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Paper

Position identification method for mobile robots using colour images

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Abstract—This paper proposes an efficient position identification method for mobile robots in the environment of a building corridor using colour images and map information. A robot can usually estimate its position from its motion history (so-called dead reckoning); however, there are occasions when the robot's position needs to be estimated without the motion history, for example when self-tracking of the motion has failed, or just after the robot power is on.

The proposed method is to identify the robot's position without the motion history. The method consists of the following three steps:

(1) map information for the mobile robot is prepared;
(2) a colour image is processed to detect a vanishing point and to generate an abstracted image. The robot moves to an appropriate position for the identification, if it is unable to identify the current position; and
(3) the current robot position is identified from the map information, the vanishing point, and the abstracted image.

The effectiveness of the proposed method is shown by the experimental results.

1. INTRODUCTION

For mobile robots, position identification is a basic function. Here, position identification means that the robot identifies its own position from the map information which is in the robot. In order to identify the current position of the mobile robot, an estimation of the approximate position is usually made and the current position confirmed using the approximate position data, external sensor data, and the environment map information. However, it is necessary that a position estimate can be made without the motion history when self-tracking fails or just after power-on, for example. There are two cases where position identification is required:

(1) confirmation of a more accurate position, when the robot knows its approximate current position; and
(2) recognition of the current position, when the robot has no information about its own current position on the environment map.

In both cases, a vision system using a TV camera is used for recognition of the position.

The vision system is an interesting subject, and much research has been published about it. For point (1) above, several position estimation methods using a three-dimensional (3D) model of the environment, object, and real image have been proposed. The current position is calculated by edge location detected from a real monochrome image [1–3]. In addition, we have proposed a robot position estimation method [4, 5] as described in Section 3.1. The method is based on calculating the current position from the motion history, generating two sets of trapezoids on the image plane (of predicted object information from the environment map and abstracted information from the real image given by the colour TV camera), and matching these two sets of information. The effectiveness of the proposed method was confirmed by some experiments [6]. By this method, in the case where the robot knows its approximate current position, the accurate position of the robot on the map can be estimated using the colour image given by the TV camera and the environment map information stored internally.

On the other hand, for the case when the robot has no current position information on the map as in point (2) above, several position estimation methods using a vision system have been proposed. Kakikura and Sakane proposed a position identification method using the silhouette matching technique [7]. This technique is leading the way as the identification method for when the robot has no current position information. However, in this method, silhouettes from all the predicted positions must be generated and a large calculation time is needed for the position identification when the number of candidate positions increases. Similarly, the robot current position can be estimated by an expansion of our previous work on point (1) above, if the image from the TV camera and the images generated from all the predicted view positions on the map can be matched. However, in a slightly complex environment like the corridor of a building, a large amount of calculation time is necessary for this procedure, and it is not a practicable method. Accordingly, it is important for mobile robots to get their approximate position first, in order to identify their position.

In this paper, an efficient robot position identification method is proposed. This method is based on our previous work [4–6, 8, 9]. It uses a colour image from a colour TV camera together with map information held in the robot, without motion history.

2. PROBLEM FORMULATION

The objective of the proposed method is to identify the current robot position and orientation for mobile robots using environment map information stored in the robot and a colour image from a colour TV camera at the current robot position. Here, the following assumptions are made about the environment of the mobile robot:

(1) the environment of the robot is a building corridor;
(2) corridors intersect vertically and corridor directions are north, south, east, or west for the sake of convenience;
(3) floors, ceilings, walls, pillars, and doors are constructed vertically or horizontally;

(4) most of the floors, ceilings, walls, and pillars are not coloured, but a few coloured objects are located in the corridor.

These conditions are drawn from a group of corridors in the college of the University of Tsukuba where our laboratory is. Also, the mobile robot can move to a suitable position until it gets a satisfactory image to identify its own position.

The TV camera is assumed to remain at a constant height and parallel to the floor. Accordingly, the parameters to be identified are the x and y coordinates and the direction θ on the two-dimensional (2D) plane.

3. PROPOSAL FOR A POSITION IDENTIFICATION METHOD FOR MOBILE ROBOTS

3.1. Identification of view point using a colour image

We have previously proposed a method for estimating an accurate view point from the environment map information and the approximate position data calculated from the motion history [5]. This technique consists of the following procedure: extracting coloured regions in the original colour image, abstracting the region to a set of trapezoids, generating real abstracted perspective information (R-API), generating estimated abstracted perspective information (E-API) (which has the same structure as R-API and is generated from the environment map and the approximate position calculated from the motion history), matching between the R-API and E-API, and calculating the accurate view point using the difference of the vertical edge position of the trapezoids between the R-API and E-API. This position estimation technique is called 'posterior estimation of the view point'. In this method, when two sets of APIs can be matched, both view points are recognized as located approximately. Therefore, if a search of all the 3D space of the x–y plane and orientation θ finds a point to match between the R-API from the original image and the E-API from the environment map and all positions of the 3D space (x, y, θ), the point is regarded as the approximate position. The accurate position can be estimated by the 'posterior estimation of the view point' on the approximate position. However, a large amount of calculation time is necessary to search all the 3D space in the usual way for a matching operation, and it is not a practical method for mobile robots which require real-time execution. Accordingly, an efficient algorithm must be used to identify the approximate robot position quickly. In the proposed identification algorithm, the efficiency is realized as follows.

3.2. An efficient algorithm for view point finding

3.2.1. Using a grid map and checking zone which indicates the possible area of the robot's position. In our previous research, an R-API abstracted from the original image and E-API generated from the environment map information can be regarded as corresponding by the matching operation and a more accurate robot position can be calculated when the error between the approximate robot position and the real robot position is smaller than about 100 cm and the error of the direction is smaller than about 10° [5]. If a grid map (defined as candidate points for the robot's position on the plane of the environment map) is prepared, and if a point can be matched between the APIs by searching, the approximate point can be estimated with an error from the real point corresponding to the grid size. If grid points on corridors without rooms can be taken as candidate points for the robot's position, greater efficiency of the search algorithm can be expected.

3.2.2. Using a vanishing point in the original image. The orientation of the TV camera relative to the corridor direction can be calculated by detection of the vanishing point in the corridor image. The direction of the robot can be calculated from the orientation to the corridor direction, and the search will be more effective because the environment is constructed vertically or horizontally.

3.2.3. Using distinctive objects. In the proposed position identification method, the saturation and colour hue value calculated from the R (red), G (green), and B (blue) intensity values in the original image are used. First, high saturation regions, i.e. coloured regions, are extracted. If two highly coloured regions can be extracted, and if these regions can be assigned to coloured distinctive objects on the environment map, and if the relationship of the two distinctive objects' positions on the map and the vanishing point on the image can be calculated, the robot position can be calculated to a specified point.

