

METHOD AND SYSTEM FOR ORDERING REFERENCE IMAGES

5 The present invention relates to the field of organizing images so as to present them in order of relevance. More particularly, the invention is concerned with organizing images depicting a physical element in the context of a search for a given physical element.

 A first example may involve finding an object among lost objects and accomplishing this by organizing images of lost objects. A second example may also involve searching for a
10 person among referenced individuals and accomplishing this by organizing images of the referenced individuals. Other examples of technical contexts may benefit from the invention.

 Traditionally, in decision-making or decision-support systems that are aimed at identifying objects or persons and are based on comparison algorithms that provide scores at the end of these comparisons, the decision to validate the comparisons is taken during a final
15 examination step (called an adjudication step) on the basis of a list of candidates that is provided by the algorithm. Similarity scores resulting from the comparisons made by the system are computed by the comparison algorithm, between the search data and the reference data. A threshold for the similarity score is usually set up to filter sufficiently relevant records, and the system will return to the operator of this decision-making system a list of records in the
20 reference database whose comparison scores for the reference data and the search data are above the threshold. The operator then has to take a decision on the basis of the list received.

 The efficiency and productivity of the decision-making system therefore depends on how quickly the operator finds and confirms valid matches between records in the reference database and the records in the search database whose search data have been subject to
25 comparison.

 To this end, results are presented in descending order of score and the operator will confirm or refute matches in that order, which is why the order of presentation and the absence of exclusion of "true positive" candidates by too restrictive filtering in the reference database are important for the productivity and efficiency of the decision-making system.

30 Thus, methods that filter images on the basis of search criteria and then compare the filtered images with a reference image, in particular by means of a neural network analysis, in such a way as to determine a score and organize the images according to their score do not always lead to satisfaction because filtering sometimes excludes the image that should have been kept.

It is also possible to avoid this pitfall by not filtering and by directly analyzing the database in its entirety, but productivity is then lower because processing time is longer and the probabilities of having a larger number of candidates to organize are greater, which decreases the likelihood that organization will reveal the truly relevant candidate(s) among the top ranks.

It should be noted that in the context of searching for lost luggage, which is done by airlines or airports, investigation time and performance are essential and are now critical, generating significant costs (search and reimbursement costs) for poorer results.

The invention aims to solve all or some of these problems by proposing a method for organizing reference images that quickly and reliably produces a list of images most relevant to the search that is formulated.

According to one aspect of the invention, a method for organizing reference images recorded in a reference database is proposed, said method being carried out by computer and comprising the following steps:

- associating with each search image at least one characterization metadatum that belongs to a class, said search images and characterization metadata forming a search database;

- receiving a search query for a sought physical element that comprises as a search criterion an identification datum pertaining to said sought physical element that belongs to the same class as the at least one characterization metadatum, said class of the identification datum being associated with a confidence index that characterizes the link between said sought physical element and said identification datum;

- filtering the search database according to the identification datum of said sought physical element by comparison with the characterization metadatum from the same class in such a way as to determine images to be sought that are associated with said query;

if the filtering of the search database determines at least two images to be sought that are associated with said query, said images to be sought not all corresponding to the same physical element:

- comparing each reference image in all or some of the reference database with said at least two images to be sought by means of an image comparison algorithm in such a way as to generate for said reference image a similarity score for the similarity between said reference image and each of said at least two images to be sought;

- modifying the generated similarity score according to the confidence index of said same class, which is common to the identification datum and to the characterization metadatum specific to the image to be sought, in particular by weighting;

- organizing all or some of said reference images by decreasing modified similarity score,

5 This method, by creating and taking into account a confidence index for the identification datum from the query, makes it possible to take into consideration, by way of this notion of a link between the sought physical element and the identification datum, the value of the search criterion, that is to say its relevance or importance. Modifying the similarity score a posteriori, according to this confidence index, makes it possible in particular not to exclude images on the

10 basis of a criterion of lower reliability. It therefore makes it possible to efficiently and quickly organize all or some of the reference images in order of relevance, said reference images showing a physical element, on the basis of a selection of search images, said search images in the search database showing a physical element, according to search criteria. Said organized reference images can then be presented to a user, such as an adjudicating operator,

15 as decision support, or for example can be used to automate selection, in particular if the modified similarity score of the first organized reference image is significantly different from the modified similarity score of the second organized reference image, the method then being able to continue, including without human intervention, in one embodiment, by sending, for example to the querier, the sought physical element that has now been found, which corresponds to the

20 one that is imaged in the first organized reference image, that is to say the one that was selected.

Advantageously, said confidence index of a class is determined prior to the query being received, thereby allowing fast processing, the confidence indices per class being recorded in a table, for example, and set by adjustments in a pilot phase.

25 Advantageously, the confidence index of a class depends on said class and on a relative quantity of physical elements that said class covers, relative to another class, thereby allowing classes to be compared with one another according to the strength of the link (relationship) that combines their members with the underlying search criterion and according to their discriminative power. Thus, for example, the determination of the confidence index of

30 a class makes it possible to take into consideration, in a combined manner:

- The fact that the identification datum in question points to a greater or lesser number of physical elements.
- The greater or lesser probability that the sought physical element is actually present among these physical elements to which the identification datum points.

In fact, the smaller the number of physical elements to which the identification datum points and the greater the probability that the sought physical element is one of those physical elements, the greater the confidence index that characterizes the link between the identification datum and the sought physical element, and therefore the greater the value of the search criterion.

The relative quantity can be statistically evaluated during a pilot calibration phase.

Advantageously, the method comprises a step of normalizing the similarity scores, in particular before using the confidence indices to modify the similarity scores, thereby allowing in particular thresholding and comparison of the scores with one another.

Advantageously, the confidence index of the class of the identification datum is dependent on the search query, thereby allowing for example the surname class to be favored when the name is rare compared to a very common name, and in this case, if the confidence index had been predetermined prior to the query (table), it is then modified.

