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(54) **AUTOMATIC GENERATION OF METADATA FOR A DIGITAL IMAGE BASED ON AMBIENT CONDITIONS**

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G06K 9/60	(2006.01)
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(52) **U.S. Cl.**

CPC ***G06F 17/30265*** (2013.01)
USPC **348/231.3**; 348/231.99; 348/231.5; 348/239; 382/305

(58) **Field of Classification Search**

USPC 348/211.2, 143, 239, 231.5, 231.3; 382/254, 305
See application file for complete search history.

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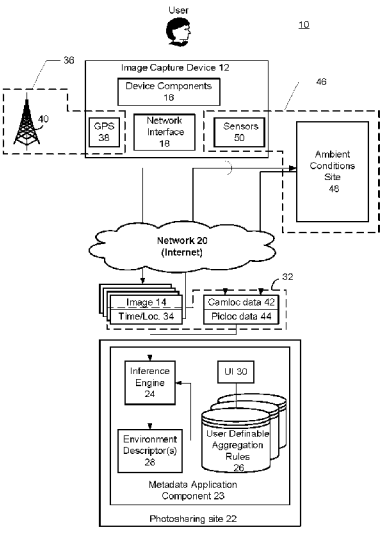
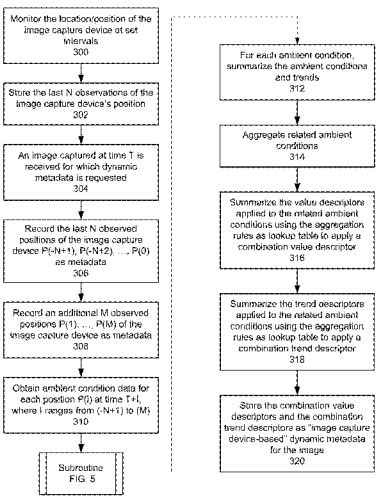
(57) **ABSTRACT**

A method and system is provided for automatically generating metadata for a digital image based on ambient conditions. Aspects of the preferred embodiment include determining a plurality of ambient conditions associated with a location of a subject of a digital image captured with a mobile image capture device, the ambient conditions existing at a time related to a time of capture of the digital image; aggregating the plurality of ambient conditions into at least one ambient environment descriptor based on user-definable aggregation rules; and associating the ambient environment descriptor with the digital image as metadata.

32 Claims, 6 Drawing Sheets





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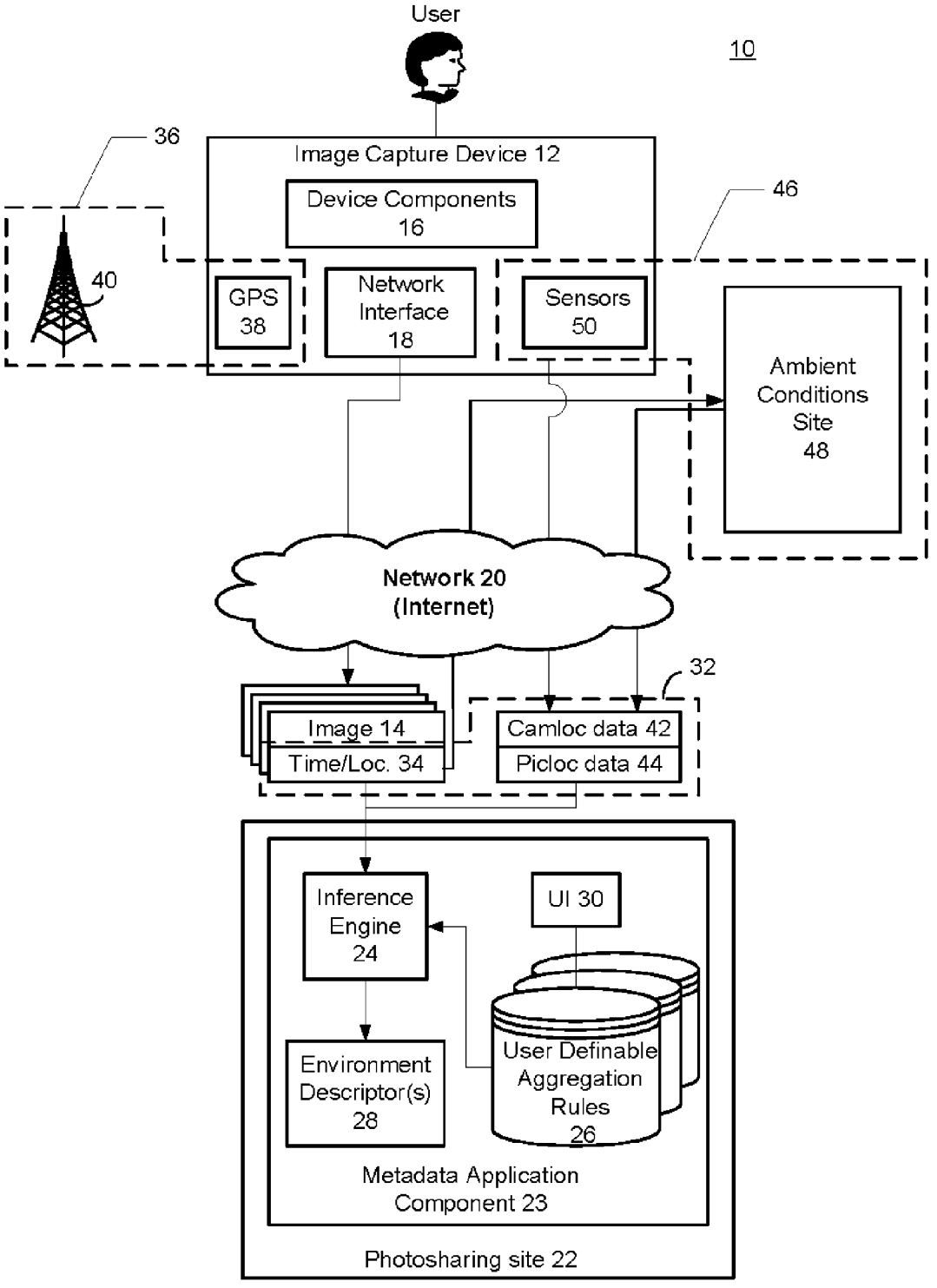
User
10
36
Image Capture Device 12
Device Components
16
46
40
GPS
38
Network
Interface
18
Sensors
50
Ambient
Conditions
Site
48
Network 20
(Internet)
32
Image 14
Time/Loc. 34
Camloc data 42
Picloc data 44
Inference
Engine
24
UI 30
Environment
Descriptor(s)
28
User Definable
Aggregation
Rules
26
Metadata Application
Component 23
Photosharing site 22

FIG. 1

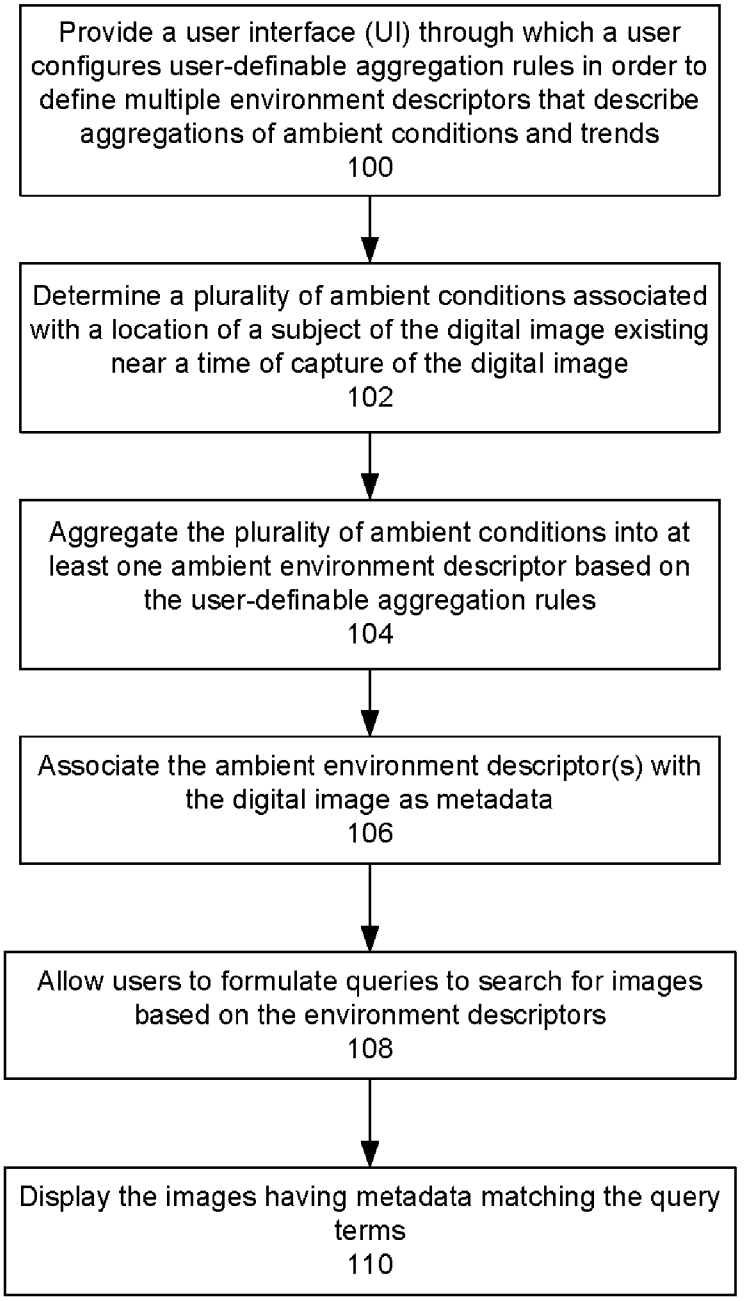
Provide a user interface (UI) through which a user configures user-definable aggregation rules in order to define multiple environment descriptors that describe aggregations of ambient conditions and trends
100
Determine a plurality of ambient conditions associated with a location of a subject of the digital image existing near a time of capture of the digital image
102
Aggregate the plurality of ambient conditions into at least one ambient environment descriptor based on the user-definable aggregation rules
104
Associate the ambient environment descriptor(s) with the digital image as metadata
106
Allow users to formulate queries to search for images based on the environment descriptors
108
Display the images having metadata matching the query terms
110

