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(54) **METHOD OF PERSONALIZED IMAGE AND VIDEO SEARCHING BASED ON A NATURAL LANGUAGE QUERY, AND AN APPARATUS FOR THE SAME**

(71) Applicant: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(72) Inventors: **Haotian Zhang**, Toronto (CA); **Allan Jepson**, Toronto (CA); **Iqbal Ismail Mohomed**, Toronto (CA); **Konstantinos Derpanis**, Toronto (CA); **Ran Zhang**, Toronto (CA); **Afsaneh Fazly**, Toronto (CA)

(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

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G06F 16/00 (2019.01)
G06F 16/535 (2019.01)
G06N 20/00 (2019.01)

(52) **U.S. Cl.**
CPC ***G06F 16/535*** (2019.01); ***G06N 20/00*** (2019.01)

(58) **Field of Classification Search**
CPC G06F 16/535; G06N 20/00
See application file for complete search history.

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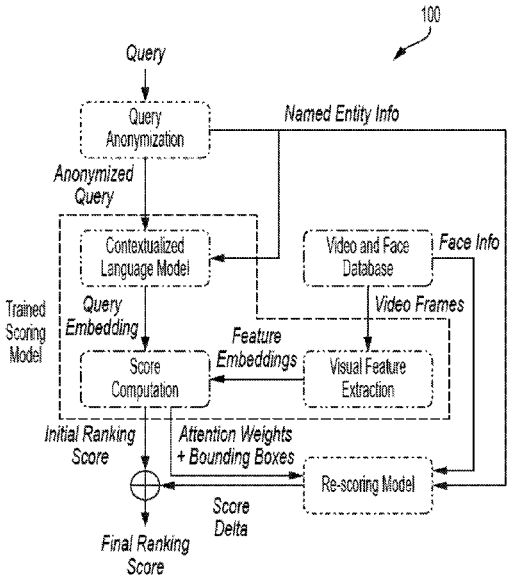
Primary Examiner — Jared M Bibbee
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

A method of personalized image retrieval includes obtaining a natural language query including a name; replacing the name in the natural language query with a generic term to provide an anonymized query and named entity information; obtaining a plurality of initial ranking scores and a plurality of attention weights corresponding to a plurality of images using a trained scoring model that inputs the anonymized query and the plurality of images; obtaining a plurality of delta scores corresponding to the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information; and obtaining a plurality of final ranking scores by modifying the plurality of initial ranking scores based on the plurality of delta scores. The trained scoring model performs semantic based searching and the re-scoring model determines a probability that faces detected in the plurality of images correspond to the name.

20 Claims, 8 Drawing Sheets



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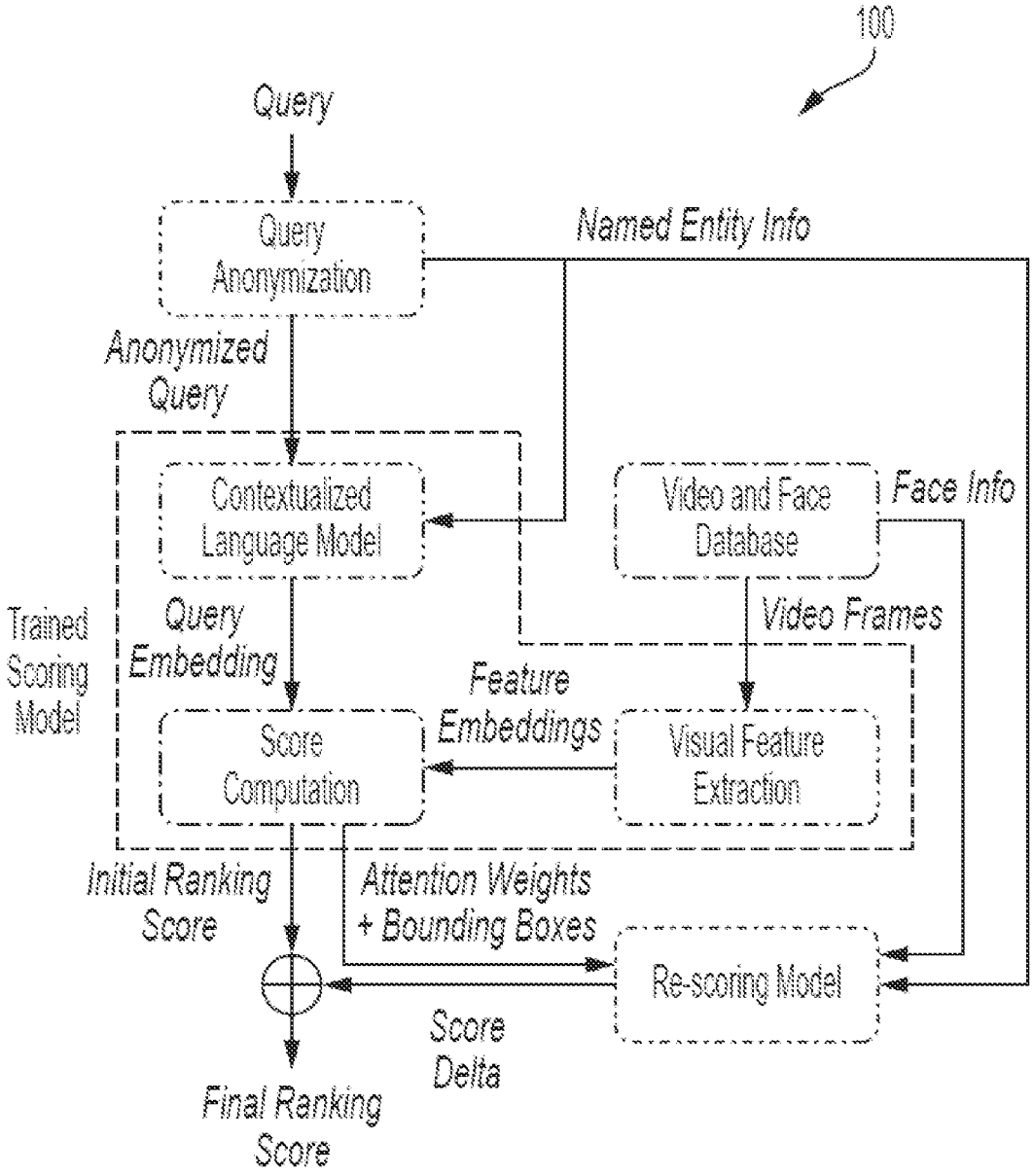
100
Query
Query Anonymization
Named Entity Info
Anonymized Query
Contextualized Language Model
Video and Face Database
Face Info
Trained Scoring Model
Query Embedding
Video Frames
Feature Embeddings
Score Computation
Visual Feature Extraction
Initial Ranking Score
Attention Weights + Bounding Boxes
Re-scoring Model
Score Delta
Final Ranking Score

