

METHOD AND APPARATUS FOR CLUSTERING, ELECTRONIC DEVICE, AND STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The disclosure is based upon and claims priority to Chinese Patent Application No. 202010981204.3 filed on September 17, 2020, the disclosure of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The disclosure relates to the technical field of computers, and particularly, to a method and apparatus for clustering, an electronic device, and a storage medium.

BACKGROUND

[0003] In the field of intelligent video analysis, face clustering is an important research direction. Captured face images in an intelligent video have temporal and spatial information, and a trajectory of a person can be well analyzed by clustering the captured face images with the temporal and spatial information to form an archive. Since a video source at a city level has the disadvantages of complex environments, poor light conditions, low resolutions, etc., the accuracy of a clustering result cannot be ensured.

SUMMARY

[0004] The disclosure provides technical solutions of a method and apparatus for clustering, an electronic device, and a storage medium.

[0005] According to an aspect of the disclosure, provided is a method for clustering,

including that: quantitative analysis may be performed on a first cluster of face features to determine whether the first cluster meets a preset clustering condition, wherein the first cluster may be obtained by clustering on the basis of a first threshold, and the preset clustering condition may be used for indicating that a plurality of face features included in the first cluster correspond to a same identity; in response to that the first cluster does not meet the preset clustering condition, the plurality of face features included in the first cluster may be released; and the plurality of face features may be clustered on the basis of a second threshold to determine a second cluster, wherein the second threshold may be greater than the first threshold.

[0006] In a possible implementation, the plurality of face features may include a cluster-center face feature corresponding to the first cluster. The operation that quantitative analysis may be performed on the first cluster to determine whether the first cluster meets the preset clustering condition may include that: cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature may be determined; a mean distance and a standard deviation distance may be determined according to the cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature; and it may be determined that the first cluster does not meet the preset clustering condition in response to that at least one of following is met: the mean distance is greater than a third threshold or the standard deviation distance is less than a fourth threshold.

[0007] In a possible implementation, after the plurality of face features are clustered on the basis of the second threshold to determine the second cluster, the method may further include that: N known clusters may be determined according to at least one of: the second cluster, or the first cluster that meets the preset clustering condition, herein $N \geq 1$; and a face feature to be clustered may be classified according to the N known clusters.

[0008] In a possible implementation, after the N known clusters are determined according to at least one of the second cluster, or the first cluster that meets the preset clustering condition, the method may further include that: cluster-center face features corresponding to the N known clusters may be clustered to obtain a cluster-center

cluster; and known clusters corresponding to cluster-center face features in the cluster-center cluster may be merged to obtain a merged cluster corresponding to a same identity.

[0009] In a possible implementation, the operation that the face feature to be clustered may be classified according to the N known clusters may include that: whether there is a target known cluster among the N known clusters may be determined, herein the cosine distance between the face feature to be clustered and the cluster-center face feature corresponding to the target known cluster may be less than a fifth threshold; and in response to that there is a target known cluster among the N known clusters, the face feature to be clustered may be classified to the target known cluster.

[0010] In a possible implementation, the operation that whether there is a target known cluster among the N known clusters may be determined may include that: k cluster-center face features having nearest Euclidean distances with the face feature to be clustered may be determined from the cluster-center face features corresponding to the N known clusters by using a k -nearest neighbor algorithm, herein $N \geq k \geq 1$; cosine distances each between the face feature to be clustered and a respective one of the k cluster-center face features may be determined; and a known cluster corresponding to a cluster-center face feature with a cosine distance less than the fifth threshold may be determined as the target known cluster.

[0011] In a possible implementation, after the face feature to be clustered is classified according to the N known clusters, the method may further include that: a plurality of face features included in each of the N known clusters may be updated on the basis of a result of classifying the face feature to be clustered; and for each known cluster, the cluster-center face feature corresponding to the known cluster may be updated according to the plurality of updated face features corresponding to the known cluster.

[0012] In a possible implementation, after whether there is a target known cluster among the N known clusters is determined, the method may further include that: in response to that there is no target known cluster among the N known clusters, the face feature to be clustered may be determined as an unclassified face feature; and a plurality of unclassified face features obtained in a preset duration may be clustered to determine a

new cluster by the k -nearest neighbor algorithm and a connected graph algorithm.

[0013] In a possible implementation, after the plurality of unclassified face features obtained in the preset duration are clustered to determine the new cluster by the k -nearest neighbor algorithm and the connected graph algorithm, the method may further include that: the N known clusters may be updated according to the new cluster.

[0014] According to an aspect of the disclosure, an apparatus for clustering is provided, including: a quantitative analysis module, configured to: perform quantitative analysis on a first cluster of face features to determine whether the first cluster meets a preset clustering condition, wherein the first cluster is obtained by clustering on the basis of a first threshold, and the preset clustering condition is used for indicating that a plurality of face features included in the first cluster correspond to a same identity; a release module, configured to: in response to that the first cluster does not meet the preset clustering condition, releasing the plurality of face features included in the first cluster; and a clustering module, configured to cluster the plurality of face features on the basis of a second threshold to determine a second cluster, wherein the second threshold is greater than the first threshold.

[0015] In a possible implementation, the plurality of face features may include a cluster-center face feature corresponding to the first cluster. The quantitative analysis module may include: a first determination submodule, configured to determine cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature; a second determination submodule, configured to determine a mean distance and a standard deviation distance according to the cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature; and a third determination submodule, configured to determine that the first cluster does not meet the preset clustering condition in response to that at least one of following is met: the mean distance is greater than a third threshold or the standard deviation distance is less than a fourth threshold.

[0016] In a possible implementation, the apparatus may include: a first determination module, configured to determine N known clusters according to at least one of: the

second cluster, or the first cluster that meets the preset clustering condition, herein $N \geq 1$; and a classification module, configured to classify, according to the N known clusters, a face feature to be clustered.

[0017] In a possible implementation, the clustering module may be further configured to cluster cluster-center face features corresponding to the N known clusters to obtain a cluster-center cluster. The apparatus further includes a merging module, configured to merge known clusters corresponding to cluster-center face features in the cluster-center cluster to obtain a merged cluster corresponding to a same identity.