Advantageously, the search database is filtered by Boolean filtering of the characterization metadatum, thereby allowing a fast search on a search database prepared for this purpose due to the characterization metadata associated with each image. In addition, filtering from a new metadatum due to computer analysis of the image, using neural networks, can be carried out to extract information that is not present in the characterization metadata, thereby allowing the new metadatum to be added to the characterization metadata if this analytical filtering is carried out upstream on the search database and provides quality information.

Advantageously, the image comparison algorithm uses a neural network.

Advantageously, the similarity score is modified by weighting or by increment/decrement, thereby allowing easy implementation, the value of the weighting factor or of the increment or decrement being dependent on the confidence index of the common class of the identification datum and the characterization metadatum that is specific to the image to be sought, thereby allowing the reference images I_{ref} for which the relationship with the search criteria is the strongest (highest confidence index) to be emphasized, and, in a simplified embodiment, the weight being able to be equal to the confidence index.

In one embodiment, the physical element is an object or a person.

Advantageously, multiple characterization metadata belonging to distinct classes are associated with all or some of the search images, thereby allowing filtering of the search database on the basis of multiple search criteria, as long as the identification data and characterization metadata in the database each share the same classes.

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Advantageously, the at least one characterization metadatum is specific to an acquisition context of said search image, thereby allowing at least one of the characterization metadata, if there are multiple, to be non-visual in particular.

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Advantageously, at least one referencing metadatum is associated with each recorded reference image, including in particular a referencing metadatum from the same class as the identification datum of said sought physical element, thereby allowing pre-filtering of the reference database, in particular on the basis of the search criterion defined by the identification datum from the same class.

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In one embodiment, the method according to the invention comprises a step of pre-filtering the reference database by comparing the identification datum of said sought physical element with the referencing metadatum from the same class in such a way as to select a part of the reference database that forms a list of candidate reference images for the comparison with said at least two images to be sought, thereby allowing the comparison step to be carried out only on a reduced list of reference images in the reference database.

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Advantageously, the identification datum is a search start date for said sought physical element and the at least one referencing metadatum of the reference image is a date of acquisition of the reference image, said referencing metadatum being specific to an acquisition context of said reference image, the pre-filtering of the reference database being dependent on said search start date, thereby allowing the reference database to be filtered according to, for example, the date on which the luggage item was lost in such a way as to exclude images of luggage items photographed at the lost luggage storage depot before the search start date from the list of candidate reference images, said search start date in this case corresponding to the date on which the luggage item was lost.

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Advantageously, the similarity score specific to the reference-image / image-to-be-sought pair is modified according to a difference between values of the referencing metadatum of the reference image and the characterization metadatum of the image to be sought from the

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same class, thereby allowing metadata that characterize the similarity between physical elements that are not considered in the comparison algorithm, either intrinsically because they are not visual in nature, or because the conditions of their illustration in the images are not guaranteed if they are visual (for example if they designate a visual detail that is too small to be reliably taken into account by the comparison algorithm, or too dependent on captured image conditions), to be taken into account.

In one embodiment, the at least one metadatum of the image is included in the image or is recorded separately in the database that contains it, thereby allowing fast and easy filtering, the record in the image, that is to say in particular in the image file, already being used for the acquisition dates, for example.

Advantageously, the at least one characterization or referencing metadatum of the search or reference image, respectively, is extracted by computer analysis of said image, in particular by means of neural networks, thereby allowing, whether for the referencing metadata of the images in the reference database or for the characterization metadata of the images in the search database, classes to be created a posteriori, in particular on the fly, thereby allowing easy enrichment of the search criteria, even though these criteria might not, for example, have been provided initially, in particular as long as these criteria are visual. In such a case, it is particularly helpful to therefore modify the weighting or increment/decrement used for modifying the similarity score so that their values take into consideration a score that is representative of the quality of the extraction of the metadatum by computer analysis.

In one embodiment, the physical element is a person, the reference images being images of referenced individuals and the search images being images of unidentified individuals that are acquired by video surveillance at different locations, the common class of the identification datum and the characterization metadatum being, for example, a date, a location or a height, thereby allowing, for an identification datum such as a location of interest at a given time, or a height of the person being sought, and the at least one characterization metadatum, such as a date of acquisition of the search image depicting the individual depicted in the search image, a height of the individual depicted in the search image, or a location at which the search image was acquired, comparison of at least one characterization metadatum with at least one search criterion and, in particular for location of interest at a given time metadata, computation of a distance between the location at which the search image was acquired and the location of interest, and even the difference between said given time and the

date of acquisition of the search image depicting the individual depicted in the search image, given that the location of interest is, for example, the location of a crime or a location specified in the context of a witness statement. The locations and dates are in particular (characterization or referencing) metadata specific to the acquisition, that is to say capture, context of the image with which the metadatum is associated.

Likewise, advantageously, the at least one referencing metadatum is a height of the individual depicted in the reference image, thereby allowing pre-filtering and especially evaluation, for each reference image, of differences in quantitative data between these referencing metadata and the identification datum from the same class, or the characterization metadatum of the image to be sought from the same class, and in particular use for modifying the similarity scores.

In one embodiment, the physical element is an object, the object being a luggage item, the reference images being images of stored luggage items and the search images being images of enrolled luggage items that were acquired when the luggage items were enrolled, thereby allowing the images acquired when the luggage item was enrolled, that is to say the photographs captured at the same time as the luggage item was checked in, in particular by means of luggage drop-off kiosks or image acquisition arches arranged downstream of check-in in luggage sorting systems, to be used, following a luggage loss query, to identify, on the basis of search criteria, the enrolment images to be sought in the referencing database, in such a way as to then compare the images to be sought that are selected by filtering on the basis of the search criteria and organize the images among the reference database: that is to say among the photographs of unattributable luggage items (that is to say those without a tag in particular) stored in the warehouses containing these unattributable lost luggage items, in order of relevance in such a way as to transmit the results of organization to an adjudicating officer in charge of following up customer queries. This application to luggage items allows, in particular, data to be analyzed centrally without necessarily having to conduct manual investigations warehouse by warehouse.

Advantageously, the search start date is that of a last enrolment of said sought luggage item or of a last flight taken with said luggage item, thereby allowing pre-filtering of the reference database.