However, in practice, many coloured distinctive objects are located in the real environment, and there are many objects with the same hue colour value, so the robot position cannot be specified to a point. In addition, if all coloured objects are listed as candidate points, a large calculation time is necessary because of the increase in candidate points. So, by classifying objects located in the environment by their colour hue value, a smaller amount of distinctive objects, which have the same colour hue value and same shape, are considered. Candidate points can be decreased efficiently if these points can be limited to distinctive objects. Here, distinctive objects are defined as two or three types of coloured red objects which occur with a frequency of one or two pieces in a corridor.

3.2.4. Using the robot motion. The mobile robot is able to move to the next position until it finds a vanishing point and at least two coloured objects, and to identify its own position by the motion algorithm indicated in Section 4.4, if the original image includes no vanishing point or not enough coloured objects.

4. STEPS TO IDENTIFY THE VIEW POINT

4.1. Flow of identification procedure

Figure 1 shows the outline procedure of the proposed identification method for mobile robots. This method has three steps.

The first step is preparation of the map information. In this step, a grid map, which indicates the candidate area of the robot position, and a distinctive object list, which defines distinctive objects in the environment, are generated from the environment map. These three sets of information are called map information. Here, the environment map and the distinctive object list are made by a human in advance.

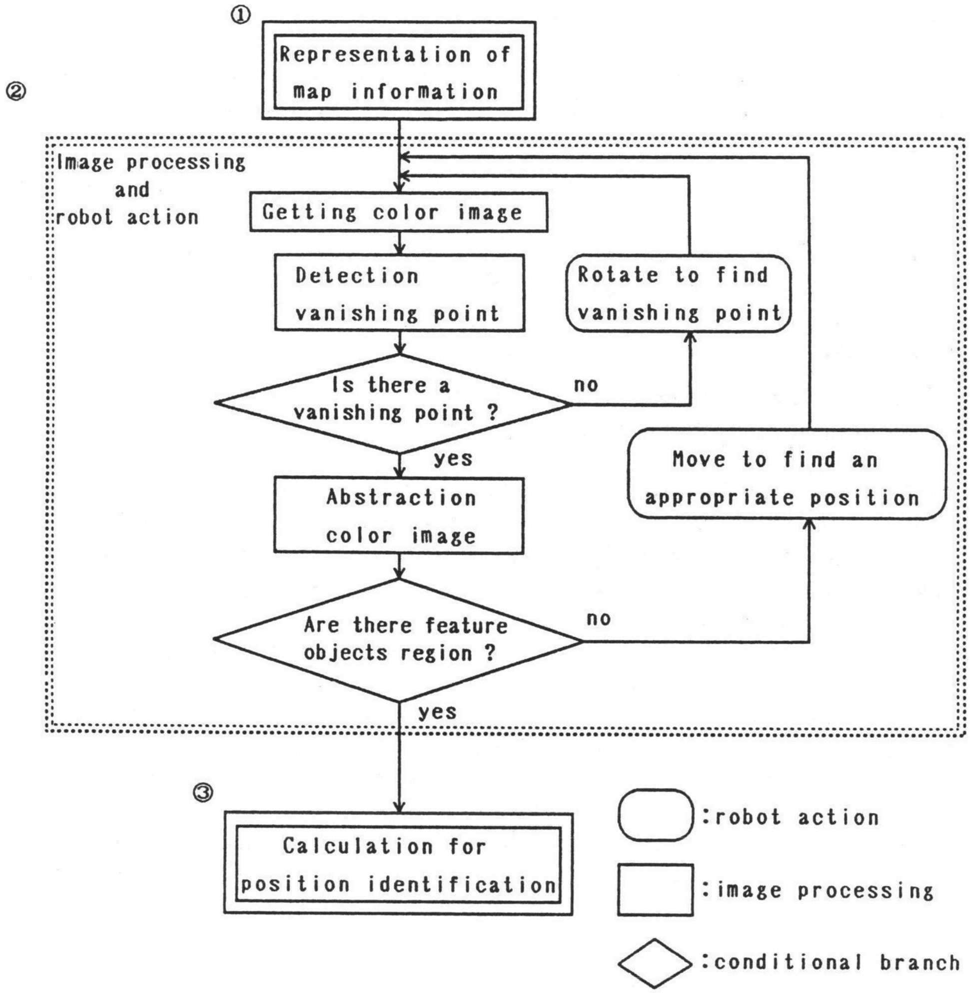


Figure 1. Position identification method.

The second step is image processing and robot motion. In the image processing, a vanishing point, which is the most important characteristic in the corridor, is extracted, and R-API is generated from the original image. When the robot judges that it cannot identify its own current position, it moves to another position.

The third step is the position identification calculation. First, candidate positions near the actual robot position on the grid map are taken, and estimated abstracted perspective images (E-APIs) are generated for each candidate position. After the matching operation between the R-API and E-APIs, matching points on the grid map are found. Finally, by the error of the vertical edge between the R-API and E-API, the posterior estimation of the view point is performed, and the accurate robot position is obtained.

Each procedure is explained in detail in the following sections.

4.2. *Preparation of map information*

4.2.1. Representation of the environment [8]. We have proposed a method to represent the indoor environment for mobile robots using a colour TV camera. The method is as follows:

(1) corridors and rooms are defined as segments and located on the global 3D *xyz* coordinate;
(2) objects such as pillars, doors, and fire extinguishers, etc. are classified into types of the same colour and shape as primitives, such as a pillar primitive or a door primitive;
(3) primitives are located in the segments.

This environment representation method is also adopted in the position identification method proposed in this paper.

4.2.2. Extraction of distinctive objects. Distinctive objects are characteristic coloured primitives. When the robot has colour information on the distinctive objects in advance, it can easily judge which colour region in the original image indicates the coloured object by checking each coloured region in the image, and a high speed procedure can be expected.

In order to compare the region in the image with the distinctive object, information about the distinctive object is represented by a list expression and defined by a 'distinctive object list'. The expression form of the distinctive object list consists of the distinctive object's name and its colour hue value as shown in Fig. 2. This distinctive object list is given by a human in advance, and it specifies objects in the environment as distinctive objects.

