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(54) **SYSTEM AND METHOD FOR DETERMINING A LOCATION BASED ON MULTIMEDIA CONTENT**

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(60) Provisional application No. 62/428,557, filed on Dec. 1, 2016, provisional application No. 61/928,468, filed on Jan. 17, 2014.

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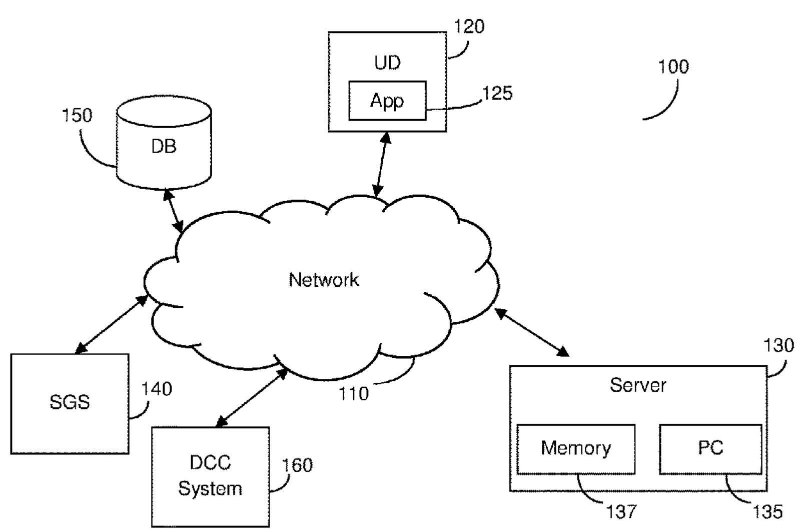
(57) **ABSTRACT**

A system and method for determining a precise location based on multimedia content. The method includes: analyzing a multimedia content element (MMCE), wherein the analysis further includes generating at least one signature to the MMCE; matching the generated at least one signature to at least one reference concept stored in a database, wherein each of the at least one stored concept is associated with a predetermined precise location; and identifying, based on the matching, a precise location depicted in the MMCE.



