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(54) **CONTEXT-AWARE TAGGING FOR AUGMENTED REALITY ENVIRONMENTS**

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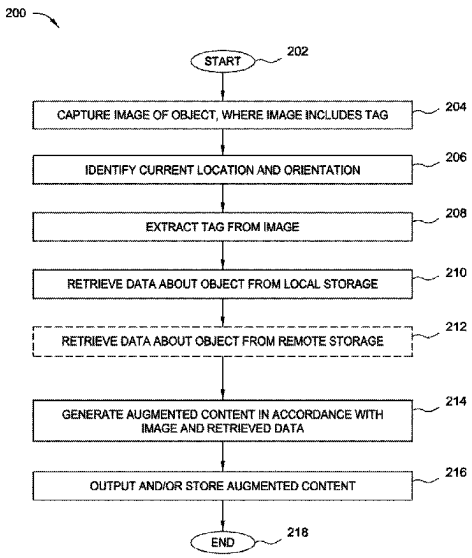
(57) **ABSTRACT**

A method for tag-based search includes capturing an image, extracting a tag from the image, identifying a location associated with the captured image, and querying stored content for information that matches the location and the tag. Local storage is checked for the information first, and remote storage may be checked subsequently. Any located information may be used to augment the image. Information located in the remote storage may be saved in the local storage until it reaches a certain age, until it fails to be accessed for a threshold period of time, or until the location moves outside a threshold radius associated with a location of the information located in the remote storage.

20 Claims, 3 Drawing Sheets



Related U.S. Application Data

continuation of application No. 14/985,559, filed on Dec. 31, 2015, now Pat. No. 9,905,051, which is a continuation of application No. 13/775,694, filed on Feb. 25, 2013, now Pat. No. 9,286,323.

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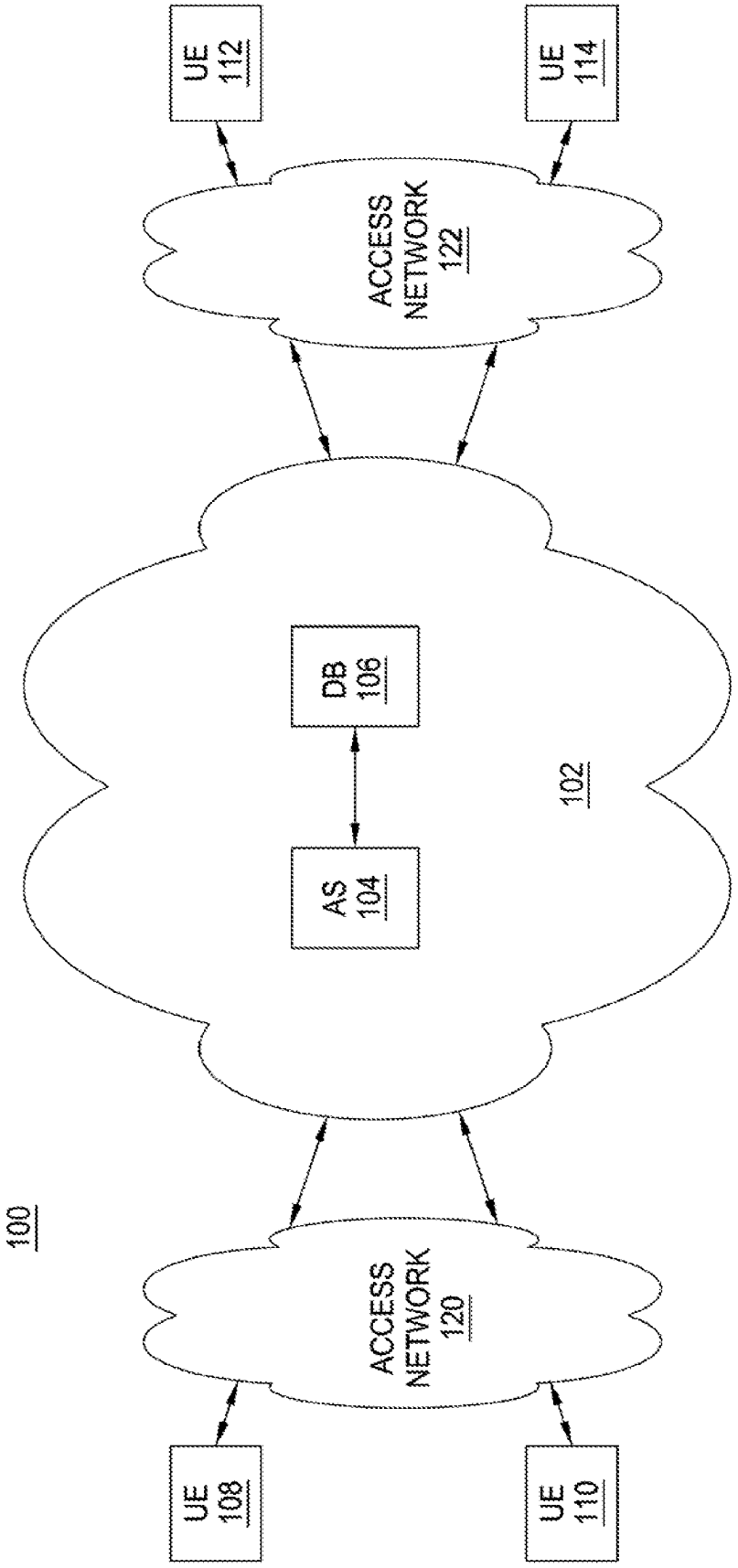
100
UE 112
UE 114
ACCESS NETWORK 122
DB 106
AS 104
102
ACCESS NETWORK 120
UE 108
UE 110