Next, a 'distinctive object location list' is generated from the environment map and the distinctive object list. The distinctive object location list is specific

```
<distinctive objects>
     ::= <distinctive object>|<distinctive objects>
<distinctive object>
     ::= (<object own name> <object color>)
```

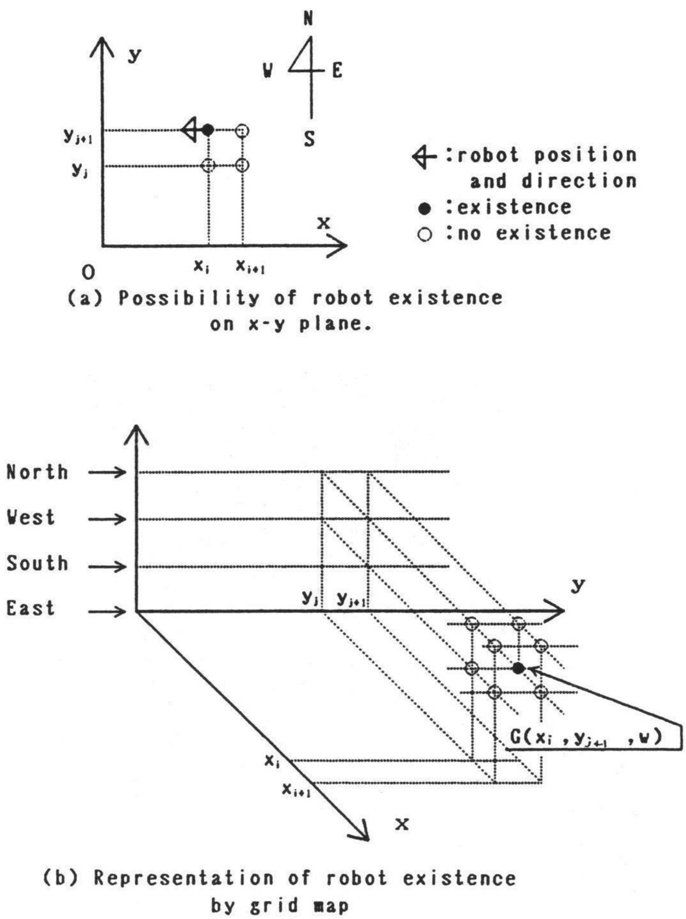
Figure 2. Expression form of distinctive object list.

```
<distinctive objects on map>
     ::= <distinctive object on map>|<distinctive objects on map>
<distinctive object on map>
     ::= <(object own name> <primitive> <x><y><th>)
```

Figure 3. Expression form of distinctive object location list.

information which is prepared from the distinctive object location in the map and the list expression. The distinctive object location list is regarded as a simplified environment map and is used for high-speed search of the map to calculate the approximate robot position from the distinctive object location. The expression of the distinctive object location list is shown in Fig. 3.

4.2.3. Grid map for preparation of possible robot position area. In the proposed identification method, the actual robot position is estimated by our previous matching operation after finding the approximate candidate robot position. A grid map is used to calculate the approximate robot position. In the grid map representation, on the 3D space of the robot position x, y and the direction of the vanishing point ψ, each grid point (x, y, ψ) has a possibility value for the robo presence. The x and y values are quantized by dividing the environment map.] is assumed that the environment for the mobile robot is constructed vertically ar horizontally, and that the robot direction is approximately the same as t'



(a) Possibility of robot existence on x-y plane.

(b) Representation of robot existence by grid map

Figure 4. Grid map representation.

vanishing point direction, i.e. the corridor direction, so the robot's actual direction can be calculated from the image centre, the vanishing point, and the ψ value of the grid point (which is either north, south, east, or west). The ψ value is quantized to four directions of north, south, east, and west. The concept of the grid map for preparation of the possible robot position is shown in Fig. 4.

The grid map space must be set to a suitable range, on which the R-API from the original image and the E-API from the map must be matched independently on the range between the grid points.

4.3. Image processing

4.3.1. Finding the vanishing point [9]. A typical corridor is shown in Fig. 5. Figure 5 is an original colour image of a corridor in the college of the University of Tsukuba where our laboratory is. The following three kinds of region edge can be seen in the corridor image:

(1) edges concentrated approximately in the centre of the image;
(2) horizontal edges; and
(3) vertical edges.

Here, most of the pixels with a diagonal brightness gradient vector belong to type (1). This edge indicates the corridor direction, and these edges are approximately concentrated on a point in the centre of the image. This the vanishing point of the horizontal line. As described in Section 2, the horizontal line can be fixed on the image plane in advance, because the TV camera is set horizontally against the floor. Accordingly, the highest frequency intersection point of the horizontal line and vertical straight lines of the brightness gradient vector on each pixel with the

Figure 5. Example of corridor village.

diagonal direction of the brightness gradient vector can be regarded as the vanishing point.

Furthermore, the angle against north, south, east, or west can be calculated by the distance between the optical centre of the image and the vanishing point, because the vanishing point in the image is indicated as one of the directions north, south, east, or west. The optical characteristics of the camera centre, etc. must be obtained in advance.

4.3.2. Extraction of the coloured region and abstraction of the image [*4*]. We have proposed an image abstraction method using extraction of the coloured region in the colour image and fitting to trapezoids. By this method, coloured objects in the real environment can be reconized.

The procedure for abstracting the colour image consists of three steps:

(1) evaluating the saturation and the colour hue value of each pixel by the following method (evaluation of the colour hue value). $I(u, v)$ and $Q(u, v)$ are produced from a matrix multiplied by the R, G, and B intensity vector at (u, v) of the original colour image as follows:

$$\begin{pmatrix} I(u, v) \\ Q(u, v) \end{pmatrix} = \begin{pmatrix} 0.60 & -0.28 & -0.32 \\ 0.21 & -0.52 & 0.31 \end{pmatrix} \begin{pmatrix} R(u, v) \\ G(u, v) \\ B(u, v) \end{pmatrix}.$$

Here, the length of the vector $V = (I(u, v), Q(u, v))$ is the saturation and the direction (the angle against the I-axis) is the colour hue value;

(2) extraction of pixels within the saturation range over the previously given threshold and generation of the region by association of the same valued pixels (segmentation of the coloured region);

(3) trapezoid fitting of each extracted region (trapezoid fitting).

4.3.3. Defining a distinctive object region and calculating its direction. The colour hue value of the coloured region and its position on the original image are given from the R-API which is generated by the abstraction of the image given by the TV camera. Coloured regions indicate coloured primitives. After referring to the distinctive object list described previously, and comparing the elements of the

```
<distinctive color regions>
      ::= <distinctive color region>|<distinctive color regions>
<distinctive color region>
      ::= (<own name>
             <ug><vg>            :centroid of distinctive object
             <color value>)
```

Figure 6. Expression form of distinctive colour region list.

distinctive object list with the colour hue value of each trapezoid in the R-API, trapezoids with the same colour hue value are extracted, to identify the distinctive object within the coloured region. Additionally, a table is generated to classify the centre of gravity positions of the extracted trapezoids on the image. This generated table indicates the distinctive objects in the image and is called the 'distinctive colour region list', shown in Fig. 6.

