one processor to:
 - project a light flow having a sequence of colours to a face;

capture a plurality of images of the face whilst a plurality of selected colours in the sequence of colours are being projected onto the face;

rearrange the plurality of images in accordance with a pre-determined order of colours; and

detect liveness of the face based on the rearranged plurality of images.

8. The device according to claim 7, wherein the sequence of colours includes a pool of colours, wherein the plurality of selected colours are selected from the pool of colours, and wherein every two adjacent colours in the pool of colours have a transitional colour band therebetween.

9. The device according to claim 8, wherein the pool of colours include red, orange, yellow, green, cyan, blue, purple, black, grey and white.

10. The device according to any one of claims 7 to 9, wherein the pre-determined order of colours includes an order of grey, blue, yellow, white, yellow, green and grey.

11. The device according to any one of claims 7 to 10, wherein the device is configured to project the plurality of selected colours to the face at predetermined time intervals, and wherein the device is further configured to capture the plurality of images of the face at the predetermined time intervals in response to initiation of the projection of the light flow.

12. The device according to claim 11, wherein when detecting liveness of the face, the device is configured to utilise a convolutional neural network to determine whether the rearranged plurality of images are from a live person.

13. A method for face liveness detection, comprising:
 projecting a light flow having a sequence of colours to a face;
 capturing a plurality of images of the face whilst a plurality of selected colours in the sequence of colours are being projected onto the face;
 rearranging the plurality of images in accordance with a pre-determined order of colours; and
 detecting liveness of the face based on the rearranged plurality of images.

14. The method according to claim 13, wherein the projecting a light flow having a sequence of colours includes projecting a light flow having a pool of colours,

wherein the plurality of selected colours are selected from the pool of colours, and wherein every two adjacent colours in the pool of colours have a transitional colour band therebetween.

15. The method according to claim 14, wherein the pool of colours include red, orange, yellow, green, cyan, blue, purple, black, grey and white.

16. The method according to any one of claims 13 to 15, wherein the pre-determined order of colours includes an order of grey, blue, yellow, white, yellow, green and grey.

17. The method according to any one of claims 1 to 16,
wherein the projecting a light flow having a sequence of colours includes projecting the plurality of selected colours to the face at predetermined time intervals, and

wherein the capturing a plurality of images of the face includes capturing the plurality of images of the face at the predetermined time intervals in response to initiation of the projection of the light flow.

18. The method according to claim 17, wherein the step of detecting liveness of the face comprises utilising a convolutional neural network to determine whether the rearranged plurality of images are from a live person.