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Gathering Missing Image Elements

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ABSTRACT

The technology relates to requesting missing data and, in particular, missing images associated with a geographic location to update and/or add to a mapping database. The system may utilize incentives to increase user participation in gathering the missing images. The collected images may be used to create a 3D reconstruction of the geographic location. The mapping database may be updated to include the revised, or new, 3D reconstruction of the location.

BRIEF SUMMARY

This paper is generally directed to systems and methods for determining locations that require additional information and sending users notifications requesting the information. The requested information may be, for example, photos or videos of a geographic location, monument, building, intersection, etc. The request may be based on a determination that the current images of specific locations are insufficient. For example, there may be no images, blurry images, images that have been corrupted, images with incomplete data, images that are outdated, etc. The requested information may be used to update and/or add to a mapping database. The request may be in the form of a notification to a device when the device is proximate to a geographic location associated with the requested information. A user may use the device to capture the requested information. The captured information, which may be in the form of a photo or video, may be received by a database. The captured information may be compared with information captured by others to create a 3D reconstruction of the location. The mapping database may be updated to include the revised, or new, 3D reconstruction of the location.

DESCRIPTION

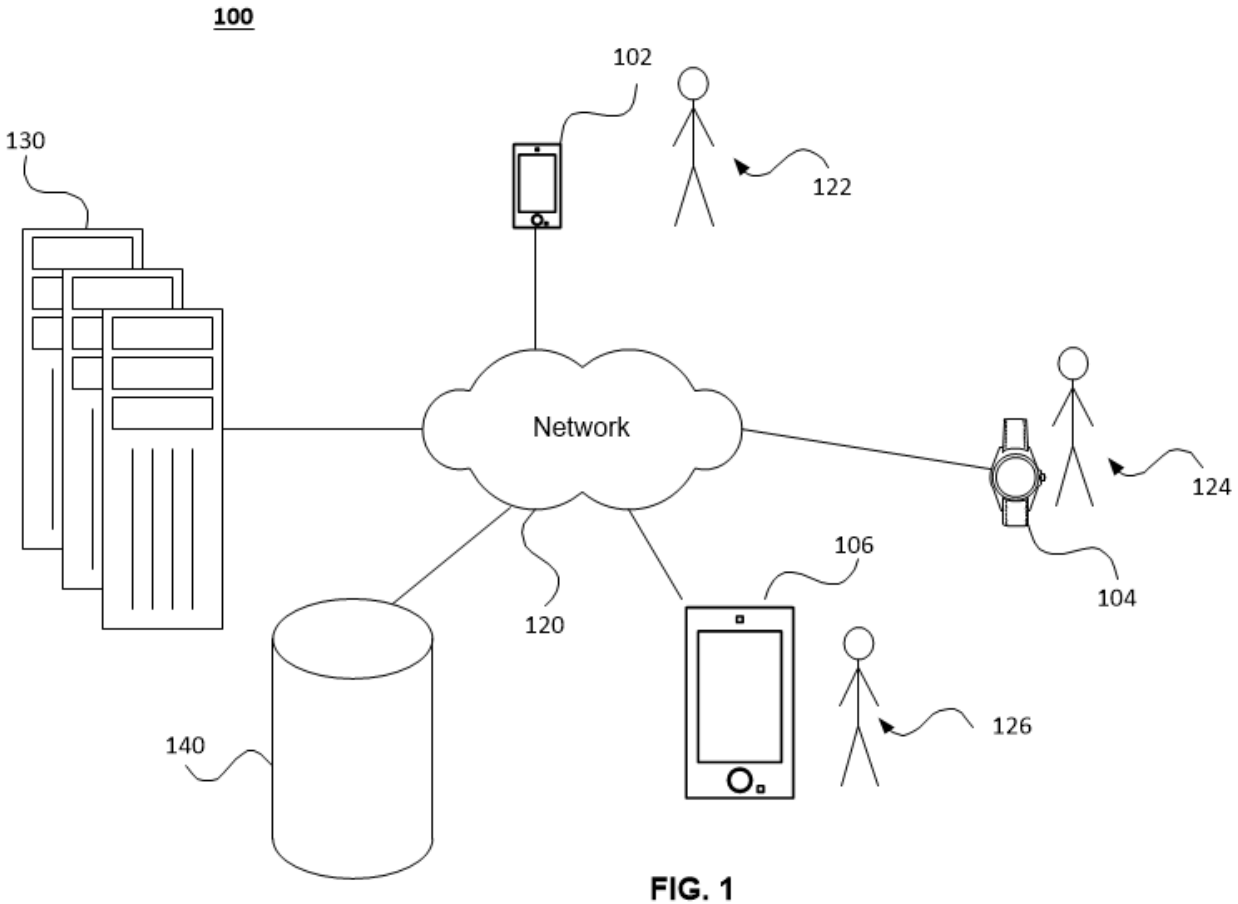

FIG. 1

Figure 1 illustrates a system for updating a mapping data to include a revised, or new, 3D reconstruction of a location. The system 100 may include a plurality of devices, 102, 104, 106 intended for use by a respective user 122, 124, 126, server computing device 130, storage system 140, and network 120.