FIG. 1

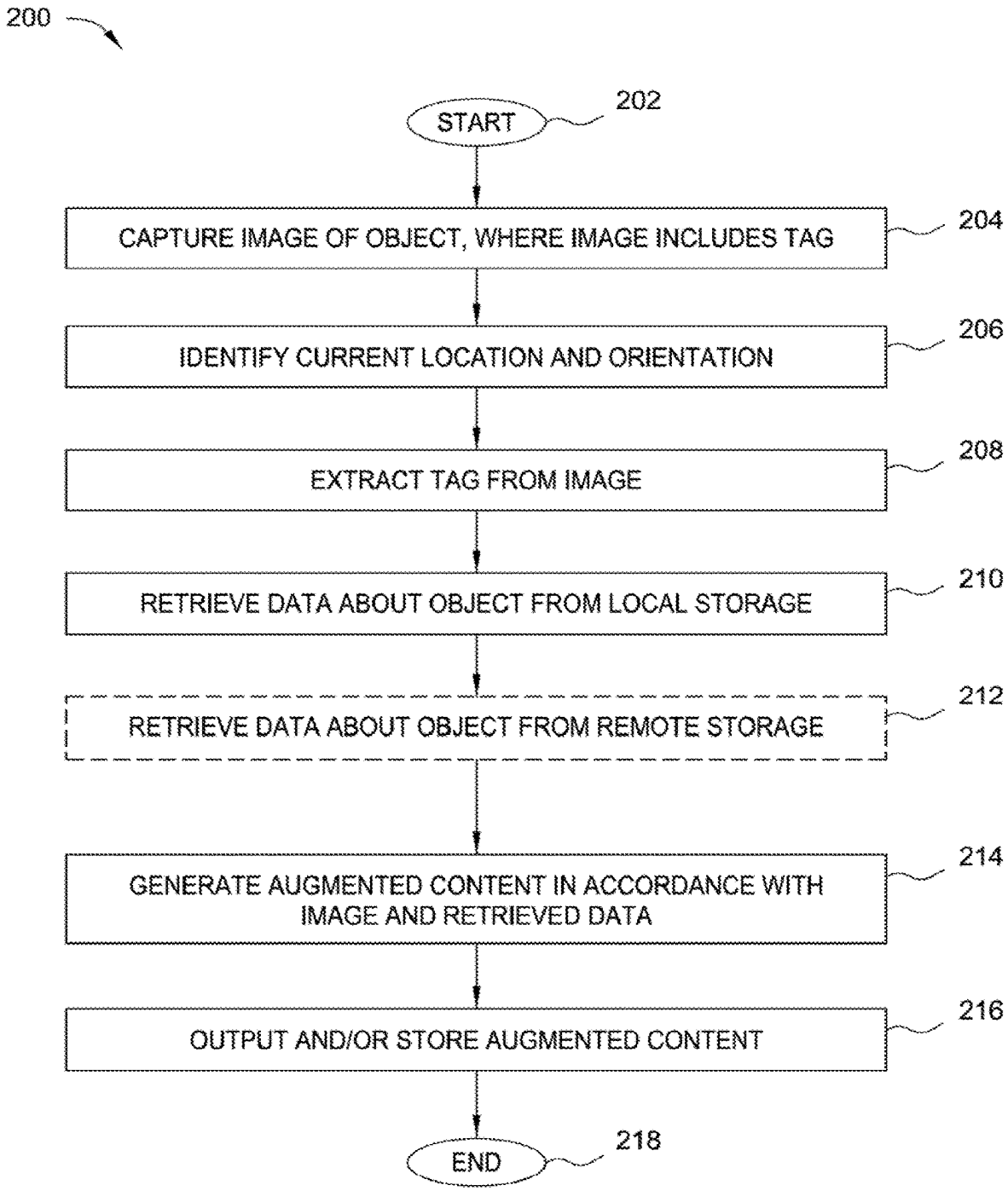
200
START
202
CAPTURE IMAGE OF OBJECT, WHERE IMAGE INCLUDES TAG
204
IDENTIFY CURRENT LOCATION AND ORIENTATION
206
EXTRACT TAG FROM IMAGE
208
RETRIEVE DATA ABOUT OBJECT FROM LOCAL STORAGE
210
RETRIEVE DATA ABOUT OBJECT FROM REMOTE STORAGE