FIG. 1

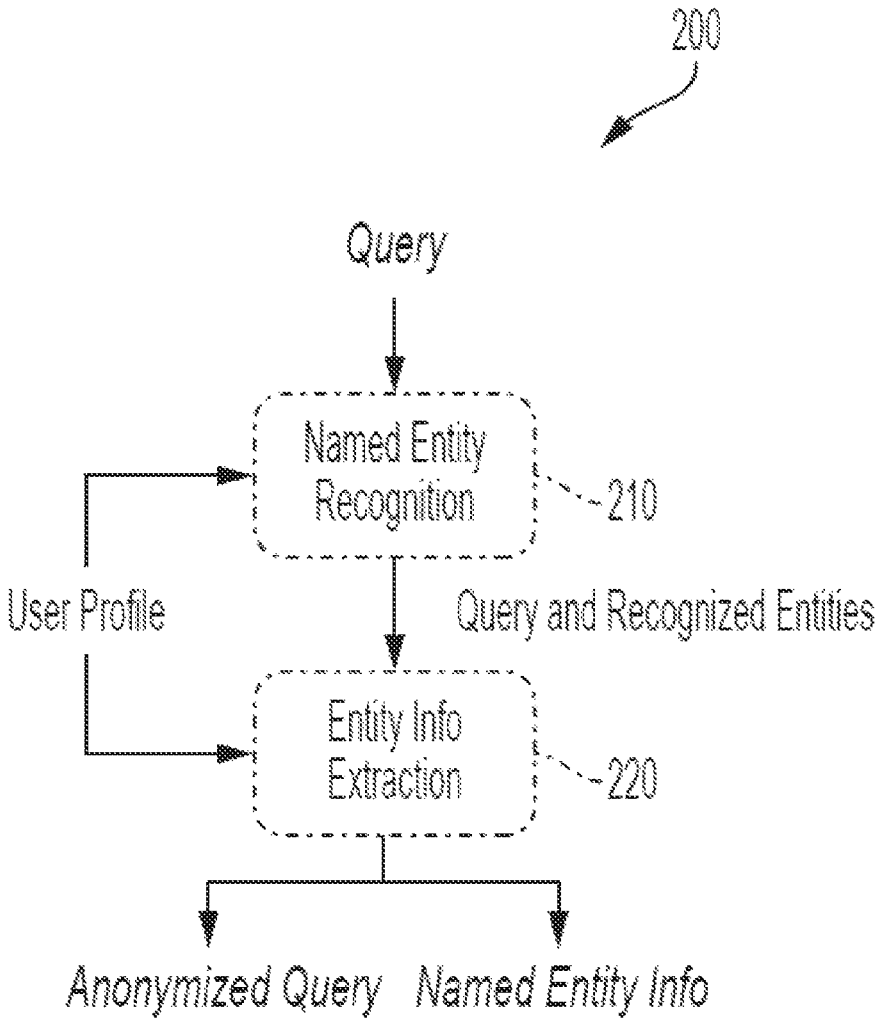
200
Query
Named Entity Recognition
210
User Profile
Query and Recognized Entities
Entity Info Extraction
220
Anonymized Query
Named Entity Info

FIG. 2

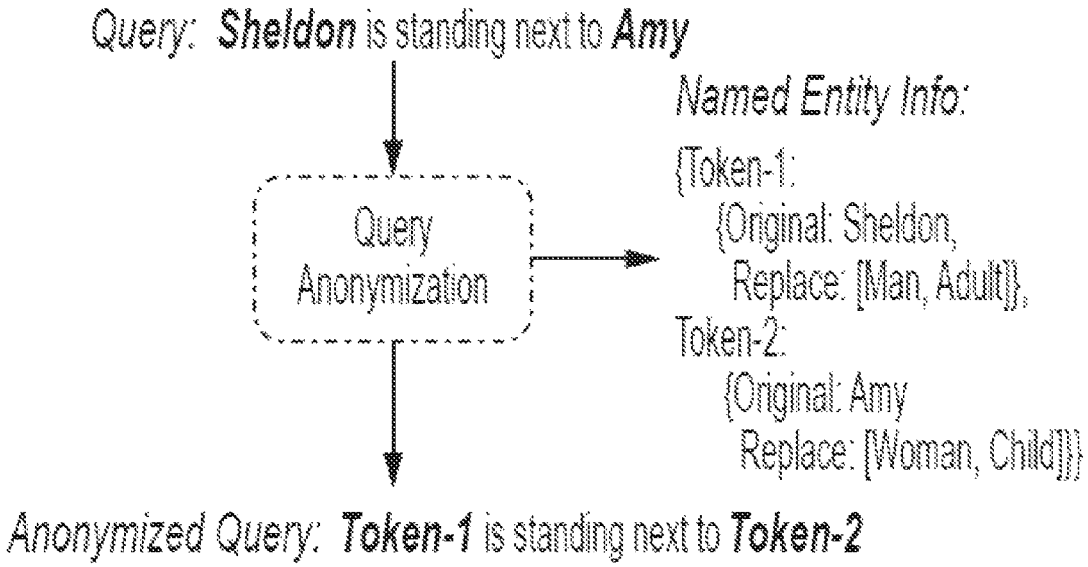
Query: Sheldon is standing next to Amy
Query Anonymization
Named Entity Info:
{Token-1:
{Original: Sheldon,
Replace: [Man, Adult]},
Token-2:
{Original: Amy
Replace: [Woman, Child]}}
Anonymized Query: Token-1 is standing next to Token-2

FIG. 3

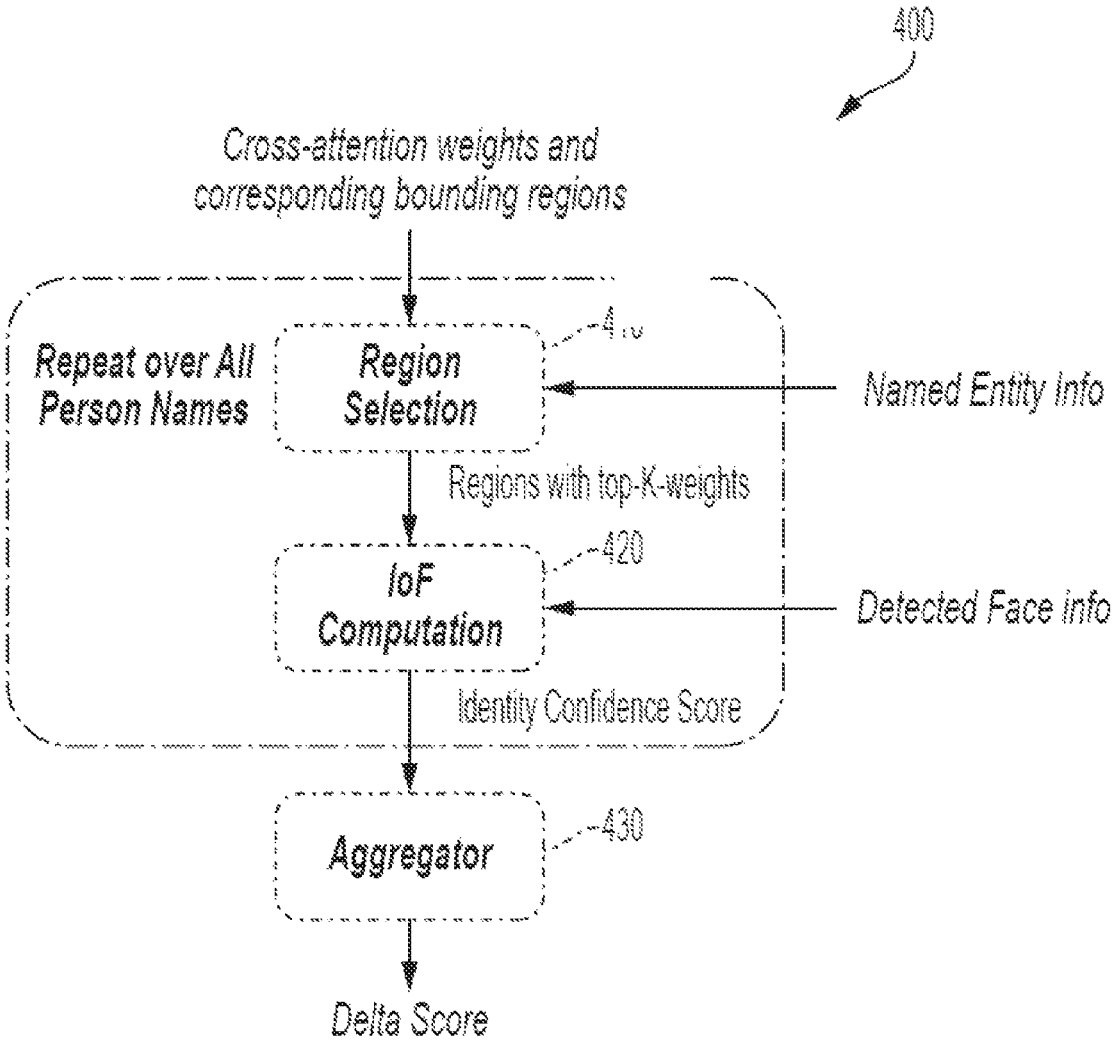
400
Cross-attention weights and corresponding bounding regions
Repeat over All Person Names
Region Selection
Named Entity Info
Regions with top-K-weights
IoF Computation
420
Detected Face Info
Identity Confidence Score
Aggregator
430
Delta Score