FIG. 2

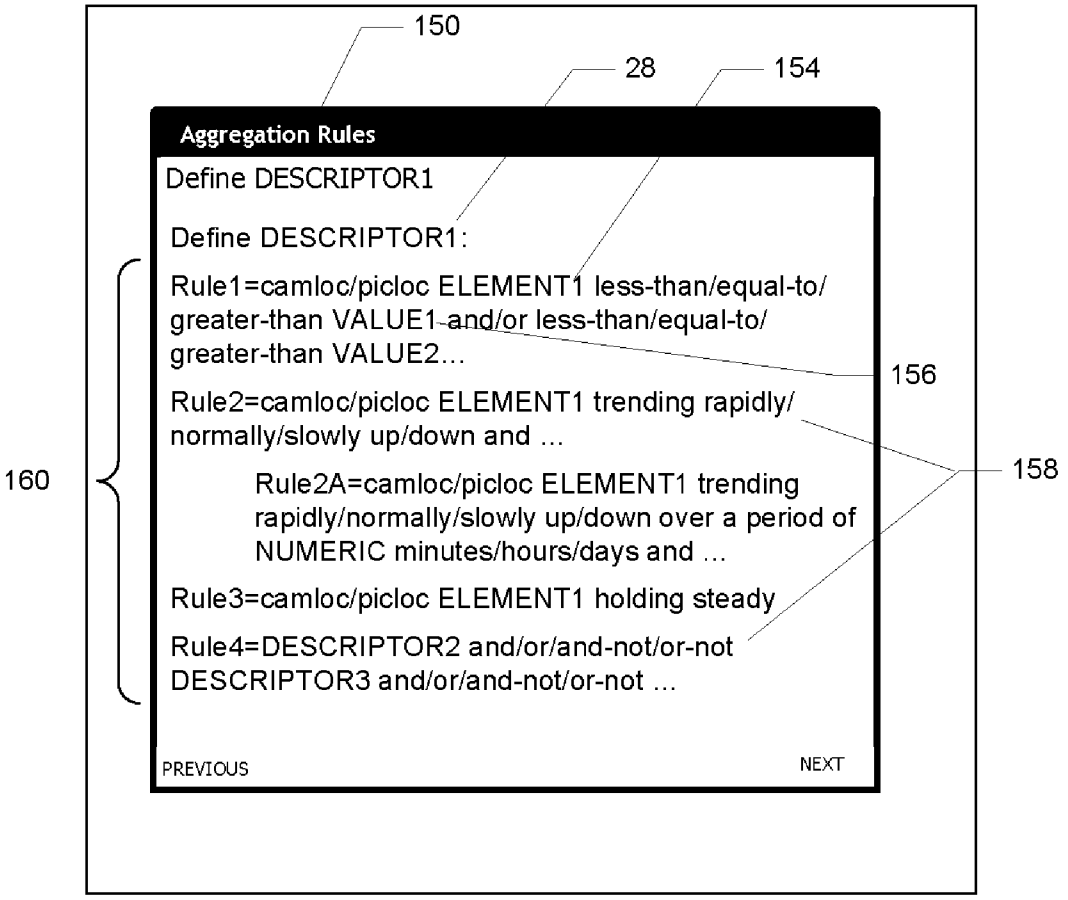
150
28
154
Aggregation Rules
Define DESCRIPTOR1
Define DESCRIPTOR1:
Rule1=camloc/picloc ELEMENT1 less-than/equal-to/ greater-than VALUE1 and/or less-than/equal-to/ greater-than VALUE2...
156
Rule2=camloc/picloc ELEMENT1 trending rapidly/ normally/slowly up/down and ...
158
160
Rule2A=camloc/picloc ELEMENT1 trending rapidly/normally/slowly up/down over a period of NUMERIC minutes/hours/days and ...
Rule3=camloc/picloc ELEMENT1 holding steady
Rule4=DESCRIPTOR2 and/or/and-not/or-not DESCRIPTOR3 and/or/and-not/or-not ...
PREVIOUS
NEXT

FIG. 3

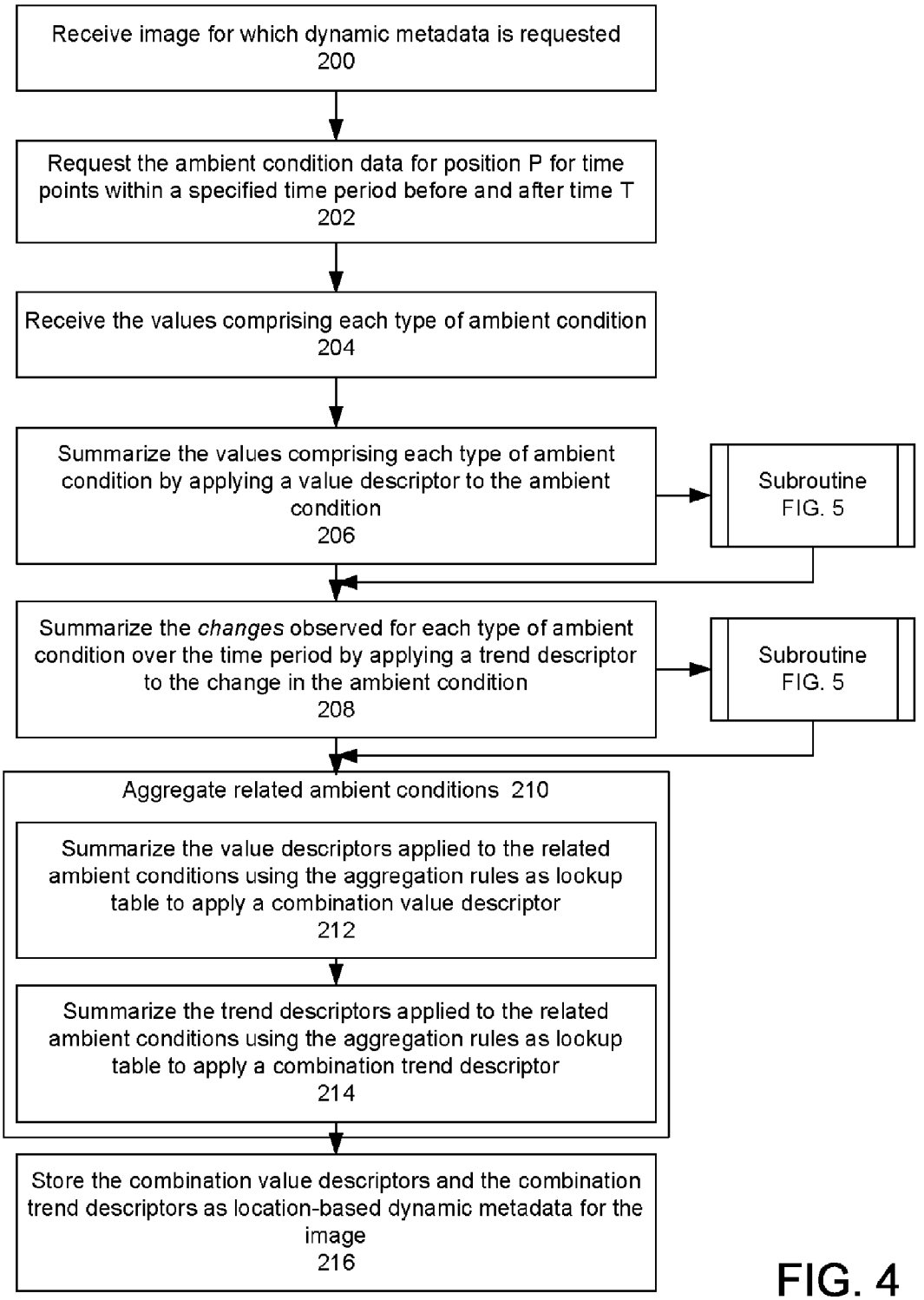
Receive image for which dynamic metadata is requested
200
Request the ambient condition data for position P for time points within a specified time period before and after time T
202
Receive the values comprising each type of ambient condition
204
Summarize the values comprising each type of ambient condition by applying a value descriptor to the ambient condition
206
Subroutine
FIG. 5
Summarize the changes observed for each type of ambient condition over the time period by applying a trend descriptor to the change in the ambient condition
208
Subroutine
FIG. 5
Aggregate related ambient conditions 210
Summarize the value descriptors applied to the related ambient conditions using the aggregation rules as lookup table to apply a combination value descriptor
212
Summarize the trend descriptors applied to the related ambient conditions using the aggregation rules as lookup table to apply a combination trend descriptor
214
Store the combination value descriptors and the combination trend descriptors as location-based dynamic metadata for the image
216