212
GENERATE AUGMENTED CONTENT IN ACCORDANCE WITH IMAGE AND RETRIEVED DATA
214
OUTPUT AND/OR STORE AUGMENTED CONTENT
216
END
218

FIG. 2

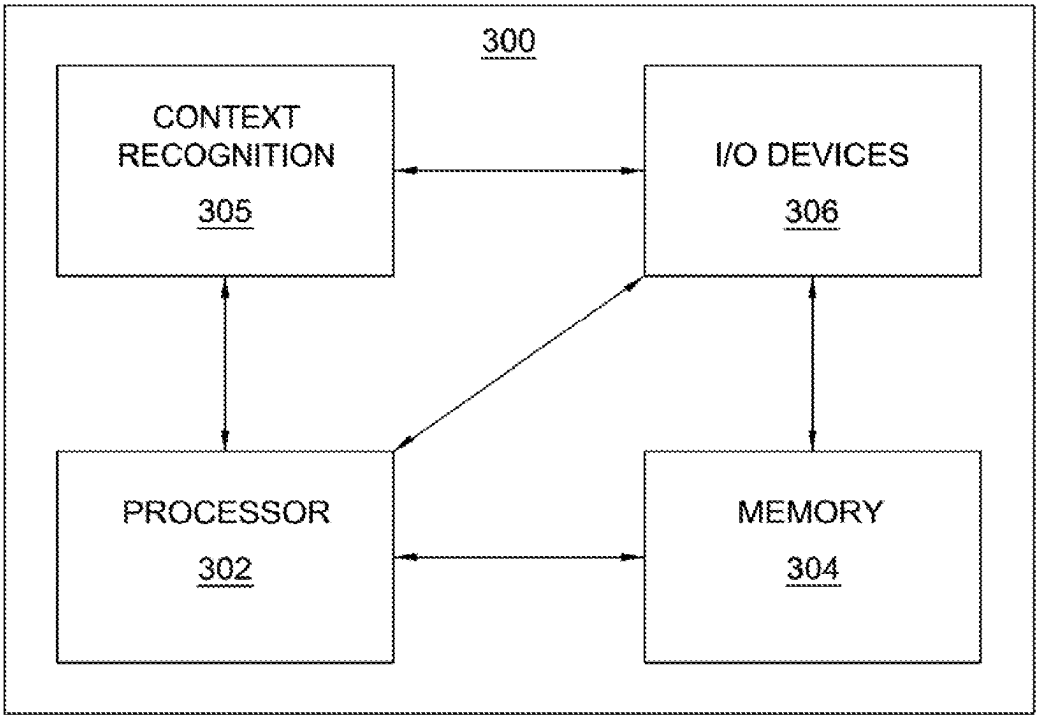
300
CONTEXT RECOGNITION
305
I/O DEVICES
306
PROCESSOR
302
MEMORY
304