FIG. 4

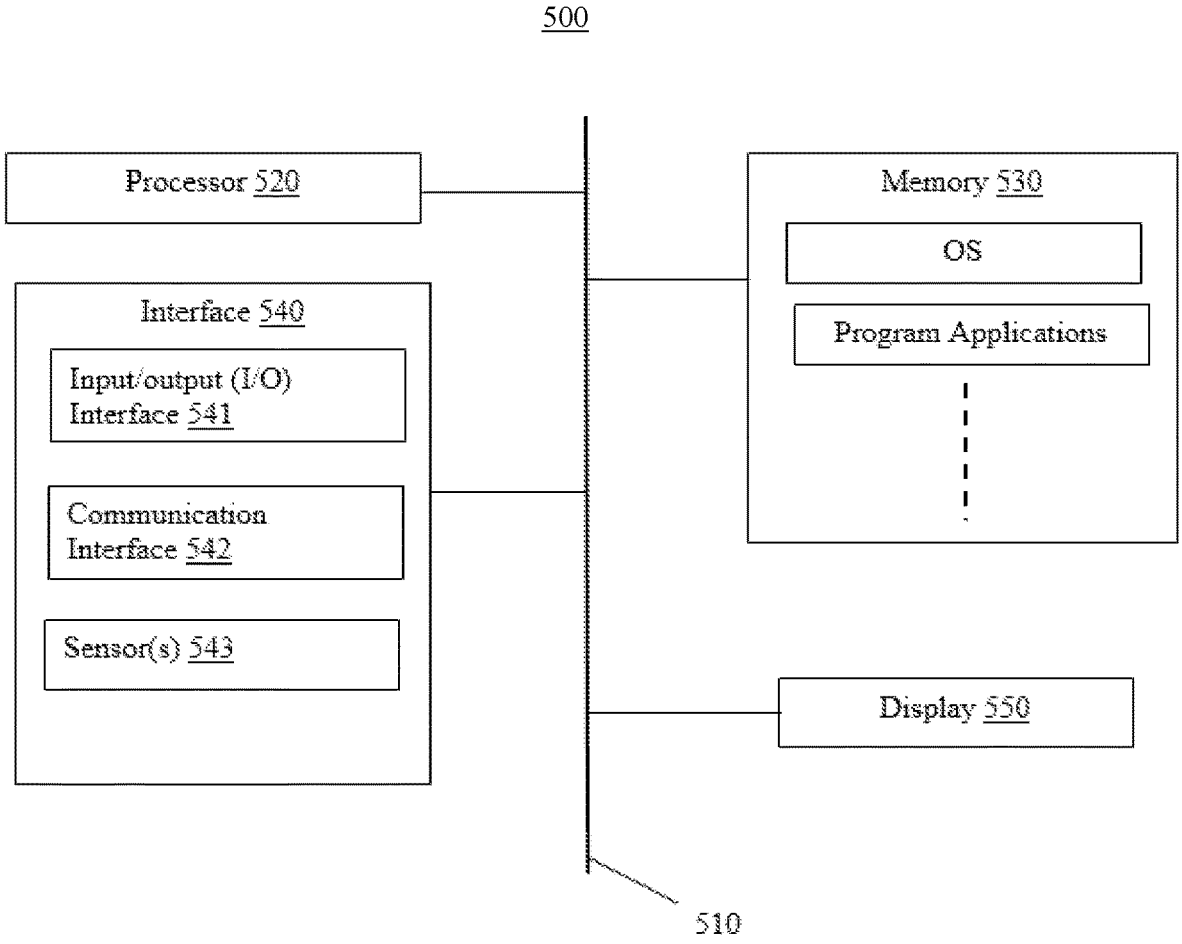
500
Processor 520
Memory 530
OS
Program Applications
Interface 540
Input/output (I/O) Interface 541
Communication Interface 542
Sensor(s) 543
Display 550
510

FIG. 5

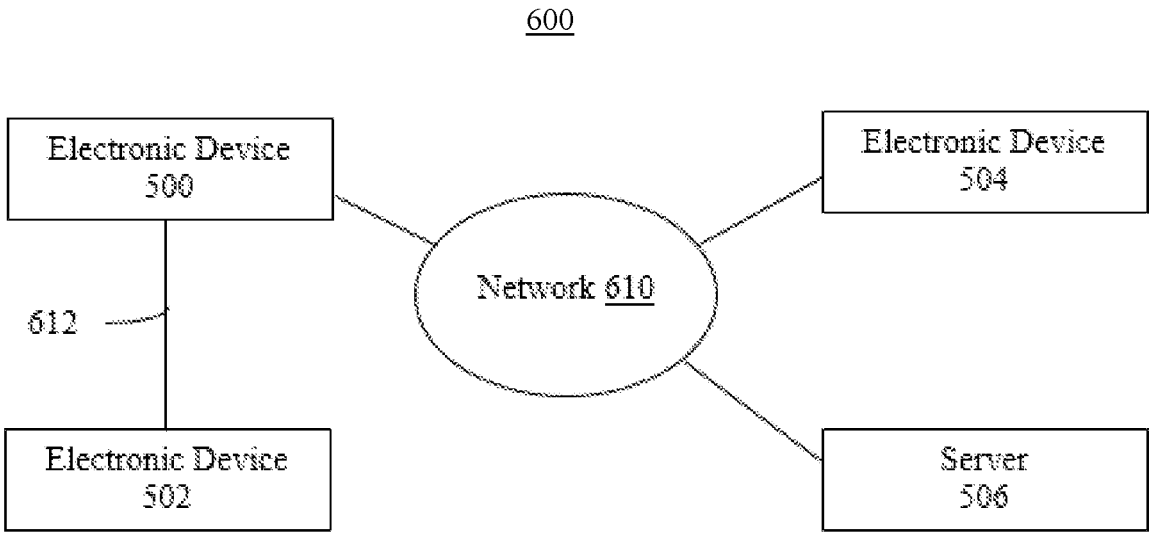
600
Electronic Device
500
Electronic Device
504
Network 610
612
Electronic Device
502
Server
506