FIG. 4

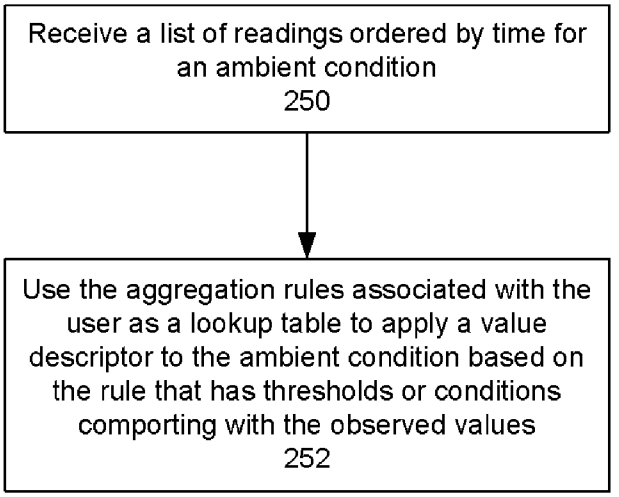
Receive a list of readings ordered by time for an ambient condition
250
Use the aggregation rules associated with the user as a lookup table to apply a value descriptor to the ambient condition based on the rule that has thresholds or conditions comporting with the observed values
252

FIG. 5

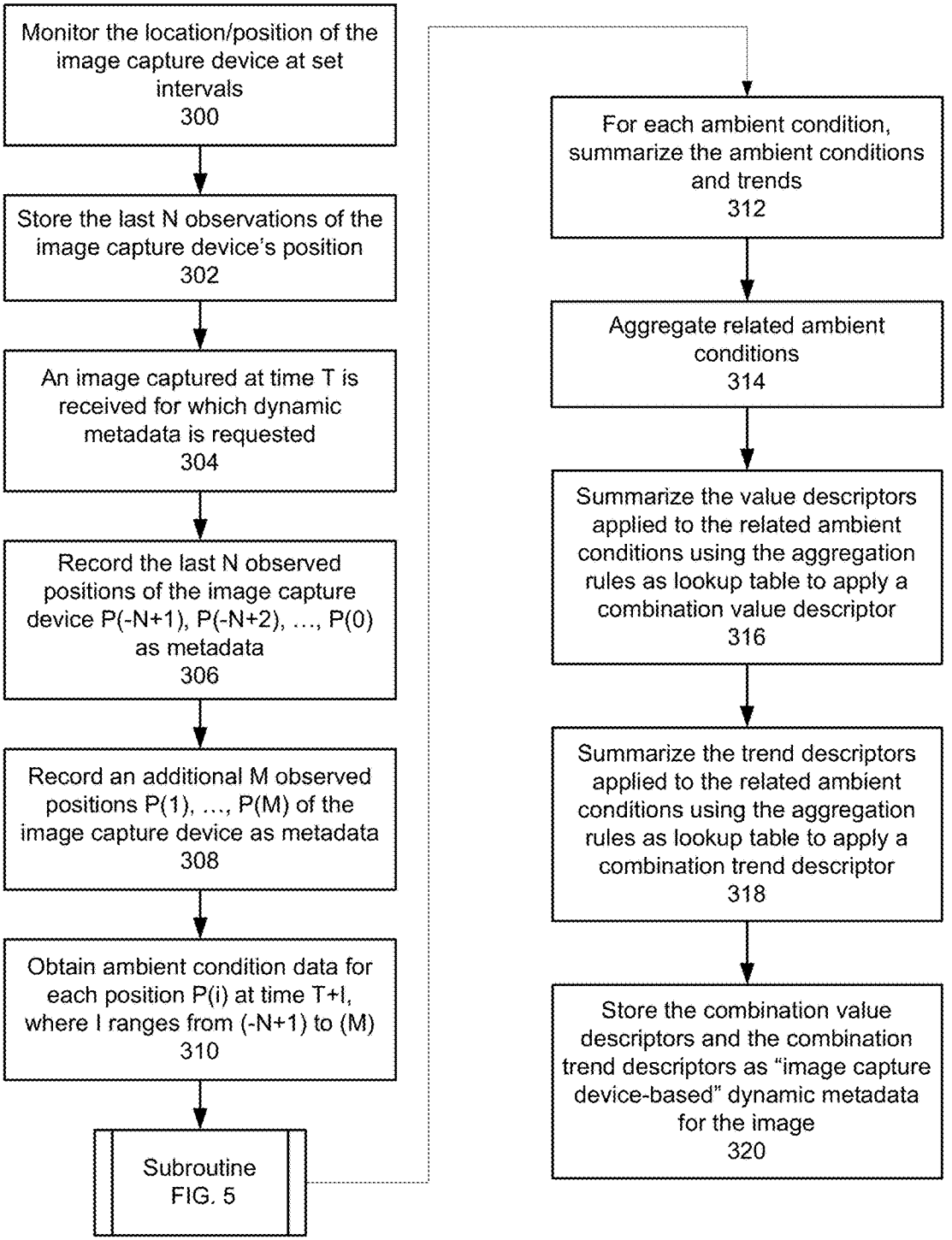
Monitor the location/position of the image capture device at set intervals
300
Store the last N observations of the image capture device's position
302
An image captured at time T is received for which dynamic metadata is requested
304
Record the last N observed positions of the image capture device P(-N+1), P(-N+2), ..., P(0) as metadata
306
Record an additional M observed positions P(1), ..., P(M) of the image capture device as metadata
308
Obtain ambient condition data for each position P(i) at time T+I, where I ranges from (-N+1) to (M)
310
Subroutine FIG. 5
For each ambient condition, summarize the ambient conditions and trends
312
Aggregate related ambient conditions
314
Summarize the value descriptors applied to the related ambient conditions using the aggregation rules as lookup table to apply a combination value descriptor
316
Summarize the trend descriptors applied to the related ambient conditions using the aggregation rules as lookup table to apply a combination trend descriptor
318
Store the combination value descriptors and the combination trend descriptors as "image capture device-based" dynamic metadata for the image
320

FIG. 6

AUTOMATIC GENERATION OF METADATA FOR A DIGITAL IMAGE BASED ON AMBIENT CONDITIONS

FIELD OF THE INVENTION

The present invention relates to digital imaging, and more particularly to a method and system for automatically generating metadata for a digital image based on ambient conditions.

BACKGROUND OF THE INVENTION

The importance of metadata for storage and retrieval of digital images is well recognized. Image metadata is essentially non-picture information that is embedded in the image in addition to the actual image data. The metadata is typically associated with a digital image either by the user or by the image capture device, e.g., a digital camera. The metadata manually provided by the user typically includes keywords, called tags, which may be used to categorize the image for subsequent searching. The metadata provided by image capture device typically includes information about the image, such as the time and date the picture was taken, by whom, with what equipment, and the like. Besides time and date, some image capture devices, such as camera phones, are also capable of automatically recording and storing location information, such as global positioning system (GPS) coordinates.

Although current digital imaging technology enables people to acquire images easily and to record additional information, retrieving the images based on metadata searches is not as easy. The challenge is not how to index the pictures using the metadata, but somehow relating a picture the user is trying to retrieve with some aspects of the user's memory about the picture. Time and location are useful as metadata, but their use to help a user search for images of interest is inherently limited. In many cases, users have a difficult time remembering the specific time or even interval of time when those pictures were taken, particularly for images taken years ago. Thus, using time to find those older pictures is often difficult.

Location may be easier to remember than image capture time, but in many cases, the user may not know the location of where a picture was taken, except within a large geographical region. For example, if a user takes a picture while driving through New Delhi, unless it is close to some famous landmark, the user might not be able to tell where exactly the picture was taken. Later, when the user tries to retrieve that picture, the user may not know what location or range of locations to use as the search terms.

In other cases, the user may have known the location where the picture was taken, but may not remember the details because the memory of the location may have faded in the user's mind. For example, if the user takes a long trip through a nature park, there may be few place names that the user can remember months later. As another example, after vacationing in a city for awhile, all the streets in the city may begin to look about the same to the user.

Searching for images using time and location may seem logical at first, but many users would find it more natural to search for information based on the feelings they had at the time the pictures were taken, or the feelings that the pictures remind them of. Although the user could attempt to solve this problem by entering his or her own metadata as captions that have meaning to them, unless the user remembers to search using exact keywords from those captions, it would still be difficult for the user to retrieve the pictures he or she desires.

The metadata should be such that it accords with human memory, so that people can use the metadata to associate pictures with things they remember.

Mor Naaman et al. provide a method for "Automatically Generating Metadata for Digital Photographs with Geographic Coordinates" in which location information for digital photographs is used to automatically generate photo-related metadata that serves as additional memory cues and filters when browsing a collection of photos. For example, given the local time and location for each photo, information such as light status (day, dusk, night and dawn) and weather (rainy, clear, warm) is retrieved and used to generate metadata.

Metadata generated using generic weather data, however, may be too vague for the user to properly recall the information when searching for the following reasons. One reason is that symbolic adjectives for certain categories of weather, such as temperature and humidity (e.g., "hot" and "cold") is subjective to each person. For example, if someone were taking pictures in Louisiana, the definition of humid would shift toward very humid, while the definition of humid would shift down for someone in Arizona. Thus, using global weather labels for subjective criteria such as temperature and humidity may result in erroneous search results.