FIG. 3

CONTEXT-AWARE TAGGING FOR AUGMENTED REALITY ENVIRONMENTS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 15/847,345, filed on Dec. 19, 2017, which is a continuation of U.S. application Ser. No. 14/985,559, filed on Dec. 31, 2015, now U.S. Pat. No. 9,905,051, which is a continuation of U.S. application Ser. No. 13/775,694, filed on Feb. 25, 2013, now U.S. Pat. No. 9,286,323, each of which is incorporated by reference in its entirety.

BACKGROUND

The present invention relates generally to mobile computing and relates more specifically to context recognition for mobile computing applications.

Context recognition allows the functions of mobile devices to be adapted to better meet the needs of the mobile devices' users. Typically, context recognition involves extracting and recognizing implicit context information from a mobile device's usage situations and environment. For instance, context may be inferred based on the mobile device's location and/or orientation (e.g., as indicated by one or more sensors integrated in the mobile device, such as a location sensor, a camera/imaging element, an accelerometer, or the like). In situations where location and orientation may not be enough to infer context, machine readable labels or tags (e.g., bar codes or matrix codes) may provide additional contextual information.

Mobile devices, however, may not be able to retrieve information from these tags effectively or efficiently due to the limited resources (e.g., computing power, bandwidth, physical memory, and the like) available in their small form factors. What is more, the resources that are available are typically shared by many operations; they cannot be dedicated to capturing, processing, recognizing, and contextualizing images and tags, which are nontrivial tasks that may require additional pre-processing. For instance, the quality of the images captured by most mobile devices is relatively low, and pre-processing may be required to compensate for distortion, blur, skew, low resolution, or the like before the images can be processed further. Moreover, as tags themselves become more complex (e.g., as in the case of matrix codes or multidimensional barcodes), so do the recognition methods required to retrieve information from the tags.

SUMMARY

A method for tag-based search includes capturing an image, extracting a tag from the image, identifying a location associated with the captured image, and querying stored content for information that matches the location and the tag. Local storage is checked for the information first, and remote storage may be checked subsequently. Any located information may be used to augment the image. Information located in the remote storage may be saved in the local storage until it reaches a certain age, until it fails to be accessed for a threshold period of time, or until the location moves outside a threshold radius associated with a location of the information located in the remote storage.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

FIG. **1** is a block diagram depicting one example of a network within which embodiments of the present invention may be deployed;

FIG. **2** is a flow diagram illustrating one embodiment of a method for context-aware tagging, according to the present invention; and

FIG. **3** is a high-level block diagram of the context recognition method that is implemented using a general purpose computing device.