[0018] In a possible implementation, the classification module may include: a fourth determination submodule, configured to determine whether there is a target known cluster among the N known clusters, herein a cosine distance between the face feature to be clustered and the cluster-center face feature corresponding to the target known cluster is less than a fifth threshold; and a classification submodule, configured to: in response to that there is a target known cluster among the N known clusters, classify the face feature to be clustered to the target known cluster.

[0019] In a possible implementation, the fourth determination submodule may include: a first determination unit, configured to: determine, from the cluster-center face features corresponding to the N known clusters by a k -nearest neighbor algorithm, k cluster-center face features having nearest Euclidean distances with the face feature to be clustered, wherein $N \geq k \geq 1$; a second determination unit, configured to: determine cosine distances each between the face feature to be clustered and a respective one of the k cluster-center face features; and a third determination unit, configured to determine a known cluster corresponding to a cluster-center face feature with a cosine distance less than the threshold as the target known cluster.

[0020] In a possible implementation, the apparatus may further include: a first update module, configured to update a plurality of face features included in each of the N known clusters on the basis of a result of classifying the face feature to be clustered; and a second update module, configured to: for each known cluster, update the cluster-center face feature corresponding to the known cluster according to the plurality of updated face features corresponding to the known cluster.

[0021] In a possible implementation, the apparatus may further include: a second determination module, configured to: in response to that there is no grabbing target known cluster among the N known clusters, determine the face feature to be clustered as an unclassified face feature. The clustering module may be further configured to cluster, by the k -nearest neighbor algorithm and a connected graph algorithm, a plurality of unclassified face features under obtained in a preset duration to determine a new cluster.

[0022] In a possible implementation, the apparatus may further include: a third update module, configured to update the N known clusters according to the new cluster.

[0023] According to an aspect of the disclosure, an electronic device is provided, including a processor, and a memory configured to store processor-executable instructions. The processor may be configured to call the instructions stored in the memory to implement the above method.

[0024] According to an aspect of the disclosure, provided is a computer-readable storage medium having stored thereon computer program instructions that, when executed by a processor, cause the processor to implement the above method.

[0025] The embodiments of the disclosure provide a computer program, which may include computer-readable codes that, when running in an electronic device, enable a processor of the electronic device to execute any method for clustering as described above.

[0026] In the embodiments of the disclosure, quantitative analysis is performed on a first cluster of face features obtained by clustering on the basis of a first threshold, so as to determine whether the first cluster meets a preset clustering condition, herein the preset clustering condition is used for indicating that multiple face features included in the first cluster correspond to a same identity; in response to that the first cluster does not meet the preset clustering condition, the multiple face features included in the first cluster are released; and the multiple face features are clustered on the basis of the second threshold greater than the first threshold to determine a second cluster. By releasing the cluster that does not meet the preset clustering condition, and re-clustering the released face features by a greater threshold, the accuracy of clustering can be effectively

improved.

[0027] It is to be understood that the above general description and the following detailed description are only exemplary and explanatory and not intended to limit the disclosure. According to the following detailed descriptions made to exemplary embodiments with reference to the drawings, other features and aspects of the disclosure may become clear.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The drawings here are incorporated in the specification as a part of the specification. These drawings illustrate embodiments consistent with the disclosure, and serve to describe technical solutions of the disclosure together with the specification.

[0029] FIG. 1A illustrates a schematic diagram of a network architecture of a method for clustering according to embodiments of the disclosure.

[0030] FIG. 1B illustrates a flowchart of a method for clustering according to embodiments of the disclosure.

[0031] FIG. 2 illustrates a schematic diagram of a method for clustering according to embodiments of the disclosure.

[0032] FIG. 3 illustrates a block diagram of an apparatus for clustering according to embodiments of the disclosure.

[0033] FIG. 4 illustrates a schematic diagram of the compositional structure of a computer device according to embodiments of the disclosure.

DETAILED DESCRIPTION

[0034] Exemplary embodiments, features and aspects of the disclosure will be described below with reference to the drawings in detail. The same reference signs in the drawings represent components with the same or similar functions. Although aspects of

the embodiments are illustrated in the drawings, the drawings are not required to be drawn to scale, unless otherwise specified.

[0035] Herein, special term "exemplary" refers to "use as an example, embodiment or illustrative". Herein, any embodiment described as "exemplary" may not be explained to be superior to or better than other embodiments.

[0036] The term "and/or" in this specification describes only an association relationship of associated objects and represents that three relationships may exist. For example, A and/or B may represent the following three cases: only A exists, both A and B exist, and only B exists.

[0037] In addition, term "at least one" in the disclosure represents any one of multiple or any combination of at least two of multiple. For example, including at least one of A, B, or C may represent including any one or more elements selected from a set formed by A, B, or C.

[0038] In addition, for describing the disclosure better, many specific details are presented in the following detailed description. It is understood by those skilled in the art that the disclosure may still be implemented even without some specific details. In some examples, methods, means, components and circuits known very well to those skilled in the art are not described in detail, so as to highlight the subject of the disclosure.

[0039] In the embodiments of the disclosure, the clustering of multiple face features may be realized through the network architecture as illustrated in FIG. 1A. FIG. 1A illustrates a schematic diagram of a network architecture of a method for clustering according to embodiments of the disclosure. The network architecture includes: a user terminal 101, a network 102, and a face feature clustering terminal 103. In order to support an exemplary application, a communication connection is established between the user terminal 101 and the face feature clustering terminal 103 through the network 102. When multiple acquired face features need to be clustered, the user terminal 101 firstly sends a first cluster of face features to the face feature clustering terminal 103 through the network 102. Secondly, the face feature clustering terminal 103 determines whether the first cluster meets a preset clustering condition by performing quantitative analysis on the first cluster. Thirdly, if the first cluster does not meet the preset clustering

condition, the multiple face features included in the first cluster are released. Finally, the multiple face features are re-clustered by using a second threshold that is greater, so as to obtain a second cluster. Thus, the cluster that does not meet the preset clustering condition is released, and the released face features are re-clustered by using a greater threshold, so that the accuracy of clustering can be effectively improved.