In addition, generic weather data tends to be regional and not sufficiently specific to the actual location of the picture. For instance, Naaman et al. generate weather metadata by translating an image's location (latitude, longitude) into a zip code and then uses the zip code and image date to query a weather web service to get weather information. The weather data returned for each day is an hourly report of the weather conditions (e.g., "rainy", "clear") and temperature. The temperature is computed as the average of temperatures measured in the hours around the photo time. The result of the query to the weather web service is then used for all photos taken in the same day and same area. The problem is that hourly weather reports of a particular zip code may not be indicative of the actual weather at the location and time of the image capture. For example, a picture of a couple kissing could have been taken just as it stopped raining and just as the sun was coming out (clearing), but the metadata for the picture generated from the weather reports may just say raining, which may not conform to what the couple may remember about the photo.

BRIEF SUMMARY OF THE INVENTION

The present invention provides a method and system for automatically generating metadata for a digital image based on ambient conditions. Aspects of the preferred embodiment include determining a plurality of ambient conditions associated with a location of a subject of a digital image captured with a mobile image capture device, the ambient conditions existing at a time related to a time of capture of the digital image; aggregating the plurality of ambient conditions into at least one ambient environment descriptor based on user-definable aggregation rules; and associating the ambient environment descriptor with the digital image as metadata.

According to the method and system disclosed herein, the generation of metadata based on environment descriptors of aggregations of ambient conditions and trends provides a natural memory cue for humans even years after an image is captured, thereby leading to improved retrieval of desired images.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a block diagram of a system for generating metadata for a digital image based on ambient conditions in accordance with a preferred embodiment.

FIG. **2** is a flow diagram illustrating a process for automatically generating metadata for a digital image in accordance with a preferred embodiment.

FIG. **3** is a diagram illustrating an exemplary user interface form interface displayed by the photosharing site configuring the user-definable aggregation rules.

FIGS. **4-6** are flow diagrams illustrating exemplary embodiments for the process of aggregating a plurality of ambient conditions into one or more ambient environment descriptors.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a method and system for generating metadata for a digital image. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the preferred embodiments and the generic principles and features described herein will be readily apparent to those skilled in the art. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features described herein.

A method and system is provided for generating metadata and to associate the metadata with a digital image for subsequent metadata-based searching. Data representative of the ambient conditions existing at a time related to a time of capture of the digital image, e.g., before, during, and after the image is collected automatically. As described above, however, simply recording the basic ambient conditions may not be adequate to capture some of the subtleties of what people can naturally remember about the prevalent weather conditions, as they perceive them. The sights and sounds at a time and place where a picture is taken, and the feelings evoked there are better captured through more sophisticated representations that are built on top of the ambient conditions.

The present invention provides a method and system for automatically generating metadata for a digital image based on ambient conditions existing at the time of the image capture that are analyzed and processed in a manner that emphasizes the dynamic nature of ambient conditions and the user's mobility and circumstances. The basic ambient conditions are used as raw data, which are then processed and summarized according to user-definable rules to produce higher-level metadata that is meaningful to users (especially to mobile users). In the preferred embodiment, both variations of ambient conditions occurring at various locations of the mobile image capture device and variations of the ambient conditions occurring at the fixed location of the subject of the image are recorded. The user-definable rules are used not only to tailor the definition of the adjectives describing subjective ambient conditions to individual users, but the user-definable rules are also used to define trends in the ambient conditions, define aggregations of the ambient conditions, and to define trends in the aggregation of ambient conditions based on the observed variations of the ambient conditions. Ambient environment descriptors are then applied to the image summarizing the set of ambient conditions and/or describing the observed trends. The ambient environment descriptor(s) may then be associated with the image metadata along with the original values of the ambient conditions. The user configurable rules are also used when a user enters ambient condition search terms to locate one or more images, such that the user's definitions are taken into account when searching the images.

The present invention is mainly described in terms of particular systems provided in particular implementations. However, one of ordinary skill in the art will readily recognize that this method and system will operate effectively in other implementations. For example, the systems, devices, and networks usable with the present invention can take a number of different forms. The present invention will also be described in the context of particular methods having certain steps. However, the method and system operate effectively for other methods having different and/or additional steps not inconsistent with the present invention.

FIG. **1** is a block diagram of a system for generating metadata for the digital image based on ambient conditions in accordance with a preferred embodiment. The system **10** includes a mobile image capture device **12** for capturing digital images **14**. The image capture device **12** includes device components **16** for carrying out the intended functions of the image capture device **12** (e.g., display, camera etc.), and may optionally include a network interface **18** for transmitting data, such as the images **14**, over a network **20** (e.g., the Internet) via wired or wireless communication. Alternatively, the image capture device **12** may transmit data and images **14** over the network **20** through the use of a personal computer (not shown). Examples of the type of devices that may comprise the image capture device **12** include a camera-phone, personal digital assistant (PDA), digital camera, and laptop, for example.

The system **10** further includes a metadata application component **23** for automatically generating metadata for the images **14**, which according to the preferred embodiment, is implemented and executed on a photosharing site **22** on the network **20**. The photosharing site **22** hosts the images **14** received from the image capture device **12** for online sharing. The metadata application component **23**, which includes an inference engine **24**, user-definable aggregation rules **26**, and a user interface **30**, is configured for automatically generating metadata for the images **14**. Automatic generation of metadata for the images **14** is accomplished through the use of the inference engine **24** that analyzes ambient conditions **32** associated with each image **14** according to the user-definable aggregation rules **26** in order to summarize the ambient conditions **32** into one or more ambient environment descriptors **28**, as described below. The metadata application component **23** can be implemented in software, executable on a suitable general or special purpose processor, hardware, or using a combination of software and hardware components. Although in a preferred embodiment the metadata application component **23** for generating metadata is implemented within a photosharing site **22**, in alternative embodiments, the metadata application component **23** may be loaded and run in a user's computer or within the image capture device **12** itself.

FIG. **2** is a flow diagram illustrating the process for automatically generating metadata for the digital image in accordance with a preferred embodiment. Referring to both FIGS. **1** and **2**, the process begins in step **100** by providing the metadata application component **23** with a user interface (UI) **30** through which a user may configure the user-definable aggregation rules **26** in order to define multiple ambient environment descriptors **28** that describe ambient conditions, trends of ambient conditions, and aggregations of ambient conditions and trends. The aggregation rules **26** configured by each user may be stored as a set of preferences under the

user's account. In a preferred embodiment, the UI **30** for configuring the user-definable aggregation rules **26** is based on forms.

FIG. **3** is a diagram illustrating an exemplary UI form interface displayed by the metadata application component **23**. The form **150** is preferably displayed in a browser window and may include drop down list (not shown) that allows a user to select ambient environment descriptors **28** and to define each ambient environment descriptor **28** by creating one or more rules **160**. Each rule **160** is created by selecting different combinations of ambient conditions existing at the camera location and/or the location of the subject of the image **14**, which are shown as "CAMLOC/PICLOC elements" **154**, ambient condition values **156**, and various types operators **158**, as shown. By selecting different combinations of CAMLOC/PICLOC elements **154**, values **156**, and operators **158**, the user can create subjective definitions for ambient environment descriptors **28** that describe ambient conditions and their trends and aggregations.

Accordingly, the aggregation rules **150** preferably include rules defining value descriptors, trend descriptors, combination value descriptors and combination trend descriptors. A value descriptor is an ambient environment descriptor **28** summarizing the values of a particular type of ambient condition. For example, for the ambient condition "temperature", a value descriptor of "Warm" could be defined as an ambient environment descriptor **28** summarizing the range of values of 70° through 76°. Similarly, a trend descriptor is an ambient environment descriptor **26** summarizing changes observed in a series of values for a particular type of ambient condition (e.g., falling, rising, steady, or decreasing, increasing, etc).

A combination value descriptor summarizes the combination of value descriptors applied to related types of ambient conditions. For example, temperature and humidity are two types of ambient conditions that are related. The user could define a combination value descriptor "Muggy" when the values for temperature and humidity are observed as being "Hot" and "Humid." Similarly, a combination trend descriptor summarizes the trend descriptors applied to related ambient conditions. For example, the aggregation rules **26** may define "Sudden shower" as a combination of "Hot", "Humid", "Decreasing temp", and "Rainy".

The user-specific subjective ambient environment descriptors **28** of ambient conditions and their trends and aggregations help make the proposed approach useful for retrieving images **24** in a way that is natural to users. The user-definable aggregation rules **26** can be created on various bases. In a preferred embodiment, the aggregation rules **26** are definable by individual users. In an alternative embodiment, the aggregation rules **26** may be defined based on different demographic groups. The demographic groups may be defined culturally, geographically, or by interest, for example.

An example of defining the aggregation rules **26** based demographic groups might be aggregation rules **26** specific to a desert region, the people of which might conceptualize and experience humidity differently than people from a wet region. For example, the definition of pleasant weather "suhavna" in summer in India involves overcast skies, especially in the afternoon, whereas northern Europeans associate pleasant weather with bright and sunny days.

Another example of defining the aggregation rules **26** based on demographic groups is defining aggregation rules that are specific to an affinity group, such as the readers of some poems or novels. Fans of the English Romantic poet Wordsworth might consider defining ambient environment descriptors **28** based on Wordsworth's many imageries of nature. One example is his poem *Written in March:*

Like an army defeated
The snow hath retreated,
And now doth fare ill
On the top of the bare hill;
The plowboy is whooping-anon-anon:
There's joy in the mountains;
There's life in the fountains;
Small clouds are sailing,
Blue sky prevailing;
The rain is over and gone!