DETAILED DESCRIPTION

In one embodiment, the invention is a method and apparatus for context-aware tagging for augmented reality environments. Embodiments of the invention perform context recognition by cross-relating collected geo-location information (e.g., longitude, latitude, altitude, direction, etc. as obtained from an open-air tracking system such as a global positioning system, Bluetooth beacons, cellular communications towers, radio frequency identification tags, or the like) with classified tag markers (e.g., bar codes, color codes, or the like) in a captured image. The tag markers may utilize visual, electronic, radio, infrared, ultraviolet, and/or other communications techniques. In some embodiments, the tag identifiers are non-unique, but uniqueness is resolved based on geographic and/or directional context. This creates a context within which the physical elements in the captured image can be classified.

FIG. **1** is a block diagram depicting one example of a network **100** within which embodiments of the present invention may be deployed. The network **100** may be any type of communications network, such as for example, an Internet Protocol (IP) network (e.g., an IP Multimedia Subsystem (IMS) network, an asynchronous transfer mode (ATM) network, a wireless network, a cellular network, a long term evolution (LTE) network, and the like). An "IP network" is broadly defined as a network that uses Internet Protocol to exchange data packets. Additional exemplary IP networks include Voice over IP (VoIP) networks, Service over IP (SoIP) networks, and the like.

In one embodiment, the network **100** may comprise a core network **102**. The core network **102** may be in communication with one or more access networks **120** and **122**. The access networks **120** and **122** may include a wireless access network (e.g., a WiFi network and the like), a cellular access network, a cable access network, a wired access network and the like. In one embodiment, the access networks **120** and **122** may all be different types of access networks, may all be the same type of access network, or some access networks may be the same type of access network and other may be different types of access networks. The core network **102** and the access networks **120** and **122** may be operated by different service providers, the same service provider or a combination thereof.

In one embodiment, the core network **102** may include an application server (AS) **104** and a database (DB) **106**. Although only a single AS **104** and a single DB **106** are illustrated, it should be noted that any number of application servers **104** or databases **106** may be deployed. For instance, in one embodiment, the core network **102** comprises a

portion of a cloud environment in which services and applications are supported in a highly distributed manner.

In one embodiment, the AS **104** is a content server. For instance, the AS **104** may run queries against the DB **106** to locate content based on tag and/or location data, as discussed in further detail below.

In one embodiment, the DB **106** is a tag database that stores a content with which tags have been associated. In one embodiment, the DB **106** stores the relationship between tag identifier ("tag-id"), location, and elements for each item of content. In a further embodiment, the DB **106** also stores a distribution of similar tags for a given location or region. In one embodiment, the DB **106** stores content relating to a plurality of subjects. In a further embodiment, multiple DBs **106** may each store content relating to a different specific subject. Additionally, the DB **106** may store augmented content generated by user endpoint devices according to methods of the present invention that are described in greater detail below. This information may be stored in encrypted form in order to protect any information that is deemed to be sensitive (e.g., geolocation data).

In one embodiment, the access network **120** may be in communication with one or more user endpoint devices (also referred to as "endpoint devices" or "UE") **108** and **110**. In one embodiment, the access network **122** may be in communication with one or more user endpoint devices **112** and **114**. In one embodiment, any of the user endpoint devices **108**, **110**, **112** and **114** may comprise a general purpose computer, as illustrated in FIG. **3** and discussed below. In one embodiment, the user endpoint devices **108**, **110**, **112** and **114** may perform, in conjunction with the AS **104**, the methods and algorithms discussed below related to context-aware tagging. For instance, at least some of the user endpoint devices **108**, **110**, **112** and **114** may comprise mobile devices having integrated sensors that capture information from which context can be inferred.

In one embodiment, the user endpoint devices **108**, **110**, **112** and **114** may be any type of endpoint device that is capable of accessing services from a cloud-based service provider, such as a desktop computer or a mobile endpoint device such as a cellular telephone, a smart phone, a tablet computer, a laptop computer, a netbook, an ultrabook, a portable media device (e.g., an MP3 player), a gaming console, a portable gaming device, and the like. It should be noted that although only four user endpoint devices are illustrated in FIG. **1**, any number of user endpoint devices may be deployed. In one embodiment, any of the user endpoint devices may have one or more sensors integrated therein. These sensors may include, for example, location sensors, environmental sensors, acoustic sensors, position sensors, optical sensors, pressure sensors, proximity sensors, imaging sensors, and the like. The AS **104** may subscribe to the outputs of these sensors.