Advantageously, the common class of the identification datum and the characterization metadatum is a size of the luggage item, a weight of the luggage item, a color of the luggage item, a flexible or rigid nature of the luggage item or an enrolment datum pertaining to the luggage item, thereby allowing, for the former, the use of non-contextual metadata, which are easily extracted by image analysis, and, for the latter, a metadatum specific to the context, the provision of, almost exclusively non-visual, information that is much more limiting because it is specific to the luggage item or the person who enrolled it, this class of identification datum allowing efficient filtering of the search database containing these metadata.

Advantageously, the characterization metadatum from a given class for enrolment of the luggage item is a receipt number, an identifier of a person dropping off the luggage item who is associated with the luggage item, a flight reservation number, a flight number or an enrolment date (corresponding to the date of acquisition of the image of the luggage item in the search database), thereby allowing, in particular, the images in the search database to be filtered according to this information, that is to say according to, for example, the surname of the person dropping off the luggage item or their frequent flyer number, and one or more queries to the databases to be formulated.

In one embodiment, multiple images in the reference database correspond to different views of the same luggage item or multiple images in the search database correspond to different views of the same luggage item, thereby increasing the chances of having pairs of images from directly comparable views for the same luggage item present in both databases (and therefore of having better similarity scores), then allowing the operator to be presented with this luggage item as a candidate for the result of the search with a rank computed according to the best available score that corresponds to the pair of images that produced it, and allowing the operator to be presented with both this pair of images and also the other images in the two databases that correspond to this candidate luggage item so as to assist with their adjudication task courtesy of additional images.

According to another aspect of the invention, a system for organizing reference images recorded in a reference database is proposed, comprising:

- an association module that associates with each search image in a search database at least one characterization metadatum that belongs to a class;
- a network communication device;

- a processing device that executes computer-readable instructions that, when executed by the processing device, cause the processing device to:

- receive, by means of the network communication device, a search query for a sought physical element that comprises as a search criterion an identification datum pertaining to said sought physical element that belongs to the same class as the at least one characterization metadatum, said class of the identification datum being associated with a confidence index that characterizes the link between said sought physical element and said identification datum;

- filtering the search database according to the identification datum of said sought physical element by comparison with the characterization metadatum from the same class in such a way as to determine images to be sought that are associated with said query;

if the filtering of the search database determines at least two images to be sought that are associated with said query, said images to be sought not all corresponding to the same physical element:

- compare each reference image in all or some of the reference database with said at least two images to be sought by means of an image comparison algorithm in such a way as to generate a similarity score for the similarity between said reference image and each of said at least two images to be sought;

- modify the generated similarity score according to the confidence index from said same class, which is common to the identification datum and to the characterization metadatum specific to the image to be sought;

- organizing all or some of said reference images by decreasing modified similarity score, This system has the same advantages as the organization method according to the invention, the organization system according to the invention being in particular capable of carrying out the organization method according to the invention in its various embodiments.

According to another aspect of the invention, a computer program comprising instructions configured to carry out each of the steps of the organization method according to the invention when said program is executed on a computer is proposed.

According to another aspect of the invention, a removable or irremovable information storage means that is partially or totally readable by a computer or a microprocessor is proposed, said means containing code instructions of a computer program for carrying out each of the steps of the method according to the invention.

In the appended drawings, which are given by way of non-limiting examples:

figure 1 shows a flowchart for the organization method according to one embodiment of the invention;

5 figure 2 shows a flowchart for the organization method configured for the case of searching for a luggage item according to an exemplary embodiment of the invention;

figure 3 shows the architecture of the system for organizing reference images according to one embodiment of the invention; and

10 figure 4 is a schematic block diagram of an organization system comprising an information processing device for implementing one or more embodiments of the invention.

The invention can be applied in different contexts; figure 1 is intended to illustrate the organization method P according to the invention in a global and synthetic manner. The method P organizes all or some of the reference images Iref recorded in a reference database
15 Bref, the method P comprising the following steps:

- associating E1 with each search image Irec in a search database Brec at least one characterization metadatum that belongs to a class;

- receiving E2 a search query REQ for a sought physical element that comprises as a search criterion an identification datum pertaining to said sought physical element that belongs
20 to the same class as the at least one characterization metadatum, said class of the identification datum being associated with a confidence index that characterizes the link between said sought physical element and said identification datum;

- filtering E3 the search database Brec according to the identification datum of said sought physical element by comparison with the characterization metadatum from the same
25 class in such a way as to determine images to be sought that are associated with said query;

if COND the filtering of the search database determines at least two images to be sought that are associated with said query, said images to be sought not all corresponding to the same physical element:

- comparing E4 each reference image in all or some of the reference database with
30 said at least two images to be sought by means of an image comparison algorithm in such a way as to generate for said reference image a similarity score for the similarity between said reference image and each of said at least two images to be sought;

- modifying E5 the generated similarity score according to the confidence index of the common class of the identification datum and the characterization metadatum specific to the
35 image to be sought, in particular by weighting or by increment/decrement;

- organizing E6 all or some of said reference images by decreasing modified similarity score.

The step of determining a confidence index for the class of the identification datum is not illustrated here because this step is preferably carried out upstream. The confidence indices of a given class then have a preset fixed value (for example following a pilot phase) and their values are independent of the query. However, this step can also be carried out in two stages, so the confidence index specific to the given class is initialized with the preset value in a first stage, then, in a second stage, between step E2 of receiving the query and step E3 of filtering the search database (or at any time between step E2 of receiving and step E5 of modifying the scores), the value of said confidence index is updated, which is in particular advantageous when the confidence index specific to the class of the identification datum depends on the search query, that is to say that, for the same class of the identification datum, the value of the confidence index specific to this identification datum will not be the same according, for example, to the "value" of the identification datum itself in the query (for example a common surname versus a rare surname), or of one of its attributes, such as the number of identification data from the same class in the query (for example the number of luggage receipts submitted). The determination step can also be carried out in one operation between step E2 of receiving the query and step E3 of filtering the search database (or at any time between step E2 of receiving and step E5 of modifying the scores), thereby allowing, in a single step, refined consideration of the features specific to each physical element to be sought. The embodiment of the determination step is advantageously a combination of these three alternatives chosen according to the class of the datum.