[0040] FIG. 1B illustrates a flowchart of a method for clustering according to embodiments of the disclosure. The method for clustering may be executed by an electronic device, such as a terminal device or a server. The terminal device may be User Equipment (UE), a mobile device, a user terminal, a terminal, a cell phone, a cordless phone, a Personal Digital Assistant (PDA), a hand-held device, a computing device, a vehicle device, a wearable device, etc. The method for clustering may be implemented by a processor by calling computer-readable instructions stored in a memory. Alternatively, the method for clustering may be executed by a server. As illustrated in FIG. 1, the method for clustering may include the following actions.

[0041] At S11, quantitative analysis is performed on a first cluster of face features to determine whether the first cluster meets a preset clustering condition. Here, the first cluster is obtained by clustering on the basis of a first threshold, and the preset clustering condition is used for indicating that multiple face features included in the first cluster correspond to a same identity.

[0042] At S12, in response to that the first cluster does not meet the preset clustering condition, the multiple face features included in the first cluster are released.

[0043] At S13, the multiple face features are clustered on the basis of a second threshold to determine a second cluster. Herein the second threshold is greater than the first threshold.

[0044] The cluster that does not meet the preset clustering condition is released, and the released face features are re-clustered by using a greater threshold, so that the accuracy of clustering can be effectively improved.

[0045] Since a video source has the disadvantages of a complex environment, poor light conditions, a low resolution, etc., face features obtained from the captured face

images of different identities will be very highly similar when the face features are obtained by performing image processing on the captured face images in the video source. Thus, face features of different identities may be clustered to the same cluster after clustering according to the similarity of the face features, thereby affecting the clustering accuracy. Therefore, the cluster that already exists in a cluster database needs subjecting to quantitative analysis, so as to ensure clustering accuracy.

[0046] In a possible implementation, the multiple face features include a cluster-center face feature corresponding to the first cluster. The operation that the quantitative analysis is performed on the first cluster to determine whether the first cluster meets the preset clustering condition includes that: cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature are determined; a mean distance and a standard deviation distance are determined according to the cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature; and it is determined that the first cluster does not meet the preset clustering condition in response to that at least one of following is met: the mean distance is greater than a third threshold, or the standard deviation distance is less than a fourth threshold.

[0047] The first cluster is a cluster that already exists in the cluster database. The first cluster subjects the quantitative analysis to determine whether the first cluster meets the preset clustering condition, that is, to determine whether the multiple face features included in the first cluster correspond to a same identity (for example, the same person).

[0048] The cosine distances each between the cluster-center face feature of the first cluster and a respective one of other face features in the first cluster besides the cluster-center face feature are determined and are recorded as S_i . The mean distance

$MEAN_SCORE = (S_1 + S_2 + \dots + S_n) / n$ of these cosine distances is calculated. Herein n is

the number of other face features in the first cluster except the cluster-center face feature.

The standard deviation distance

$STD_SCORE = \sqrt{((S_1 - MEAN_SCORE)^2 + (S_2 - MEAN_SCORE)^2 + \dots + (S_n - MEAN_SCORE)^2) / n}$ of these

cosine distances is calculated.

[0049] In the case where the first cluster includes a large number of face features, in order to improve the calculation efficiency, the other face features in the first cluster except the cluster-center face feature may be sampled and extracted firstly, and the cosine distances each between the cluster-center face feature and a respective one of the sampled and extracted face features are determined. Next, the mean distance and the standard deviation distance are calculated. A sampling condition may be determined according to actual situations, which is not specifically limited in the disclosure. For example, since the face feature is obtained according to a captured face image acquired from the video source, the captured face image has temporal and spatial information, so that the face feature also has temporal and spatial information. Therefore, the other face features in the first cluster except the cluster-center face feature may be sampled and extracted according to the temporal and spatial information thereof.

[0050] After the quantitative analysis is performed on the cluster to obtain the above mean distance and the standard deviation distance, whether the first cluster meets the preset clustering condition is further determined according to the mean distance and the standard deviation distance. A smaller mean distance or a larger standard deviation distance indicates that face features in the first cluster are more similar to each other. That is, the multiple face features included in the first cluster all correspond to a same identity, the first cluster meets the preset clustering condition, and the clustering accuracy of the first cluster is higher. That is to say, a larger mean distance or a smaller standard deviation distance indicates a lower clustering accuracy of the first cluster.

[0051] Therefore, in response to that at least one of following is met: the mean distance is greater than a third threshold or the standard deviation distance is less than a fourth threshold, it is determined that the first cluster does not meet the preset clustering condition. In such a case, the clustering accuracy of the first cluster is low.

[0052] In order to improve the clustering accuracy, multiple face features in the first cluster that does not meet the preset clustering condition are released. If the first cluster is obtained by clustering by using a first threshold (the similarity between face features included in the first cluster is greater than the first threshold), then the multiple face features are re-clustered by using a second threshold greater than the first threshold to obtain a second cluster (the similarity between face features included in the second

cluster is greater than the second threshold), so as to effectively improve the clustering accuracy.

[0053] FIG. 2 illustrates a schematic diagram of a method for clustering according to embodiments of the disclosure. Cluster releasing may be implemented through timed tasks periodically by performing the above operations of quantitative analysis, releasing, and re-clustering on the first cluster that already exists in the cluster database. As illustrated in FIG. 2, a cluster merging/release task 202 is executed on the basis of a task scheduler 201. A first cluster in the cluster database 203 is read, and then the above operations of quantitative analysis, releasing, and re-clustering are performed on the first cluster; and then the second cluster obtained by re-clustering is returned to the cluster database 203. In performing a cluster merging task, the task scheduler 201 reads cluster-center face features corresponding to N known clusters in the cluster database 203, and executes the above clustering task 204 to obtain a cluster-center face cluster. In addition, the task scheduler 201 is used to perform a face feature classification task 205 on faces, read the face feature to be clustered from a spatial and temporal database 206, and read the cluster-center face features corresponding to the N known clusters in the cluster database 203.

[0054] In a possible implementation, the method further includes that: N known clusters are determined according to at least one of: the second cluster, or the first cluster that meets the preset clustering condition, herein $N \geq 1$; and a face feature to be clustered is classified according to the N known clusters.