Using the user-defined aggregation rules **26** of the preferred embodiment, a fan of Wordsworth could create a completely new ambient environment descriptor **28** based on this poem as follows:

a. [Current time] Wind speed: gentle breeze AND
b. [Current time] Skies: partly cloudy AND
c. [Current time] Rain: none AND
d. [Last week] Rain: yes

Users accessing the photosharing site **22** could then search for images that describe March weather as described by Wordsworth: the snow level is rapidly decreasing, the rain has stopped, and visibility is partly cloudy and clearing. It might be interesting to enthusiasts to look for pictures from other regions of the world that satisfy the same criteria, e.g., snowed some weeks previously, melted snow [except at higher elevations], rain a few days ago, no rain now, partly cloudy skies, light breeze.

In addition, the aggregation rules **26** may be configured for different demographic groups by combining the aggregation rules from the users comprising the respective demographic groups. For example, sets of aggregation rules **26** may be configured for different regions of the United States, such as Northeast, Southeast, Midwest, South, Mountain, Northwest, and Southwest, by aggregating, combining, and/or averaging the aggregation rules **26** of the users located in those respective regions.

Referring again to FIG. **2**, in step **102**, once the aggregation rules **26** have been provided, a plurality of ambient conditions **32** associated with a location of a subject of the digital image **14** existing at a time related to a time of capture of the digital image **14** are determined. The ambient conditions **26** may include weather and non-weather related conditions. Examples of weather conditions include, but are not limited to, temperature, humidity, barometric pressure, visibility, season, and wind. Examples of non-weather conditions include, but are not limited to, time, location, heading, elevation, and brightness level. The weather and non-weather related conditions may correspond to the subject of the image **14**, the image capture device **12**, or both.

Referring to FIG. **1**, in one embodiment, time and location data **34** may be included with each of the images **14** as image metadata when the images **14** are uploaded to the photosharing site **22**. The time and location data **34** may be determined by a location-determining means **36** that is capable of determining and recording the changing location of the image capture device **12** over time. In a preferred embodiment, the location-determining means **36** comprises a GPS component **38** within the image capture device **12**. In an alternative embodiment, the location-determining means **36** comprises a network triangulation component **40** (e.g., using cell tower triangulation), a detailed description of which is outside the scope of this description.

As described above, however, simply recording the basic ambient conditions has drawbacks and may be insufficient as memory aids to help the user search for images **14**. According to one aspect of the preferred embodiment, the dynamic nature of ambient conditions and the user's mobility and

circumstances are taken into account during the process of automatically generating metadata by processing and analyzing two main varieties of dynamism:

1) variations of ambient conditions over time at the fixed location of the subject of the digital image, referred to here as picture location (PICLOC) data **42**; and
2) variations of ambient conditions over time at the location of the image capture device **12**, referred to here as camera location (CAMLOC) data **44**.

The metadata application component **23** preferably receives PICLOC data **42** and the CAMLOC data **44** as a series of ambient conditions readings within a specified period of time related to a time of the image capture **12**, which may include for a set period of time before the time of image capture, at the time of image capture, and after the time of image capture. These sets of basic ambient conditions are treated as raw data, which are then processed and summarized by the inference engine **24** and user-definable aggregation rules **26** to produce higher-level metadata, the ambient environment descriptors **28**, that describe ambient condition aggregations and trends.

As an example of producing high-level metadata based on changes in ambient conditions over time at the picture location and at the camera location, consider the following scenario. A user takes a picture in bright conditions, but it may matter a lot to the user to know that it just stopped raining. People remember such changes in ambience better, and these changes produce a distinctive feeling, in this example, because maybe the sky is brighter and the air is clearer than in other circumstances, and there is the smell of wet earth. In this example, the variations in ambient conditions at the location where a given picture is taken are recorded, even though the camera was not at that location the whole time. For example, according to the present embodiment, if it just stopped raining by the Tower of Pisa moments before the user got there and took the picture, the time and date of the picture is used to retrieve these changes in conditions, and these variations of conditions are aggregated into higher-level descriptors that convey this notion.

An example of ambient conditions that vary over time at the location of the camera is when the camera moves from a cloudy to a bright or from a bright to a cloudy region. The user's feeling about the picture in this example may be quite different than if he or she had only a static set of ambient conditions to describe the picture.

The CAMLOC data **42** and the PICLOC data **44** may be determined by ambient condition determining means **46**. The ambient condition determining means **46** may comprise the following:

1) an ambient conditions site **48** on the network **20** that provides the PICLOC data **44** to the metadata application component **23** based on the specified time and location **34**,
2) sensors **38** on the image capture device **12** for sensing ambient condition values in real-time and for storing the ambient condition values as the CAMLOC data **42**, or
3) a combination of both 1) and 2).

The PICLOC data **44** is retrieved by querying the ambient conditions site **48** with a specified time and location **34** of the image **14**. In a preferred embodiment, the ambient conditions site **48** returns values for each type of ambient condition, rather than an adjective describing the values. That is, rather than returning ambient condition adjectives such as "hot, mild, or cold" as the temperature, the ambient conditions site **48** preferably returns the actual temperature values, e.g., 73° , 74° , 76° , over the specified time period.

The CAMLOC data **42** is provided if the image capture device **12** includes sensors **50** for sensing ambient condition values in real-time and recording the values as image metadata. A suitably equipped image capture device **12** can capture more specific kinds of ambient conditions. For example, if the image capture device **12** is equipped appropriately, the image capture device **12** can associate the captured image **14** with the local temperature or atmospheric pressure or humidity as well as brightness at the time the picture is taken. Because the image capture device **12** is typically located near where the picture is being taken, the image capture device **12** can provide the most accurate and valuable information-generally, better than such information from a remote website. The CAMLOC data can, however, be approximated by retrieving information from a remote external service. As such, the data can correspond to where and when the specified image is captured.

In an exemplary embodiment, examples of the sensors **50** that the image capture device **12** may be equipped with include a light meter, a thermometer for measuring temperature, a barometer for measuring humidity, an altimeter for measuring elevation, and a digital compass for measuring heading. Most image capture devices **12** are already equipped with a light meter to measure light intensity. However, the current approach is to record the brightness both prior to the flash and during the flash (when appropriate) to determine how bright it was in general and how bright it was during the image capture. The combination of the brightness in the location where the image **14** is captured and the general conditions is important. For example, if a person captures the image **14** while inside a cathedral, the detected brightness at the camera location might be quite dark even though it is midday and the brightness at the picture location is quite bright.

Data recorded by the digital compass and the altimeter are examples of non-weather elements that may be useful for invoking the user's memory (e.g., recording "North" as the direction of travel as the user travels from Italy to Switzerland and elevation changes "going uphill"). Heading and elevation changes can be specified over larger or shorter intervals to capture general or particular trends. For example, a trek north may involve some small turns in other directions.

For some images **14**, the location of the image capture device **12** and the subject of the image may be the same position (within a distance threshold). Assuming the image capture device **12** has remained at that location for a sufficient period of time, the CAMLOC data **42** and the PICLOC data **44** would be the same and only one set of data is necessary. However, in cases where the image capture device **12** is moving prior to or after image capture, then the CAMLOC data **42** would include values for ambient conditions where the camera had been during the specified time frames before, during and after image capture. In cases where the subject of the image **14** is far away, such as a picture of a distant mountain peak or landmark, then the CAMLOC data **42** and the PICLOC data **44** might be different and the PICLOC data **44** could be determined by using the camera location to determine zip code and then use the zip code to query the ambient condition site **48** to obtain the conditions in the general area of the subject. Alternatively, for subjects whose GPS location or address is known, the ambient conditions site **48** could be queried with this information directly.

Whether there is a benefit from including sensors **50** on the image capture device **12** depends on the nature of the queries that will be formulated. For some applications, it might be adequate to record only the camera's changing position over time in order to obtain the PICLOC data **44** from the ambient conditions site **48**. When the location of the image capture device **12** is changing quickly (e.g., when the user is traveling on a motorcycle, car, train, plane, or even a bicycle) and the

queries involve medium or long intervals (say an hour), then the ambient conditions site **48** contacted with position and time would be able to provide the necessary CAMLOC data **42**. For example, if the user travels from one town to the next or through a geographical structure such as a valley, this would be reasonable. When the location of the image capture device **12** is changing slowly (e.g., when the user is traveling on foot) and the queries involve brief intervals (say five minutes), then broad coverage by the ambient conditions site **48** may not be adequate. The ambient conditions site **48** would need to provide ambient data with fine granularity or sensors would be required on the image capture device **12** to capture the necessary ambient conditions.

Referring to FIG. **2**, after the plurality of ambient conditions **32** is determined, in step **104** the inference engine **24** aggregates the ambient conditions **32** into at least one ambient environment descriptor **28** based on the user-definable aggregation rules **26**. As described above, if the image capture device **12** includes sensors **50**, then the metadata application component **23** receives the CAMLOC data **42** along with other image metadata, including the time and location **34**. The time and location **34** may then be used to retrieve the PICLOC data **44** from the ambient conditions site **48**.

In one embodiment, the PICLOC data **44** is retrieved when the image **14** is received by the metadata application component **23** and added to an image library or web album. In a second embodiment, the PICLOC data **44** is retrieved sometime after it is received and stored, such as during a batch metadata generation process. In this embodiment, the PICLOC data **44** can be retrieved during generation of the metadata, rather than in real-time. In a third embodiment, the image capture device **12** may use the time and location **34** to retrieve the PICLOC data **44** from the ambient conditions site **48**, and then pass the PICLOC data **44** with the image to the metadata application component **23**.

In step **106**, the metadata application component **23** associates the ambient environment descriptor(s) **28** with the digital image **14** as metadata. The user ID of the user is used to retrieve the aggregation rules **26** created by the user/image owner. The reasoning engine **24** then applies the aggregation rules **26** to the CAMLOC data **42** and/or the PICLOC data **44** associated with the image **14** and stores the output environment descriptors **28** as image metadata that describe the ambient conditions and trends for the image **14**.