FIG. 6

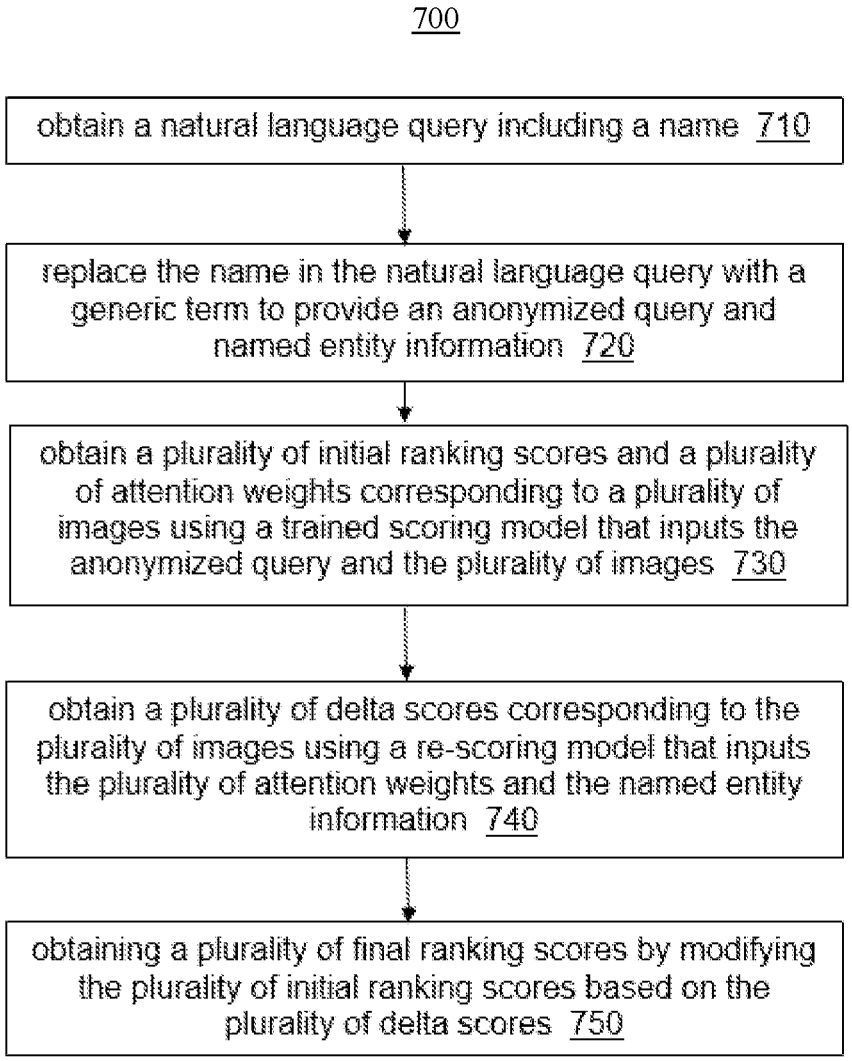
700
obtain a natural language query including a name 710
replace the name in the natural language query with a generic term to provide an anonymized query and named entity information 720
obtain a plurality of initial ranking scores and a plurality of attention weights corresponding to a plurality of images using a trained scoring model that inputs the anonymized query and the plurality of images 730
obtain a plurality of delta scores corresponding to the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information 740
obtaining a plurality of final ranking scores by modifying the plurality of initial ranking scores based on the plurality of delta scores 750

FIG. 7

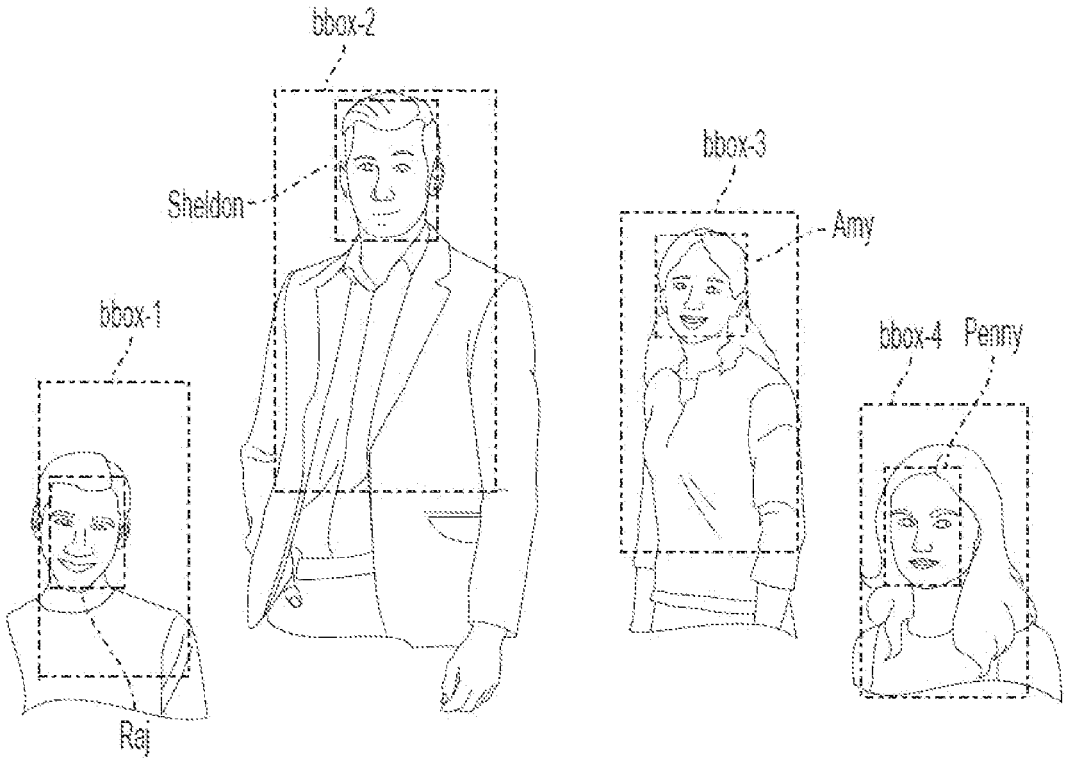

FIG. 8

METHOD OF PERSONALIZED IMAGE AND VIDEO SEARCHING BASED ON A NATURAL LANGUAGE QUERY, AND AN APPARATUS FOR THE SAME

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is based on and claims priority under 35 U.S.C. § 119 to U.S. Provisional Patent Application No. 63/151,293 filed on Feb. 19, 2021, in the U.S. Patent & Trademark Office, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

1. Field

The disclosure relates to video searching, and more particularly to a method of personalized image and video searching based on a natural language query including proper names, and an apparatus for the same.

2. Description of Related Art

Image searching is becoming increasingly popular due to an increasing amount of stored data corresponding to images and videos. Related image searching processes input independent keywords that correspond to either labels of detectors or close synonyms/misspellings. These processes cannot process natural language based queries, such as sentences or phrases. Further, these related processes often fail to return appropriate results due to failures in different detectors.

SUMMARY

According to an aspect of the disclosure, a method of personalized image retrieval includes obtaining a natural language query including a name; replacing the name in the natural language query with a generic term to provide an anonymized query and named entity information; obtaining a plurality of initial ranking scores and a plurality of attention weights corresponding to a plurality of images using a trained scoring model that inputs the anonymized query and the plurality of images; obtaining a plurality of delta scores corresponding to the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information; and obtaining a plurality of final ranking scores by modifying the plurality of initial ranking scores based on the plurality of delta scores. The trained scoring model performs semantic based searching. The the re-scoring model determines a probability that one or more faces detected in the plurality of images correspond to the name.