[0055] After the above quantitative analysis is performed on the first cluster in the cluster database, the cluster database includes at least one of: a first cluster (i.e., a first cluster that is not released after the quantitative analysis) that meets the preset clustering condition, or a second cluster which is a new cluster. These clusters are collectively referred to as N known clusters in a cluster database. The face feature to be clustered may be classified by using the N known clusters in the cluster database, so as to improve the efficiency of face clustering.

[0056] In a possible implementation, the method further includes that: cluster-center face features corresponding to the N known clusters are clustered to obtain a cluster-

center cluster; and known clusters corresponding to cluster-center face features included in the cluster-center cluster are merged.

[0057] Since the video source has the disadvantages of a complex environment, poor light conditions, a low resolution, etc., the similarity between the face features obtained from the captured face images of the same identity will be very low when the face features are obtained by performing image processing on the captured face images in the video source. Thus, the face features of the same identity may be clustered to different clusters after clustering according to the similarity between the face features, thereby affecting the clustering accuracy. Therefore, the existing clusters corresponding to the same identity in the cluster database need to be merged, so as to improve the clustering accuracy.

[0058] Euclidean distances each between the face feature to be clustered and a respective one of the cluster-center face features corresponding to the N known clusters are determined, and k cluster-center face features with the nearest Euclidean distances are obtained by using a k -nearest neighbor algorithm. Cosine distances each between the face feature to be clustered and a respective one of the k cluster-center face features are determined. A point set and an edge set are constructed by using a connected graph algorithm of a distributed graph processing framework (Spark GraphX) and the cosine distances, so as to obtain a connected subset, thereby obtaining a cluster-center cluster. Multiple cluster-center face features included in the cluster-center cluster may be determined to correspond to a same identity, and known clusters corresponding to the cluster-center face features included in the cluster-center cluster are then merged. In this way, different clusters of face features of the same identity are merged, so that the clustering accuracy can be effectively improved.

[0059] The cluster merging may also be implemented through timed tasks periodically by performing the above operations of performing cluster-center face feature clustering and cluster merging on the N known clusters in the cluster database. Still taking the above FIG. 2 as an example, as illustrated in FIG. 2, the cluster merging task is executed on the basis of the task scheduler 201. The cluster-center face features corresponding to N known clusters in the cluster database 203 are read, and the clustering task 204 is executed for the above cluster-center face features to obtain a cluster-center face cluster.

Then, known clusters corresponding to cluster-center face features included in the cluster-center cluster are merged in the cluster database according to the cluster-center face cluster.

[0060] In a possible implementation, the operation that the face feature to be clustered is classified according to the N known clusters includes that: whether there is a target known cluster among the N known clusters is determined, herein a cosine distance between the face feature to be clustered and the cluster-center face feature corresponding to the target known cluster is less than a fifth threshold; and in response to that there is a target known cluster among the N known clusters, the face feature to be clustered is classified to the target known cluster.

[0061] The city-level resident population is fixed, which means that after an intelligent video capture system runs for a period of time, total clusters in the cluster database are relatively stable, which means that most of face features corresponding to captured face images generated each day may be directly classified into N known clusters that already exist in the cluster database. Therefore, a face feature to be clustered is classified by according to the N known clusters in the cluster database without directly performing the clustering operation, so as to improve the timeliness of clustering.

[0062] Still taking the above FIG. 2 as an example, the spatial and temporal database includes a new captured face image obtained according to a video source, and a face feature to be clustered corresponding to the new captured face image. The classification task 205 is executed on the basis of the task scheduler 201. The face feature to be clustered in the spatial and temporal database 206 and the cluster-center face features corresponding to the N known clusters in the cluster database 203 are read. If the cluster-center face features corresponding to the N known clusters in the cluster database already exist in the a video memory of a Graphics Processing Unit (GPU), then the task scheduler schedules the GPU to directly read the cluster-center face features corresponding to the N known clusters from the video memory instead of reading from the cluster database. Then, whether there is a target known cluster among the N known clusters is determined according to the cluster-center face features corresponding to the N known clusters.

[0063] In a possible implementation, the operation that whether there is a target known cluster among the N known clusters is determined includes that: k cluster-center face features having nearest Euclidean distances with the face feature to be clustered are determined from the cluster-center face features corresponding to the N known clusters by a k -nearest neighbor algorithm, herein $N \geq k \geq 1$; cosine distances each between the face feature to be clustered and a respective one of the k cluster-center face features may be determined; and a known cluster corresponding to the cluster-center face feature with a cosine distance less than the fifth threshold is determined as the target known cluster.

[0064] The Euclidean distances each between the face feature to be clustered and a respective one of the cluster-center face features corresponding to the N known clusters are respectively determined, and k cluster-center face features with the nearest Euclidean distances with the face feature to be clustered are obtained by the k -nearest neighbor algorithm. In order to make a distance result more accurate, the cosine distances each between the face feature to be clustered and a respective one of the k cluster-center face features are respectively determined, and then whether there is a cluster-center face feature having the cosine distance with the face feature to be clustered less than a fifth threshold is determined. If yes, the known cluster corresponding to the cluster-center face feature having the cosine distance with the face feature to be clustered less than the fifth threshold is determined as the target known cluster. The fact that cosine distance between the target known cluster and the face feature to be clustered is less than the fifth threshold indicates that the target known cluster is highly similar with the face feature to be clustered, and the target known cluster and the face feature to be clustered can be clustered into the same cluster. Therefore, after the target known cluster is determined, the face feature to be clustered is classified into the target known cluster in the cluster database.

[0065] In a possible implementation, the method further includes that: multiple face features included in each of the N known clusters are updated on the basis of a result of classifying the face feature to be clustered; and for each known cluster, the cluster-center face feature corresponding to the known cluster is updated according to the multiple updated face features corresponding to the known cluster.

[0066] Since face features to be clustered are continuously added to the spatial and

temporal database and the task scheduler continuously executes the classification task, N known clusters in cluster database change continuously. Therefore, multiple face features included in each of the N known clusters are updated according to a classification task result. For example, for a certain known cluster, a new face feature is added after the classification task is performed once.

[0067] Considering the continuous update of the known clusters, in order to ensure the accuracy of the cluster-center face features corresponding to the known clusters, the cluster-center face features corresponding to the known clusters are re-trained periodically according to multiple updated face features corresponding to the known clusters.