4.4. Assessment of the possibility of identification and movement to a suitable identification area

The robot should judge from the image whether position identification is possible or not from the following two conditions, and if it is judged as impossible, the robot rotates or moves until the two conditions are met:

(1) a vanishing point is included in the original image;
(2) at least two distinctive objects are included in the image.

First, at the initial position, the robot detects a vanishing point from the given colour image. By detection of the vanishing point, the robot's orientation against the coordinate direction can be calculated. In the case where there is no vanishing point in the image, the robot should rotate until a vanishing point is detected. If a vanishing point can be detected, the R-API is generated by the abstraction operation from the original image, and the coloured region with the same colour as the distinctive object. If a region with the same colour as a distinctive object cannot be extracted, the robot judges that it is not able to identify its position, and it moves in the vanishing point direction, i.e. the corridor direction, until it can extract a distinctive coloured region. At the position where the robot can detect a vanishing point and at least two distinctive objects in the image, it identifies its position.

If the robot reaches the end of the corridor and cannot move ahead, it judges that it cannot identify its position.

4.5. Position identification algorithm

4.5.1. Determination of possible area on a grid map using the direction of a distinctive object on the original image. The colour original image model from the TV camera is shown in Fig. 7. Now let the u-axis of the vanishing point be u_v and the centre of gravity positions of distinctive objects A and B be u_a and u_b, respectively. As shown in Fig. 8, let the positions of these objects A and B on the x–y plane of the real environment be $P_a(x_a, y_a)$ and $P_b(x_b, y_b)$, respectively. Then the view point to get the image shown in Fig. 7 is an intersection $P(x_v, y_v)$ of the line L_a and the line L_b. Here, lines L_a and L_b are represented by the following equations:

$$L_a:\quad y - y_a = \tan(\theta_a - \theta_v)(x - x_a)$$
$$L_b:\quad y - y_b = \tan(\theta_b - \theta_v)(x - x_b).$$

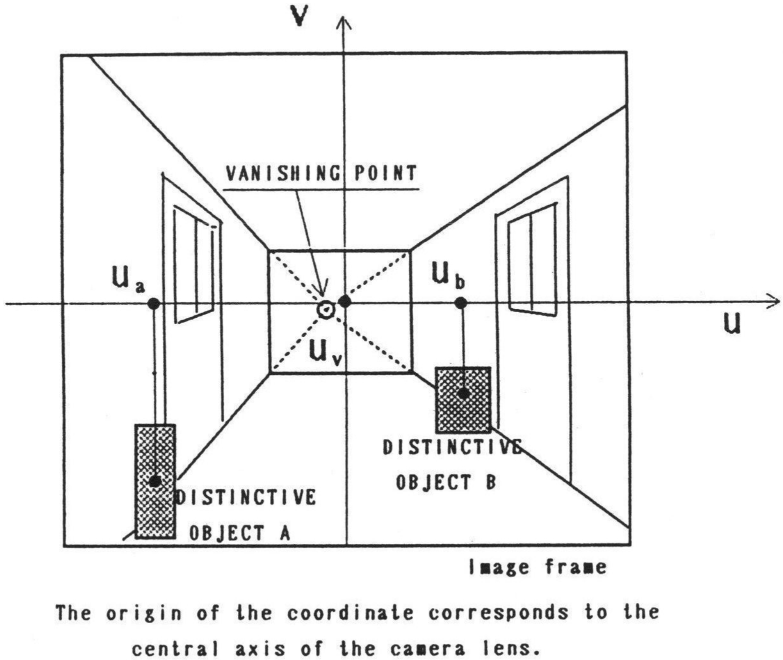


Figure 7. Coordinate on image plane.

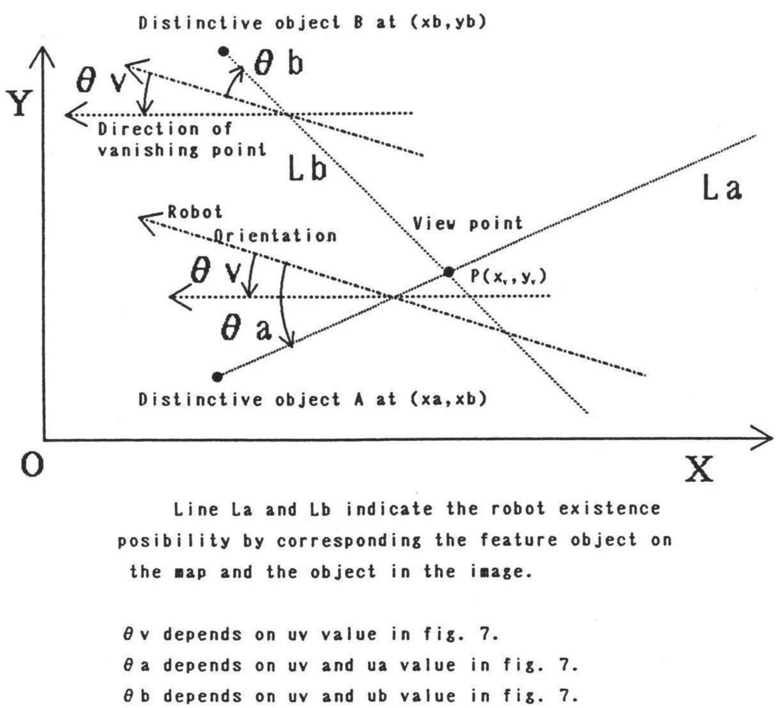


Figure 8. Position in relation to distinctive objects and view point.

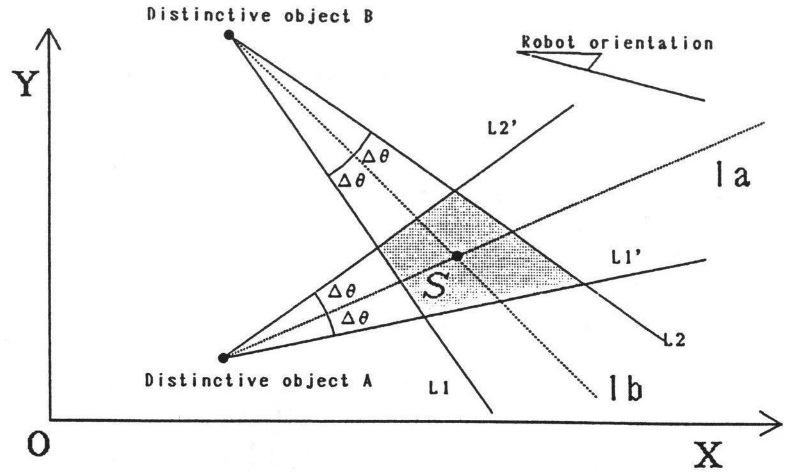


Figure 9. Fan area for representation of possibility of robot existence. S is a fan area to indicate the existent possibility of the robot. $\Delta\theta$ depends on errors by calculation for the location of the vanishing point and distinctive colour region in the image.