According to another aspect of the disclosure, an apparatus for personalized image retrieval, the apparatus includes at least one memory storing instructions; and at least one processor configured to execute the instructions to: obtain a natural language query including a name; replace the name in the natural language query with a generic term to provide an anonymized query and named entity information; obtain a plurality of initial ranking scores and a plurality of attention weights corresponding to a plurality of images using a trained scoring model that inputs the anonymized query and the plurality of images; obtain a plurality of delta scores corresponding to the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information; and obtain a plurality of final ranking scores by modifying the plurality of initial ranking scores based on the plurality of delta scores. The trained scoring model performs semantic based searching. and The re-scoring model determines a probability that one or more faces detected in the plurality of images correspond to the name.

According to yet another aspect of the disclosure, a non-transitory computer-readable medium storing instructions comprising: one or more instructions that, when executed by one or more processors, cause the one or more processors to: obtain a natural language query including a name; replace the name in the natural language query with a generic term to provide an anonymized query and named entity information; obtain a plurality of initial ranking scores and a plurality of attention weights corresponding to a plurality of images using a trained scoring model that inputs the anonymized query and the plurality of images; obtain a plurality of delta scores corresponding to the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information; and obtain a plurality of final ranking scores by modifying the plurality of initial ranking scores based on the plurality of delta scores. The trained scoring model performs semantic based searching. The re-scoring model determines a probability that one or more faces detected in the plurality of images correspond to the name

Additional aspects will be set forth in part in the description that follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features, and aspects of embodiments of the disclosure will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a diagram showing a general overview of a method **100** for personalized image and video searching based on natural language inputs according to an embodiment;

FIG. **2** is flowchart of a query anonymization process according to an embodiment;

FIG. **3** is a diagram of a query anonymization process according to an embodiment;

FIG. **4** is a diagram of a re-scoring model according to an embodiment;

FIG. **5** diagram of an electronic device for performing the personalized image and video searching method according to an embodiment;

FIG. **6** is a diagram of a network environment for performing the personalized image and video searching method according to an embodiment;

FIG. **7** is a flowchart of a method for personalized image and video searching based on natural language inputs according to an embodiment;

FIG. **8** is a diagram for explaining the implementation of the method for personalized image and video searching on an image according to an embodiment.

DETAILED DESCRIPTION

The following detailed description of example embodiments refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

The foregoing disclosure provides illustration and description, but is not intended to be exhaustive or to limit the implementations to the precise form disclosed. Modifications and variations are possible in light of the above disclosure or may be acquired from practice of the implementations.

As used herein, the term "component" is intended to be broadly construed as hardware, firmware, or a combination of hardware and software.

It will be apparent that systems and/or methods, described herein, may be implemented in different forms of hardware, firmware, or a combination of hardware and software. The actual specialized control hardware or software code used to implement these systems and/or methods is not limiting of the implementations. Thus, the operation and behavior of the systems and/or methods were described herein without reference to specific software code—it being understood that software and hardware may be designed to implement the systems and/or methods based on the description herein.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the disclosure of possible implementations. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one claim, the disclosure of possible implementations includes each dependent claim in combination with every other claim in the claim set.

No element, act, or instruction used herein should be construed as critical or essential unless explicitly described as such. Also, as used herein, the articles "a" and "an" are intended to include one or more items, and may be used interchangeably with "one or more." Furthermore, as used herein, the term "set" is intended to include one or more items (e.g., related items, unrelated items, a combination of related and unrelated items, etc.), and may be used interchangeably with "one or more." Where only one item is intended, the term "one" or similar language is used. Also, as used herein, the terms "has," "have," "having," or the like are intended to be open-ended terms. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

FIG. **1** is a diagram showing a general overview of a method **100** for personalized image and video searching based on natural language inputs according to an embodiment.

As shown in FIG. **1**, the method **100** may input a query. The query may be a natural language query including proper names such as "Sheldon is standing next to Amy."

A query anonymization operation **110** may be performed on the input natural language query including proper names to obtain an anonymized query and named entity information. An embodiment of the query anonymization is shown in FIGS. **2** and **3**.

As shown in FIG. **2**, a name and entity recognition operation **210** may be performed on the query to provide an entity information extraction operation **220** with the query and recognized entities. Based on the input query and recognized entities, the entity information extraction operation **220** obtains a anonymized query and named entity information.

FIG. **3** shows an example of an operation for obtaining an anonymized query. As shown in FIG. **3**, the named query "Sheldon is standing to next to Amy" is broken down into tokens representing each word, which include Token-1 for the name "Sheldon" and Token-2 for the name "Amy." Based on Token-1 being detected as a man's name, the token may be replaced by a generic term such as man or adult. Based on Token-2 being detected as a woman's name, the token may be replaced with a generic term such as woman or child. Accordingly, the named query "Sheldon is standing to next to Amy" may be converted to anonymized query "man is standing next to woman."

At operation **120**, the anonymized query may be input into a trained scoring model that ranks images based on the anonymized query to obtain initial ranking scores for each image. In the scoring model, a contextualized language model may convert the anonymized query into a vector that is mapped to an embedding space (query embedding). A visual feature extractor may input one or more images from an image or video database, and may extract features from the one or more images. The extracted features may then be converted to a vector that is also mapped to an embedding space (feature embedding).

A score computation may be performed by comparing the query embedding and the feature embedding of an image to provide an initial ranking score for the image. As such, the initial ranking score may indicate an anonymous ranking of an image. The score computation may also output an attention weight corresponding to an images. The attention weight may be obtained by determining a similarity scores based on a comparison between tokens associated with the words of the anonymized query and bounding regions of the images.

As discussed above, the query anonymization operation **110** may output name entity information based on the names in the input query that were replaced by generic terms. The name entity information may be input into the re-scoring model. As shown in FIG. **1**, face information provided by a face database may also be input into the rescoring model.

At operation **130**, the re-scoring model may generate a delta score based on the attention weights, the face information, and the named entity information. An embodiment of a rescoring model **400** is shown in FIG. **4**.

As shown in FIG. **4**, a region selection operation **410** and an intersection-over-face (IoF) computation **420** are performed for each name extracted from the query.

At the region selection operation **410**, regions with the top cross-attention weights are selected and associated with the named entity information (i.e. "Sheldon"). For example, the K-amount of regions with the highest weights ("top-K weights") may be selected and input into the IoF computation with the named entity information.

The IoF computation **420** may obtain an identity confidence score for each of the regions with the top-K weights based on detected face information. For example, the faces detected in the regions with the top-K weights are referenced with the named entity information such as "Sheldon" to determine a probability (confidence score) that the detected face is Sheldon. That is, based on the detected face information, the IoF computation determines a confidence that a detected face in a region corresponds to the person associated with the named entity information.

At operation **430**, the regions with the top-K weights and the corresponding confidence scores are aggregated to obtain a delta score.

As shown in FIG. **1**, at operation **140**, the initial ranking score, which was determined by the scoring model based on the anonymous query, is modified based on the delta score corresponding to the name information. Accordingly, the final ranking score is based on the anonymized query and the proper names from the input query to provide an image

searching function that can retrieve images based on a natural language input including proper names.

The method **100** may be performed by electronic device **500** of FIG. **5**, in a network environment **600** as shown in FIG. **6**, according to an embodiment. FIGS. **5** and **6** are for illustration only, and other embodiments of the electronic device and network could be used without departing from the scope of this disclosure.

As shown in FIG. **5** electronic device **500** includes at least one of a bus **510**, a processor **520** (or a plurality of processors), a memory **530**, an interface **540**, or a display **550**.

Bus **510** may include a circuit for connecting the components **520**, **530**, **540**, and **550** with one another. Bus **510** may function as a communication system for transferring data between the components, or between electronic devices.

