Flexible A* For Mobile Intelligent Robot Navigation

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Abstract. Positioning and map construction are two fundamental missions for the indoor navigation with no a preferred map of an autonomous mobile robot. A mobile robot system used for synchronous positioning and mapping (SLAM) is designed for an indoor spontaneous mobile robot. Because variant sensor modeling for laser scope finder is adopted for the extraction of some two-dimensional context characteristics and vertical margins. Applying Kalman filtering (KF) to positioning and grid map construction synchronously are showed. In addition, this research considers navigation algorithm based on A* algorithm, which is often used in game programming. Flexible A* algorithm has been implemented and tested widely in numerous simulations operates. The outcomes demonstrate that the considered method effectively distributes the robot over the environment and allows them to accomplish its mission quickly.

Keywords: Flexible A*, Mobile Robot, Navigation, Kalman filtering.

1. Introduction
Localization is one of the essential missions for initiative mobile robots, namely, determining its own position in the global coordinate. A lot of methods rely on a prior material of the context, usually in the form of a hand-made CAD maps [1], [2]. However, accurate information of environments is provided infrequently. Hence, significant attention has been brought to simultaneous localization and mapping (SLAM) as in [3], [4]. In the study of SLAM, laser scope finder and monocular visual sensor designed for data detection from the context is conducive to improving the precision of localization and mapping [5].

2. Flexible A* Algorithm
Flexible A* algorithm like A* applies an optimal search and observes the least-cost route from a specific primary node to one objective node (out of one or more reasonable objectives). A distance-plus-cost heuristic role (mainly indicated f(x)) is used for the determination of the order where the search visits nodes in the tree. The distance-plus-cost heuristic is the amount of two roles:

1. the route-cost role, the cost from the beginning node to the present node (mainly indicated by g(x))
2. accepted "heuristic predication" of the distance to the objective (mainly indicated by h(x)).
In case of admissible heuristic function $h$, the actual mini cost of realizing the objective is never overestimated, then $A^*$ is itself admissible (or optimal) if a closed set is not applied. In case of a closed set applied, $h$ must be monotonic (or uniform) for $A^*$ to be optimized.

3. Simultaneous Localization and Mapping
Experiments are taken in a semi-constructed indoor context. During the mapping of the SLAM algorithm, metric map is usually used. The mapping approach, locally using metric maps and globally adopting topological map, is excellent in feasibility and robustness in usage. The vector of horizontal linear characteristic is

$$L_g = (\rho g , \alpha g)^T$$

In the global map. By the models for the change displayed in [5], the computation of the vectors of linear characteristics in the local map is shown below:

$$\hat{L}_l = H_k X + L_g$$

Were
4. Simulation Results and Analysis

The experiment conducted for the analysis of the integrated work of the localization measures as a navigation exercise and disparity maps for localization. For fusing correct angle corners, it is necessary to adopt a corner fitting approach. In [5] an approach used to fit orthogonal lines is demonstrated, where the relationship of points to lines is clear.

\[
H_k = \begin{bmatrix} H_{11} & H_{12} & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \end{bmatrix}, \quad L_k = \begin{bmatrix} \rho_k \\ \alpha_k \end{bmatrix},
\]

\[
H_{11} = \frac{x}{y} \cos(\beta - \alpha_k) - \frac{y}{r} \sin(\beta - \alpha_k),
\]

\[
H_{12} = \frac{x}{r} \cos(\beta - \alpha_k) + \frac{x}{r} \sin(\beta - \alpha_k),
\]

\[
r = \sqrt{x^2 + y^2}, \quad \beta = \arctan(y/x)
\]

Fig. 3 Simulation environment

(Electrical Engineering Department)

The number of square distances of the points from the fitted straight line is minimized by singular value decomposition. Since the laser scanner runs essentially in polar coordinates by the measurement of scopes to objects at discrete bearings, there are correlated mistakes in Cartesian coordinates. In addition, there are different covariance matrixes of every point, which brings precise mistake prediction for the approach demonstrated in [5] complex.

Fig. 4 KF + A* simulation

at time T, b) at time T + K, c) at time T + L

For the test of SLAM with senior laser, robot was boosted around our department, then out into the corridor. The robot was boosted from one end to the other end of the corridor and back to the lab.
The logging of odometry and laser measurements was made during the more-than-75-meter travel by the robot. Fig. 4 describes an instance for sonar laser segmentation with a door, a wall, and table leg displayed as a square. Starting on the right-hand side and ceases at the right doorframe because of sonar margin and corner returns. This line is refused because it is made of less line points. Drawn between the right and left doorframes, a new line is recognized because there are adequate points. The follow-up effective line is drawn from the left frame until the table leg with a sonar margin and a scope break.

![Figure 4](image1.png)

**Fig. 4** KF + Flexible A* simulation

a) at time $T$, b) at time $T + K$, c) at time $T + L$

![Figure 5](image2.png)

**Fig. 5** KF + Flexible A* simulation

Other important sets of experiments have been conducted inside a room, in consideration of a short trajectory of 20m with the characteristics of different orientation variations. The modelling of the room has been made carefully, allowing a precise evaluation of the distance and angle errors between the final position and the related configuration estimated.

5. **Conclusions**

Exacting environmental characteristics from the laser transducers for the establishment of metric map was the main study. People found that it is possible to augment a SLAM algorithm for the incorporation of the metric of map lines merge and characteristic fusion. The method shown was adopted on spontaneous mobile robot navigation in indoor established context. The experiment outcomes showed that the method can realize the precise SLAM mission. People also observed that the suggested approach was achieved on embed mobile robot platform.

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