[0068] In a possible implementation, the method further includes that: in response to that there is no target known cluster among N known clusters, the face feature to be clustered is determined as an unclassified face; and multiple unclassified face features obtained in a preset duration are clustered to determine a new cluster by the k -nearest neighbor algorithm and a connected graph algorithm.

[0069] When the above classification task is executed, if there is no target known cluster among the N known clusters, it indicates that the face feature to be clustered cannot be classified into any of the N known clusters that already exist in the cluster database, and the face feature to be clustered is determined as an unclassified face feature. When multiple unclassified face features are accumulated in the preset duration, a clustering operation is executed on the basis of the task scheduler.

[0070] Still taking the above FIG. 2 as an example, the clustering operation is executed on the basis of the task scheduler. Multiple unclassified face features obtained in a preset duration are clustered to determine a new cluster, and the new cluster and the face features included in the new cluster are sent to the cluster database.

[0071] Euclidean distances between the unclassified face features are determined, and k unclassified face features with the nearest Euclidean distances are obtained by the k -nearest neighbor algorithm. Then cosine distances between the k unclassified face features are calculated, and then a point set and an edge set are constructed by using the cosine distances and the connected graph algorithm, so as to obtain a connected subset,

thereby obtaining a new cluster.

[0072] In a possible implementation, the method further includes that: the N known clusters are updated according to the new cluster.

[0073] With the execution of the clustering task, the new cluster is added to the cluster database, so that the N known clusters may be updated according to the new cluster. For example, before executing the clustering task, the N known clusters include six known clusters, and then two new clusters are obtained by the clustering task and are sent to the cluster database. Thus, the updated N known clusters include eight known clusters, and then the updated eight known clusters may be used for a subsequent classification task again.

[0074] In a possible implementation, after the captured face images are obtained according to the video source and the corresponding face features are obtained according to the captured face images in the spatial and temporal database, corresponding feature indexes are constructed for the face features so that the face features may be queried based on the feature indexes subsequently. Since the face features included in the N known clusters in the cluster database all come from the spatial and temporal database, a cluster index may be constructed for each known cluster according to the feature indexes corresponding to the face features included in the known clusters, so that the known cluster may be queried based on the cluster index subsequently, to further obtain face features corresponding to the known cluster. After the N known clusters in the cluster database are updated, the cluster index corresponding to each known cluster may be further updated according to the feature indexes corresponding to the face features included in the known cluster.

[0075] In an actual application scenario, when the trajectory of a user is analyzed by using the cluster corresponding to the face feature, it is hoped that the trajectory of the user appears in the archive of the person in a timely manner, that is, there are certain requirements on the timeliness of clustering. The timeliness in clustering the face features to be clustered can be improved in the above way of combining the execution of the classification task and the clustering task. Thus, the trajectory can be studied and judged more comprehensively.

[0076] In some case judgment cases, it is not hoped that the archive of a person is mixed with the trajectories of other persons, or that multiple archives correspond to the trajectory of the same person, that is, there are certain requirements on clustering accuracy. The clustering accuracy can be improved in the above way of combining the execution of the cluster releasing task and the cluster merging task. Thus, the trajectory can be studied and judged more comprehensively.

[0077] In the embodiments of the disclosure, quantitative analysis is performed on a first cluster of face features that is obtained by clustering on the basis of a first threshold, so as to determine whether the first cluster meets a preset clustering condition. Herein the preset clustering condition is used for indicating that multiple face features included in the first cluster correspond to a same identity. In response to that the first cluster does not meet the preset clustering condition, the multiple face features included in the first cluster are released; and the multiple face features are clustered on the basis of a second threshold greater than the first threshold to determine a second cluster. The cluster that does not meet the preset clustering condition is released, and the released face features are re-clustered by using a greater threshold, so that the clustering accuracy can be effectively improved.

[0078] It can be understood that various method embodiments mentioned in the disclosure may be combined to form combined embodiments without departing from principles and logics, which is not described in the disclosure for saving space. It can be understood by those skilled in the art that, in the above method of the detailed description, a specific execution sequence of actions should be determined by functions and probable internal logic thereof.

[0079] In addition, the disclosure further provides an apparatus for clustering, an electronic device, a computer-readable storage medium, and a program, all of which can be used to implement any method for clustering provided in the disclosure. Corresponding technical solutions, description, and the corresponding disclosure may refer to the method part, which will not be elaborated herein.

[0080] FIG. 3 illustrates a block diagram of an apparatus for clustering according to the embodiments of the disclosure.

[0081] As illustrated in FIG. 3, the apparatus 30 includes a quantitative analysis module 31, a release module 32, and a clustering module 33.

[0082] The quantitative analysis module 31 is configured to perform quantitative analysis on a first cluster of face features to determine whether the first cluster meets a preset clustering condition. The first cluster is obtained by clustering on the basis of a first threshold, and the preset clustering condition is used for indicating that multiple face features included in the first cluster correspond to a same identity. The release module 32 is configured to: in response to that the first cluster does not meet the preset clustering condition, release the multiple face features included in the first cluster. The clustering module 33 is configured to cluster the multiple face features on the basis of a second threshold to determine a second cluster. The second threshold is greater than the first threshold.

[0083] In a possible implementation, the multiple face features include a cluster-center face feature corresponding to the first cluster. The quantitative analysis module 31 includes a first determination submodule, a second determination module, and a third determination submodule.

[0084] The first determination submodule is configured to determine cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature. The second determination submodule is configured to determine a mean distance and a standard deviation distance according to the cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature. The third determination submodule is configured to determine that the first cluster does not meet the preset clustering condition in response to that at least one of following is met: the mean distance is greater than a third threshold or the standard deviation distance is less than a fourth threshold.

[0085] In a possible implementation, the apparatus 30 includes: a first determination module and a classification module.

[0086] The first determination module is configured to determine N known clusters according to at least one of: the second cluster, or the first cluster that meets the preset

clustering condition. Herein $N \geq 1$. The classification module is configured to classify, according to the N known clusters, a face feature to be clustered.

