

CLAIMS:

1. A system for location determination, the system comprising:

a computing device comprising at least one processor and a memory accessible to the at least one processor;

wherein the memory comprises a library of reference background images and metadata for each reference background image, wherein the metadata comprises location information; and

wherein the memory stores program code executable by the at least one processor to configure the at least one processor to:

receive an input image data from a remote computing device, wherein the input image data includes image data of at least one image captured by the remote computing device at a location to be determined;

process the received input image data using a background matching module to identify a matching reference background image;

determine location information corresponding to the input image data based on the metadata of the matching reference background image in the library; and

transmit the determined location information to the remote computing device.

2. The system of claim 1, wherein the background matching module comprises: a background feature extractor neural network, and the at least one processor is further configured to identify the matching reference background image by:

extracting background descriptors from the at least one captured image using the background feature extractor neural network;

selecting one or more candidate matching images from the library of background images based on the extracted background descriptors;

performing geometric matching between the at least one captured image and the candidate matching images to select the matching reference background image.

3. The system of claim 2, wherein the geometric matching comprises identifying common visual features in the at least one captured image and each of the candidate matching images.

4. The system of claim 2 or claim 3, wherein the geometric matching is performed using a random sample consensus process.

5. The system of any one of claims 2 to 4, wherein the background feature extractor neural network is trained to extract background descriptors corresponding to one or more stationary features in the at least one captured image.

6. The system of any one of claims 1 to 5, wherein the memory stores program code executable by the at least one processor to further configure the at least one processor to:

receive GPS data corresponding to the input image from the remote computing device, wherein the GPS data comprises a low data quality indicator;

generate a GPS correction signal based on the determined location information;

transmit the GPS correction signal to the remote computing device.

7. The system of any one of claims 1 to 5, wherein the memory stores program code executable by the at least one processor to further configure the at least one processor to:

receive GPS data corresponding to the input image from the remote computing device, wherein the GPS data comprises a low data quality indicator;

determine a subset of images from the library of background images based on the GPS data; and

select the one or more candidate matching images from the subset of images from the library of background images based on the extracted background descriptors.

8. A system for location determination in an urban area, the system comprising:

at least one camera, wherein the at least one camera is positioned to capture images of the urban area while the at least one camera is moving in the urban area;

a computing device moving with the at least one camera and in communication with the at least one camera to receive the captured images;

the computing device comprising at least one processor and a memory accessible to the at least one processor;

wherein the memory comprises a library of reference background images and metadata for each reference background image, wherein the metadata comprises location information;

wherein the memory stores program code executable by the at least one processor to configure the at least one processor to:

process a captured image using a background matching module to identify a matching reference background image;

determine a location of the at least one camera and the computing device based on the metadata of the matching reference background image.

9. The system of claims 8, wherein processing the captured image using a background matching module comprises:

extracting background descriptors from the captured image;

selecting one or more candidate matching images from the library of reference background images based on the extracted background descriptors;

performing geometric matching between the captured image and the candidate matching images to select the matching reference background image.

10. The system of claim 9, wherein the background matching module comprises a background feature extractor neural network configured to extract background descriptors corresponding to one or more stationary features in the at least one captured image.

11. The system of claim 9 or claim 10, wherein the geometric matching is performed using a random sample consensus process; and

wherein the geometric matching comprises identifying common visual features in the at least one captured image and each of the candidate matching images.

12. The system of any one of claims 8 to 11, wherein the computing device is configured to determine the location in real-time.

13. A computer implemented method for location determination, the method performed by a computing device comprising at least one processor in communication with a memory, the method comprising:

receiving an input image by the computing device from a remote computing device, wherein the input image corresponds to a location to be determined;

processing the received input image using a background matching module provided in the memory of the computing device to identify a matching reference background image from among a library of reference background images stored in the memory;

determining location information corresponding to the input image based on the metadata of the matching reference background image; and

transmitting the determined location information to the remote computing device.

14. The method of claim 13, wherein the background matching module comprises: a background feature extractor neural network, and the method further comprises identifying the matching reference background image by:

extracting background descriptors from the at least one captured image using the background feature extractor neural network;

selecting one or more candidate matching images from the library of background images based on the extracted background descriptors;

performing geometric matching between the at least one captured image and the candidate matching images to select the matching reference background image.

15. The method of claim 14, wherein the geometric matching comprises identifying common visual features in the at least one captured image and each of the candidate matching images.

16. The method of claim 14 or claim 15 wherein the geometric matching is performed using a random sample consensus process.

17. The method of any one of claims 13 to 16, wherein the background feature extractor neural network is trained to extract background descriptors corresponding to one or more permanent stationary features in the at least one captured image.

18. The method of any one of claims 13 to 17, wherein the method further comprises:

receiving GPS data corresponding to the input image from the remote computing device, wherein the GPS data comprises a low data quality indicator;

generating a GPS correction signal based on the determined location information;

transmitting the GPS correction signal to the remote computing device;

wherein the GPS correction signal comprises information accessible by the remote computing device to determine a more accurate GPS location data.

19. The method of any one of claims 13 to 17, wherein the method further comprises:

receiving GPS data corresponding to the input image from the remote computing device, wherein the GPS data comprises a low data quality indicator;

determining a subset of images from the library of background images based on the GPS data; and

selecting the one or more candidate matching images from the subset of images from the library of background images based on the extracted background descriptors.

20. A computer implemented method for location determination, the method performed by a computing device comprising at least one processor in communication with a memory, the method comprising:

receiving an input image by the computing device from a remote computing device, wherein the input image corresponds to a location to be determined;

processing the received input image using a background matching module provided in the memory of the computing device to identify a matching reference background image from among a library of reference background images stored in the memory;

determining location information corresponding to the input image based on the metadata of the matching reference background image; and

transmitting the determined location information to the remote computing device.

21. A system for location determination in an urban area, the system comprising:

at least one camera, wherein the at least one camera is positioned to capture images of the urban area while the at least one camera is moving in the urban area;

a computing device moving with the at least one camera and in communication with the at least one camera to receive the captured images;

the computing device comprising at least one processor and a memory accessible to the at least one processor;

wherein the memory comprises a library of reference background images and metadata for each reference background image, wherein the metadata comprises location information;

wherein the memory stores program code executable by the at least one processor to configure the at least one processor to:

process a captured image using a background matching module to identify a matching reference background image;

determine a location of the at least one camera and the computing device based on the metadata of the matching reference background image.

22. A computer-readable storage medium storing instructions that when executed by a computer cause the computer to perform the method of any one of claims 13 to 21.