It should be noted that the network **100** has been simplified. For example, the network **100** may include other network elements (not shown) such as border elements, routers, switches, policy servers, security devices, a content distribution network (CDN) and the like.

FIG. **2** is a flow diagram illustrating one embodiment of a method **200** for context-aware tagging, according to the present invention. The method **200** may be executed, for example, by any of the user endpoint devices **108**, **110**, **112** and **114** illustrated in FIG. **1**. As such, and for the purposes of illustration, reference is made in the discussion of the method **200** to exemplary user endpoint device **108**. However, it will be appreciated that the method **200** may be executed on devices other than or in addition to the user endpoint device **108**.

The method **200** begins in step **202**. In step **204**, the user endpoint device **108** captures an image of an object in proximity to the user endpoint device **108**. The image is captured using an imaging sensor (e.g., camera) integrated in the user endpoint device **108**. The image includes at least one tag (e.g., a bar code, a color code, or the like). For instance, the image may depict a tree to which a machine readable label is affixed.

In step **206**, the user endpoint device **108** identifies its current location (i.e., the location from which the image is captured in step **204**) and orientation using one or more geolocation sensors integrated in the user endpoint device (e.g., a location sensor, an environmental sensor, a position sensor, a proximity sensor, an accelerometer, or the like). For instance, a global positioning sensor may provide the user endpoint device's current positional coordinates (e.g., latitude, longitude, altitude, direction, etc.), while an accelerometer may provide the current orientation of the user endpoint device **108**. In one embodiment, the location and orientation are periodically saved to local storage (e.g., cache) on the user endpoint device **108**, and the user endpoint device **108** simply retrieves the most recent saved location and position in step **206**. In another embodiment, the current location and position are identified on-demand in step **206** and subsequently saved to the local storage.

In step **208**, the user endpoint device **108** extracts the tag from the image captured in step **204**. In one embodiment, the tag is extracted using one or more image processing techniques that recognize the tag and identify its features.

In step **210**, the user endpoint device **108** retrieves data about the object from the user endpoint device's local storage (e.g., cache and/or tag database). This data may be retrieved by querying the local storage for content whose tags match the tag extracted from the image in step **208**. The query also includes the current position and orientation of the user endpoint device **108**. In one embodiment, the data retrieved in step **210** includes content identified based on statistical analysis of possible tags associated with the current location, based on similarity of elements present in the current location. For instance, continuing the above example, the probability of the image depicting a specific species of tree can be inferred based on a model of the statistical distribution of similar species present in the current location (e.g., models of biomass distribution).

In optional step **212** (illustrated in phantom), the user endpoint device **108** retrieves data about the object from remote storage, such as the DB **106**. This data may be retrieved by querying the remote storage for content whose tags match the tag extracted from the image in step **208**. The query also includes the current position and orientation of the user endpoint device **108**. In one embodiment, the data retrieved in step **212** includes content identified based on statistical analysis of possible tags associated with the current location, based on similarity of elements present in the current location. In one embodiment, at least some of the data retrieved from the remote storage is subsequently stored in the local storage (along with its tag(s) and related location/position data). In one embodiment, step **212** is only performed when the data retrieved in step **210** is determined to be insufficient and/or incomplete.

In step **214**, the user endpoint device **108** generates augmented content in accordance with the image captured in step **204** and the data retrieved in steps **210** and/or **212**. For instance, based on the example described above, the aug-

mented content may comprise an image of the tree with information about the tree (e.g., name, genus, species, group, etc.) visually superimposed over the image.

In step **216**, the user endpoint device **108** outputs the augmented content. For instance, the user endpoint device **108** may display an augmented image of the object on a display of the user endpoint device **108**. In one embodiment, the augmented content is stored either locally on the device or remotely (e.g., on the DB **106**).