Server computing device 130 may identify locations having missing information. For example, the server computing device 130 may determine that the images of specific locations are insufficient, are missing, the images are defective, etc., such that a 3-D reconstruction of that location is infeasible. In some examples, insufficiency may be measured by a heuristic, such as a threshold number of images per world coordinate. If the number of images fail to satisfy the

threshold, the server computing device 130may determine that the images of the specific location is insufficient.

According to some examples, the server computing device 130 may identify locations having missing information based on a scarcity of point clouds or contextual parsing. In some examples, the server computing device 130 may identify locations with less 3D reconstruction than others. For example, the server computing device 130 may determine a number of points, or pixels, of a 3D reconstruction of a location and compare that number of points to a predetermined number of points. If the determined number of points exceeds the predetermined number of points, the server may determine that there is enough information to create a 3D reconstruction. If the determined number of points is below the predetermined number of points, the server may determine that more information is required for that given location.

The server computing device 130 may identify driving and/or flying paths that are used to collect information. Based on the identified driving and flying paths, the server may identify locations that need additional information. For example, if information was collected by cameras on a car driving down the road, the cameras may capture information pertaining to the fronts of the buildings on the street but may not capture information pertaining to the sides and/or back of the buildings on the street. The server computing device 130 may identify the sides and/or backs of buildings along the path as locations that require additional information in order to create a 3D reconstruction.

In some examples, the server computing device 130 may determine that additional information is needed because of the volume of user requests for a particular location. For example, if a large number of users 122-126 are requesting information for an address or other location, the

server computing device 130 may determine that additional images are needed to satisfy the demand for information regarding the location.

The server computing device 130 may transmit a notification to a device 102-106 via network 120 when the device 102-106 is proximate to a geographic location associated with the required information. For example, the device's current location may be determined using a global positioning system ("GPS") or the like. The current location of the device 102-106 may be compared with one or more locations, associated with required information, provided by the server computing device 130. The device 102-106 may be in periodic communication with the server computing device 130 via network 120 to determine whether the device is near a desired location.

The notification may be a visual notification that is displayed on the display of the device 102-106. In some examples, the notification may, additionally or alternatively, be audible, such as by playing sound through the speakers of the device 102-106. In some examples, the notification may be notified by a flashing screen, beeping speaker, vibration, etc., when the device 102-106 is proximate to a required location. As shown in Figure 2, below, the notification may include a map indicating the current location 230 of the device 102 and location(s) 232, 234, 236 associated with the required information. For example, the map may include visual indicators proximate to and/or representative of locations that the server computing device 130 has determined require additional information.