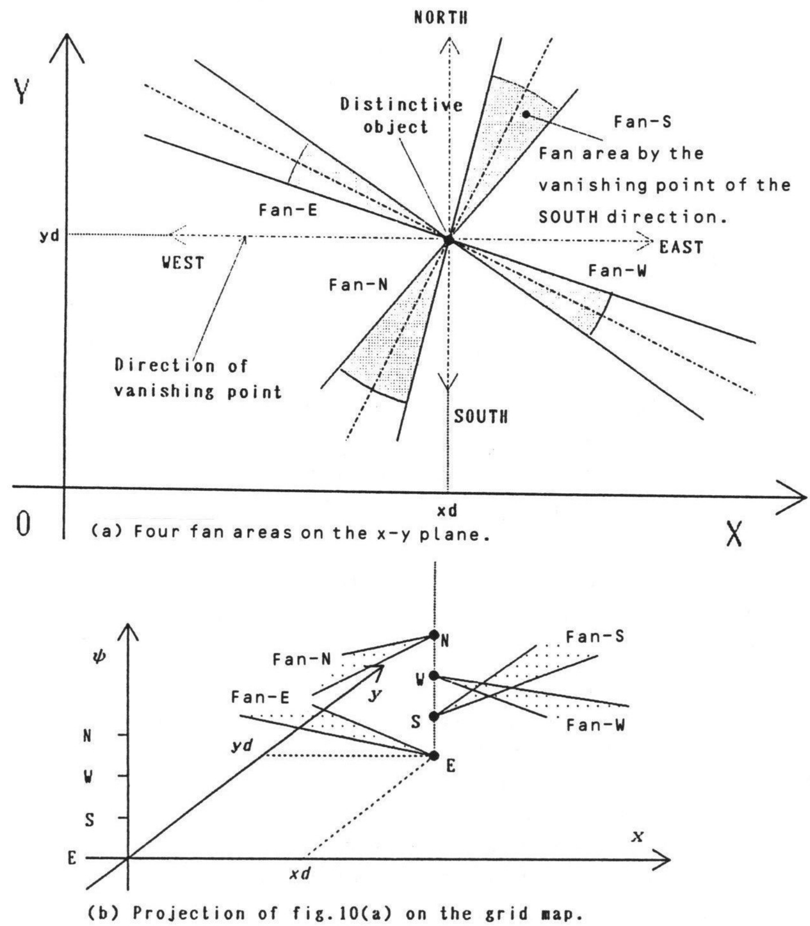


Figure 10. Four fan areas by four directions of a vanishing point.

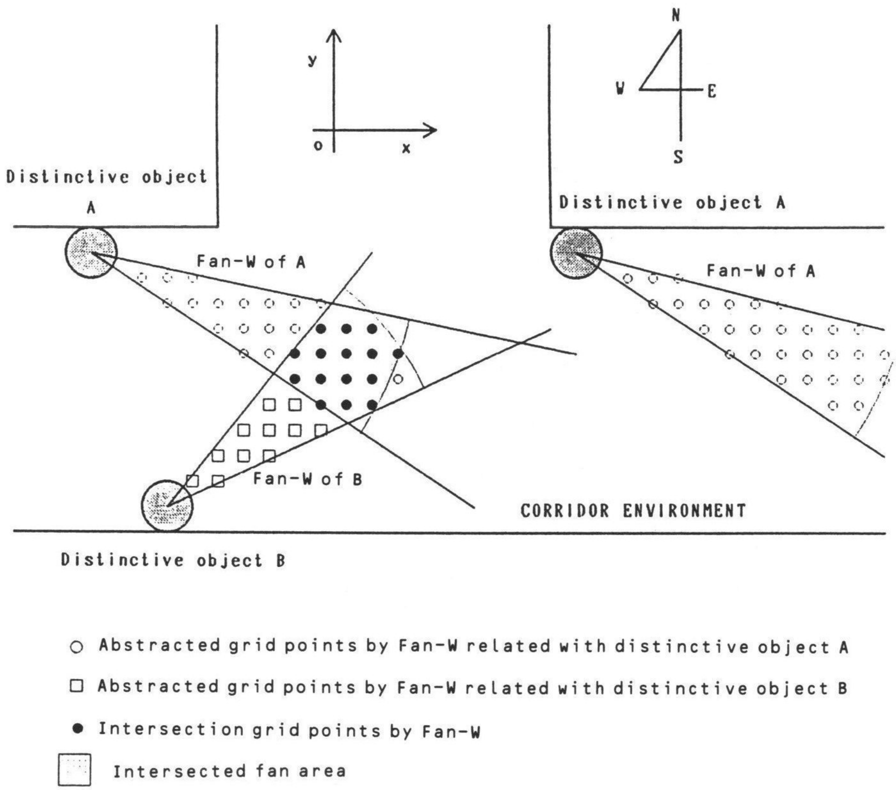


Figure 11. Projection technique for extracting candidate points of robot position.

In fact, an angle error occurs when both the vanishing point and the centre of gravity of the colour region are detected.

Therefore, the fan area which has a suitable open angle of error $\Delta\theta$ is defined as shown in Fig. 9. The area surrounded by the lines L_1, L_2, L_1', and L_2' is the possible robot position fan area in Fig. 9. The size of the fan area is determined by the object visible range and depends on the size of the distinctive object. Anyway, the directions of the vanishing point, i.e. the directions of the object from the robot, are four in number (north, south, east, and west) and not just one direction. In Fig. 10a, fan areas to indicate four directions of view points.

The projection of the fan areas to the grid map are shown in Fig. 10b. On the grid map, by calculating the common area related to each distinctive object, the set of grid points to get the approximate view point can be given as shown in Fig. 11.

The flow of the previous procedure is shown in Fig. 12. This procedure is the grid map search, and it reduces the candidate points of the possible robot position. This method is a very efficient searching operation because the conditional branch for the highest probability of the possible robot position is located on the outer loop.