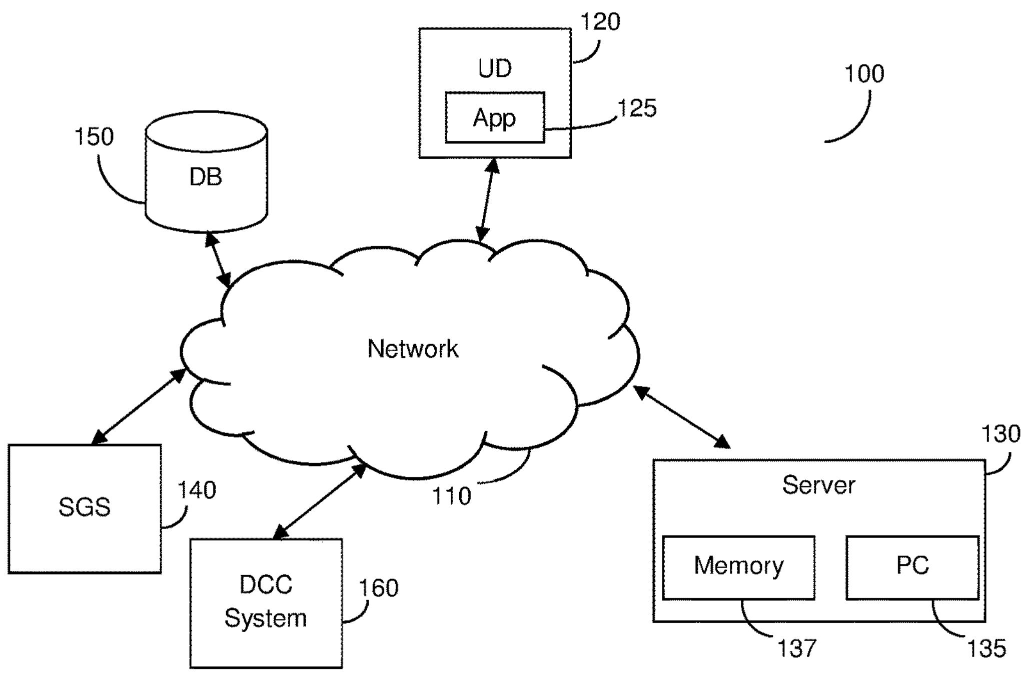

120
UD
App
125
100
150
DB
Network
110
SGS
140
DCC
System
160
130
Server
Memory
PC
137
135

FIG. 1

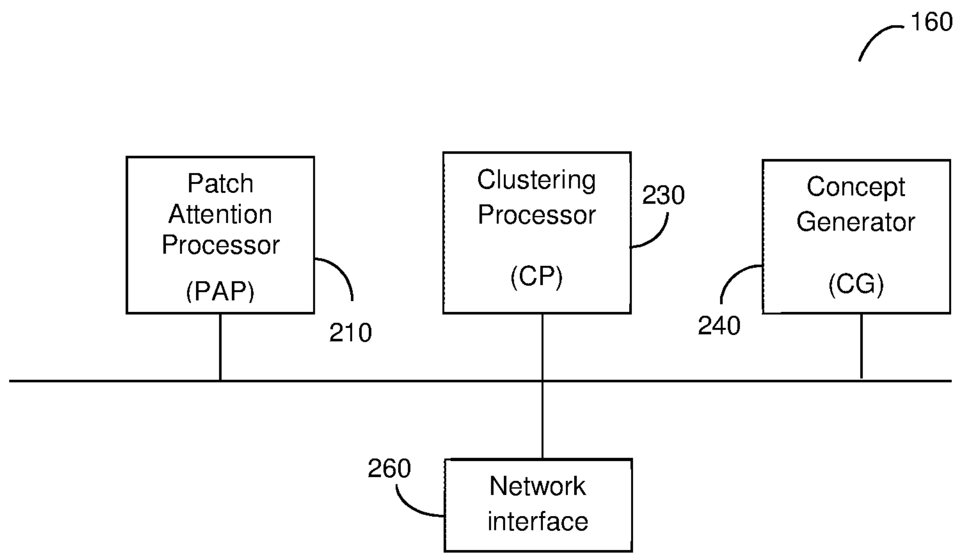

160
Patch Attention Processor
(PAP)
210
Clustering Processor
(CP)
230
Concept Generator
(CG)
240
260
Network interface

FIG. 2

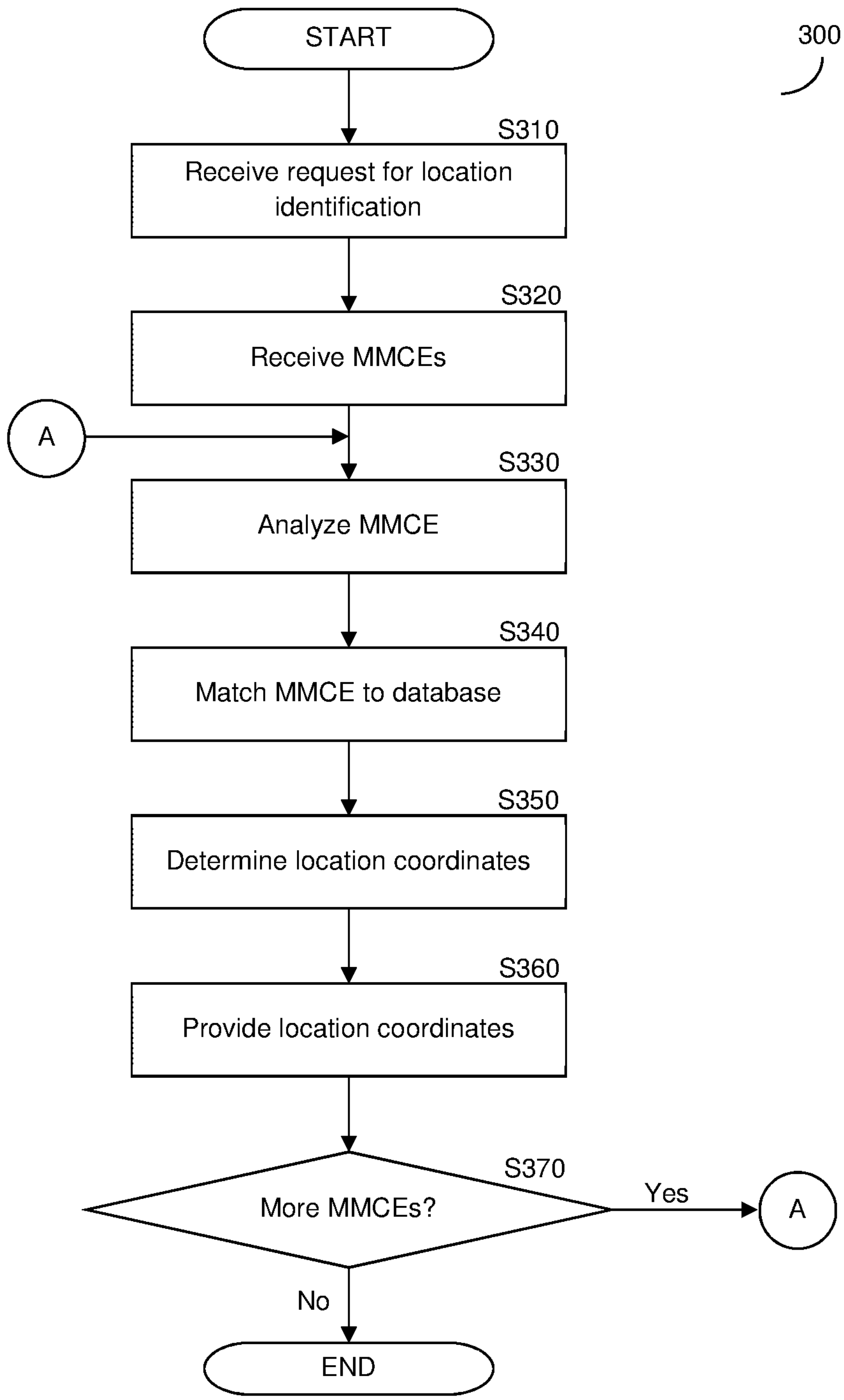

300
START
S310
Receive request for location identification
S320
Receive MMCEs
A
S330
Analyze MMCE
S340
Match MMCE to database
S350
Determine location coordinates
S360
Provide location coordinates
S370
More MMCEs?
Yes
A
No
END