In step **108**, users are allowed to formulate queries via the metadata application component **23** to search for images **14** based on the dynamic ambient environment descriptors **28**. In step **110**, the metadata application component **23** produces any images **14** having metadata that matches the query terms.

To enable query processing, the images **14** may be indexed according to their environment descriptors **28**, CAMLOC data **42**, and PICLOC data **44**. In a preferred embodiment, only the ambient condition values for a short period before and after the time of image capture need be stored for a given image **14**. For example, if a user took pictures in Rome only in the month of June, 2004, the metadata application component **23** need not store ambient condition data for Rome in the month of July, 2004. In a preferred embodiment, only the ambient condition data that occurred a few minutes or hours before and after a given image **14** is captured need be stored.

Using the UI **30**, the user may formulate sophisticated queries by describing variations in ambient conditions, and aggregations of ambient conditions and trends. Queries may be formulated and stored by end-users or the metadata application component **23** can create and display query templates through the UI **30** allowing users of the site to execute those queries. In a preferred embodiment, the user formulates queries based on PICLOC data **44** and CAMLOC data **42** elements.

Assuming the user posing the query has configured the user-definable aggregation rules **26**, then the symbolic descriptions of the PICLOC data **44** and CAMLOC data **42** elements (and their variations and combinations) are analyzed based on the definitions provided in the user's aggregation rules **26**. For example, the user can specify a certain kind of weather as "hot" or "cold"—presumably different for a typical Egyptian than for a typical Norwegian. This results in a name associated with the known ambient condition elements. Later images **14** can be mapped through well-known techniques like "nearest neighbor" to associate images **14** (based on its ambient condition elements and changes to them) with the specified symbolic term. In an alternative embodiment, the above descriptions can be tuned for different sets of images **14** automatically by considering each given set of images **14** separately or biasing the image **14** based on the climate where they were taken.

The query can be formulated in any one of the following ways. The user can specify the desired PICLOC data **44** and CAMLOC data **42** elements numerically (e.g., 83°). The user can specify the desired ambient condition elements using symbolic descriptions (e.g., "hot"). The user can specify variations (over time or over time and space) in the desired PICLOC data **44** and CAMLOC data **42** elements using symbolic descriptions. The user can specify correlated sets of the desired PICLOC data **44** and CAMLOC data **42** elements using symbolic descriptions.

The following is an example query based on variations in the PICLOC data **44**: "Find pictures taken in Rome last summer when it was warm and dry but before it got hot and humid that afternoon." The following is an example query based on variations in the CAMLOC data **42**: "Find pictures taken when I came out of the fog, while driving in the vicinity of Berkeley, Calif., last winter."

In summary, the queries can be thought of as being formulated in terms of patterns of variation based on the underlying ambient conditions. During query execution, the inference engine **24** evaluates a given pattern in terms of the ambient condition data **32** that was previously recorded or summarized.

The approach provided by the preferred embodiment presents several advantages. The approach of the preferred embodiment automatically creates metadata: there is little or no overhead on the user and thus usability is high. Another advantage is that the generation of metadata based on environment descriptors of aggregations of ambient conditions and trends is natural for humans and works as a great memory cue even years after an image is captured. This leads to improved retrieval of desired images. The more the enhancement of users' memory can be enabled and metadata that evokes their memories, the better for the precision as well as the quality of the experience. Aggregations of ambient conditions and trends are useful even for pictures that are taken indoors because, even when indoors, people often (if not always) remember the ambient conditions that existed outside. In other words, aggregations of ambient conditions and trends provide another set of dimensions by which users can search for information—fortunately, dimensions that human beings possibly have an innate ability to recognize and associate with their emotions.

FIGS. **4-6** are flow diagrams illustrating in further detail the process performed by the inference engine **24** for aggre-

gating a plurality of ambient conditions into one or more ambient environment descriptors **28** corresponding to step **104** in FIG. **2**.

FIG. **4** is flow diagram of the process for aggregating the PICLOC data **44**, which embody variations in ambient conditions at a fixed location in accordance with a preferred embodiment. The process begins in step **200** in which an image **14** is received for which metadata is requested that has an image capture time T and a location/position of P. The request may be explicitly initiated by the user, or by a metadata service that the user subscribes to, perhaps provided by the photosharing site **22**.

In step **202**, the ambient condition data for position P for time points within a specified time period before and after time T is requested. As an example, the time period is in minutes (e.g., T−30 minutes, or T+15 minutes), but other time periods might be equally desirable.

In step **204**, the values comprising each type of ambient condition (temperature, humidity, and so on) are received. In step **206**, the values comprising each type of ambient condition are summarized over the above time period by applying a value descriptor to the ambient condition, preferably using the subroutine described in FIG. **5**.

FIG. **5** is a flow diagram of a subroutine that may be used to summarize an ambient condition or a change in an ambient condition. The process begins is step **250** by receiving a list of readings ordered by time for an ambient condition. In step **252**, the aggregation rules **26** associated with the user are used as a lookup table to apply a value descriptor to the ambient condition based on the rule **160** that has thresholds or conditions comporting with the observed values. For example, if the observed readings for temperature were 70° through 76°, and a rule defines "Warm" as an average temperature of 73°, then temperature is assigned the value descriptor of "Warm".

Referring again to FIG. **4**, after each of the ambient conditions are summarized, then in step **208**, the changes observed for each type of ambient condition are summarized over the time period by applying a trend descriptor to the change in the ambient condition, preferably using the subroutine described in FIG. **5**. In this case, however, the subroutine will apply a trend descriptor, rather than a value descriptor. Trend descriptors for temperature may include rapidly decreasing, decreasing, steady, increasing, and rapidly increasing, for instance. These same trend descriptors may be applied to other ambient conditions, such as brightness and humidity as well.

In step **210**, related ambient conditions are aggregated by performing step **212** and **214**. In step **212**, the value descriptors applied to the related ambient conditions are summarized using the aggregation rules **26** as a lookup table to apply a combination value descriptor. The following are example rules for combining related ambient conditions, showing how two or more conditions can be combined.

1. muggy=warm and very humid
2. sweltering=hot and humid
3. balmy=mild, breezy, and partially humid
4. driving rain=rain and windy
5. monsoon-like=warm and gusty and rainy and winds-from-South-South-West

In step **214**, the trend descriptors applied to the related ambient conditions are summarized using the aggregation rules **26** as a lookup table to apply a combination trend descriptor. Examples of trend descriptor rules indicating summarizations of changes in an ambient condition include:

Sudden shower=hot and humid transitioning to cooler and rainy, and

Clearing=foggy, cold, and partly humid transitioning to brightening, warming, and with falling humidity.

The following are additional example rules indicating summarizations of changes in an ambient condition. Here DELTA refers to the change in value or trend of the given ambient condition element. Square brackets are used to refer to a time point relative to the present time point, which is assumed to be T. Here the base time unit is 1 minute, but could alternatively be 5 minutes or another suitable time period.

Darkening from=[T] DELTA(brightness)=decreasing.

Just-darkened=[T−1] DELTA(brightness)=decreasing and brightness=low.

Sudden cloud=DELTA(brightness)=decreasing and brightness=medium and (humidity=medium or humidity=high).

In step **216**, the combination value descriptors and the combination trend descriptors (singly and aggregated, as available) are stored as location-based metadata for the image **14**. Unless there are space constraints, it can be simplest to store both the basic and the derived summary data for convenience, meaning that the value descriptors and the trend descriptors for each of the ambient conditions may also be stored. Under space constraints, the basic data may be discarded and only the summary data stored.

FIG. **6** is flow diagram of the process for aggregating the CAMLOC data **44**, which embody variations in ambient conditions at a location of the image capture device over time. The process begins in step **300** in which the location/position of the image capture device **12** is monitored at set intervals, such as every five minutes, for instance. In step **302**, a rolling set of the last N observations of the image capture device's position are stored. As an example, the last **10** positions may be retained.

In step **304**, an image **14** capture at time T is received for which metadata is requested. In step **306**, the last N observed positions (including the current position) of the image capture device **12** P(−N+1), P(−N+2), . . . , P(**0**) are recorded as metadata, where P(**0**) corresponds to the current position, i.e., where the image is captured. In step **308**, an additional M observed positions P(**1**), . . . , P(M) of the image capture device **12** are recorded as metadata. As an example, the last 9 positions and the next 5 may be recorded in addition to the current position. That is, N=10 and M=5.

In step **310**, ambient condition data **32** is obtained for each position P(i) at time T+I, where I ranges from (−N+1) to (M). If the capture device **12** includes sensors **50**, then the ambient condition data **32** may be obtained from the image capture device **12**. Otherwise, the ambient condition may be requested from the ambient condition site **48** by either the image capture device **12** or the metadata application component **23**.

In step **312**, for each ambient condition (brightness, humidity, and so on), the inference engine **24** summarizes the ambient conditions and trends using the subroutine shown in FIG. **5**.

In step **314**, related ambient conditions are aggregated by performing steps **316** and **318**. In step **316**, the value descriptors applied to the related ambient conditions are summarized using the aggregation rules **26** as a lookup table to apply a combination value descriptor. In step **318**, the trend descriptors applied to the related ambient conditions are summarized using the aggregation rules **26** as lookup table to apply a combination trend descriptor.

In step **320**, the combination value descriptors and the combination trend descriptors are stored (singly and aggregated, as available) as "camera-based" metadata for the image **14**.