4.5.2. Determination of the representative point in the candidate area and determination of the approximate robot position using a matching operation with R-API and E-API. By a segmentation operation on the connection to the

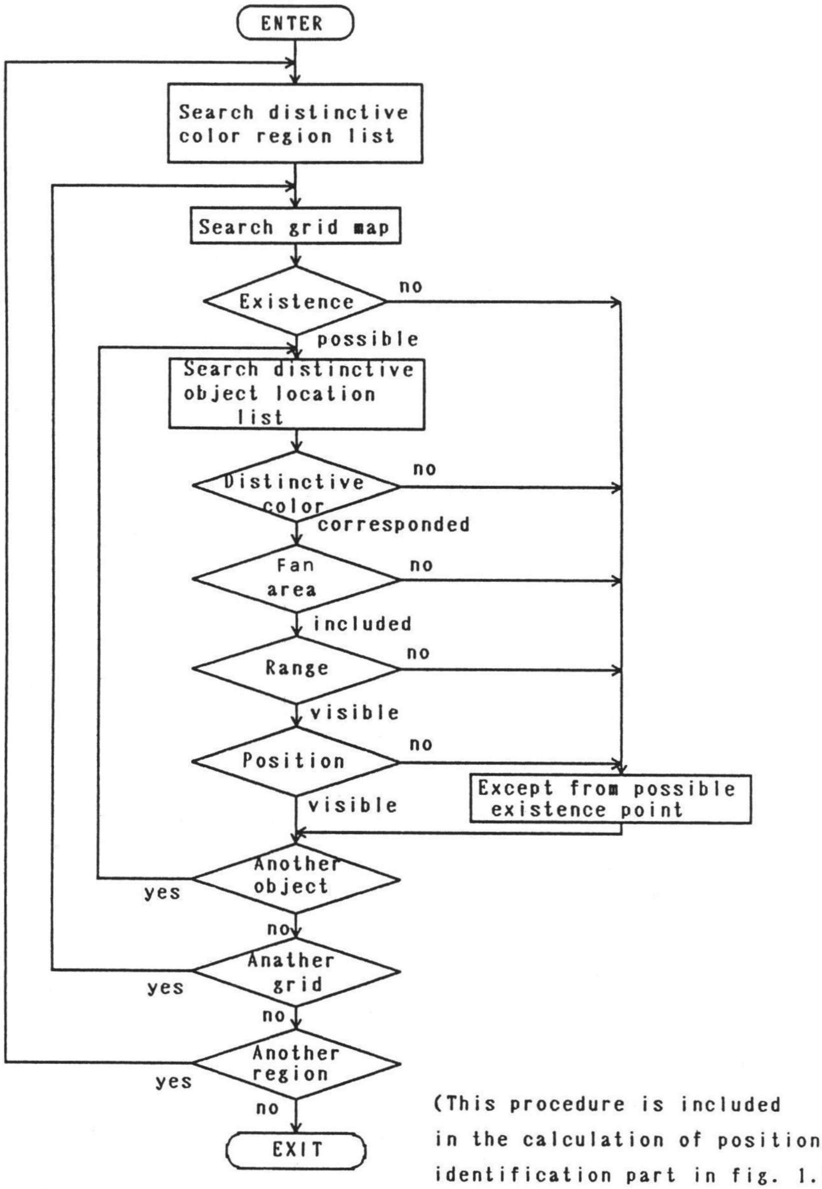


Figure 12. Flow chart to extract candidate point of robot position.

neighbouring grid point from the grid point set given by the previous operation, these grid points are arranged as the candidate area of the possible view point position, and the gravity centre of the area is regarded as the representative point of the candidate points. E-API [8] at the given representative point is generated from the environment map. The structure of E-API is the same as R-API, as in Section 4.3.2. Next the possibility of matching E-API and R-API is checked. The checking method adopted is the enlarged trapezoid technique using the relation based on the APIs' area and the colour hue value. This matching operation is done for both APIs. If all the area of non-corresponding trapezoids is not over a suitable threshold, it can be said that the match has succeeded, and the point at which the E-API is generated is regarded as the approximate view point, i.e. the robot position [5].

4.5.3. Posterior estimation of the accurate position using edges in the image [5]. Finally, a more accurate position of the view point is calculated by 'posterior estimation'. In order to estimate the view point, the least-squares method is applied using the differences of the vertical edges of the trapezoids in both the APIs, its position on the map, and approximate position given by the previous operation.

5. EXPERIMENTS AND DISCUSSION

5.1. Environment for experiments

In order to confirm the efficiency of the proposed position identification method, we carried out some experiments in a real environment. The environment was the first floor of E-building of the college in the University of Tsukuba. The experimental real environment map is shown in Fig. 13. In this corridor, many yellow doors, three red fire extinguishers, and three blue trash cans are located as coloured objects. The red fire extinguisher and the blue trash can are taken as distinctive objects. Figure 13 shows the actual robot position with its orientation and candidate points of the possible robot position represented by the grid map. Here, the scale of the grid is 40 cm.

The colour image is produced by a small colour CCD camera made by Micro-Technica (M-852), and digitized on a NEXUS 6400 made by NEXUS Co. The

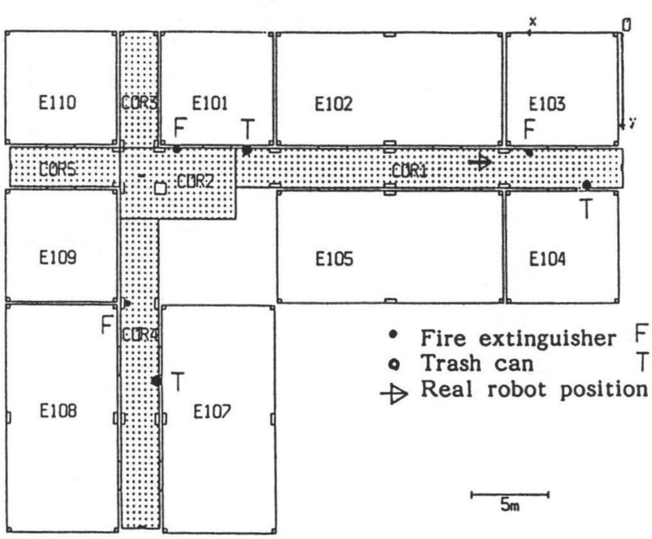


Figure 13. Map of real environment (the college of the University of Tsukuba).

program is written in C on a SUN-3. The image consists of three colours, R, G, and B, and it has 256×240 size and 256 gray scale/pixel.