The method **200** ends in step **218**.

As discussed above, various data that facilitates context-aware tagging, including the location and position of the user endpoint device **108** and content retrieved from remote storage, is saved in the local storage of the user endpoint device **108**. In one embodiment this data is saved only temporarily. For instance, the data may be deleted from the local storage if it reaches a certain age or is not accessed for a threshold period of time. In a further embodiment, data that relates to objects that are outside a threshold radius from the user endpoint device's current location ("proximity region") is also deleted.

Thus, the method **200** provides a hybrid approach augmented reality that combines positioning information with context-based local tags. Local and remote content is interwoven expedite recognition of context and to reduce the need for communication with remote devices. Specifically, the method **200** first attempts to recognize context and satisfy data requests using locally stored content before querying remote data sources. Any data that is retrieved from remote sources is stored locally at least temporarily, based on the immediate needs to the user endpoint device **108**. The user endpoint device **108** can therefore accurately recognize context and satisfy data requests while minimizing the size of the tag database that (e.g., local and remote storage) that must be maintained to do so.

Moreover, by cross-relating geolocation and tag-captured information, the amount of processing and communications required to recognize context and satisfy data requests can be significantly reduced. This allows the amount of information required to be stored with the tags to be likewise reduced, accepting non-uniqueness in tag identifiers.

The above-described advantages make the present invention especially well-suited to mobile devices and other small form factor devices that are characterized by limited memory and/or communication capabilities, although the present invention is not so limited.

FIG. **3** is a high-level block diagram of the context recognition method that is implemented using a general purpose computing device **300**. The general purpose computing device **300** may comprise, for example, any of the user endpoint devices **108**, **110**, **112** and **114** illustrated in FIG. **1**. In one embodiment, a general purpose computing device **300** comprises a processor **302**, a memory **304**, a context recognition module **305** and various input/output (I/O) devices **306** such as a display, a keyboard, a mouse, a sensor, a stylus, a microphone or transducer, a wireless network access card, an Ethernet interface, and the like. In one embodiment, at least one I/O device is a storage device (e.g., a disk drive, an optical disk drive, a floppy disk drive). In one embodiment, the memory **304** includes cache memory, including a tag database that stores the relationship between tag identifier, location, and elements. In a further embodiment, the tag database also stores a distribution of similar tags for a given location or region. It should be understood that the context recognition module **305** can be implemented as a physical device or subsystem that is coupled to a processor through a communication channel.

Alternatively, the context recognition module **305** can be represented by one or more software applications (or even a combination of software and hardware, e.g., using Application Specific Integrated Circuits (ASIC)), where the software is loaded from a storage medium (e.g., I/O devices **306**) and operated by the processor **302** in the memory **304** of the general purpose computing device **300**. Thus, in one embodiment, the context recognition module **305** for context-aware tagging for augmented reality environments, as described herein with reference to the preceding figures, can be stored on a tangible computer readable storage medium or device (e.g., RAM, magnetic or optical drive or diskette, and the like).

It should be noted that although not explicitly specified, one or more steps of the methods described herein may include a storing, displaying and/or outputting step as required for a particular application. In other words, any data, records, fields, and/or intermediate results discussed in the methods can be stored, displayed, and/or outputted to another device as required for a particular application. Furthermore, steps or blocks in the accompanying figures that recite a determining operation or involve a decision, do not necessarily require that both branches of the determining operation be practiced. In other words, one of the branches of the determining operation can be deemed as an optional step.

While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof. Various embodiments presented herein, or portions thereof, may be combined to create further embodiments. Furthermore, terms such as top, side, bottom, front, back, and the like are relative or positional terms and are used with respect to the exemplary embodiments illustrated in the figures, and as such these terms may be interchangeable.