FIG. 3

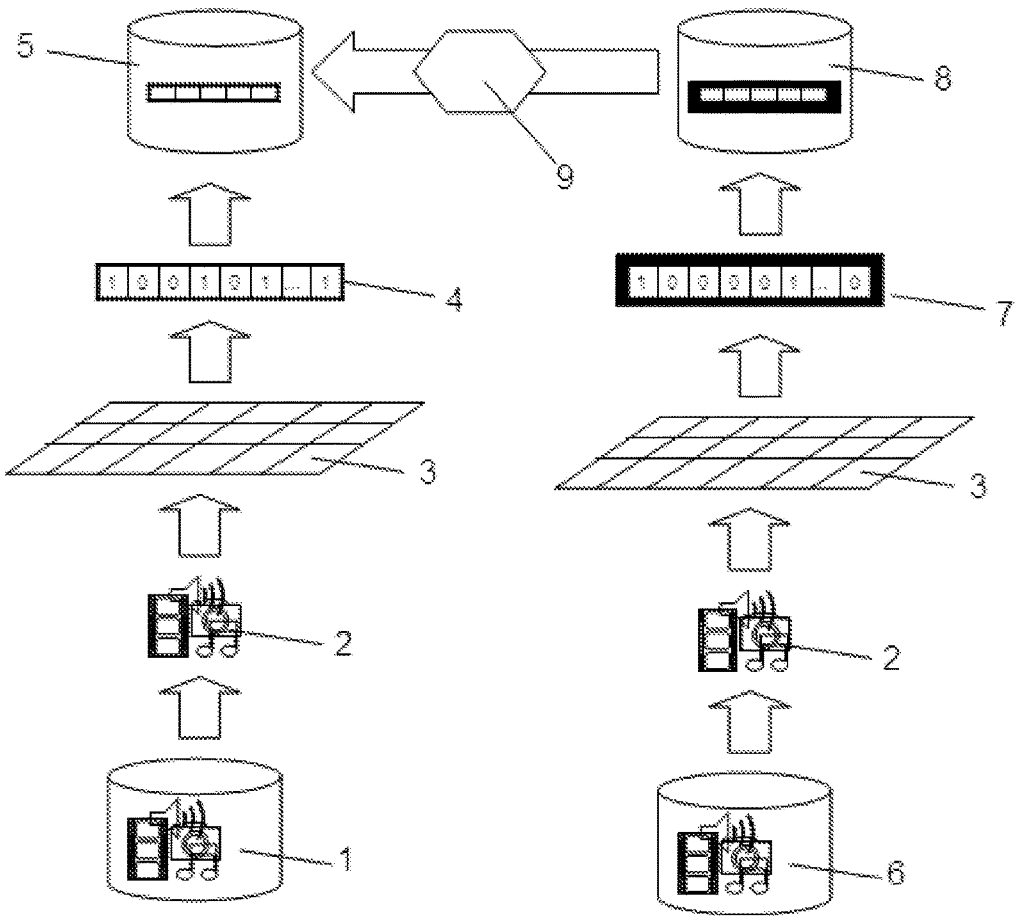


FIG. 4

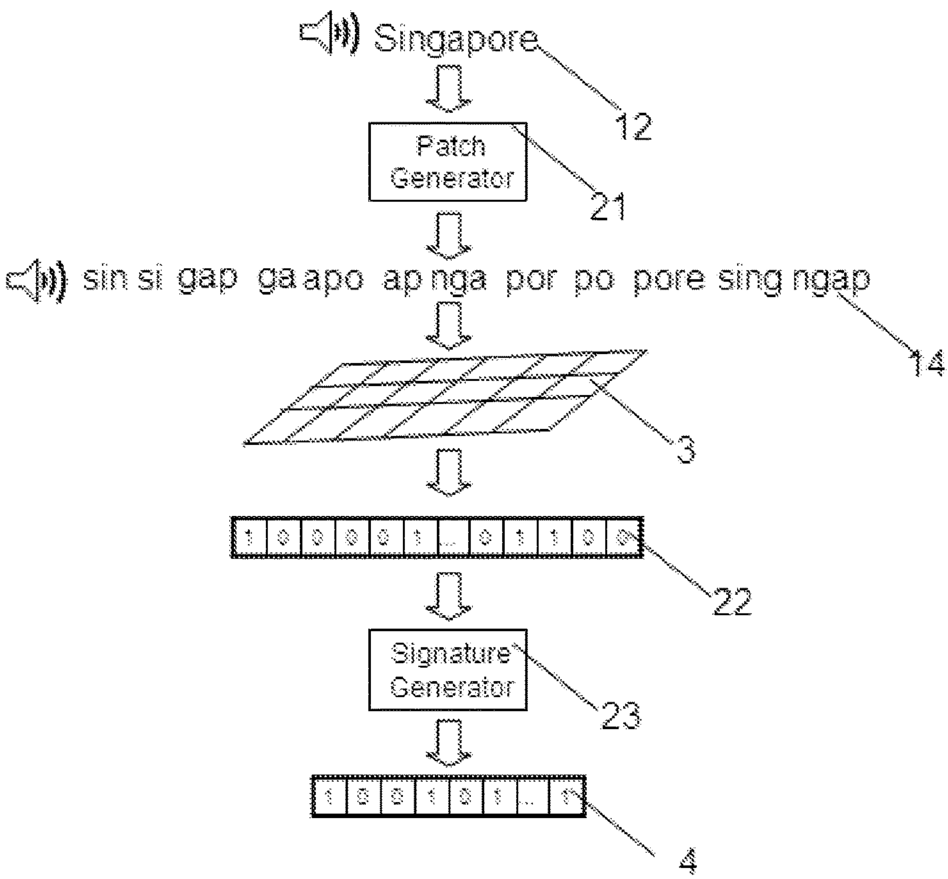

Singapore
12
Patch Generator
21
sin si gap ga apo ap nga por po pore sing ngap
14
3
1 0 0 0 0 1 ... 0 1 1 0 0
22
Signature Generator
23
1 0 0 1 0 1 .. 1
4

FIG. 5

SYSTEM AND METHOD FOR DETERMINING A LOCATION BASED ON MULTIMEDIA CONTENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/428,557 filed on Dec. 1, 2016. This application is also a continuation-in-part of U.S. patent application Ser. No. 14/597,324 filed on Jan. 15, 2015, now pending, which claims the benefit of U.S. Provisional Application No. 61/928,468, filed on Jan. 17, 2014. The Ser. No. 14/597,324 application is a continuation-in-part of U.S. patent application Ser. No. 13/766,463 filed on Feb. 13, 2013, now U.S. Pat. No. 9,031,999. The Ser. No. 13/766,463 application is a continuation-in-part of U.S. patent application Ser. No. 13/602,858 filed on Sep. 4, 2012, now U.S. Pat. No. 8,868,619. The Ser. No. 13/602,858 application is a continuation of U.S. patent application Ser. No. 12/603,123 filed on Oct. 21, 2009, now U.S. Pat. No. 8,266,185, which is a continuation-in-part of:

