In an embodiment, the liveness detection includes an eye opening or closing action detection, a mouth opening or closing action detection, a head nodding action detection and head shaking action detection. As shown in table 1, it provides a correspondence between each action and a mutual exclusion group set. When the eye opening or closing action is detected, the mutual exclusion group set includes an opening or closing degree set, a pitch angle set and a rotation angle set; when the mouth opening or closing action is detected, the mutual exclusion group set includes a pitch angle set and a rotation angle set; when the head nodding action is detected, the mutual exclusion group set includes the opening or closing degree set and the rotation angle set; when the head shaking action is detected, the mutual exclusion group set includes the opening or closing degree set and the pitch angle set. In an embodiment, at least one set in the mutual exclusion group set satisfies both the corresponding extremum condition and the monotone condition, that is, satisfies the mutual exclusion condition.

Table 1 Correspondence between the action satisfying the liveness detection condition and the mutual exclusion group set

	Closing Value Set corresponding to the eye region	Opening or Closing Degree Set corresponding to the mouth region	Pitch Angle Set	Rotation Degree Set
Eye Opening or Closing Action		Belongs to the mutual exclusion group set	Belongs to the mutual exclusion group set	Belongs to the mutual exclusion group set
Mouth Opening or Closing Action			Belongs to the mutual exclusion group set	Belongs to the mutual exclusion group set
Head Nodding Action		Belongs to the mutual exclusion group set		Belongs to the mutual exclusion group set

which is currently being detected may be determined as the target action, thus the feature value set matching the target action may be determined, and then a complementation action may be determined according to the complementation condition, thus the feature value set matching the complementation action may be determined, then the complementation group set is generated according to at least one feature value set matching the at least one complementation action. When each feature value set of the complementation group set satisfies the extremum condition and monotone condition, it is determined that in the detection process of the target action, a natural action of the user is recognized, so as to improve the probability that the user is a living body. The extremum condition of the liveness detection can be modified to make the feature value to quickly reach the threshold defined in the extremum condition, therefore it is easier for legitimate users to pass through the liveness detection more quickly and easily.

Through the configuration of the complementation condition, when an action of natural postures of the user is detected, the extremum condition is modified to accelerate the speed of detection of a legitimate user and improve the efficiency of the liveness detection.

In an embodiment, the liveness detection includes an eye opening or closing action detection, a mouth opening or closing action detection, a head nodding action detection and a head shaking action detection. As shown in table. 2, it provides a correspondence between each action and a complementation group set. When the eye opening or closing action is detected, the complementation group set is empty; when the mouth opening or closing action is detected, the complementation group set includes the closing value set; when the head nodding action is detected, the complementation group set includes the closing value set; when the head shaking action is detected, the complementation group set includes the closing value set. At least one set in the complementation group set satisfies both the corresponding extremum condition and the monotone condition, that is, the at least one set satisfies the complementation condition.

Table 2 Correspondence between the action satisfying the liveness detection condition and the complementation group set

	Closing Value Set corresponding to the eye region	Opening or Closing Degree Set corresponding to the mouth region	Pitch Angle Set	Rotation Angle Set
Eye Opening or				

What is claimed is:

1. A liveness detection method, comprising:

in a case of satisfying a liveness detection starting condition, acquiring an image frame in a video in real time;

recognizing, in the image frame, at least two facial organ regions of a user, and updating a feature value set corresponding to each of the at least two recognized facial organ regions according to a feature value calculated based on the recognized facial organ region corresponding to the feature value set, wherein each of the at least two facial organ regions corresponds to at least one feature value set, each of the at least one feature value set corresponds to one extremum condition, and each of the at least one feature value set comprises at least one feature value; and

performing a liveness detection on the user according to data features in a combination set formed by at least two feature value sets corresponding to the at least two facial organ regions and extremum conditions respectively corresponding to the at least two feature value sets;

wherein performing the liveness detection on the user according to the data features in the combination set formed by the at least two feature value sets corresponding to the at least two facial organ regions and according to the extremum conditions respectively corresponding to the at least two feature value sets comprises:

selecting, from feature value sets matching the at least two facial organ regions, the at least two feature value sets matching a liveness detection condition to generate the combination set;

determining, according to the data features in the combination set, a magnitude variation of the feature value in each feature value set, and determining a posture variation, matching the magnitude variation of the feature value in each feature value set, of each facial organ region; and

performing, according to the posture variation of each facial organ region, a detection of at least one action satisfying the liveness detection condition on each feature value set in the combination set in real time, and detecting whether a magnitude of a feature value in a feature value set matching each action satisfies an extremum condition of the feature value set; and

