CLAIMS

1. A method of localising a robot using a scale plan of a designated environment, comprising:

- identifying reference features from the scale plan;
- generating a predicted pose of the robot's current location on the scale plan based on the identified reference features, the predicted pose comprises a plurality of particles each representing a potential location of the robot;
- scanning on-site reference features of the current location;
- generating a map for the current location to localise the robot, based on the scanned on-site reference features of the current location and last N frames of historical scans of previous on-site reference features of a plurality of locations in the designated environment that the robot traversed through before reaching the current location; the last N frames being fewer than total frames of the historical scans of the previous on-site reference features;
- calculating a weight for each particle based on the map for the current location and the scale plan;
- obtaining a best weight from the calculated weights for the plurality of particles; and
- initiating a closed-loop process if the best weight exceeds a closed-loop threshold.

2. The method according to claim 1, wherein the closed-loop process comprises storing all frames of historical scans.

3. The method according to claim 2, wherein the closed-loop process further comprises generating and updating a map of the designated environment using all frames stored.

4. The method according to any preceding claim, further comprising updating the predicted pose of the robot on the scale plan based on the calculated weights.

5. The method according to any preceding claim, further comprising converting the scale plan to a first gradient direction map and converting the map for the current location to a second gradient direction map for calculating the weight for each particle, wherein the first gradient direction map includes a first gradient direction representing a respective reference normal direction of surface to each reference feature identified on the scale plan and the second gradient direction map includes a second gradient direction representing a respective on-site normal direction of a surface to each on-site reference feature scanned at the current location.

6. The method according to any preceding claim, further comprising converting the scale plan to a gradient magnitude map for calculating the weight for each particle, wherein the gradient magnitude map includes a gradient of magnitude representing a respective distribution for each reference feature identified on the scale plan, with a centre of each identified reference feature carrying a higher magnitude value than an edge of the respective identified reference feature.

7. The method according to any preceding claim, wherein the weight for at least one of the plurality of particles is calculated to be proportional to the magnitude value of a corresponding cell in the gradient magnitude map.

8. The method according to any preceding claim, wherein the map for the current location comprises a sensed pose of the robot and the scanned on-site reference features of the current location comprise a fixed or immovable object of the designated environment, the weight for at least one of the plurality of particles is calculated to be inverse proportional to a distance between the sensed pose and the fixed or immovable object.

9. The method according to any preceding claim, wherein the N is chosen from a range from 50 to 150.

10. The method according to any preceding claim, wherein the scanned on-site reference features of the current location is stored as a latest frame of historical scans for generating the map for the current location when the robot traverses to a next location from the current location.

11. The method according to any preceding claim, wherein two neighbouring frames of the last N frames of historical scans share an overlap of on-site reference features.

12. A system for localising a robot using a scale plan of a designated environment, comprising:

i. a sensor module, configured to detect on-site reference features; and

ii. a processor, configured to:

- identify reference features from the scale plan;
- generate a predicted pose of the robot's current location on the scale plan based on the identified reference features, the predicted pose comprises a plurality of particles each representing a potential location of the robot;
- scan on-site reference features of the current location;
- generate a map for the current location to localise the robot, based on the scanned on-site reference features of the current location and last N frames of historical scans of previous on-site reference features of a plurality of locations in the designated environment that the robot traversed through before reaching the current location; the last N frames being fewer than total frames of the historical scans of the previous on-site reference features;
- calculating a weight for each particle based on the map for the current location and the scale plan;
- obtaining a best weight from the calculated weights for the plurality of particles; and
- initiating a closed-loop process if the best weight exceeds a closed-loop threshold.

13. The system according to claim 12, wherein the closed-loop process comprises storing all frames of historical scans.

14. The system according to claim 13, wherein the closed-loop process further comprises generating and updating a map of the designated environment using all frames stored.

15. The system according to any of claims 12 to 14, the processor is configured to further update the predicted pose of the robot on the scale plan based on the calculated weights.

16. The system according to any of claims 12 to 15, the processor is configured to further convert the scale plan to a first gradient direction map and convert the map for the current location to a second gradient direction map for calculating the weight for each particle, wherein the first gradient direction map includes a first gradient direction representing a respective reference normal direction of surface to each reference feature identified on the scale plan and the second gradient direction map includes a second gradient direction representing a respective on-site normal direction of a surface to each on-site reference feature scanned at the current location.

17. The system according to any of claims 12 to 16, the processor is configured to further convert the scale plan to a gradient magnitude map for calculating the weight for each particle, wherein the gradient magnitude map includes a gradient of magnitude representing a respective distribution for each reference feature identified on the scale plan, with a centre of each identified reference feature carrying a higher magnitude value than an edge of the respective identified reference feature.

18. The system according to any of claims 12 to 17, wherein the weight for at least one of the plurality of particles is calculated to be proportional to the magnitude value of a corresponding cell in the gradient magnitude map.

19. The system according to any of claims 12 to 18, wherein the map for the current location comprises a sensed pose of the robot and the scanned on-site reference features of the current location comprise a fixed or immovable object of the designated environment, the weight for at least one of the plurality of particles is calculated to be inverse proportional to a distance between the sensed pose and the fixed or immovable object.

20. The system according to any of claims 12 to 19, wherein the N is chosen from a range from 50 to 150.

21. The system according to any of claims 12 to 20, wherein the processor stores the scanned on-site reference features of the current location as a latest frame of historical scans for generating the map for the current location when the robot traverses to a next location from the current location.

22. The system according to any of claims 12 to 21, wherein two neighbouring frames of the last N frames of historical scans share an overlap of on-site reference features.

23. A robot, comprising:

i. a system according to any of claims 12 to 22; and

ii. a controller configured to control an operation of the robot in a designated environment based on a localisation result provided by the system.

24. A non-transitory computer-readable storage medium for storing a computer program, when executed by a processor, performs a method of localising a robot in a designated environment according to any of claims 1 to 11.