[0002] (1) U.S. patent application Ser. No. 12/084,150 having a filing date of Apr. 7, 2009, now U.S. Pat. No. 8,655,801, which is the National Stage of International Application No. PCT/IL2006/001235 filed on Oct. 26, 2006, which claims foreign priority from Israeli Application No. 171577 filed on Oct. 26, 2005, and Israeli Application No. 173409 filed on Jan. 29, 2006;

[0003] (2) U.S. patent application Ser. No. 12/195,863 filed on Aug. 21, 2008, now U.S. Pat. No. 8,326,775, which claims priority under 35 USC 119 from Israeli Application No. 185414, filed on Aug. 21, 2007, and which is also a continuation-in-part of the above-referenced U.S. patent application Ser. No. 12/084,150;

[0004] (3) U.S. patent application Ser. No. 12/348,888, filed on Jan. 5, 2009, now pending, which is a continuation-in-part of the above-referenced U.S. patent application Ser. No. 12/084,150, and the above-referenced U.S. patent application Ser. No. 12/195,863; and

[0005] (4) U.S. patent application Ser. No. 12/538,495, filed on Aug. 10, 2009, now U.S. Pat. No. 8,312,031, which is a continuation-in-part of the above-referenced U.S. patent application Ser. No. 12/084,150, the above-referenced U.S. patent application Ser. No. 12/195,863, and the above-referenced U.S. patent application Ser. No. 12/348,888.

[0006] All of the applications referenced above are hereby incorporated by reference.

TECHNICAL FIELD

[0007] The present disclosure relates generally to the analysis of multimedia content, and more specifically to determining a location based on an analysis of multimedia content.

BACKGROUND

[0008] Access to maps and location-based driving directions are readily available on many user devices, such as smartphones, through websites and dedicated applications. One process that is integral to the use of such systems is "geocoding." Geocoding is the process of converting a description of a location from a format that is meaningful to humans, such as a street address, an intersection, or name of a point of interest, to a location on the earth's surface in a format usable by computers, typically represented by numerical longitude and latitude values such as those used in a geographical coordinate system.

[0009] To request the display of a map using such an application, a user describes the location at which the map should be centered. To request directions within a mapping application, the user describes both the desired origin and destination. The application will then convert the requested locations to coordinates using a geocoding process.

[0010] A shortcoming of the geocoding process is that often users themselves are not sure of the exact location that they seek. In certain circumstances, accurately setting a location is critical, especially, for example, when mapping tools are used for ride hiring services in hectic urban areas. Additionally, even when a user is aware of the desired exact location, it can be difficult to input such information within an application. For example, if a user is waiting for a hired car service to pick them up at an intersection, it can be difficult and cumbersome to input the exact location within the intersection on a map, such as which side of the street, which corner of the intersection, how far from the actual intersection, and the like.

[0011] It would therefore be advantageous to provide a solution that would overcome the challenges noted above.

SUMMARY

[0012] A summary of several example embodiments of the disclosure follows. This summary is provided for the convenience of the reader to provide a basic understanding of such embodiments and does not wholly define the breadth of the disclosure. This summary is not an extensive overview of all contemplated embodiments, and is intended to neither identify key or critical elements of all embodiments nor to delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more embodiments in a simplified form as a prelude to the more detailed description that is presented later. For convenience, the term "an embodiment" may be used herein to refer to a single embodiment or multiple embodiments of the disclosure.

[0013] Certain embodiments disclosed herein include a method for determining a precise location based on multimedia content, the method including: analyzing a multimedia content element (MMCE), wherein the analysis further comprises generating at least one signature to the MMCE; matching the generated at least one signature to at least one concept stored in a database, wherein each of the at least one stored concept is associated with a predetermined precise location; and identifying, based on the matching, a precise location depicted in the MMCE.

[0014] Certain embodiments disclosed herein also include a non-transitory computer readable medium having stored thereon instructions for causing one or more processing units to execute a process for determining a precise location based on multimedia content, the process comprising: analyzing a multimedia content element (MMCE), wherein the analysis includes generating at least one signature to the MMCE; matching the generated at least one signature to at least one concept stored in a database, wherein each of the at least one stored concept is associated with a predetermined precise location; and identifying, based on the matching, a precise location depicted in the MMCE.

[0015] Certain embodiments disclosed herein also include a system for determining a precise location based on mul-

timedia content, comprising: a processing circuitry; and a memory, the memory containing instructions that, when executed by the processing circuitry, configure the system to: analyze a multimedia content element (MMCE), wherein the analysis includes generating at least one signature to the MMCE; match the generated at least one signature to at least one concept stored in a database, wherein each of the at least one stored concept is associated with a predetermined location; and identify, based on the matching, a precise location depicted in the MMCE.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The subject matter disclosed herein is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features, and advantages of the disclosed embodiments will be apparent from the following detailed description taken in conjunction with the accompanying drawings.

[0017] FIG. **1** is a network diagram utilized to describe the various disclosed embodiments.

[0018] FIG. **2** is an example diagram of a Deep Content Classification system for creating concepts according to an embodiment.

[0019] FIG. **3** is a flowchart illustrating a method for determining a location based on a multimedia content element according to an embodiment.

[0020] FIG. **4** is a block diagram depicting the basic flow of information in the signature generator system.

[0021] FIG. **5** is a diagram showing the flow of patches generation, response vector generation, and signature generation in a large-scale speech-to-text system.

DETAILED DESCRIPTION

[0022] It is important to note that the embodiments disclosed herein are only examples of the many advantageous uses of the innovative teachings herein. In general, statements made in the specification of the present application do not necessarily limit any of the various claimed embodiments. Moreover, some statements may apply to some inventive features but not to others. In general, unless otherwise indicated, singular elements may be in plural and vice versa with no loss of generality. In the drawings, like numerals refer to like parts through several views.