Processor **520** may include one or more of a central processing unit (CPU), a graphics processor unit (GPU), an accelerated processing unit (APU), many integrated core (MIC), a field-programmable gate array (FPGA), or a digital signal processing (DSP). Processor **520** may control at least one of other components of electronic device **500**, and/or perform an operation or data processing relating to communication. Processor **520** may execute one or more programs stored in memory **530**.

Memory **530** may include a volatile and/or a non-volatile memory. Memory **530** may store information, such as one or more commands, data, programs (one or more instructions), or applications, etc., that is related to at least one other component of the electronic device **500** and for driving and controlling electronic device **500**. For example, commands or data may formulate an operating system (OS). Information stored in memory **530** may be executed by processor **520**.

The application may include one or more embodiments as discussed above. These functions can be performed by a single application or by multiple applications that each carry out one or more of these functions.

Display **550** may include, for example, a liquid crystal display (LCD), a light emitting diode (LED) display, an organic light emitting diode (OLED) display, a quantum-dot light emitting diode (QLED) display, a microelectromechanical systems (MEMS) display, or an electronic paper display. Display **550** can also be a depth-aware display, such as a multi-focal display. Display **550** is able to present, for example, various contents (such as text, images, videos, icons, or symbols).

Interface **540** may include input/output (I/O) interface **541**, communication interface **542**, and/or one or more sensors **543**. I/O interface **541** serves as an interface that can, for example, transfer commands or data between a user or other external devices and other component(s) of electronic device **500**.

Sensor(s) **543** may meter a physical quantity or detect an activation state of electronic device **500** and may convert metered or detected information into an electrical signal. For example, sensor(s) **543** may include one or more cameras or other imaging sensors for capturing images of scenes. The sensor(s) **543** may also include a microphone, a keyboard, a mouse, one or more buttons for touch input, a gyroscope or gyro sensor, an air pressure sensor, a magnetic sensor or magnetometer, an acceleration sensor or accelerometer, a grip sensor, a proximity sensor, a color sensor (such as a red green blue (RGB) sensor), a bio-physical sensor, a temperature sensor, a humidity sensor, an illumination sensor, an ultraviolet (UV) sensor, an electromyography (EMG) sensor, an electroencephalogram (EEG) sensor, an electrocardiogram (EGG) sensor, an infrared (IR) sensor, an ultrasound sensor, an iris sensor, or a fingerprint sensor. The sensor(s) **543** can further include an inertial measurement unit. In addition, sensor(s) **543** can include a control circuit for controlling at least one of the sensors included here. Any of these sensor(s) **543** can be located within or coupled to electronic device **500**. Sensor(s) **543** may be used to detect touch input, gesture input, hovering input using an electronic pen or a body portion of a user, etc.

Communication interface **542**, for example, may be able to set up communication between electronic device **500** and an external electronic device (such as a first electronic device **502**, a second electronic device **504**, or a server **506** as shown in FIG. **6**). As shown in FIG. **6**, communication interface **542** may be connected with a network **610** and/or **612** through wireless or wired communication architecture to communicate with an external electronic device. Communication interface **142** may be a wired or wireless transceiver or any other component for transmitting and receiving signals.

FIG. **6** shows an example network configuration **600** according to an embodiment. Electronic device **500** of FIG. **5** may be connected with a first external electronic device **502**, a second external electronic device **504**, or a server **506** through network **610** and/or **612**. Electronic device **500** may be wearable device, an electronic device-mountable wearable device (such as an FIMD), etc. When electronic device **500** is mounted in the electronic device **502** (such as the FIMD), electronic device **500** may communicate with electronic device **502** through communication interface **542**. Electronic device **500** may be directly connected with electronic device **502** to communicate with electronic device **502** without involving a separate network. Electronic device **500** may also be an augmented reality wearable device, such as eyeglasses, that include one or more cameras.

The first and second external electronic devices **502** and **504** and server **506** may each be a device of a same or a different type than electronic device **500**. According to some embodiments, server **506** may include a group of one or more servers. Also, according to some embodiments, all or some of the operations executed on electronic device **500** may be executed on another or multiple other electronic devices (such as electronic devices **502** and **504** or server **506**). Further, according to some embodiments, when electronic device **500** should perform some function or service automatically or at a request, electronic device **500**, instead of executing the function or service on its own or additionally, can request another device (such as electronic devices **502** and **504** or server **506**) to perform at least some functions associated therewith. The other electronic device (such as electronic devices **502** and **504** or server **506**) may be able to execute the requested functions or additional functions and transfer a result of the execution to electronic device **500**. Electronic device **500** can provide a requested function or service by processing the received result as it is or additionally. To that end, a cloud computing, distributed computing, or client-server computing technique may be used, for example. While FIGS. **5** and **6** show that electronic device **500** including communication interface **542** to communicate with external electronic devices **502** and **504** or server **506** via the network **610** or **612**, electronic device **500** may be independently operated without a separate communication function according to some embodiments.

Server **506** may include the same or similar components **510**, **520**, **530**, **540**, and **550** as electronic device **500** (or a suitable subset thereof). Server **506** may support driving

electronic device **500** by performing at least one of operations (or functions) implemented on electronic device **500**. For example, server **506** can include a processing module or processor that may support processor **520** of electronic device **500**.

The wireless communication may be able to use at least one of, for example, long term evolution (LTE), long term evolution-advanced (LTE-A), 5th generation wireless system (5G), millimeter-wave or 60 GFIz wireless communication, Wireless USB, code division multiple access (CDMA), wideband code division multiple access (WCDMA), universal mobile telecommunication system (UMTS), wireless broadband (WiBro), or global system for mobile communication (GSM), as a cellular communication protocol. The wired connection may include, for example, at least one of a universal serial bus (USB), high definition multimedia interface (HDMI), recommended standard 232 (RS-232), or plain old telephone service (POTS). The network **610** or **612** includes at least one communication network, such as a computer network (like a local area network (LAN) or wide area network (WAN)), Internet, or a telephone network.

Although FIG. **6** shows one example of a network configuration **600** including an electronic device **500**, two external electronic devices **502** and **504**, and a server **506**, various changes may be made to FIG. **6**. For example, the network configuration **500** could include any number of each component in any suitable arrangement. In general, computing and communication systems come in a wide variety of configurations, and FIG. **5** does not limit the scope of this disclosure to any particular configuration. Also, while FIG. **5** shows one operational environment in which various features disclosed in this patent document can be used, these features could be used in any other suitable system.

The forecasting method may be written as computer-executable programs or instructions that may be stored in a medium.

The medium may continuously store the computer-executable programs or instructions, or temporarily store the computer-executable programs or instructions for execution or downloading. Also, the medium may be any one of various recording media or storage media in which a single piece or plurality of pieces of hardware are combined, and the medium is not limited to a medium directly connected to electronic device **100**, but may be distributed on a network. Examples of the medium include magnetic media, such as a hard disk, a floppy disk, and a magnetic tape, optical recording media, such as CD-ROM and DVD, magneto-optical media such as a floptical disk, and ROM, RAM, and a flash memory, which are configured to store program instructions. Other examples of the medium include recording media and storage media managed by application stores distributing applications or by websites, servers, and the like supplying or distributing other various types of software.

The personalized image and video searching method may be provided in a form of downloadable software. A computer program product may include a product (for example, a downloadable application) in a form of a software program electronically distributed through a manufacturer or an electronic market. For electronic distribution, at least a part of the software program may be stored in a storage medium or may be temporarily generated. In this case, the storage medium may be a server or a storage medium of server **106**.

FIG. **7** is a flowchart of a method **700** of personalized image or video searching based on natural language inputs according to an embodiment.