The search database Brec therefore contains records, which are a record in the form of images, given that these images can also come from video streams. These records Irec in the search database Brec have associated characterization metadata from the outset (in particular for the metadata specific to the acquisition context, for example the acquisition date, etc.) or after an image analysis (for example a size of the physical element), these characterization metadata being used for filtering E3 the search database, filtering that is preferably Boolean but can also be accompanied by a neural network analysis of images, in particular if certain metadata were not yet associated with all search images Irec (such as a new visual feature that would have been mentioned as a search criterion). If said analysis of images in the database makes it possible to determine and associate the new metadatum with all images Irec in the search database before filtering, then a new class of characterization metadatum is created and used by the Boolean filtering. The characterization metadata can be associated with each image by directly including them in the image file, or they can be

recorded separately in the, in particular centralized, search database Brec, for example in the form of a table, a combination of the two embodiments also allowing secure redundancy of information. It should also be noted that the nature of the storage may also depend on the metadatum itself, some possibly being sensitive, especially among the metadata specific to the acquisition context, and requiring special conditions, some of these data possibly advantageously being encrypted. The characterization metadata used for filtering E3 the search database are chosen according to the identification data that form the search criteria imposed by the query, and for each search criterion a confidence index is determined and associated with the class of the identification datum. This confidence index illustrates the value of the search criterion by characterizing the strength of the link between said sought physical element and said identification datum. This confidence index will thus be representative of the selective value of said search criterion, in particular in such a way as to represent the level of certainty that the physical element selected on the basis of this search criterion does indeed correspond to the sought physical element. In fact, a low confidence index implies a low probability that the physical element selected by filtering in the search database corresponds to the one that is sought, whereas a high confidence index implies a high probability that the physical element selected by filtering in the search database corresponds to the one that is sought. This confidence index thus makes it possible to extend the search in a controlled manner because this confidence index will be taken into consideration in the step of a posteriori modification of similarity scores. In particular, a table containing the confidence index specific to each class of metadatum can be stored, their calibration values resulting from an optimization pilot phase, for example.

The records selected at the end of the filtering E3 of the search database Brec: that is to say the images to be sought, are then used to compare them E4 with the records (here also in the form of images) in the reference database Bref courtesy of an image comparison algorithm (also called a matching algorithm). The purpose of this comparison is to be able to determine whether records in the search database match records in the reference database. During the comparison E4 the metadata (whether characterization metadata or possibly reference metadata), as such, are not used because the comparison algorithm is essentially based on the analysis of the pixels of the image or on the use of trained neural networks for the image comparison. At the output of this comparison step E4, a similarity score is generated for each reference-image / image-to-be-sought pair.

It is in step E5 that this similarity score is modified according to the confidence index specific to the image to be sought Irec, this confidence index being the one from the class common to the identification datum and the characterization metadatum since it is on the basis

of the identification datum in question that the image to be sought in this case was selected. This modification E5 of the similarity score is preferably accomplished by weighting, thereby allowing, because of its commutative nature, resilience with respect to the order of multiple modification steps, since if the search image was selected on the basis of multiple identification data, that is to say that it met the criterion in question each time, multiple modifications are made according to the confidence index specific to said identification datum, not all search images necessarily having met all criteria. The weighting (or increment/decrement) factors, which are specific to each class and linked to the confidence indices, are preferably stored in a table, or can be computed according to a formula in which one of the parameters is the confidence index. Since the reference images Iref are compared with multiple images to be sought Irec (for example multiple captured images, or the same search image compared multiple times with different search criteria headings), at least two similarity scores are computed for each reference image because this score is computed for each reference-image / image-to-be-sought pair; it is therefore advantageous to include, in the organizing step E6, for said reference image Iref, a selection of the maximum score among the scores of said reference-image Iref / image-to-be-sought Irec pairs, in such a way as to allow optimized organization and that each reference image Iref is presented only once (only one rank) to the adjudicating officer, in the order given by the organizing step E6. The same logic for selecting the maximum score by groups of images (multiple views) Iref of the same physical element applies in such a way, for example, as not to display the different views of the same physical element at different positions in the organized list issued to the adjudicating officer. Alternatively, multiple queries can be made, each query comprising only one identification datum, consolidation by selecting the maximum score from the modified similarity scores of each reference image being carried out in the organizing step E6. It will therefore be understood that modifying E5 the scores according to the confidence index therefore changes the order of presentation of the candidates (by decreasing scores) between organization at the end of the comparison step E4 and the organizing E6, thereby allowing the adjudicating officer to process matches sorted in descending order of scores by first seeing possible matches having higher probability of being true matches ('true positives' in the language of decision-making systems) and thereby allowing, as a result, the productivity and efficiency of the decision-making process as a whole to be improved.

In the remainder of the description, the organization method is described in two context examples, one in which the physical element to be sought is an object, in particular a luggage item, and another in which the physical element to be sought is a person.

Thus, the exemplary embodiment shown in figure 2 falls within the context of the loss of a luggage item by a traveler. The purpose of the organization method is therefore to help an adjudicating officer to identify the luggage item declared lost by a traveler among unattributable luggage items (without a check-in tag on the luggage item, the tag attached to the luggage item when it was enrolled having been lost or improperly attached, or not attached, for example) stored in one or more warehouse(s). Photographs (for example on scales in such a way as to have the weight available) of these unattributable luggage items are taken and form the reference database, while photographs taken when the luggage items were enrolled pre-trip form the search database. It will be understood that this embodiment is useful for air transport.

Upon check-in, luggage enrolment systems as described in patent application FR1902969 capture images Irec of each luggage item and other information associated with said luggage item (for example the identity of the person dropping off the luggage item, their frequent flyer number, the reservation number, number of the flight taken, the weight of the luggage item, etc.) that forms in particular characterization metadata specific to the acquisition context that are recorded in the search database, the images Irec / metadata set forming the search database Brec, each image Irec being associated with at least one characterization metadatum, and in particular with at least one characterization metadatum specific to the acquisition context.