[0023] The various disclosed embodiments include a method and system for determining a location based on an analysis of multimedia content. In some embodiments, the method includes receiving an input multimedia content element (MMCE), analyzing the input MMCE and metadata associated the MMCE to generate signatures based on the content depicted within the MMCE, generating concepts based on the signatures, comparing the generated signatures and concepts to previously generated signatures and concepts that are associated with predetermined precise locations, e.g., from a database; and determining the precise location of the input MMCE. The determined location can be provided to a user device in the form of location coordinates.

[0024] FIG. **1** shows a network diagram **100** utilized to describe the various disclosed embodiments. A user device **120**, a server **130**, a signature generator system (SGS) **140**, a database **150**, and a deep content classifier (DCC) system **160** are communicatively connected via a network **110**. The network **110** may include the Internet, the world-wide-web (WWW), a local area network (LAN), a wide area network (WAN), a metro area network (MAN), and other networks capable of enabling communication between elements of a system **100**.

[0025] The user device **120** may be, but is not limited to, a mobile phone, a smart phone, a personal computer (PC), a tablet computer, a wearable computing device, and other kinds of wired and mobile devices capable of capturing, uploading, browsing, viewing, listening, filtering, and managing MMCEs as further discussed herein below. The user device **120** may have installed thereon an application **125**. The application **125** may be downloaded from an application repository, such as the Apple® AppStore®, Google Play®, or any repository hosting software applications for download.

[0026] The user device **120** includes a storage (not shown) containing one or more MMCEs, such as, but not limited to, an image, a photograph, a graphic, a screenshot, a video stream, a video clip, a video frame, an audio stream, an audio clip, combinations thereof, portions thereof, and the like. Additionally, the user device **120** may include an MMCE capturing mechanism, such as an image camera, a video camera, a microphone, and the like.

[0027] A server **130** is connected to the network **110** and is configured to communicate with the user device **120**. The server **130** may include a processing circuitry (PC) **135** and a memory **137**. The processing circuitry **135** may be realized as one or more hardware logic components and circuits. For example, and without limitation, illustrative types of hardware logic components that can be used include field programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), application-specific standard products (ASSPs), system-on-a-chip systems (SOCs), general-purpose microprocessors, microcontrollers, digital signal processors (DSPs), and the like, or any other hardware logic components that can perform calculations or other manipulations of information.

[0028] In an embodiment, the memory **137** is configured to store software. Software shall be construed broadly to mean any type of instructions, whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. Instructions may include code (e.g., in source code format, binary code format, executable code format, or any other suitable format of code). The instructions, when executed by the one or more processors, cause the processing circuitry **135** to perform the various processes described herein. Specifically, the instructions, when executed, cause the processing circuitry **135** to determine location based on analyzing multimedia content, as discussed further herein below.

[0029] In an embodiment, the server **130** may further be configured to identify metadata associated with each of the MMCEs. The metadata may include, for example, a time stamp of the capturing of the MMCE, the device used for the capturing, a location pointer, tags, comments, Global Positioning System (GPS) coordinates associated with the MMCE, and the like. The server **130** may further be configured to access location data from the user device **120** directly, such as a GPS sensor of a smart phone.

[0030] The database **150** is configured to store either previously generated signatures, concepts that have been previously generated based on signatures, or a combination thereof. The database **150** is accessible by the server **130**, either via the network **110** (as shown in FIG. **1**) or directly (not shown).

[0031] The SGS **140** and the DCC system **160** are utilized by the server **130** to perform the various disclosed embodiments. The SGS **140** and the DCC system **160** may be connected to the server **130** directly (not shown) or through the network **110** (as shown in FIG. **1**). In certain configurations, the DCC system **160** and the SGS **140** may be embedded in the server **130**. In an embodiment, the server **130** is connected to or includes an array of computational cores configured as discussed in more detail below.

[0032] In an embodiment, the server **130** is configured to access an input MMCE from the user device **120** and to send the input MMCE to the SGS **140**, the DCC system **160**, or both. The decision of which to be used (the SGS **140**, the DCC system **160**, or both) may be a default configuration or may depend on the circumstances of the particular MMCE being analyzed, e.g., the file type, the file size of the MMCE, the clarity of the content within the MMCE, and the like. In an embodiment, the SGS **140** receives the input MMCE and returns signatures generated thereto. The generated signature(s) may be robust to noise and distortion as discussed regarding FIGS. **4** and **5** below.

[0033] According to another embodiment, the analysis of the input MMCE may further be based on a concept structure (hereinafter referred to as a "concept") determined for the input MMCE. A concept is a collection of signatures representing elements of the unstructured data and metadata describing the concept. As a non-limiting example, a 'Superman concept' is a signature-reduced cluster of signatures describing elements (such as MMCEs) related to, e.g., a Superman cartoon: and a set of metadata providing a textual representation of the Superman concept. Techniques for generating concept structures are also described in the above-referenced U.S. Pat. No. 8,266,185 to Raichelgauz et al., the contents of which are hereby incorporated by reference.

[0034] According to this embodiment, a query is sent to the DCC system **160** to match the input MMCE to at least one concept. The identification of a concept matching the input MMCE includes matching signatures generated for the input MMCE (such signature(s) may be produced either by the SGS **140** or the DCC system **160**) and comparing the generated signatures to reference signatures representing predetermined concepts. The signatures to which the input MMCE is compared may be stored in and accessed from the database **150**. The matching can be performed across all concepts maintained by the system DCC **160**.

[0035] Based on the generated signatures, concepts, or both, the server **130** is configured to identify a precise location indicated, mentioned, shown, or otherwise represented by at least a portion of the input MMCE. The location is identified by comparing signatures, concepts, or both, to reference concepts that are associated with predetermined precise locations, as further detailed below in FIG. **3**. The precise location can further include latitudinal and longitudinal coordinates representing a place that can be displayed on a map. The identified precise location can be sent to the user device **120** for display thereon, such as through an application **125**, e.g., a mapping application.