At operation **710**, a natural language query including a name (or multiple names) may be obtained. For example, a query may state "Sheldon is standing next to Amy." According to an embodiment, when the method **700** is being performed on device **500**, the natural language query may be obtained through the I/O interface **541** based on a user input or may be received through the communication interface **542**.

At operation **720**, the name (or multiple names) in the natural language query may be replaced with a generic term (or multiple generic terms) to provide an anonymized query and named entity information. The anonymized query may be obtained through the process shown in FIGS. **2** and **3** to obtain the anonymized query "man is standing next to woman" and the named entity information "Sheldon" and "Amy." The anonymized query may be converted into a query vector ($E=\{e_1, \ldots e_n\}$) in a common embedding space where n equals the number of tokens in the anonymized query. According to an embodiment, each token represents one word of the query.

At operation **730**, a plurality of initial ranking scores and a plurality of attention weights may be obtained for each of a plurality of images using a trained scoring model that inputs the anonymized query and the plurality of images. The trained scoring model may obtain a feature vector $V=\{v_i, \ldots v_k\}$ in the common embedding space for each image where k equals a number of image region proposals.

According to an embodiment, the trained scoring model may determine a similarity score between the query vector and the feature vector which are both mapped to the common embedding space. The similarity score between region i and token j may be obtained using the following equations.

The cosine similarity between region i and token j is represented by Equation 1.

$$s_{ij} = \frac{v_i^T e_j}{\|v_i\|\|e_j\|} \quad \text{[Equation 1]}$$

The similarities are normalized and thresholded at zero to provide Equation 2.

$$\bar{s}'_{ij} = \frac{[s_{ij}]_+}{\sqrt{\sum_{j=1}^{n} [s_{ij}]_+^2}} \quad \text{[Equation 2]}$$

A weighted combination of image region features a_j^v is defined in Equation 3.

$$a_j^v = \sum_{i=1}^{k} a'_{ij} v_i \quad \text{[Equation 3]}$$

Equation 4 shows what represents in Equation 3.

$$\alpha'_{ij} = \frac{\exp(\lambda_1 \bar{s}'_{ij})}{\sum_{k=1}^{k} \exp(\lambda_1 \bar{s}'_{ij})} \quad \text{[Equation 4]}$$

The similarity between a_j^v and e_j is shown in Equation 5.

$$R(e_j, a_j^v) = \frac{e_j^T a_j^v}{\|e_j\| \|a_j^v\|} \quad \text{[Equation 5]}$$

The similarity score between the feature vector and the query vector is obtained based on Equation 6.

$$S(I_t, Q) = \frac{\sum_{j=1}^{n} R(e_j, a_j^v)}{n} \quad \text{[Equation 6]}$$

According to other embodiments, pooling operations such as LogSumExp pooling may be used when obtaining the initial similarity score.

At operation **740**, a delta score may be obtained for each of the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information.

In the following disclosure, the set of names of all known identities in the query is represented by K, and a single person name token P∈K. According to an embodiment, the delta score may be obtained based on the following process in which the named entity information includes a token P representing a single name in the input query that is the z-th token in the input query.

In some cases, the region e_z that is most attended to may not contain a face (e.g. could include a different body part). As such, a top m regions with the highest attention values (i.e. highest α_{iz}' values) may be selected, where m is a hyper parameter. By implementing this selection process, $\sigma_m(P)$ may be the set of identifiers of the regions that e_z is most attended to, as shown in Equation 7 below.

$$\sigma_m(P) = \arg \max_{s \subset \{1, \ldots, n\}, |s|=m} \sum_{i \in s} \alpha_{iz}' \quad \text{[Equation 7]}$$

Equation 8 (below) defines the IoF between F(P) and R_σ, where F(P) is a face region corresponding to name P, R_σ is the image region corresponding to σ, and |.| is a size of the region bounding box.

$$IoF(F(P), R_\sigma) = \frac{|F(P) \cap R_\sigma|}{|F(P)|} \quad \text{[Equation 8]}$$

For each token P in the query, an identity confidence score h(P) may be obtained based on Equation 9 (below).

$$h(P) = \max_{\sigma \in \sigma_m(P)} IoF(F(P), R_\sigma) \quad \text{[Equation 9]}$$

The delta score may be determined based on Equation 10 (below).

$$\text{delta score} = \sum_{P \in K} h(P)\delta \quad \text{[Equation 10]}$$

In Equation 10, δ is a constant hyper parameter greater than zero (for example, δ=0.1).

At operation **750**, a plurality of final ranking scores may be obtained by modifying the plurality of initial ranking scores based on the plurality of delta scores. For example, a final ranking score for an image $\hat{S}(I_t, Q)$ may be obtained based on Equation 11 which adds the delta score to the initial ranking score $S(I_t, Q)$.

$$\hat{S}(I_t, Q) = S(I_t, Q) + \sum_{P \in \mathcal{P}} h(P)\delta; \quad \text{[Equation 11]}$$

If there are multiple faces detected for P, h(P) may be set to zero due to potential reliability issues of the face detector.

According to some embodiments, a face filter can be applied to the final similarity score for each image. For example, if no faces of named entities are detected in an image (i.e. a current frame of a video), the score of the image will not be considered, or equivalently, set to negative infinity when the aggregation function is max pooling.

FIG. **8** is a diagram for explaining the implementation of the method **700** on an image according to an embodiment. In FIG. **8**, the text "Sheldon is standing next to Amy" is input as the query, which is converted into the anonymized query "man is standing next to woman."

Based on the query "man is standing next to woman," the trained scoring model obtains bounding regions bbox-1 through bbox-4 in the image. Attention weights corresponding to each token of the anonymized query are obtained for each bounding region. As such, attention weights [w_1, w_2, w_3, w_4] for the "man" token and attention weights [u_1, u_2, u_3, u_4] for the "women" token are obtained for bbox-1 through bbox-4.

The re-scoring model inputs the attention weights [w_1, w_2, w_3, w_4] for the "man" token and attention weights [u_1, u_2, u_3, u_4] for the "women" token, the named entity information (e.g. "Sheldon" and "Amy"), and face information obtained from the face database.

If the weight w_2 has the highest value over all weights w_1-w_4, the contextualized embedding of the "man" token (i.e. the embedding not only contains object information, but also context information such as action of the person) can be grounded to bbox-2. Combining the named entity information, face information, and bounding region information corresponding to bbox-2, there is a high certainty/probability that bbox-2 contains the face of Sheldon, which indicates that the image is likely the image to which the query is referring. Thus, the initial ranking score for the image, that was generated by the trained model, is increased based on the name specific processing of the re-scoring model. The "women" tokens may be processed in a similar manner.

The above discussion refers to processing single images, which may be frames of a video. According to an embodiment, video searching may be performed as discussed below. For video I and query Q, the initial ranking score S(I,Q) may be obtained based on Equation 12 (below).

$$S(I,Q) = \text{AGG}(\{S(I_t, Q) | I_t \in I\}) \quad \text{[Equation 12]}$$

In Equation 12, I_t is the t-th frame of video I and AGG(.) is the aggregation function. According to an embodiment, AGG(.) may take the form of max or average pooling, or weighted average of the image specific scores can be learned.

According to an embodiment, the re-scoring model may modify the attention weights α_{ij}' obtained through the trained model, as opposed to modifying the similarity scores produced by the trained model.