[0087] In a possible implementation, the clustering module 33 is further configured to cluster cluster-center face features corresponding to the N known clusters to obtain a cluster-center cluster. The apparatus 30 further includes a merging module. The merging module is configured to merge known clusters corresponding to cluster-center face features in the cluster-center cluster to obtain a merged cluster corresponding to a same identity.

[0088] In a possible implementation, the classification module includes a fourth determination module and a classification submodule.

[0089] The fourth determination module is configured to determine whether there is a target known cluster among the N known clusters. Herein a cosine distance between the face feature to be clustered and the cluster-center face feature corresponding to the target known cluster is less than a fifth threshold. The classification submodule is configured to: in response to that there is a target known cluster among the N known clusters, classify, to the target known cluster, the face feature to be clustered.

[0090] In a possible implementation, the fourth determination submodule includes a first determination unit, and a second determination unit, and a third determination unit.

[0091] The first determination unit is configured to: determine, from the cluster-center face features corresponding to the N known clusters by a k -nearest neighbor algorithm, k cluster-center face features having nearest Euclidean distances with the face feature to be clustered. Herein $N \geq k \geq 1$. The second determination unit is configured to determine cosine distances each between the face feature to be clustered and a respective one of the k cluster-center face features. The third determination unit is configured to determine a known cluster corresponding to a cluster-center face feature with a cosine distance less than the threshold as the target known cluster.

[0092] In a possible implementation, the apparatus 30 further includes: a first update module and a second update module.

[0093] The first update module is configured to update multiple face features included in the N known clusters on the basis of a result of classifying the face feature to be clustered. The second update module is configured to: for each known cluster, update the cluster-center face feature corresponding to the known cluster according to the multiple updated face features corresponding to the known cluster.

[0094] In a possible implementation, the apparatus 30 further includes a second determination module. The second determination module is configured to: in response to that there is no target known cluster among the N known clusters, determine the face feature to be clustered as an unclassified face feature. The clustering module 33 is further configured to cluster, by the k -nearest neighbor algorithm and a connected graph algorithm, multiple unclassified face features under obtained in a preset duration to determine a new cluster.

[0095] In a possible implementation, the apparatus 30 further includes a third update module. The third update module is configured to update the N known clusters according to the new cluster.

[0096] It is to be noted that, in the embodiments of the disclosure, when implemented in form of a software functional module and sold or used as an independent product, the above method for clustering may also be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions of the disclosure substantially or part making contributions to the conventional art may be embodied in form of software product, and the computer software product is stored in a storage medium, including instructions configured to enable a computer device (which may be a terminal, a server, or the like) to execute all or part of the actions of the method in each embodiment of the disclosure. The foregoing storage medium includes: various media capable of storing program codes, such as a USB flash drive, a mobile hard disc, a Read-Only Memory (ROM), a magnetic disc, or a compact disc. Therefore, the embodiments of the disclosure are not limited to any specific hardware and software combination.

[0097] In some embodiments, the functions or modules of the apparatus provided by the embodiments of the disclosure can be used to execute the method described in the above method embodiments, and its specific implementation may refer to the description

of the above method embodiment, which will not be described again for simplicity.

[0098] The embodiments of the disclosure further provide a computer-readable storage medium having stored thereon computer program instructions. The above method is implemented when the computer program instructions are executed by a processor. The computer-readable storage medium may be a non-volatile computer readable storage medium.

[0099] The embodiments of the disclosure further provide a computer program product, including computer-readable code. When the computer-readable code run on a device, a processor in the device executes instructions to implement the method for clustering provided by any one of the above embodiments.

[00100] The embodiments of the disclosure further provide another computer program product, which is configured to store computer-readable instructions. When the instructions are executed, a computer executes the operations of the method for clustering provided by any one of the previous embodiments.

[00101] Correspondingly, the embodiments of the disclosure provide a computer device. FIG. 4 illustrates a schematic diagram of the compositional structure of the computer device according to embodiments of the disclosure. As illustrated in FIG. 4, the computer device 400 includes a processor 401, at least one communication bus, a communication interface 402, at least one external communication interface, and a memory 403. The communication interface 402 is configured to implement connection and communication among these components. The communication interface 402 may include a display screen. The external communication interface may include a standard wired interface and a standard wireless interface. The processor 401 is configured to execute an image processing program in the memory, so as to implement the actions of the method for clustering provided by the above embodiments. The electronic device may be provided as a terminal, a server, or other forms of devices. For example, the electronic device may be a mobile phone, a computer, a digital broadcast terminal, a messaging device, a game console, a tablet device, medical equipment, fitness equipment, a personal digital assistant, or the like.

[00102] The above descriptions about the apparatus for clustering, the computer device,

and the storage medium are similar to descriptions about the above method embodiments, technical descriptions and beneficial effects similar to those of the method embodiments are achieved, which may refer to the above method embodiments, and will not be described in detail herein. Technical details undisclosed in the apparatus for clustering, the computer device, and the storage medium of the disclosure may be understood with reference to the descriptions about the method embodiments of the disclosure.

[00103] The disclosure may be systems, methods, and/or computer program products. The computer program products may include a computer-readable storage medium loaded with computer-readable program instructions configured to enable a processor to implement each aspect of the disclosure.

[00104] The computer-readable storage medium may be a physical device capable of retaining and storing an instruction used by an instruction execution device. For example, the computer-readable storage medium may be, but not limited to, an electric storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any appropriate combination thereof. More specific examples (non-exhaustive list) of the computer-readable storage medium include a portable computer disk, a hard disk, a RAM, a ROM, an EPROM (or a flash memory), an SRAM, a Compact Disc Read-Only Memory (CD-ROM), a Digital Video Disk (DVD), a memory stick, a floppy disk, a mechanical encoding device, for example, a punched card or in-slot raised structure with an instruction stored therein, and any appropriate combination thereof. Herein, the computer-readable storage medium is not explained as a transient signal, for example, radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a wave guide or another transmission medium (for example, a light pulse propagating through an optical fiber cable) or an electric signal transmitting through an electric wire.