[0036] It should be appreciated that generating signatures allows for more accurate analysis of MMCEs in comparison to, for example, relying on metadata alone. The signatures generated for the MMCEs allow for recognition and classification of MMCEs such as content-tracking, video filtering, multimedia taxonomy generation, video fingerprinting, speech-to-text, audio classification, element recognition, video/image search and any other application requiring content-based signatures generation and matching for large content volumes such as, web and other large-scale databases. For example, a signature generated by the SGS **140** for a picture showing a car enables accurate recognition of the model of the car from any angle at which the picture was taken.

[0037] It should be noted that only one user device **120** and one application **125** are discussed with reference to FIG. **1** merely for the sake of simplicity. However, the embodiments disclosed herein are applicable to a plurality of user devices that can communicate with the server **130** via the network **110**, where each user device includes at least one application.

[0038] FIG. **2** shows an example diagram of a DCC system **160** for creating concepts. The DCC system **160** is configured to receive an MMCE, for example from the server **130**, database **150**, or user device **120**, via a network interface **260**.

[0039] The MMCE is processed by a patch attention processor (PAP) **210**, resulting in a plurality of patches that are of specific interest, or otherwise of higher interest than other patches. A more general pattern extraction, such as an attention processor (AP) (not shown) may also be used in lieu of patches. The AP receives the MMCE that is partitioned into items; an item may be an extracted pattern or a patch, or any other applicable partition depending on the type of the MMCE. The functions of the PAP **210** are described herein below in more detail.

[0040] The patches that are of higher interest are then used by a signature generator, e.g., the SGS **140** of FIG. **1**, to generate signatures based on the patch. It should be noted that, in some implementations, the DCC system **160** may include the signature generator. A clustering processor (CP) **230** inter-matches the generated signatures once it determines that there are a number of patches that are above a predefined threshold. The threshold may be defined to be large enough to enable proper and meaningful clustering. With a plurality of clusters, a process of clustering reduction takes place so as to extract the most useful data about the cluster and keep it at an optimal size to produce meaningful results. The process of cluster reduction is continuous. When new signatures are provided after the initial phase of the operation of the CP **230**, the new signatures may be immediately checked against the reduced clusters to save on the operation of the CP **230**. A more detailed description of the operation of the CP **230** is provided herein below.

[0041] A concept generator (CG) **240** is configured to create concept structures (hereinafter referred to as concepts) from the reduced clusters provided by the CP **230**. Each concept comprises a plurality of metadata associated with the reduced clusters. The result is a compact representation of a concept that can now be easily compared against an MMCE to determine if the received MMCE matches a concept stored, for example, in the database **150** of FIG. **1**. This can be done, for example and without limitation, by providing a query to the DCC system **160** for finding a match between a concept and a MMCE.

[0042] It should be appreciated that the DCC system **160** can generate a number of concepts significantly smaller than the number of MMCEs. For example, if one billion (10^9) MMCEs need to be checked for a match against another one billion MMCEs, typically the result is that no less than $10^9 \times 10^9 = 10^{18}$ matches have to take place. The DCC system **160** would typically have around 10 million concepts or less, and therefore at most only $2 \times 10^6 \times 10^9 = 2 \times 10^{15}$ comparisons need to take place, a mere 0.2% of the number of matches that have had to be made by other solutions. As the number of concepts grows significantly slower than the number of MMCEs, the advantages of the DCC system **160** would be apparent to one with ordinary skill in the art.

[0043] FIG. **3** is a flowchart illustrating a method **300** for determining a precise location based on an analysis of multimedia content elements according to an embodiment.

[0044] At optional S**310**, a request for a precise location is received. The request may include user input, such as a textual query including a street address, an intersection of two or more streets, a name of a place of interest, e.g., a business name, and the like. In an embodiment, the request includes a selection of an area on a map, such as dropping a pin on a location within a mapping application. According an embodiment, the request may be received from a user via a user device. The user device may be, for example, a mobile phone, a smart phone, a personal computer (PC), a tablet computer, an electronic wearable device (e.g., glasses, a watch, etc.), and the like.

[0045] At S**320**, one or more input MMCEs are received for analysis. In an embodiment, the input MMCEs are received from the user device. The input MMCEs may include an image, a graphic, a video stream, a video clip, an audio stream, an audio clip, a video frame, a photograph, combinations thereof and portions thereof. In an embodiment, the input MMCEs are captured by the user device at a desired location (e.g., a desired location for pickup), and include one or more images of the desired location surroundings, such as buildings, street signs, natural or artificial landmarks, infrastructure, and the like.

[0046] At S**330**, each input MMCE is analyzed in order to identify a precise location associated with the input MMCE. The analysis includes generation of at least one signature based on each input MMCE. In an embodiment, the signatures are generated by a signature generation system or a deep-content classification system, as discussed herein, which may generate a signature for an MMCE via a large number of at least partially statistically independent computational cores. The signatures may be generated for one or more elements depicted within an MMCE. For example, if an MMCE is a photograph of a street corner, where the photograph includes an image of various elements, such as a storefront, a street sign, and a tree, a signature may be generated for each of the various elements.

[0047] The analysis may further include analysis of metadata associated with the MMCE. Metadata may include a time stamp of the capturing of the MMCE, the device used for the capturing, a location pointer, tags, comments, Global Positioning System coordinates associated with the MMCE, and the like. The metadata analysis may further include generating signatures to the metadata.

[0048] In an embodiment, the analysis further includes the determination of a concept based on each generated signature. The concepts are generated by a process of inter-matching of the signatures once it is determined that there is a number of elements therein above a predefined threshold. That threshold needs to be large enough to enable proper and meaningful clustering.

[0049] Each concept is a collection of signatures representing MMCEs and metadata describing the concept, and acts as an abstract description of the content to which the signature was generated. As a non-limiting example, a 'Superman concept' is a signature-reduced cluster of signatures representing elements (such as MMCEs) related to, e.g., a Superman cartoon, and a set of metadata including a textual representation of the Superman concept. As another example, metadata of a concept represented by the signature generated for a picture showing a bouquet of red roses is "flowers." As yet another example, metadata of a concept represented by the signature generated for a picture showing a bouquet of wilted roses is "wilted flowers".