In addition, the airline or airport is set up to collect all luggage items that have lost their identification tag and are therefore unattributable, consequently cannot be transported to their intended destination, and are therefore lost. These lost luggage items converge on one or more locations where they will be stored and photographed, these being the reference images Iref that form the reference database Bref. It will therefore be understood that this reference database Bref is dynamic here, depending on arrivals of lost luggage items and withdrawals of luggage items whose owner has been found.

When a traveler comes forward to make a claim by indicating that they have lost a luggage item, a list of identification data as search criteria is then compiled. A search query for the sought (lost) luggage item that comprises the identification datum in question as a search criterion is then sent to the organization system. If certain information communicated by the traveler is not available (for example the date of purchase of the luggage item), that is to say cannot be extracted from the search database, and therefore does not correspond to a class of characterization metadatum, this information is preferably not part of the query (which does not mean that the information will not be used, but means that it is not used in the context of the method described here) or is excluded from the query, and thus reformulated, in the receiving step E2. The search query REQ for a sought physical element comprises as a search

criterion one or more identification data pertaining to said sought physical element that belong to classes, for example the traveler declaring their luggage item lost indicates that the lost luggage item is red, rigid and that the context of the loss of the luggage item is such a flight on such a date, associated with their name. The descriptive features provided by the traveler may be positive or negative. Advantageously, if the traveler submits a photograph of the luggage item that they are declaring lost at the time of their declaration, this photograph can be used in step E3 of filtering the search database in such a way as to use not only the photograph taken by the traveler, which could be of lower quality, in the comparison step but also the search images Irec (and the multiple other views of the luggage item in said image Irec) which would in particular have had the best scores in the filtering step E3.

The search database Brec is filtered in step E3 according to the identification datum of the sought luggage item by comparison with the characterization metadatum from the same class in such a way as to determine images to be sought that are associated with said query.

Possible classes that should be mentioned include:

- the surname and first name of the traveler, linked to the traveler and to people having the same name as them and therefore covering all of their luggage items known to the system for the data retention period,
- the reservation number (which may be linked to multiple persons such as a family or group and therefore to all of their luggage items, including the lost luggage item),
- the flight number (linked to all of the passengers on the flight and to all of their luggage items),
- the frequent flyer number,
- the number of the luggage receipt, etc.

As a result, multiple images to be sought that do not correspond to the same luggage item are generally selected unless, for example, the traveler has attached their luggage receipt. This is because the identification datum such as the name implies selection of the luggage items of a person having the same name, the frequent flyer number includes all luggage items that they have been able to check in on their previous flights and sometimes multiple luggage receipts are attached because the traveler does not know which one corresponds to the lost luggage item, and the other information provided does not allow one of them to be distinguished. The condition COND according to which at least two images to be sought Irec have been selected, and therefore associated with said sought physical element, is therefore very generally met even in the case of thresholding. When this condition is not met (not shown in the figures for clarity) this means that only one image Irec in the search database Brec has been selected, and it is then only necessary to carry out a comparison between each reference

image in all or some of the reference database and said image to be sought Irec selected by means of an image comparison algorithm in such a way as to generate for each reference image a similarity score for the similarity between said reference image and the image to be sought; and then to organize all or some of said reference images by decreasing modified
5 similarity score.

The fact that a confidence index is subsequently used makes it possible to avoid having to exclude search criteria, and the filtering will therefore not be excessively discriminating and will not eliminate a “true positive”, each selected image to be sought Irec having the associated metadatum that justifies its inclusion in this list of images to be sought.

10 The confidence index of the class specific to an identification datum is determined in particular according to the ability of this class to unequivocally describe the lost luggage item, and therefore the lower the confidence index the less discriminating it will be, widening the list of candidates: images to search for, which is why using them in parallel is useful.

Advantageously, the confidence index of the class of the identification datum is
15 dependent on the search query; thus, for example, for a group of receipts corresponding to all of the enrolled luggage items of the passenger (including the lost luggage item), the confidence index of the “receipt number” class will be all the lower the more receipts there are in the group of receipts.

As the “frequent flyer number” (i.e. the passenger’s unique customer number for the
20 airline) covers all luggage items checked in on trips made by that traveler with the airline during the data retention period, for example 3 months, the confidence index of the “frequent flyer number” class will therefore be higher, for example, than that specific to the surname because it is more discriminating than the latter.

The step of determining these confidence indices specific to each class is therefore
25 preferably dependent on the query REQ, in such a way as to make their value as representative of the link between the sought luggage item and said identification data as possible.

Using these confidence indices makes it possible to take into consideration the fact that enrolment luggage camera systems are not installed at all airports at all hold luggage
30 enrolment points, since in such a case, for example, the frequent flyer number would be used to obtain search images Irec of different luggage items of the traveler that were acquired during previous enrolment at equipped airports, these luggage items possibly being more or less numerous and the relevant confidence index being less than that which would have been specific to the receipt of the luggage item linked to the flight following which the luggage item
35 was lost.

The use of various identification data provides, in particular, robustness against incompleteness of coverage of the airport network or against failure of an acquisition device in the network or against poor quality of certain images in the search database, since it is thus possible to select past enrolment images, from other airports, that are not directly linked to the trip during which the luggage was lost.

The comparison step E4 generates similarity scores for each reference-image / image-to-be-sought pair, and then in step E5 these similarity scores are modified according to the class specific to the image to be sought (which justified its selection) in question.

Advantageously, the comparison step E4 is carried out on the basis of a three-dimensional image, given that, if the search images Irec or reference images Iref are two-dimensional, a three-dimensional representation is modeled beforehand to generate said three-dimensional image in each case, for the image to be sought on the basis of the multiple characterization images Irec specific to said enrolled luggage item that are acquired in different views, and for the reference image on the basis of the reference images Iref of the luggage item without a tag that are acquired in different views at the storage location. This embodiment allows filtering and comparison only on the basis of the three-dimensional representations, that is to say by pairs of "objects".