5.2. Experimental results

Experiment 1. First, the actual robot position is

$$(x,\ y,\ \theta) = (914.0\ \text{cm},\ 853.0\ \text{cm},\ 180.0^\circ).$$

At this point, the given colour image was as shown in Fig. 5. An extracted vanishing point is shown in Fig. 14. Trapezoids of the R-API from the image abstraction operation are shown in Fig. 15. A red fire extinguisher and a blue trash can were extracted from the R-API by the map preparation. Candidate points of the possible robot position using the red distinctive object of the fire extinguisher on the grid map are shown in Fig. 16. Candidate points of the possible robot position using both the red distinctive object of the fire extinguisher and the blue distinctive object on the grid map are shown in Fig. 17. E-APIs from areas A and B in Fig. 17 are shown in Figs 18 and 19, respectively. The matching operation between the R-API in Fig. 15 and the E-API in Fig. 18 succeeded, so the actual robot position may be in area A. The position finally calculated by the vertical edge error between R-API

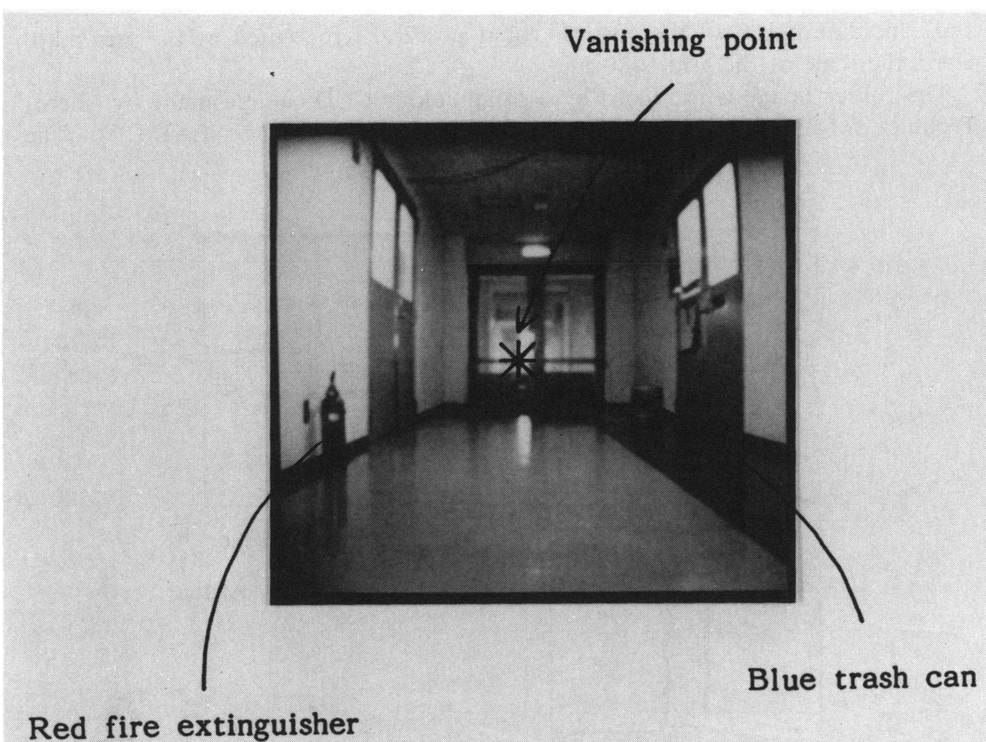


Figure 14. A detected vanisning point.

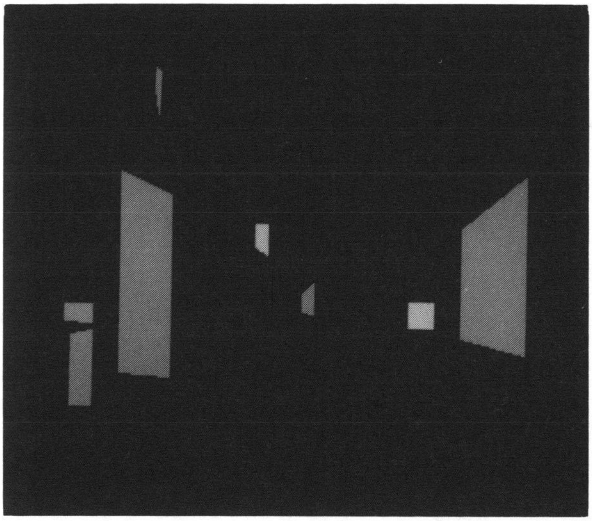


Figure 15. Abstracted image from Fig. 5.

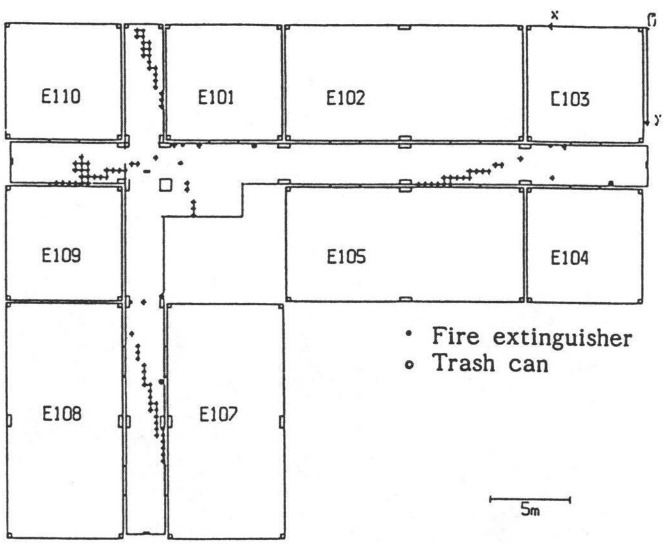


Figure 16. Extracted position and orientation for indication of position possibility by red distinctive objects (fire extinguisher) on the grid map. (Arrows (↑) indicate the position and orientation).

and E-API was

$$(x,\ y,\ \theta) = (905.7\ \text{cm},\ 847.3\ \text{cm},\ 184.4^\circ),$$

as shown in Fig. 20.

Experiment 2. Second, the actual robot position is

$$(x,\ y,\ \theta) = (2285.0\ \text{cm},\ 872.0\ \text{cm},\ -14.0^\circ).$$

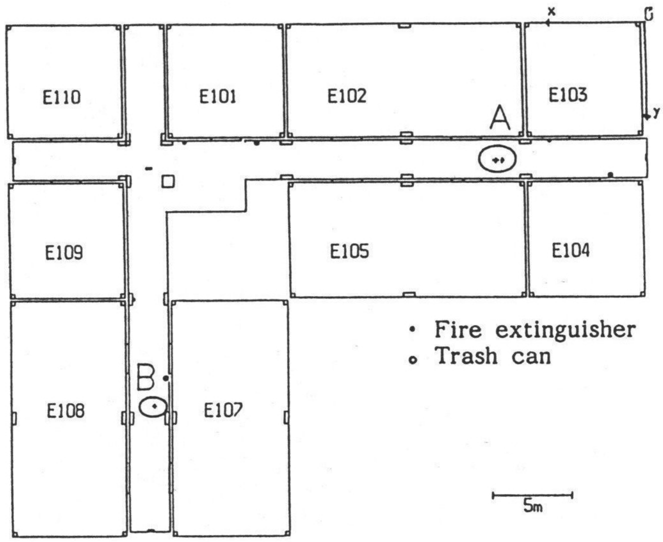


Figure 17. Extracted position and orientation for indication of position possibility by red distinctive objects and a blue one (trash can) on the grid map.