[0050] At S**340**, based on the analysis, the input MMCE is matched to a database. The matching includes comparing the generated signatures, determined concepts, or both, to one or more previously generated reference concepts. Each reference concept is associated with a reference location. The reference concepts may be stored in and accessed from a database, such as the database **150** of FIG. **1**.

[0051] As a non-limiting example, if the determined concept of the input MMCE indicates the left side of a particular statue of a bull, and the reference concepts associate that exact statue with a particular location, e.g., the charging bull statue located in the Wall Street district of lower Manhattan on Broadway street, where the charging bull is facing north, a location is determined that the MMCE has been captured on the western side of the charging bull statue.

[0052] At S**350**, location coordinates associated with the determined location are determined. The location coordinates may be generated based on a predetermined list of reference coordinates associated with the matching reference location. The reference coordinates may be accessed from a database, or queried from a web source over a network. The coordinates may be generated in a numerical format using a geographic coordinate system, such as latitudinal and longitudinal values including degrees, minutes, and seconds.

[0053] At optional S**360**, the determined location coordinates are provided to a user device, e.g., through a mapping application. In an embodiment, the location coordinates are provided to a second user. For example, if a first user sends a location request from a first user device using a ride-hiring application, the determined location coordinates may be provided to a second user on an application running on a second user device, where the second user is offering ride-hiring services. In some implementations, the first user may provide additional information, such as an image of themselves, to allow the second user to identify the first user more easily. The additional information may include the input MMCEs.

[0054] At S**370**, it is checked if additional MMCEs have been received, and if so, execution continues with S**330**; otherwise, execution terminates.

[0055] FIGS. **4** and **5** illustrate the generation of signatures for the multimedia content elements by the SGS **120** according to one embodiment. An exemplary high-level description of the process for large scale matching is depicted in FIG. **4**. In this example, the matching is for a video content.

[0056] Video content segments **2** from a Master database (DB) **6** and a Target DB **1** are processed in parallel by a large number of independent computational Cores **3** that constitute an architecture for generating the Signatures (hereinafter the "Architecture"). Further details on the computational Cores generation are provided below.

[0057] The independent Cores **3** generate a database of Robust Signatures and Signatures **4** for Target content-segments **5** and a database of Robust Signatures and Signatures **7** for Master content-segments **8**. An exemplary and non-limiting process of signature generation for an audio component is shown in detail in FIG. **5**. Finally, Target Robust Signatures and/or Signatures are effectively matched, by a matching algorithm **9**, to Master Robust Signatures and/or Signatures database to find all matches between the two databases.

[0058] To demonstrate an example of the signature generation process, it is assumed, merely for the sake of simplicity and without limitation on the generality of the disclosed embodiments, that the signatures are based on a single frame, leading to certain simplification of the computational cores generation. The Matching System is extensible for signatures generation capturing the dynamics in-between the frames. In an embodiment, the signature generator **140** is configured with a plurality of computational cores to perform matching between signatures.

[0059] The Signatures' generation process is now described with reference to FIG. **5**. The first step in the process of signatures generation from a given speech-segment is to breakdown the speech-segment to K patches **14** of random length P and random position within the speech segment **12**. The breakdown is performed by the patch generator component **21**. The value of the number of patches K, random length P and random position parameters is determined based on optimization, considering the tradeoff between accuracy rate and the number of fast matches required in the flow process of the server **130** and SGS **140**. Thereafter, all the K patches are injected in parallel into all computational Cores **3** to generate K response vectors **22**, which are fed into a signature generator system **23** to produce a database of Robust Signatures and Signatures **4**.

[0060] In order to generate Robust Signatures, i.e., Signatures that are robust to additive noise L (where L is an integer equal to or greater than 1) by the Computational Cores **3** a frame 'i' is injected into all the Cores **3**. Then, Cores **3** generate two binary response vectors: one which is a Signature vector, and one which is a Robust Signature vector.

[0061] For generation of signatures robust to additive noise, such as White-Gaussian-Noise, scratch, etc., but not robust to distortions, such as crop, shift and rotation, etc., a core $Ci=\{n_i\}$ $(1\leq i\leq L)$ may consist of a single leaky integrate-to-threshold unit (LTU) node or more nodes. The node n_i equations are:

$$V_i = \sum_j w_{ij} k_j$$

$$n_i = \theta(Vi - Th_x)$$

[0062] where, θ is a Heaviside step function; w_{ij} is a coupling node unit (CNU) between node i and image component j (for example, grayscale value of a certain pixel j); k_j is an image component 'j' (for example, grayscale value of a certain pixel j); Th_X is a constant Threshold value, where 'x' is 'S' for Signature and 'RS' for Robust Signature; and Vi is a Coupling Node Value.

[0063] The Threshold values Th_X are set differently for Signature generation and for Robust Signature generation. For example, for a certain distribution of V_i values (for the set of nodes), the thresholds for Signature (Th_S) and Robust Signature (Th_{RS}) are set apart, after optimization, according to at least one or more of the following criteria:

[0064] 1: For:

$$V_i > Th_{RS}$$

$$1-p(V>Th_S)-1-(1-\epsilon)^l \ll 1$$

i.e., given that I nodes (cores) constitute a Robust Signature of a certain image I, the probability that not all of these I nodes will belong to the Signature of same, but noisy image, is sufficiently low (according to a system's specified accuracy).

[0065] 2:

$$p(V_i > Th_{RS}) \approx l/L$$

i.e., approximately I out of the total L nodes can be found to generate a Robust Signature according to the above definition.

[0066] 3: Both Robust Signature and Signature are generated for a certain frame i.