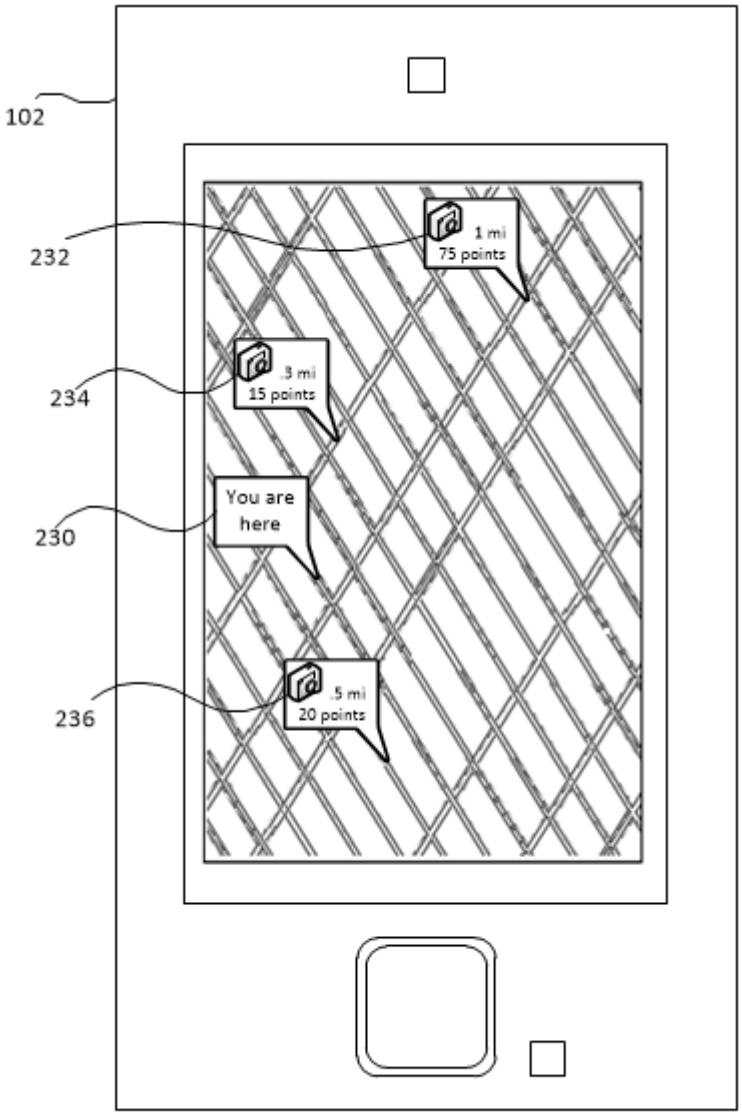

FIG. 2

Upon receipt of the notification, the user 122-126 may travel to the desired location, if necessary, and collect the required information. In some examples, an application may launch on the device 102-106 allowing the user 122-126 to take and preview a captured image. The application may provide the user 122-126 with assistance in determining the correct orientation, such as an indication of the current orientation of the device 102-106.

According to some examples, the application may be an augmented reality ("AR") or visual reality ("VR") application. In such an example, the AR/VR application may be a gaming application that has users 122-126 looking for an asset that is planted in the region of the desired location. When the user 122-126 finds the asset, the user 122-126 may capture images and/or videos that are then sent to the server.

The user 122-126 may receive incentives to provide the required information. For example, the device 102-106 may display a confirmation screen that thanks the user 122-126 for the information and indicates the amount of points earned or to be earned. The user 122-126 may compete with other users to earn the most points. Other incentives may include, for example, recognizing the user 122-126 by giving them a title that represents the extent of their contributions. In some examples, the system 100 may publicly identify the user 122-126 who provided a particular image as the photographer or source when other users view the image. The system 100 may further reward the user 122-126 by tacking user participation and allowing users to see how many times an uploaded image has been viewed.

According to some examples, the server computing device 130 may also assign values that are redeemable for some other rewards. For example, each location and required information may be associated with a point, token, monetary, or an arbitrary value. The locations identified as requiring additional information may be associated with a value indicative of the importance of additional images. For example, where there is no image data, the point value for capturing and uploading an image may be greater than where image quality is poor. The point value where image quality is poor may be greater than where the image is out of date. In this regard, the user 122-126 may be incentivized to gather and upload required information to accumulate point values. In some examples, the server computing device 130 may verify the image prior to awarding points to a user

122-126. The points may be, in some examples, redeemed for items, additional recognition, money, etc.

If the user 122-126 captures an image or video in response to the notification, the server computing device 130 may perform various verifications. For example, upon receipt of an image, the server computing device 130 may determine whether the image matches other information about the location that is already accessible by the server. The verification process may involve manual moderation or computer processing to match an image against any known images. The computer processing may be, for example, image feature matching. The image feature matching may be done using a scale-invariant feature transform ("SIFT") or speeded up robust features ("SURF"). SURF may use image filters and scale-space representations to match features within the collected images. SIFT may identify key points of images, such as the edge of a building or known infrastructures, such as roads or sidewalks, and determine an amount of overlap between two or more images.

The server computing device 130 may use the verified images to create and/or enhance a 3D reconstruction of the location. For example, the server computing device 130 may create or enhance a 3D reconstruction of the location using multi-view stereo. The multi-view stereo may group images based on context, such as the time of day the image was taken, what type of camera took the photo, etc. Grouping images based on their context may increase the accuracy of the 3D reconstruction.

The server computing device 130 may register the 3D reconstruction with the existing mapping database. The mapping database may be stored, for example, in storage system 140. For example, any newly created or enhanced reconstructions may be overlaid on the locations of the 3D reconstructed that were identified as requiring additional information. This may provide for a

more localized approach for updating the 3D reconstructions in the mapping database. A localized approach may require less computational power than using augmentation.