[00105] The computer-readable program instructions described here may be downloaded from the computer-readable storage medium to each computing/processing device or downloaded to an external computer or an external storage device through a network such as the Internet, a Local Area Network (LAN), a Wide Area Network (WAN) and/or a wireless network. The network may include a copper transmission cable, optical fiber transmission, wireless transmission, a router, a firewall, a switch, a gateway

computer and/or an edge server. A network adapter card or network interface in each computing/processing device receives the computer-readable program instructions from the network and forwards the computer-readable program instructions for storage in the computer-readable storage medium in each computing/processing device.

[00106] The computer program instructions configured to execute the operations of the disclosure may be assembly instructions, Instruction Set Architecture instructions, machine instructions, machine related instructions, microcode, firmware instructions, state setting data, or source code or target code edited by one or any combination of more programming languages, the programming language including an object-oriented programming language such as Smalltalk and C++ and a conventional procedural programming language such as "C" language or a similar programming language. The computer-readable program instructions may be completely executed in a computer of a user or partially executed in the computer of the user, executed as an independent software package, executed partially in the computer of the user and partially in a remote computer, or executed completely in the remote server or a server. Under the condition that the remote computer is involved, the remote computer may be connected to the computer of the user through any type of network including a Local Area Network or a Wide Area Network, or may be connected to an external computer (for example, connected to an Internet service provider through the Internet). In some embodiments, an electronic circuit such as a programmable logic circuit, a field programmable gate array, or a programmable logic array may be customized by state information of computer-readable program instructions, and the electronic circuit may execute the computer-readable program instructions, thereby implementing each aspect of the disclosure.

[00107] Herein, each aspect of the disclosure is described with reference to flowcharts and/or block diagrams of the method, device (system) and computer program product according to the embodiments of the disclosure. It is to be understood that each block in the flowcharts and/or the block diagrams and a combination of blocks in the flowcharts and/or the block diagrams may be implemented by computer-readable program instructions.

[00108] These computer-readable program instructions may be provided for a processor of a universal computer, a dedicated computer or another programmable data

processing device, to produce a machine to further generate a device that realizes a function/action specified in one or more blocks in the flowcharts and/or the block diagrams when the instructions are executed through the computer or the processor of the other programmable data processing device. These computer-readable program instructions may also be stored in a computer-readable storage medium, and through these instructions, the computer, the programmable data processing device and/or another device may work in a specific mode, so that the computer-readable medium including the instructions includes a product including instructions for implementing each aspect of the function/action specified in one or more blocks in the flowcharts and/or the block diagrams.

[00109] These computer program instructions can also be loaded to a computer, another programmable data processing device, or other devices, so that a series of operating actions are performed on the computer or the another programmable data processing device or the other devices to produce a computer-implemented process, and therefore instructions executed on the computer, or the another programmable data processing device, or the other devices implement functions/actions specified in one or more flows in the flowcharts and/or one or more blocks in the block diagrams.

[00110] The flowcharts and block diagrams in the drawings illustrate probably implemented system architectures, functions and operations of the system, method, and computer program product according to multiple embodiments of the disclosure. On this aspect, each block in the flowcharts or the block diagrams may represent part of a module, a program segment or an instruction, and the part of the module, the program segment or the instruction includes one or more executable instructions configured to realize a specified logical function. In some alternative implementations, the functions marked in the blocks may also be realized in a sequence different from those marked in the drawings. For example, two continuous blocks may actually be executed substantially concurrently and may also be executed in a reverse sequence sometimes, which is determined by the involved functions. It is also to be noted that each block in the block diagrams and/or the flowcharts and a combination of the blocks in the block diagrams and/or the flowcharts may be implemented by a dedicated hardware-based system configured to execute a specified function or operation or may be implemented by a combination of a special hardware and computer instructions.

[00111] The computer program product may be specifically realized by means of hardware, software or a combination thereof. In an optional embodiment, the computer program product is specifically embodied as a computer storage medium, and in another optional embodiment, the computer program product is specifically embodied as software products, such as a Software Development Kit (SDK).

[00112] Embodiment of the disclosure has been described above. The above descriptions are exemplary, non-exhaustive and also not limited to each disclosed embodiment. Many modifications and variations are apparent to those of ordinary skill in the art without departing from the scope and spirit of described embodiments of the disclosure. The terms used herein are selected to explain the principle and practical application of embodiments or improvements in the technologies in the market best or enable others of ordinary skill in the art to understand each embodiment disclosed herein.

INDUSTRIAL APPLICABILITY

[00113] The embodiments of the disclosure provide a method and apparatus for clustering, an electronic device, and a storage medium. The method includes the following. Quantitative analysis is performed on a first cluster of face features to determine whether the first cluster meets a preset clustering condition. The first cluster is obtained by clustering on the basis of a first threshold, and the preset clustering condition is used for indicating that multiple face features included in the first cluster correspond to a same identity. In response to that the first cluster does not meet the preset clustering condition, the multiple face features included in the first cluster are released. The multiple face features are clustered on the basis of a second threshold to determine a second cluster. The second threshold is greater than the first threshold.

CLAIMS

1. A method for clustering, comprising:

performing quantitative analysis on a first cluster of face features to determine whether the first cluster meets a preset clustering condition, wherein the first cluster is obtained by clustering on the basis of a first threshold, and the preset clustering condition is used for indicating that a plurality of face features included in the first cluster correspond to a same identity;

in response to that the first cluster does not meet the preset clustering condition, releasing the plurality of face features included in the first cluster; and

clustering the plurality of face features on the basis of a second threshold to determine a second cluster, wherein the second threshold is greater than the first threshold.

2. The method of claim 1, wherein the plurality of face features comprise a cluster-center face feature corresponding to the first cluster; and

performing quantitative analysis on the first cluster of face features to determine whether the first cluster meets the preset clustering condition comprises:

determining cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature;

determining a mean distance and a standard deviation distance according to the cosine distances; and

determining that the first cluster does not meet the preset clustering condition in response to that at least one of following is met: the mean distance is greater than a third threshold, or the standard deviation distance is less than a fourth threshold.

3. The method of claim 1 or 2, wherein after clustering the plurality of face features on the basis of the second threshold to determine the second cluster, the method further comprises:

determining N known clusters according to at least one of: the second cluster, or the first cluster that meets the preset clustering condition, wherein $N \geq 1$; and

classifying, according to the N known clusters, a face feature to be clustered.