The modification E5 here is carried out by weighting, for example the weighting factors are positive and the weighting indices specific to high confidence indices may therefore be greater than 1, while the weighting factors specific to low confidence indices may then be less than 1. Alternatively, the weighting factors may be bounded between 0 and 1. The weighting factors, for the sake of simplification, may be equal to the confidence indices, their calibration and possible update (determination in two steps) then being defined accordingly. It is easy to understand that when an image to be sought has been selected on the basis of multiple identification data:

- either their weighting factors can be multiplied (or, respectively, added in the case of an increment/decrement) together

- or, preferably, the weighting factor specific to the highest confidence index will be used in such a way as to select the most solid, that is to say the narrowest (strength of the link) or the most promising (with the strongest discriminative power), relationship,

in such a way as to carry out the operational modification computation only once for each similarity score of the image to be sought (for each image-to-be-sought / reference-image pair).

Then, for each reference image, the maximum modified score among the modified scores (because there are as many scores as there are images to be sought) is preferably

selected to strengthen organization and avoid the appearance of duplicates that involve the same object appearing, but are present in different reference images, with different ranks.

The method may also comprise a thresholding step, for example incorporated in the organizing step E6 in such a way as to organize, and therefore present only, the reference
 5 images whose final modified similarity score would be greater than a predetermined threshold, or alternatively the presentation to the adjudicating officer may display only a predetermined number of reference images, amounting to replacing the minimum threshold with a maximum rank.

It should be mentioned that the reference database Bref may advantageously contain
 10 metadata, called referencing metadata, which metadata may have been added to the image file from the outset (for example date of acquisition of the reference image) or for example associated a posteriori after an image analysis (for example color of the luggage item).

If, for each image Iref in the reference database Bref, a referencing metadatum from a given class is available and this given class is common to that of a characterization metadatum,
 15 then this referencing metadatum can also be used. Advantageously, the referencing metadata comprise values, for example if we consider a metadatum that were "damaged zipper" it could have the value: yes, no and N/A if the information was not able to be extracted (image of the zipper unusable, etc.), in particular by analysis of the reference images Iref by means of neural networks.

20 The optional steps related to the referencing metadata are shown in dotted lines in figure 2.

Advantageously, referencing metadata are associated with the reference images in step EA, thereby subsequently allowing, for example if a metadatum from the acquisition date class is available, in a pre-filtering (in particular by Boolean filtering) step EPF, selection, from
 25 the reference images Iref in the reference database Bref, of only unattributable luggage items (without a tag) whose acquisition date is a date later than or equal to the date of the flight that caused the loss of the luggage item, also known as the search start date. At the end of this pre-filtering step EPF, therefore, a restricted list of candidate reference images is generated, and the comparison in step E4 will therefore be carried out on this restricted list only.

30 If not all images in the reference database are present, at least some of the images Iref in the reference database Bref are associated with a referencing metadatum from a given class and this given class is common to that of a characterization metadatum, then this referencing metadatum can also be used.

Thus, additionally or in parallel, in a step EA (which is shown here after the modification
 35 step E5 but could also take place between the comparison step E4 and the modification step

E5 or form part of the score modification step E5) of adjusting the similarity scores, the similarity scores of each reference image are adjusted according to the identity of their value, their similarity, or the numerical difference between their values in the two databases Bref, Brec. This allows, in particular for visual metadata, for example not specific to the acquisition context, such as color, them not to be used as a filter in step EPF (to avoid losing true positives) but to be used to raise the similarity score of luggage items that share the same color. This embodiment is particularly useful when an identification datum from the same class has been provided in the query REQ, and in particular in the case of the “surname” class; this is because when the referencing metadatum specific to this “surname” class is successfully associated with the reference image Iref (either manually by an operator during the taking of photographs that associates the surname as a referencing metadatum with the image (because they have read it inside the luggage item or on an external label) or by image analysis by means of in particular an optical character recognition algorithm, for example applied to an area of the reference image marked as a tag holder of the luggage item), this increases the similarity score according to the proximity of the referencing metadatum (the name “detected” in the reference image Iref) and the characterization metadatum (the “enroled” name).

In another variant of application of the method according to the invention, another luggage search method, carried out for example in addition to the procedure described above, involves applying the method by swapping the databases. Thus, the database of unattributable luggage items (without a tag), which is formed in the locations at which these luggage items converge, forms the search database in this case (and no longer the reference database). The query REQ remains unchanged except that in this case the identification data belonging to classes that are not specific to the acquisition context: such as dimensions of the luggage item, color, flexible or rigid nature, etc., make more sense, since the characterization metadata specific to the other classes are actually missing, the tag on the luggage item having been lost, and therefore do not filter anything. At the end of the filtering E3, the images to be sought are submitted for comparison E4 against the reference database, which comprises the images of the enroled luggage items (captured images acquired at luggage enrolment points at airports). The rest of the method remains unchanged.

In the second context example, the physical element to be sought is a person, this embodiment not being illustrated separately as it can be understood with reference to the existing figures.

In this context of carrying out the method according to the invention, for example when searching for a person who has committed a crime as part of an investigation, the query or queries REQ are formed on the basis of calls for witnesses and the search criteria comprise identification data such as the location of the crime and the (known or presumed) height of the person being sought. For this type of class of characterization metadatum, the confidence index will be, for example, decreasing the more the distance between the location of interest and the location of the video surveillance camera used to acquire the record increases, or decreasing the more the difference between the presumed height and the estimated height in the search image Irec increases.

The search database Brec consists of records from in particular video surveillance cameras and in which individuals appear, and more specifically from cameras located in the surroundings of a location of interest, such as the location of the crime, and pre-processing of the records is therefore preferably carried out in such a way as to extract the video sequences of interest, that is to say in which at least one individual appears.

In step E3, a filter linked to the characterization metadatum from the class: date is applied, for example, in such a way as to concentrate the search from, or around, the date of interest, such as the actual date of the crime, which would have been provided as an identification datum.

In each instance, the reference database Bref consists of records, for example in the form of annotated image files, that feature individuals known to the investigative services, even though these individuals would not necessarily be identified but, for example, merely associated with a given case at this stage.

In the comparison step E4, a biometric comparison is carried out.

Once the comparison step E4 has been carried out, the similarity scores are modified in step E5 using said confidence indices.