[0067] It should be understood that the generation of a signature is unidirectional, and typically yields lossless compression, where the characteristics of the compressed data are maintained but the uncompressed data cannot be reconstructed. Therefore, a signature can be used for the purpose of comparison to another signature without the need of comparison to the original data. The detailed description of the Signature generation can be found in U.S. Pat. Nos. 8,326,775 and 8,312,031, assigned to common assignee, which are hereby incorporated by reference for all the useful information they contain.

[0068] A Computational Core generation is a process of definition, selection, and tuning of the parameters of the cores for a certain realization in a specific system and application. The process is based on several design considerations, such as:

[0069] (a) The Cores should be designed so as to obtain maximal independence, i.e., the projection from a signal space should generate a maximal pair-wise distance between any two cores' projections into a high-dimensional space.

[0070] (b) The Cores should be optimally designed for the type of signals, i.e., the Cores should be maximally sensitive to the spatio-temporal structure of the injected signal, for example, and in particular, sensitive to local correlations in time and space. Thus, in some cases a core represents a dynamic system, such as in state space, phase space, edge of chaos, etc., which is uniquely used herein to exploit their maximal computational power.

[0071] (c) The Cores should be optimally designed with regard to invariance to a set of signal distortions, of interest in relevant applications.

[0072] A detailed description of the Computational Core generation and the process for configuring such cores is discussed in more detail in the above referenced U.S. Pat. No. 8,655,801, the contents of which are hereby incorporated by reference.

[0073] As used herein, the phrase "at least one of" followed by a listing of items means that any of the listed items can be utilized individually, or any combination of two or more of the listed items can be utilized. For example, if a system is described as including "at least one of A, B, and C," the system can include A alone; B alone; C alone; A and B in combination; B and C in combination; A and C in combination; or A, B, and C in combination.

[0074] The various embodiments disclosed herein can be implemented as hardware, firmware, software, or any combination thereof. Moreover, the software is preferably implemented as an application program tangibly embodied on a program storage unit or computer readable medium consisting of parts, or of certain devices and/or a combination of devices. The application program may be uploaded to, and executed by, a machine comprising any suitable architecture. Preferably, the machine is implemented on a computer platform having hardware such as one or more central processing units ("CPUs"), a memory, and input/output interfaces. The computer platform may also include an operating system and microinstruction code. The various processes and functions described herein may be either part of the microinstruction code or part of the application program, or any combination thereof, which may be executed by a CPU, whether or not such a computer or processor is explicitly shown. In addition, various other peripheral units may be connected to the computer platform such as an additional data storage unit and a printing unit. Furthermore, a non-transitory computer readable medium is any computer readable medium except for a transitory propagating signal.

[0075] All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the principles of the disclosed embodiment and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the disclosed embodiments, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure.

What is claimed is:

1. A method for determining a precise location based on multimedia content, comprising:

analyzing a multimedia content element (MMCE), wherein the analysis further comprises generating at least one signature to the MMCE;

matching the generated at least one signature to at least one concept stored in a database, wherein each of the at least one stored concept is associated with a predetermined precise location; and

identifying, based on the matching, a precise location depicted in the MMCE.

2. The method of claim **1**, further comprising:

generating location coordinates based on the identified precise location.

3. The method of claim **1**, further comprising:

determining at least one concept based on the generated at least one signature; and

matching the determined at least one concept to the at least one concept stored in the database.

4. The method of claim **3**, wherein each concept is a collection of signatures and metadata describing the concept.

5. The method of claim **3**, wherein the at least one concept is determined by querying a concept-based database using the at least one signature.

6. The method of claim **1**, wherein the at least one signature is robust to noise and distortion.

7. The method of claim **1**, wherein each signature is generated by a signature generator system including a plurality of at least partially statistically independent computational cores, wherein the properties of each core are set independently of the properties of each other core.

8. The method of claim **1**, wherein each of the at least one signature is generated based on at least one of: the MMCE, and metadata associated with the MMCE.

9. The method of claim **8**, wherein the metadata includes at least one of: a time stamp of the MMCE, a device used to capture the MMCE, a location pointer, tags, comments, and Global Positioning System (GPS) coordinates associated with the MMCE.

10. A non-transitory computer readable medium having stored thereon instructions for causing one or more processing units to execute a process for determining a precise location based on multimedia content, the process comprising:

analyzing a multimedia content element (MMCE), wherein the analysis further comprises generating at least one signature to the MMCE;

matching the generated at least one signature to at least one reference concept stored in a database, wherein each of the at least one reference concepts are associated with a predetermined precise location; and

identifying, based on the matching, a precise location depicted in the MMCE.

11. A system for determining a precise location based on multimedia content, comprising:

a processing circuitry; and

a memory, the memory containing instructions that, when executed by the processing circuitry, configure the system to:

analyze a multimedia content element (MMCE), wherein the analysis includes generating at least one signature to the MMCE;

match the generated at least one signature to at least one concept stored in a database, wherein each of the at least one stored concept is associated with a predetermined precise location; and

identify, based on the matching, a precise location depicted in the MMCE.

12. The system of claim **11**, wherein the system is further configured to:

generate location coordinates based on the identified precise location.

13. The system of claim **11**, wherein the system is further configured to:

determine at least one concept based on the generated at least one signature; and

match the determined at least one concept to the at least one concept stored in the database.

14. The system of claim **13**, wherein each concept is a collection of signatures and metadata describing the concept.

15. The system of claim **13**, wherein the at least one concept is determined by querying a concept-based database using the at least one signature.

16. The system of claim **11**, wherein the at least one signature is robust to noise and distortion.

17. The system of claim **11**, wherein each signature is generated by a signature generator system including a plurality of at least partially statistically independent computational cores, wherein the properties of each core are set independently of the properties of each other core.

18. The system of claim **11**, wherein each of the at least one signature is generated based on at least one of: the MMCE, and metadata associated with the MMCE.

19. The system of claim **18**, wherein the metadata includes at least one of: a time stamp of the MMCE, a device used to capture the MMCE, a location pointer, tags, comments, and Global Positioning System (GPS) coordinates associated with the MMCE.

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