In Equation 13 (below), Z represents a set of query token indexes corresponding to the named entity. For example, if the person name token P is the z-th token, then z∈Z. As such, the modified attention weights β_{ij}' are obtained as shown in Equation 13.

$$\beta'_{ij} = Relu\left(\alpha'_{ij} - \sum_{z\in\mathbf{Z}}(1-h_{iz})\alpha'_{iz}q_{zj}\right) \quad \text{[Equation 13]}$$

In Equation 13, h_{iz} denotes the confidence that region I corresponds to named person z and q_{iz} is the similarity between the z-th and j-the token, as shown in Equation 14 (below).

$$q_{zj} = Relu\left(\frac{e_z^T e_j}{\|e_z\|\|e_j\|}\right) \quad \text{[Equation 14]}$$

According to an embodiment, the confidence term h_{iz} can be binary. For example, h_{iz}=1 if IoF(F(z), R_i) is bigger than a certain threshold, and h_{iz}=0 otherwise.

According to another embodiment, h_{iz} can be obtained based on Equation 15 (below).

$$h_{iz} = \frac{IoF(F(z), R_i)}{\sum_{F\in\mathcal{F}(R_i)} IoF(F, R_i) + c_g} IoF(F(z), R_i) \quad \text{[Equation 15]}$$

In equation 15, the face regions that intersect with region R_i are set to be F(R_i) and $0<c_g<1$. If the face corresponding to the z-th token has been detected and F(z)∈F(R_i) (i.e. the face region intersects with R_i), h_{iz} is determined based on Equation 15. If F(P)∉$\mathcal{F}$(R_σ), h_{iz} is set to zero.

According to an embodiment, the trained scoring model may be downloaded to a device performing the method **700**. At inference time, the method **700** may user on-device data to do retrieval. Since visual feature extraction is independent of query processing, video features can be precomputed and stored for inference.

The foregoing disclosure provides illustration and description, but is not intended to be exhaustive or to limit the implementations to the precise form disclosed. Modifications and variations are possible in light of the above disclosure or may be acquired from practice of the implementations.

As used herein, the term "component" is intended to be broadly construed as hardware, firmware, or a combination of hardware and software.

It will be apparent that systems and/or methods, described herein, may be implemented in different forms of hardware, firmware, or a combination of hardware and software. The actual specialized control hardware or software code used to implement these systems and/or methods is not limiting of the implementations. Thus, the operation and behavior of the systems and/or methods were described herein without reference to specific software code—it being understood that software and hardware may be designed to implement the systems and/or methods based on the description herein.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the disclosure of possible implementations. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one claim, the disclosure of possible implementations includes each dependent claim in combination with every other claim in the claim set.

What is claimed is:

1. A method of personalized image retrieval comprising:
- obtaining a natural language query including a name;
- replacing the name in the natural language query with a generic term to provide an anonymized query and named entity information;
- obtaining a plurality of initial ranking scores and a plurality of attention weights corresponding to a plurality of images using a trained scoring model that inputs the anonymized query and the plurality of images;
- obtaining a plurality of delta scores corresponding to the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information; and
- obtaining a plurality of final ranking scores by modifying the plurality of initial ranking scores based on the plurality of delta scores,
- wherein the trained scoring model performs semantic based searching; and
- wherein the re-scoring model determines a probability that one or more faces detected in the plurality of images correspond to the name.

2. The method of claim **1**, wherein the plurality of attention weights of the plurality of images are based on bounding regions of the plurality of images and corresponding similarity scores, and
- wherein the similarity scores are obtained based on semantic information obtained from the anonymized query.

3. The method of claim **2**, wherein the trained scoring model obtains the bounding regions using a feature extraction model and obtains the semantic information using a contextualized language model.

4. The method of claim **2**, wherein the re-scoring model is configured to detect face regions in the plurality of images and obtains the plurality of delta scores based on a spatial relationship between the bounding regions and the detected face regions.

5. The method of claim **4**, wherein the re-scoring model is configured to generate a positive delta score for a current image based on a face corresponding to the name being located within a bounding region of the current image.

6. The method of claim **1**, wherein the natural language query includes a plurality of names, and the plurality of delta scores are obtained based on named entity information corresponding to the plurality of names.

7. The method of claim **1**, wherein the plurality of final ranking scores are obtained by adding the plurality of delta scores to the plurality of initial ranking scores.

8. An apparatus for personalized image retrieval, the apparatus comprising:
- at least one memory storing instructions; and
- at least one processor configured to execute the instructions to:
  - obtain a natural language query including a name;
  - replace the name in the natural language query with a generic term to provide an anonymized query and named entity information;
  - obtain a plurality of initial ranking scores and a plurality of attention weights corresponding to a plural-

ity of images using a trained scoring model that inputs the anonymized query and the plurality of images;

obtain a plurality of delta scores corresponding to the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information; and

obtain a plurality of final ranking scores by modifying the plurality of initial ranking scores based on the plurality of delta scores,

wherein the trained scoring model performs semantic based searching; and

wherein the re-scoring model determines a probability that one or more faces detected in the plurality of images correspond to the name.

9. The apparatus of claim **8**, wherein the plurality of attention weights of the plurality of images are based on bounding regions of the plurality of images and corresponding similarity scores, and

wherein the similarity scores are obtained based on semantic information obtained from the anonymized query.

10. The apparatus of claim **9**, wherein the trained scoring model obtains the bounding regions using a feature extraction model and obtains the semantic information using a contextualized language model.

11. The method of claim **9**, wherein the re-scoring model is configured to detect face regions in the plurality of images and obtains the plurality of delta scores based on a spatial relationship between the bounding regions and the detected face regions.

12. The apparatus of claim **10**, wherein the re-scoring model is configured to generate a positive delta score for a current image based on a face corresponding to the name being located within a bounding region of the current image.

13. The apparatus of claim **8**, wherein the natural language query includes a plurality of names, and the plurality of delta scores are obtained based on named entity information corresponding to the plurality of names.

14. The apparatus of claim **8**, wherein the plurality of final ranking scores are obtained by adding the plurality of delta scores to the plurality of initial ranking scores.

15. A non-transitory computer-readable medium storing instructions, the instructions comprising: one or more instructions that, when executed by one or more processors, cause the one or more processors to:

obtain a natural language query including a name;

replace the name in the natural language query with a generic term to provide an anonymized query and named entity information;

obtain a plurality of initial ranking scores and a plurality of attention weights corresponding to a plurality of images using a trained scoring model that inputs the anonymized query and the plurality of images;

obtain a plurality of delta scores corresponding to the plurality of images using a re-scoring model that inputs the plurality of attention weights and the named entity information; and

obtain a plurality of final ranking scores by modifying the plurality of initial ranking scores based on the plurality of delta scores,

wherein the trained scoring model performs semantic based searching; and

wherein the re-scoring model determines a probability that one or more faces detected in the plurality of images correspond to the name.

16. The non-transitory computer-readable medium of claim **15**, wherein the plurality of attention weights of the plurality of images are based on bounding regions of the plurality of images and corresponding similarity scores, and

wherein the similarity scores are obtained based on semantic information obtained from the anonymized query.

17. The non-transitory computer-readable medium of claim **16**, wherein the trained scoring model obtains the bounding regions using a feature extraction model and obtains the semantic information using a contextualized language model.

18. The non-transitory computer-readable medium of claim **16**, wherein the re-scoring model is configured to detect face regions in the plurality of images and obtains the plurality of delta scores based on a spatial relationship between the bounding regions and the detected face regions.

19. The nn-transitory computer-readable medium of claim **18**, wherein the re-scoring model generates a positive delta score for a current image based on a face corresponding to the name being located within a bounding region of the current image.

20. The non-transitory computer-readable medium of claim **15**, wherein the natural language query includes a plurality of names and the plurality of delta scores are obtained based on named entity information corresponding to the plurality of names.

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