To further illustrate the preferred embodiment, consider the following examples of queries that could be posed based on descriptions of environment descriptors **28** using CAM-LOC data **42** elements.

EXAMPLE 1

Search for Images Taken Soon Before the User Exited a Car or Taxi

Average speed close to picture event below 3 miles per hour, and
Peak speed in 5-10 minutes before picture event above 10 miles per hour.

EXAMPLE 2

Search for Images Taken by a Number of Users Visiting the Lake District in England

On-walking-trip: Over an interval of x hours before and after this image: peak speed approximately 3 miles per hour.
On-bicycle-trip: Over an interval of x hours before and after this image: average speed peak speed approximates 8 miles per hour.
On wet ground but no rain: Over an area where there was rain the previous night.
On walking trip over wet ground: combine above definitions.

EXAMPLE 3

Search for Images Taken by a User and Others While on Train Trips Through the Alps or While Driving a Car in the San Francisco Bay Area

Sudden fog (happens often when going from one valley to the next): For an interval of x minutes before this image there was no fog but for an interval of y minutes before this image there was a fog (where y<x).
Sudden clearing: reverse of above.

EXAMPLE 4

Search for Images Taken in the US Gulf Coast Before, During, and After Hurricane Katrina

Before: when the barometric pressure was falling and wind speeds were increasing
In the eye: when the cloud cover had cleared and the barometric pressure had stopped falling.

A method and system for automatically generating metadata based on ambient conditions has been disclosed. The present invention has been described in accordance with the embodiments shown, and one of ordinary skill in the art will readily recognize that there could be variations to the embodiments, and any variations would be within the spirit and scope of the present invention. For example, the present invention can be implemented using hardware, software, a computer readable medium containing program instructions, or a combination thereof. Software written according to the present invention is to be either stored in some form of computer-readable medium such as memory or CD-ROM, , and is to be executed by a processor. Accordingly, many modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the appended claims.

What is claimed is:

1. A method for automatically generating metadata for a user for a digital image, comprising:
obtaining user-definable aggregation rules of the user that includes at least one of:
a rule indicating that "muggy" is specified when a plurality of ambient conditions is "warm" and "very humid";
a rule indicating that "sweltering" is specified when the plurality of ambient conditions is "hot" and "humid";
a rule indicating that "balmy" is specified when the plurality of ambient conditions is "mild", "breezy", and "partially humid";
a rule indicating that "driving rain" is specified when the plurality of ambient conditions is "rainy" and "windy";
a rule indicating that "monsoon-like" is specified when the plurality of ambient conditions is "warm" and "gusty" and "rainy" and "winds from the South to South-West";
a rule indicating that "Sudden shower" is specified when the plurality of ambient conditions is "hot" and "humid" transitioninq to "cooler" and "rainy"; and
a rule indicating that "Clearing" is specified when the plurality of ambient conditions is "foggy", "cold", and "partly humid" transitioninq to "brightening", "warming", and with "falling humidity";
determining a plurality of ambient conditions existing at a time related to a time of capture of the digital image and associated with a location of a subject of the digital image captured with a mobile image capture device even when the mobile image capture device is in a different location, wherein determining the plurality of ambient conditions includes determining variations of the ambient conditions over time by receiving readings of the ambient conditions at a plurality of times including at least one of a time before the time of capture, at the time of capture, and after the time of capture;
aggregating and transforming data associated with the plurality of ambient conditions into at least one ambient trend descriptor based on the obtained user- definable aggregation rules wherein the aggregating includes aggregating the variations of the ambient conditions determined over the plurality of times;
associating the ambient trend descriptor with the digital image as metadata; and
enabling a user to search for the digital image based on the at least one ambient trend descriptor.

2. The method of claim **1** wherein determining the plurality of ambient conditions at the location of the subject of the digital image further comprises receiving the ambient conditions from at least one of;
an online information source, and
from sensors of the image capture device.

3. A method for automatically generating metadata for a user for a digital image, comprising:
obtaining user-definable aggregations rules of the user that includes at least one of:
a rule indicating that "muggy" is specified when a plurality of ambient conditions is "warm" and "very humid";
a rule indicating that "sweltering" is specified when the plurality of ambient conditions is "hot" and "humid";
a rule indicating that "balmy" is specified when the plurality of ambient conditions is "mild", "breezy", and "partially humid";

a rule indicating that "driving rain" is specified when the plurality of ambient conditions is "rainy" and "windy";

a rule indicating that "monsoon-like" is specified when the plurality of ambient conditions is "warm" and "gusty" and "rainy" and "winds from the South to South-West";

a rule indicating that "Sudden shower" is specified when the plurality of ambient conditions is "hot" and "humid" transitioning to "cooler" and "rainy"; and

a rule indicating that "Clearing" is specified when the plurality of ambient conditions is "foggy", "cold", and "partly humid" transitioning to "brightening", "warming", and with "falling humidity";

determining a plurality of ambient conditions existing at a time related to a time of capture of the digital image and associated with a location of a subject of the digital image captured with a mobile image capture device even when the mobile image capture device is in a different location, wherein determining the plurality of ambient conditions includes determining variations of the ambient conditions over time by receiving readings of the ambient conditions for at least one of a fixed location of the subject of the digital image and a location of the image capture device at a plurality of times including at least one of a time before the time of capture, at the time of capture, and after the time of capture;

aggregating and transforming data associated with the plurality of ambient conditions into at least one ambient environment descriptor based on the obtained user-definable aggregation rules wherein the aggregating includes aggregating the variations of the ambient conditions determined over the plurality of times;

associating the ambient environment descriptor with the digital image as metadata; and

enabling a user to search for the digital image based on the at least one ambient environment descriptor.

4. The method of claim **3** wherein the ambient conditions include weather-related ambient conditions and non-weather related ambient conditions.

5. The method of claim **4** wherein the weather-related ambient conditions include any combination of temperature, humidity, barometric pressure, visibility, season, and wind.

6. The method of claim **4** wherein the non-weather related ambient conditions include any combination of at least one of location, heading, elevation, and brightness level of at least one of the subject and the image capture device.

7. The method of claim **1** further including providing a user interface through which the aggregation rules are configured to define the at least one ambient environment descriptor.

8. The method of claim **7** wherein the aggregation rules are configured for each individual end-user, thereby allowing subjective ambient environment descriptors to be defined.

9. The method of claim **7** wherein the aggregation rules are configured for different demographic groups.

10. The method of claim **3** wherein aggregating the plurality of ambient conditions into an ambient environment descriptor further comprises,

receiving values for each of the ambient conditions within a specified time period before and after the time of capture; and

for each of the ambient conditions,

summarizing the values of the ambient condition by applying an value descriptor to the ambient condition; and

summarizing changes in the values of the ambient condition by applying a trend descriptor to the ambient condition.

11. A method for automatically generating metadata for a digital image, comprising:

determining a plurality of ambient conditions associated with a location of a subject of the digital image captured with a mobile image capture device even when the mobile image capture device is in a different location, the ambient conditions existing at a time related to a time of capture of the digital image;

aggregating the plurality of ambient conditions and transforming data associated with the plurality of ambient conditions into at least one ambient environment descriptor based on user-definable aggregation rules wherein aggregating the plurality of ambient conditions into an ambient environment descriptor further comprises receiving values for each of the ambient conditions within a specified time period before and after the time of capture,

for each of the ambient conditions, summarizing the values of the ambient condition by applying an value descriptor to the ambient condition, and summarizing changes in the values of the ambient condition by applying a trend descriptor to the ambient condition, aggregating related ones of the ambient conditions by,

summarizing the value descriptors applied to the related ambient conditions using the user-definable rules as a lookup table to apply a combination value descriptor and

summarizing the trend descriptors applied to the related ambient conditions using the user-definable rules as a lookup table to apply a combination trend descriptor; and

associating the ambient environment descriptor with the digital image as metadata.

12. The method of claim **11** wherein aggregating the plurality of ambient conditions into an ambient environment descriptor further comprises storing the combination value descriptors and the combination trend descriptors as the image metadata.

13. The method of claim **12** wherein aggregating the plurality of ambient conditions into an ambient environment descriptor further comprises storing the value descriptors and the trend descriptors for each of the ambient conditions as the image metadata.

14. The method of claim **12** wherein determining the plurality of ambient conditions further comprises determining variations of the ambient conditions over time for both a fixed location of the subject of the digital image, and a location of the image capture device.

15. The method of claim **1** wherein enabling a user to search for the digital image based on the ambient environment descriptor includes allowing searches to be performed for the digital image by specifying desired metadata including the at least one ambient environment descriptor.

16. The method of claim **15** further comprising allowing searches to be performed for the digital image by specifying variations of the ambient conditions over time for both a fixed location of the subject of the digital image, and a location of the image capture device.