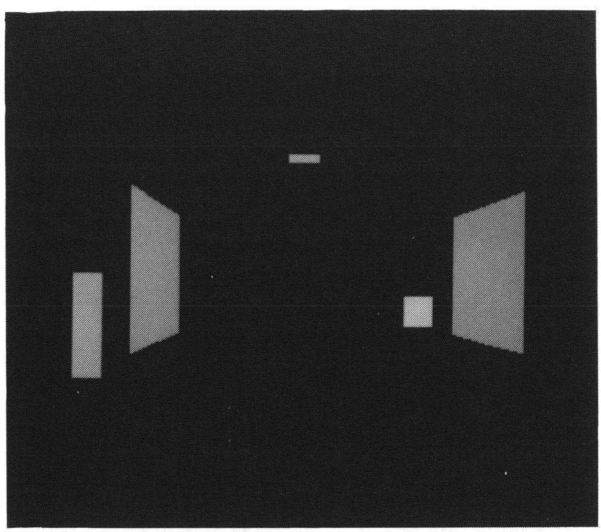


Figure 18. Estimated perspective information (E-API) on area A in Fig. 17.

At this point, the given colour image was as shown in Fig. 21. Then the finally calculated position was

$$(x,\ y,\ \theta) = (2267.4\ \text{cm},\ 887.0\ \text{cm},\ -14.7^{\circ}).$$

This result is also shown in Fig. 20.

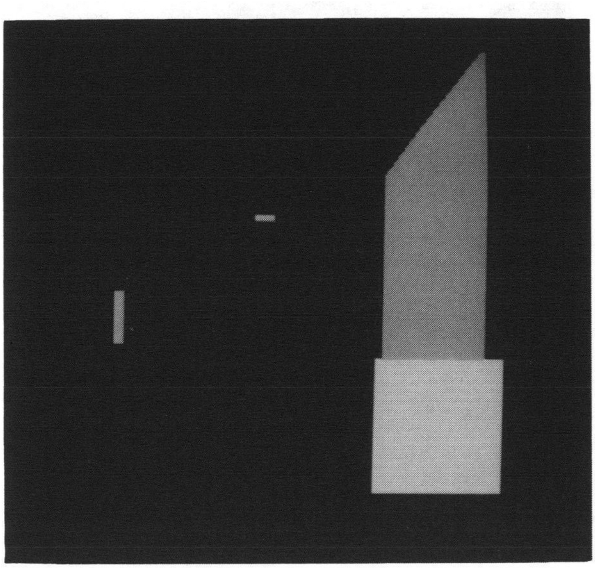


Figure 19. Estimated perspective information (E-API) on area B in Fig. 17.

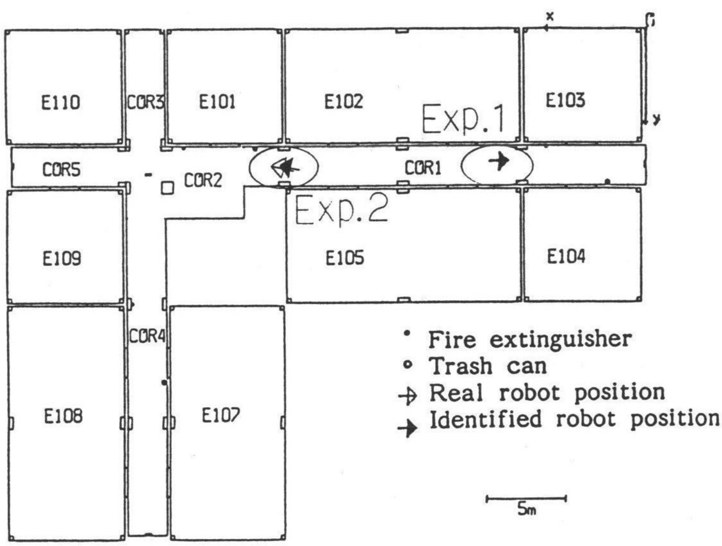


Figure 20. Identified robot position.

Figure 21. Example of corridor image (for Experiment 2).

5.3. Discussion

Two points are discussed concerning the experimental results of the proposed method:

(1) the accuracy of identified robot position; and
(2) the possibility of real-time execution.

Concerning the accuracy of the identified position, the error between the actual robot position and the identified position ε is

$$(\Delta x, \Delta y, \Delta\theta) = (8.3 \text{ cm}, 5.7 \text{ cm}, -4.4^\circ)$$

in the case of experiment 1, and

$$(\Delta x, \Delta y, \Delta\theta) = (17.6 \text{ cm}, -15.0 \text{ cm}, 0.7^\circ)$$

in the case of experiment 2. The cause of the error is regarded as the measurement error of the actual robot position, the error between the real environment and the map information, and the detected vertical edge position error in the original image. However, the error ε is small enough compared to the robot size, and it can be regarded as an acceptable error.

On the possibility of real-time execution, 2 min is necessary for the complete position identification procedure. The time is made up of 45 s for extracting a vanishing point, 15 s or so for generating the R-API, 50 s for determining the area indicating the possibility of the robot position on the grid map, 1 s for determining the approximate position by matching the R-API and E-API, and 1 s for calculating the accurate position by posterior estimation. The number of points on the grid map to be searched is about 10000, and if the matching operation is adopted on all grid points and all directions for the position identification, a large amount of calculation time may be necessary. By the proposed position identification method, this calculation time is reduced to about 50 s. With calculation time, the position cannot be identified during running. The case where the robot cannot know its own position on the map is just after power-on, so the position identification method is suitable for a mobile robot which needs real-time execution.

6. CONCLUSION

In this paper, a position identification method for an indoor mobile robot which has no current position information has been proposed using a colour image and environment map information, and its efficiency was confirmed by some experiments. A process to estimate current position from a map and the scene using objects on the map distinctive to humans has been discussed in the proposed method. The possibility of realizing the proposed method on a small-size computer on a mobile robot was confirmed by some experiments.

Two problems remain to be solved:

(1) examination of the algorithm for a mobile robot moving to a new position until it finds distinctive objects, and judging the possibility of the identification. The proposed method is based on extraction of a distinctive colour region from the given image. However, the colour information is greatly affected by the lighting conditions. Accordingly,

(2) development of a matching method between R-API and E-API unaffected by the lighting conditions.

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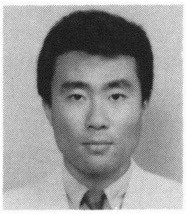

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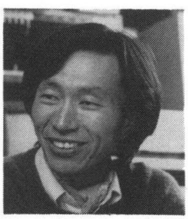

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