As illustrated above, in this context it is also possible to use the referencing metadata, in such a way as to evaluate, for a class of characterization metadatum, the mathematical distance between the value of the characterization metadatum and the value of the referencing metadatum from the same class, for example for height in this case, and then to adjust the similarity score in step EA. Other classes of metadata, such as language spoken, can also be used, especially since the records for the search database Brec come from videos, the soundtracks of which can therefore be analyzed so that languages spoken can sometimes be identified, the language possibly also having been provided in the reference database Bref by annotation by other investigators, for example.

Figure 3 illustrates the architecture of the system S for organizing reference images according to one embodiment of the invention, in the global context of a decision support system.

It shows the means MAref for acquiring the reference images, such as the camera(s) used in storage locations for luggage items without tags, these means MAref for acquiring the reference images possibly already being capable of incorporating referencing metadata in the image file, such as the acquisition date, also known as capture date, of the reference image Iref.

It also shows the means MArec for acquiring the search images, such as the camera(s) used in locations for enrolling luggage items at check-in, these means MArec for acquiring the search images possibly already being capable of incorporating characterization metadata in the image file, such as the acquisition date, also known as capture date, of the search image Irec.

The system S for organizing reference images comprises:

- an association module MArec that associates with each search image Irec in a search database Brec at least one characterization metadatum that belongs to a class;

- a possible (if the referencing metadata are used) association module MAref that associates with each reference image Iref in a reference database Bref at least one referencing metadatum (from the same class as at least one characterization metadatum or as at least one identification datum);

- a network communication device DC (shown centrally here for clarity) through which the various information passes, communications being shown here in particular by the various arrows;

- a processing device DT that executes computer-readable instructions that, when executed by the processing device, cause the processing device to:

- receive, by means of the network communication device, a search query for a sought physical element that comprises as a search criterion an identification datum pertaining to said sought physical element that belongs to the same class as the at least one characterization metadatum;

- filter the search database according to the identification datum of said sought physical element by comparison with the characterization metadatum from the same class in such a way as to determine images to be sought that are associated with said query; if the filtering of the search database determines at least two images to be sought that are associated with said query, said images to be sought not all corresponding to the same physical element;

- determine for the class of the identification datum a confidence index that characterizes the link between said sought physical element and said identification datum;

- compare each reference image in all or some of the reference database with said at least two images to be sought by means of an image comparison algorithm in such a way as to generate a similarity score for the similarity between said reference image and each of said at least two images to be sought;

- modify the generated similarity score according to the confidence index of the common class of the identification datum and the characterization metadatum specific to the image Iref to be sought;

- organize all or some of said reference images Iref by decreasing modified score.

The classification of the results is then displayed on a screen connected to the processing device DT or transmitted to a third party computing device (for example a mobile communication terminal) via the network communication device.

The processing device DT could be shown containing the association modules MAref, MArec, but here the choice has been made to separate them because the respective association steps EA and E1 can be carried out, for example, by an acquisition module that would contain the acquisition means or else by a remote server.

In the case of biometric data, as used in the context of searching for a person, the data are encrypted as they pass through the network communication device.

Figure 4 is a schematic block diagram of an organization system S comprising an information processing device DT for implementing one or more embodiments of the invention.

This device typically corresponds to the processing device DT of figure 3. The information processing device DT may be centralized or distributed. The information processing device DT comprises, for example, one or more peripherals such as a microcomputer, a workstation or a remote server of a telecommunication network. The processing device DT comprises a communication bus connected to:

- a central processing unit 601, such as a microprocessor, denoted CPU;
- a random access memory 602, denoted RAM, for storing the executable code of the method for implementing the invention, and the registers suitable for recording the calibrations necessary for carrying out the method according to embodiments of the invention; the memory capacity of the device may be supplemented by an optional RAM memory connected to an expansion port, for example;

- a read-only memory 603, denoted ROM, for storing computer programs for implementing the embodiments of the invention;

- a network interface 604, denoted NET, which is normally connected to a communications network over which digital data to be processed are transmitted or received. The network interface 604 may be a single network interface, or be composed of a set of different network interfaces (for example wired and wireless interfaces, or various types of wired or wireless interfaces). Data packets are sent over the network interface for transmission or are read from the network interface for reception under the control of the software application executed on the processor 601;

- a user interface 605 for receiving inputs from a user or for displaying information to a user;

- a storage device 606 denoted HD that is capable of storing the databases Bred and Brec, and also the confidence indices;

- an input/output module 607 for receiving/sending data from/to external peripherals such as a hard disk, a removable storage medium, etc.

The executable code may be stored in a nonvolatile memory 603, for example a flash memory or a read-only memory, on the storage device 606 or on a removable digital medium such as, for example, a disk. According to one variant, the executable code of the programs can be received by means of a communications network, via the network interface 604, so as to be stored in one of the storage means of the communication device 600, such as the storage device 606, before being executed.

The central processing unit 601 is configured to control and direct execution of the instructions or of segments of software code of the program or programs according to one of the embodiments of the invention, which instructions are stored in one of the aforementioned storage means. After being turned on, the CPU 601 is capable of executing instructions from the main RAM memory 602 that relate to a software application. Such software, when executed by the processor 601, causes the methods described to be carried out.

The program can in particular be executed on a remote server and its output is then transferred via the network interface 604 to the local user interface GUI 605 for display.

In this embodiment, the device is a programmable device that uses software to implement the invention. However, in the alternative, it should be noted that at least some of the steps of the present invention can be carried out in the hardware (for example in the form of an application-specific integrated circuit (ASIC) or in the form of a programmable logic component or FPGA (field-programmable gate array)), for example operations for computing certain referencing metadata on the fly could be carried out within luggage drop-off kiosks or image acquisition arches arranged downstream of check-in in luggage sorting systems.

The invention allows identification of the best starting points, which are the images to be sought, among the search database Brec and then classification of the results for the adjudicating officer or the investigator according to their confidence index, and not merely according to the score initially assigned by the image comparison algorithm. The risk of exclusion is therefore reduced and the confidence index allows candidates to be considered relative to one another according to the degree of discrimination of the criterion that is the basis for retaining the candidate in question, which improves the efficiency of the organization method because the order presented will already take into consideration multiple criteria and their value as a criterion.