wherein performing the liveness detection on the user according to the data features in the combination set formed by the at least two feature value sets corresponding to the at least two facial organ regions and according to the extremum conditions respectively corresponding to the at least two feature value sets further comprises:

in a process of the detection of the at least one action satisfying the liveness detection condition, in a case of at least one feature value set in the combination set satisfying a mutual exclusion condition, determining that the liveness detection fails; and

in the process of the detection of the at least one action satisfying the liveness detection condition, in a case of at least one feature value set in the combination set satisfying a complementation condition, modifying the at least two extremum conditions corresponding to the at least two feature value sets in the combination set;

wherein the mutual exclusion condition is a condition where an action irrelevant to a currently detected action is detected, and the complementation condition is a condition where an occurable action irrelevant to the currently detected action is detected.

2. The method of claim 1, further comprising:

in a case of satisfying a liveness detection normal ending condition, determining that the user is a living body according to a result that each detection result of the at least one action satisfying the liveness detection condition is successful,

wherein the liveness detection normal ending condition comprises that each detected action is detected successfully or detection time exceeds a set detection duration.

3. The method of claim 1, wherein determining that the at least one feature value set in the combination set satisfies the mutual exclusion condition comprises:

determining a mutual exclusion group set in the combination set according to the mutual exclusion condition and the at least one action satisfying the liveness detection condition; and

determining that the at least one feature value set in the combination set satisfies the mutual exclusion condition, in response to both a first maximum feature value and a first minimum feature value determined in the at least one feature value set of the mutual exclusion group set satisfying at least one extremum condition respectively corresponding to the at least one feature value set, and the first maximum feature value, the first minimum feature value, and at least one feature value between the first maximum feature value and the first minimum feature value satisfying a monotone condition.

4. The method of claim 1, wherein determining that the at least one feature value set in the combination set satisfies the complementation condition comprises:

determining a complementation group set in the combination set according to the complementation condition and the at least one action satisfying the liveness detection

condition; and

determining that the at least one feature value set in the combination set satisfies the complementation condition, in response to both a second maximum feature value and a second minimum feature value determined in the at least one feature value set of the complementation group set satisfying at least one extremum condition respectively corresponding to the at least one feature value set, and the second maximum feature value, the second minimum feature value, and at least one feature value between the second maximum feature value and the second minimum feature value satisfying a monotone condition.

5. The method of claim 1, wherein updating the feature value set corresponding to each of the at least two recognized facial organ regions according to the feature value calculated based on the recognized facial organ region corresponding to the feature value set comprises:

determining the image frame, in which each recognized facial organ region satisfies a non-obscuration condition, as a target image frame, calculating a feature value matching each facial organ region in the target image frame, and updating and storing the feature value into a feature value set corresponding to the each facial organ region matching the feature value.

6. The method of claim 5, wherein determining that all recognized facial organ regions in the image frame satisfy the non-obscuration condition comprises:

for each facial organ region, inputting the image frame into a pre-trained obscuration determination network model matching the facial organ region, and acquiring an obscuration determination result, output by the obscuration determination network model, of the facial organ region in the image frame; and

in a case where the obscuration determination result of the facial organ region is non-obscured, determining that the facial organ region satisfies the non-obscuration condition.

7. The method of claim 1, after detecting whether the magnitude of the feature value in the feature value set matching each action satisfies the extremum condition of the feature value set, further comprising:

determining that a detection result of an action is successful, in a case where a third maximum feature value and a third minimum feature value determined in a feature value set, which matches the action satisfying the liveness detection condition, satisfy an extremum condition of the feature value set, and the third maximum feature value, the third minimum feature value, and at least one feature value between the third maximum feature value and the third minimum feature value satisfy a monotone condition.

8. A liveness detection apparatus, comprising:

a real-time image frame acquisition module, configured to acquire an image frame in a video in real time, in a case of satisfying a liveness detection starting condition;

a feature value set update module, configured to recognize, in the image frame, at least two facial organ regions of a user, and update a feature value set corresponding to each of the at least two recognized facial organ region according to a feature value calculated based on the recognized facial organ region corresponding to the feature value set, wherein each of the at least two facial organ regions corresponds to at least one feature value set, each of the at least one feature value set corresponds to one extremum condition, and each of the at least one feature value set comprises at least one feature value; and

a liveness determination module, configured to perform a liveness detection on the user according to data features in a combination set formed by at least two feature value sets corresponding to the at least two facial organ regions and extremum conditions respectively corresponding to the at least two feature value sets;