What is claimed is:

1. A method comprising:

extracting, by a mobile device, a machine-readable label from an image of a first object captured by the mobile device;

matching, by the mobile device, the extracted machine-readable label to a local entry for the first object in a local data store stored on the mobile device, wherein the local data store contains entries for a distribution of objects, wherein each entry comprises identifying information for an object of the distribution of objects, and wherein the distribution of objects describes a distribution of a set of objects, wherein the set of objects consists of objects that share characteristics and are within a proximity from the mobile device when the image of the first object is captured;

inferring, by the mobile device, an identity of the first object based on identifying information from the local entry for the first object;

querying a remote database for one or more content elements associated with the inferred identity of the first object by transmitting a query including the inferred identity of the first object from the local data store, wherein the remote database stores, for each object of a plurality of objects, the identifier and additional content elements about the object; and

generating for display on the mobile device content that comprises the queried one or more content elements for the first object.

2. The method of claim **1**, wherein the remote database stores augmented content generated by users from one or

more other mobile devices, and wherein the additional content elements comprise the augmented content.

3. The method of claim 1, wherein the machine-readable label is a bar code.

4. The method of claim 1, wherein the inferring comprises:

determining a probability that the first object matches the inferred identity.

5. The method of claim 1, further comprising:

capturing, by the mobile device, a location of the mobile device when the image of the first object is captured,

wherein the query includes the location of the first object corresponding to the captured location.

6. The method of claim 5, further comprising:

capturing, by the mobile device, an orientation of the mobile device when the image of the first object is captured,

wherein the query includes the orientation.

7. The method of claim 1, wherein the location associated with the mobile device is identified using information from an open-air tracking system.

8. The method of claim 1, wherein the open-air tracking system is a Global Positioning System.

9. The method of claim 1, wherein the generating comprises:

superimposing the queried one or more content elements over the image of the first object.

10. The method of claim 1, further comprising:

updating which objects are in the set of objects of the distribution of objects based on location data from the mobile device.

11. A computer program product comprising a non-transitory computer-readable storage medium containing computer program code for:

extracting, by a mobile device, a machine-readable label from an image of a first object captured by the mobile device;

matching, by the mobile device, the extracted machine-readable label to a local entry for the first object in a local data store stored on the mobile device, wherein the local data store contains entries for a distribution of objects, wherein each entry comprises identifying information for an object of the distribution of objects, and wherein the distribution of objects describes a distribution of a set of objects, wherein the set of objects consists of objects that share characteristics and are within a proximity from the mobile device when the image of the first object is captured;

inferring, by the mobile device, an identity of the first object based on identifying information from the local entry for the first object;

querying a remote database for one or more content elements associated with the inferred identity of the first object by transmitting a query including the inferred identity of the first object from the local data store, wherein the remote database stores, for each object of a plurality of objects, the identifier and additional content elements about the object; and

generating for display on the mobile device content that comprises the queried one or more content elements for the first object.

12. The computer program product of claim 11, wherein the remote database stores augmented content generated by users from one or more other mobile devices, and wherein the additional content elements comprise the augmented content.

13. The computer program product of claim 11, wherein the machine-readable label is a bar code.

14. The computer program product of claim 11, wherein the inferring comprises:

determining a probability that the first object matches the inferred identity.

15. The computer program product of claim 11, wherein the computer-readable storage medium further contains computer program code for:

capturing, by the mobile device, a location of the mobile device when the image of the first object is captured,

wherein the query includes the location of the first object corresponding to the captured location.

16. The computer program product of claim 15, wherein the computer-readable storage medium further contains computer program code for:

capturing, by the mobile device, an orientation of the mobile device when the image of the first object is captured,

wherein the query includes the orientation.

17. The computer program product of claim 11, wherein the location associated with the mobile device is identified using information from an open-air tracking system.

18. The computer program product of claim 17, wherein the open-air tracking system is a Global Positioning System.

19. The computer program product of claim 11, wherein the generating comprises:

superimposing the queried one or more content elements over the image of the first object.

20. The computer program product of claim 11, wherein the computer-readable medium further contains computer program code for:

updating which objects are in the set of objects of the distribution of objects based on location data from the mobile device.

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