17. A system for automatically generating metadata for a user for a digital image, comprising:

a mobile image capture device for capturing the digital image;

means for determining a plurality of ambient conditions existing at a time related to a time of capture of the digital image and associated with a location of a subject of the digital image device even when the digital image device is in a different location;

a metadata application component for:

automatically generating the metadata for the digital images by obtaining user-definable aggregation rules of the user that includes at least one of:

a rule indicating that "muggy" is specified when the plurality of ambient conditions is "warm" and "very humid";

a rule indicating that "sweltering" is specified when the plurality of ambient conditions is "hot" and "humid";

a rule indicating that "balmy" is specified when the plurality of ambient conditions is "mild", "breezy", and "partially humid";

a rule indicating that "driving rain" is specified when the plurality of ambient conditions is "rainy" and "windy";

a rule indicating that "monsoon-like" is specified when the plurality of ambient conditions is "warm" and "gusty" and "rainy" and "winds from the South to South-West";

a rule indicating that "Sudden shower" is specified when the plurality of ambient conditions is "hot" and "humid" transitioning to "cooler" and "rainy"; and

a rule indicating that "Clearing" is specified when the plurality of ambient conditions is "foggy", "cold", and "partly humid" transitioning to "brightening", "warming", and with "falling humidity,"

aggregating the plurality of ambient conditions into at least one ambient environment descriptor based on the obtained user-definable aggregation rules, for associating the ambient environment descriptor with the digital image as metadata, wherein the aggregating includes aggregating variations of the ambient conditions determined over a plurality of times, and enabling a user to search for the digital image based on the at least one ambient environment descriptor.

18. The system of claim **17** wherein the means for determining a plurality of ambient conditions determines variations of the ambient conditions over time by receiving readings of the ambient conditions at a plurality of times including at least one of a time before the time of capture, at the time of capture, and after the time of capture.

19. The system of claim **18** wherein the means for determining a plurality of ambient conditions determines weather-related ambient conditions and non- weather related ambient conditions, wherein the weather-related ambient conditions include any combination of temperature, humidity, barometric pressure, visibility, season, and wind, and the non-weather related ambient conditions include any combination of location, heading, elevation, and brightness level of at least one of the subject and the image capture device.

20. The system of claim **19** wherein the means for determining a plurality of ambient conditions further comprises ambient condition determining means for determining at least one of,

variations of ambient conditions over time at the fixed location of the subject of the digital image, referred to as picture location (PICLOC) data, and

variations of ambient conditions over time at the location of the image capture device, referred to camera location (CAMLOC) data.

21. The system of claim **20** wherein the ambient condition determining means include at least one of,

an ambient conditions site on a network that provides the PICLOC data based on a specified time and location, and

sensors in the image capture device for sensing ambient condition values in real- time and for storing the ambient condition as the CAMLOC data.

22. The system of claim **17** wherein the metadata application component includes a user interface for allowing the user to configure the aggregation rules to define the at least one ambient environment descriptor, and to perform searches for the digital image by specifying desired metadata including the at least one ambient environment descriptor.

23. The system of claim **17** wherein the metadata application component aggregates the plurality of ambient conditions into an ambient environment descriptor by,

receiving values for each of the ambient conditions within a specified time period before and after the time of capture; and

for each of the ambient conditions,

summarizing the values of the ambient condition by applying an value descriptor to the ambient condition; and

summarizing changes in the values of the ambient condition by applying a trend descriptor to the ambient condition.

24. A system for automatically generating metadata for a user for a digital image, comprising:

a mobile image capture device for capturing the digital image;

means for determining a plurality of ambient conditions existing at a time related to a time of capture of the digital image and associated with a location of a subject of the digital image device even when the digital image device is in a different location, wherein the means for determining a plurality of ambient conditions determines variations of the ambient conditions over time by receiving readings of the ambient conditions at a plurality of times including at least one of a time before the time of capture, at the time of capture, and after the time of capture; and

a metadata application component for obtaining user-definable aggregation rules for the user, automatically generating the metadata for the digital images by aggregating the plurality of ambient conditions into at least one ambient environment descriptor based on the obtained user-definable aggregation rules, and for associating the ambient environment descriptor with the digital image as metadata, wherein the metadata application component aggregates the plurality of ambient conditions over the plurality of times into an ambient environment descriptor by:

receiving values for each of the ambient conditions within a specified time period before and after the time of capture; and

for each of the ambient conditions:

summarizing the values of the ambient condition by applying an value descriptor to the ambient condition; and

summarizing changes in the values of the ambient condition by applying a trend descriptor to the ambient condition

aggregating related ones of the ambient conditions by,

summarizing the value descriptors applied to the related ambient conditions using the user-definable able rules as lookup table to apply a combination value descriptor; and

summarizing the trend descriptors applied to the related ambient conditions using the user-definable rules as lookup table to apply a combination trend descriptor; and

enabling a user to search for the digital image based on the at least one ambient environment descriptor.

25. The system of claim **24** wherein the metadata application component aggregates the plurality of ambient conditions into an ambient environment descriptor by storing at least one of the combination value descriptors and the combination trend descriptors as the image metadata and storing the value descriptors and the trend descriptors for each of the ambient conditions as the image metadata.

26. An executable software product stored on a non- transitory computer-readable medium containing program instructions for automatically generating metadata for a digital image, the program instructions including:

obtaining user-definable aggregation rules that includes at least one of:

a rule indicating that "muggy" is specified when a plurality of ambient conditions is "warm" and "very humid";

a rule indicating that "sweltering" is specified when the plurality of ambient conditions is "hot" and "humid";

a rule indicating that "balmy" is specified when the plurality of ambient conditions is "mild", "breezy", and "partially humid";

a rule indicating that "driving rain" is specified when the plurality of ambient conditions is "rainy" and "windy";

a rule indicating that "monsoon-like" is specified when the plurality of ambient conditions is "warm" and "gusty" and "rainy" and "winds from the South to South-West";

a rule indicating that "Sudden shower" is specified when the plurality of ambient conditions is "hot" and "humid" transitioning to "cooler" and "rainy"; and

a rule indicating that "Clearing" is specified when the plurality of ambient conditions is "foggy", "cold", and "partly humid" transitioning to "brightening", "warming", and with "falling humidity";

determining a plurality of ambient conditions existing at a time related to a time of capture of the digital image and associated with a location of a subject of the digital image captured with a mobile image capture device even when the mobile image capture device is in a different location;

aggregating the plurality of ambient conditions into at least one ambient environment descriptor based on the obtained user-definable aggregation rules, wherein the aggregating includes aggregating variations of the ambient conditions determined over a plurality of times;

associating the ambient environment descriptor with the digital image as metadata; and

enabling the user to search for the digital image based on the ambient environment descriptor.

27. A method for automatically generating and searching metadata for a digital image, comprising:

determining a plurality of ambient conditions over time at a location of a subject of the digital image captured with a mobile image capture device even when the image capture device is in a different location, the ambient conditions existing at a time related to a time of capture of the digital image;

aggregating the plurality of ambient conditions into at least one ambient trend descriptor based on user-definable aggregation rules, wherein the aggregating includes aggregating variations of the ambient conditions determined over a plurality of times and the user-definable aggregation rules includes at least one of:

a rule indicating that "muggy" is specified when the plurality of ambient conditions is "warm" and "very humid";

a rule indicating that "sweltering" is specified when the plurality of ambient conditions is "hot" and "humid";

a rule indicating that "balmy" is specified when the plurality of ambient conditions is "mild", "breezy", and "partially humid";

a rule indicating that "driving rain" is specified when the plurality of ambient conditions is "rainy" and "windy";

a rule indicating that "monsoon-like" is specified when the plurality of ambient conditions is "warm" and "gusty" and "rainy" and "winds from the South to South-West";

a rule indicating that "Sudden shower" is specified when the plurality of ambient conditions is "hot" and "humid" transitioninq to "cooler" and "rainy"; and

a rule indicating that "Clearing" is specified when the plurality of ambient conditions is "foggy", "cold", and "partly humid" transitioning to "brightening", "warming", and with "falling humidity";

associating the ambient trend descriptor with the digital image as metadata; and

enabling a user to search for the digital image based on the ambient trend descriptor.

28. A method for searching images based on automatic generation of metadata for a digital image, comprising:

receiving a search query from a user that includes at least one ambient environment descriptor associated with at least one digital image;

obtaining the user's user-definable aggregation rules that includes at least one of:

a rule indicating that "muggy" is specified when a plurality of ambient conditions is "warm" and "very humid";

a rule indicating that "sweltering" is specified when the plurality of ambient conditions is "hot" and "humid";

a rule indicating that "balmy" is specified when the plurality of ambient conditions is "mild", "breezy", and "partially humid";

a rule indicating that "driving rain" is specified when the plurality of ambient conditions is "rainy" and "windy";

a rule indicating that "monsoon-like" is specified when the plurality of ambient conditions is "warm" and "gusty" and "rainy" and "winds from the South to South-West";

a rule indicating that "Sudden shower" is specified when the plurality of ambient conditions is "hot" and "humid" transitioning to "cooler" and "rainy"; and

a rule indicating that "Clearing" is specified when the plurality of ambient conditions is "foggy", "cold", and "partly humid" transitioning to "brightening", "warming", and with "falling humidity";

evaluating the search query based on the user-definable aggregation rules to retrieve the at least one digital image associated with the at least one ambient environment descriptor; and

displaying the retrieved at least one image.

29. The method of claim **28**, wherein obtaining the user's user-definable aggregation rules comprises:

obtaining aggregation rules based on the user's demographics; and

wherein evaluating the search query based on the user-definable aggregation rules to retrieve images associated with the at least one ambient environment descriptor comprises evalu-

ating the search query based on the aggregation rules based on the user's demographics to retrieve images associated with the at least one ambient environment descriptor.

30. The method of claim **29** wherein the demographics are defined culturally and geographically

31. The method of claim **29** wherein the aggregations rules are defined specific to an affinity group.

32. The method of claim **28** wherein the user-definable rules include rules defining ambient condition terms including a plurality of terms selected from "warm", "hot", "humid", "very humid", "partially humid", "mild", "breezy", "rainy", "windy", "gusty", "cool", "cold", "warming", "falling", "rising", "steady", "decreasing", and "increasing".

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