4. The method of claim 3, wherein after determining the N known clusters according to at least one of: the second cluster, or the first cluster that meets the preset clustering condition, the method further comprises:

clustering cluster-center face features corresponding to the N known clusters to obtain a cluster-center cluster; and

merging known clusters corresponding to cluster-center face features in the cluster-center cluster to obtain a merged cluster corresponding to a same identity.

5. The method of claim 3 or 4, wherein classifying, according to the N known clusters, the face feature to be clustered comprises:

determining whether there is a target known cluster among the N known clusters, wherein a cosine distance between the face feature to be clustered and the cluster-center face feature corresponding to the target known cluster is less than a fifth threshold; and

in response to that there is a target known cluster among the N known clusters, classifying, to the target known cluster, the face feature to be clustered.

6. The method of claim 5, wherein determining whether there is a target known cluster among the N known clusters comprises:

determining, from the cluster-center face features corresponding to the N known clusters by a k -nearest neighbor algorithm, k cluster-center face features having nearest

Euclidean distances with the face feature to be clustered, wherein $N \geq k \geq 1$;

determining cosine distances each between the face feature to be clustered and a respective one of the k cluster-center face features; and

determining a known cluster corresponding to a cluster-center face feature a cosine distance less than the fifth threshold as the target known cluster.

7. The method according to any one of claims 3 to 6, wherein after classifying, according to the N known clusters, the face feature to be clustered, the method further comprises:

updating a plurality of face features included in each of the N known clusters on the basis of a result of classifying the face feature to be clustered; and

for each known cluster, updating the cluster-center face feature corresponding to the known cluster according to the plurality of updated face features corresponding to the known cluster.

8. The method of any one of claims 5 to 7, wherein after determining whether there is a target known cluster among the N known clusters, the method further comprises:

in response to that there is no target known cluster among the N known clusters, determining, the face feature to be clustered as an unclassified face feature; and

clustering, by the k -nearest neighbor algorithm and a connected graph algorithm, a plurality of unclassified face features obtained in a preset duration to determine a new cluster.

9. The method of claim 8, wherein after clustering, by the k -nearest neighbor algorithm and the connected graph algorithm, the plurality of unclassified face features obtained in the preset duration to determine the new cluster, the method further comprises:

updating the N known clusters according to the new cluster.

10. An apparatus for clustering, comprising:

a quantitative analysis module, configured to perform quantitative analysis on a first cluster of face features to determine whether the first cluster meets a preset clustering condition, wherein the first cluster is obtained by clustering on the basis of a first threshold, and the preset clustering condition is used for indicating that a plurality of face features included in the first cluster correspond to a same identity;

a release module, configured to: in response to that the first cluster does not meet the preset clustering condition, releasing the plurality of face features included in the first cluster;

a clustering module, configured to cluster the plurality of face features on the basis of a second threshold to determine a second cluster, wherein the second threshold is greater than the first threshold.

11. The apparatus of claim 10, wherein the plurality of face features comprise a cluster-center face feature corresponding to the first cluster, and the quantitative analysis module comprises:

a first determination submodule, configured to determine cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature;

a second determination submodule, configured to determine a mean distance and a standard deviation distance according to the cosine distances each between the cluster-center face feature and a respective one of other face features in the first cluster besides the cluster-center face feature; and

a third determination submodule, configured to determine that the first cluster does not meet the preset clustering condition in response to that at least one of following is met: the mean distance is greater than a third threshold, or the standard deviation distance is less than a fourth threshold.

12. The apparatus of claim 10 or 11, further comprising:

a first determination module, configured to determine N known clusters according to at least one of: the second cluster, or the first cluster that meets the preset clustering condition, wherein $N \geq 1$;

a classification module, configured to classify, according to the N known clusters, a face feature to be clustered.

13. The apparatus of claim 12, wherein the clustering module is further configured to cluster cluster-center face features corresponding to the N known clusters to obtain a cluster-center cluster; and the apparatus further comprises:

a merging module, configured to merge known clusters corresponding to cluster-center face features in the cluster-center cluster to obtain a merged cluster corresponding to a same identity.

14. The apparatus of claim 12 or 13, wherein the classification module comprises:

a fourth determination submodule, configured to determine whether there is a target known cluster among the N known clusters, wherein a cosine distance between the face feature to be clustered and the cluster-center face feature corresponding to the target known cluster is less than a fifth threshold;

a classification submodule, configured to: in response to that there is a target known cluster among the N known clusters, classify, to the target known cluster, the face feature to be clustered.

15. The apparatus of claim 14, wherein the fourth determination submodule comprises:

a first determination unit, configured to: determine, from the cluster-center face features corresponding to the N known clusters by a k -nearest neighbor algorithm, k

cluster-center face features having nearest Euclidean distances with the face feature to be clustered, wherein $N \geq k \geq 1$;

a second determination unit, configured to determine cosine distances each between the face feature to be clustered and a respective one of the k cluster-center face features; and

a third determination unit, configured to determine a known cluster corresponding to a cluster-center face feature with a cosine distance less than the threshold as the target known cluster.

16. The apparatus of any one of claims 12 to 15, further comprising:

a first update module, configured to update a plurality of face features included in each of the N known clusters on the basis of a result of classifying the face feature to be clustered; and

a second update module, configured to: for each known cluster, update the cluster-center face feature corresponding to the known cluster according to the plurality of updated face features corresponding to the known cluster.

17. The apparatus of any one of claims 14 to 16, further comprising:

a second determination module, configured to: in response to that there is no target known cluster among the N known clusters, determine the face feature to be clustered as an unclassified face feature,

wherein the clustering module is further configured to cluster, by the k -nearest neighbor algorithm and a connected graph algorithm, a plurality of unclassified face features under obtained in a preset duration to determine a new cluster.

18. The apparatus of claim 17, further comprising:

a third update module, configured to update the N known clusters according to the

new cluster.

19. An electronic device, comprising:

a processor, and

a memory configured to store processor-executable instructions,

wherein the processor is configured to call the instructions stored in the memory to execute the method of any one of claims 1 to 9.

20. A computer-readable storage medium having stored thereon computer program instructions that, when executed by a processor, cause the processor to implement the method of any one of claims 1 to 9.