wherein the liveness determination module comprises an extremum condition determination module configured to:

select, from feature value sets matching the at least two facial organ regions, the at least two feature value sets matching a liveness detection condition to generate the combination set;

determine, according to the data features in the combination set, a magnitude variation of the feature value in each feature value set, and determine a posture variation, matching the magnitude variation of the feature value in each feature value set, of each facial organ region; and

perform, according to the posture variation of each facial organ region, a detection of at least one action satisfying the liveness detection condition on each feature value set in the combination set in real time, and detect whether a magnitude of a feature value in a feature value set matching each action satisfies an extremum condition of the feature value set; and

wherein the apparatus further comprises:

a mutual exclusion condition determination module, configured to, in a process of the detection of the at least one action satisfying the liveness detection condition, in a case of at least one feature value set in the combination set satisfying a mutual exclusion condition, determine that the liveness detection fails; and

a complementation condition determination module, configured to, in the process of the detection of the at least one action satisfying the liveness detection condition, in a case of at least one feature value set in the combination set satisfying a complementation condition, modify at least two extremum conditions corresponding to the at least two feature value sets in the combination set;

wherein the mutual exclusion condition is a condition where an action irrelevant to a currently detected action is detected, and the complementation condition is a condition where an occurable action irrelevant to the currently detected action is detected.

9. The apparatus of claim 8, further comprising:

a liveness detection module, configured to, in a case of satisfying a liveness detection normal ending condition, determine that the user is a living body according to a result that each detection result of the at least one action satisfying the liveness detection condition is successful,

wherein the liveness detection normal ending condition comprises that each detected action is detected successfully or detection time exceeds a set detection duration.

10. The apparatus of claim 8, wherein the mutual exclusion condition determination module comprises:

a mutual exclusion group set determination module, configured to determine a mutual exclusion group set in the combination set according to the mutual exclusion condition and the at least one action satisfying the liveness detection condition; and

a mutual exclusion group set detection module, configured to determine that the at least one feature value set in the combination set satisfies the mutual exclusion condition, in response to both a first maximum feature value and a first minimum feature value determined in the at least one feature value set of the mutual exclusion group set satisfying at least one extremum condition respectively corresponding to the at least one feature value set, and the first maximum feature value, the first minimum feature value, and at least one feature value between the first maximum feature value and the first minimum feature value satisfying a monotone condition.

11. The apparatus of claim 8, wherein the complementation condition determination module comprises:

a complementation group set determination module, configured to determine a complementation group set in the combination set according to the complementation condition

and the at least one action satisfying the liveness detection condition; and

a complementation group set detection module, configured to determine that the at least one feature value set in the combination set satisfies the complementation condition, in response to both a second maximum feature value and a second minimum feature value determined in the at least one feature value set of the complementation group set satisfying at least one extremum condition respectively corresponding to the at least one feature value set, and the second maximum feature value, the second minimum feature value, and at least one feature value between the second maximum feature value and the second minimum feature value satisfying a monotone condition.

12. The apparatus of claim 8, wherein the feature value set update module comprises:

an obscuration determination module, configured to determine the image frame, in which each recognized facial organ region satisfies a non-obscuration condition, as a target image frame, calculate a feature value matching each facial organ region in the target image frame, and update and store the feature value into a feature value set corresponding to the each facial organ region matching the feature value.

13. The apparatus of claim 12, wherein a non-obscuration determination module comprises:

an obscuration determination network model detection module, configured to, for each facial organ region, input the image frame into a pre-trained obscuration determination network model matching the facial organ region, and acquire an obscuration determination result, output by the obscuration determination network model, of the facial organ region in the image frame; and

an obscuration detection module, configured to determine that the facial organ region satisfies the non-obscuration condition, in a case where the obscuration determination result of the facial organ region is non-obscured.

14. The apparatus of claim 8, further comprising:

an action condition detection module, configured to determine that a detection result of an action is successful, in a case where both a third maximum feature value and a third minimum feature value determined in a feature value set, which matches the action satisfying the liveness detection condition, satisfy an extremum condition of the feature value set, and the third maximum feature value, the third minimum feature value and at least one feature value between the third maximum feature value and the third minimum feature value satisfies a monotone condition.

15. An electronic device, comprising:

at least one processor; and

a memory, configured to store the at least one program;

wherein the at least one program, when executed by the at least one processor, causes the at least one processor to perform the method of any one of claims 1 to 7.

16. A computer-readable storage medium, storing a computer program, wherein the computer program, when executed by a processor, performs the method of any one of claims 1 to 7.