Claims

1. A method (P) for organizing reference images (Iref) recorded in a reference database (Bref), said method being carried out by computer and comprising the following steps:
 - 5 - associating (E1) with each search image (Irec) at least one characterization metadatum that belongs to a class, said search images (Irec) and characterization metadata forming a search database (Brec);
 - receiving (E2) a search query (REQ) for a sought physical element that comprises as a search criterion an identification datum pertaining to said sought physical element that belongs to the same class as the at least one characterization metadatum, said class of the identification datum being associated with a confidence index that characterizes the link between said sought physical element and said identification datum;
 - 10 - filtering (E3) the search database (Brec) according to the identification datum of said sought physical element by comparison with the characterization metadatum of the same class in such a way as to determine images to be sought that are associated with said query; if (COND) the filtering of the search database (Brec) determines at least two images to be sought that are associated with said query, said images to be sought not all corresponding to the same physical element:
 - 15 - comparing (E4) each reference image in all or some of the reference database with said at least two images to be sought by means of an image comparison algorithm in such a way as to generate for said reference image a similarity score for the similarity between said reference image and each of said at least two images to be sought;
 - 20 - modifying (E5) the generated similarity score according to the confidence index of said same class, which is common to the identification datum and to the characterization metadatum specific to the image to be sought, in particular by weighting;
 - 25 - organizing (E6) all or some of said reference images by decreasing modified similarity score.
 - 30
2. The organization method as claimed in the preceding claim, characterized in that the confidence index of a class depends on said

class and on a relative quantity of physical elements that said class covers, relative to another class.

- 5 3. The organization method as claimed in any one of the preceding claims, characterized in that at least one referencing metadatum is associated with each recorded reference image (Iref), including in particular a referencing metadatum from the same class as the identification datum of said sought physical element.
- 10 4. The organization method as claimed in the preceding claim, characterized in that it comprises a step (EPF) of pre-filtering the reference database (Bref) by comparing the identification datum of said sought physical element with the referencing metadatum from the same class in such a way as to select a part of the reference database (Bref)
15 that forms a list of candidate reference images (Iref) for the comparison with said at least two images to be sought.
- 20 5. The organization method as claimed in the preceding claim, characterized in that the identification datum is a search start date for said sought physical element and the at least one referencing
25 metadatum of the reference image (Iref) is a date of acquisition of the reference image, said referencing metadatum being specific to an acquisition context of said reference image, the pre-filtering (EPF) of the reference database being dependent on said search start date.
- 30 6. The organization method as claimed in any one of claims 3 to 5, characterized in that the similarity score specific to the reference-image (Iref) / image-to-be-sought (Irec) pair is modified according to a difference between values of the referencing metadatum of the
35 reference image (Iref) and the characterization metadatum of the image to be sought from the same class.
7. The organization method as claimed in any one of the preceding claims, characterized in that the similarity score is modified by weighting, the
value of the weighting factor being dependent on the confidence index

of the common class of the identification datum and the characterization metadatum specific to the image to be sought.

- 5 8. The organization method as claimed in any one of the preceding claims, characterized in that the at least one characterization or referencing metadatum of the search (Irec) or reference (Iref) image, respectively, is extracted by computer analysis of said image (Irec, Iref), in particular by means of neural networks.
- 10 9. The organization method as claimed in any one of the preceding claims, characterized in that the physical element is a person, the reference images (Iref) being images of referenced individuals and the search images (Irec) being images of unidentified individuals that are acquired by video surveillance at different locations, the common class of the identification datum and the characterization metadatum being, for
15 example, a date, a location or a height.
- 20 10. The organization method as claimed in any one of claims 1 to 8, characterized in that the physical element is an object, the object being a luggage item, the reference images (Iref) being images of stored luggage items and the search images (Irec) being images of enrolled luggage items that were acquired when the luggage items were enrolled.
- 25 11. The organization method as claimed in claims 5 and 10, characterized in that the search start date is that of a last enrolment of said sought luggage item or of a last flight taken with said luggage item.
- 30 12. The organization method as claimed in either one of claims 10 and 11, characterized in that the common class of the identification datum and the characterization metadatum is a size of the luggage item, a weight of the luggage item, a color of the luggage item, a flexible or rigid nature of the luggage item or an enrolment datum pertaining to the luggage item.

13. The organization method as claimed in the preceding claim,
 characterized in that the characterization metadatum from a given class
 for enrolment of the luggage item is a receipt number, an identifier of a
 person dropping off the luggage item who is associated with the
 luggage item, a flight reservation number, a flight number or an
 enrolment date.

14. A system (S) for organizing reference images recorded in a reference
 database, comprising:

- an association module (MArec) that associates with each search image
 (Irec) in a search (Irec) database (Brec) at least one characterization
 metadatum that belongs to a class;

- a network communication device (DC);

- a processing device (DT) that executes computer-readable instructions
 that, when executed by the processing device, cause the processing
 device to:

- receive, by means of the network communication device (DC), a search
 query (REQ) for a sought physical element that comprises as a search
 criterion an identification datum pertaining to said sought physical
 element that belongs to the same class as the at least one
 characterization metadatum, said class of the identification datum being
 associated with a confidence index that characterizes the link between
 said sought physical element and said identification datum;

- filter the search database (Brec) according to the identification datum of
 said sought physical element by comparison with the characterization
 metadatum of the same class in such a way as to determine images to
 be sought that are associated with said query;

if the filtering of the search database determines at least two images to
 be sought that are associated with said query, said images to be sought
 not all corresponding to the same physical element:

- compare each reference image in all or some of the reference database
 with said at least two images to be sought by means of an image
 comparison algorithm in such a way as to generate a similarity score for
 the similarity between said reference image and each of said at least two
 images to be sought;

5

- modify the generated similarity score according to the confidence index of said same class, which is common to the identification datum and to the characterization metadatum specific to the image to be sought;
- organize all or some of said reference images by decreasing modified similarity score.

15. A computer program comprising instructions configured to carry out each of the steps of the organization method (P) as claimed in any one of claims 1 to 13 when said program is executed on a computer.