Pre-computed Alternative Paths and the Evaluation for Indoor Navigation Based on Elevation Information

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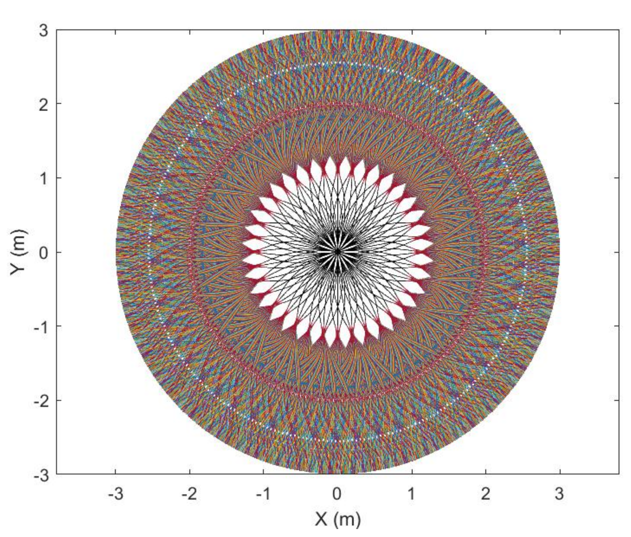
Motivation

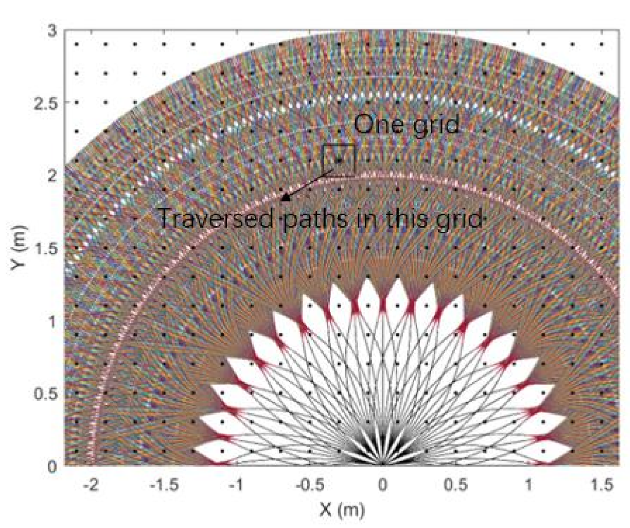
With plenty of planning strategies though, still there are challenges in auto-navigation in dynamic environment due to the complicated real situations.

Existing traditional searching based algorithms like A* or D* are time consuming for real time path planning, Learning and estimation based methods are not highly reliable and risky in application.

Method

1. Generate a bunch of available path candidates offline in a basic map and stored them to form a path space.





2. Construct the Kalman-filter-based grid map that stores elevation information online, which can be described by Eq.1,

$$h(t)=\begin{cases} z_t, & if\ z_t > h(t) \wedge d_M(z_t,h(t)) > c \\ h(t-1), & if\ z_t < h(t) \wedge d_M(z_t,h(t)) > c \\ h(t)=\dfrac{1}{\sigma_{z_t}^2+\sigma_{h(t-1)}^2}\left(\sigma_{z_t}^2 h(t-1)+\sigma_{h(t-1)}^2 z_t\right), & else \end{cases} \quad \text{Eq.1}$$

with variance shown in Eq.2.

$$\sigma_{h(t)}^2=\begin{cases} \sigma_{z_t}^2, & if\ z_t > h(t) \wedge d_M(z_t,h(t)) > c \\ \sigma_{h(t-1)}^2, & if\ z_t < h(t) \wedge d_M(z_t,h(t)) > c \\ \dfrac{1}{\dfrac{1}{\sigma_{h(t-1)}^2}+\dfrac{1}{\sigma_{z_t}^2}}, & else \end{cases} \quad \text{Eq.2}$$

3. Evaluate each path according to the constructed grid map according to Eq.1.

$$score=(1-w_d\cdot\widetilde{\theta})\cdot\left(10-\left|\frac{\theta_h-180}{18}\right|\right)^3-w_h\cdot\sum h_i \quad \text{Eq.3}$$

where

- w_d and w_h are the tuning variables,
- $\widetilde{\theta}=|\theta_{desired}-\theta_h|$ is the angle difference between the end point of the path and the desired heading direction,
- and $\sum h_i$ is the accumulated height of the grids that the path passes by.

4. Track path to perform auto-navigation by classic PID controller.

$$\begin{bmatrix}\widetilde{\omega}\\ \widetilde{\upsilon}\end{bmatrix}=\begin{bmatrix} K_{p\omega}\delta_\vartheta+K_{i\omega}\int\delta_\vartheta+K_{d\omega}\dfrac{d\delta_\vartheta}{dt} \\ K_{pv}\delta_s+K_{iv}\int\delta_s+K_{dv}\dfrac{d\delta_s}{dt}\end{bmatrix} \quad \text{Eq.4}$$

Simulation

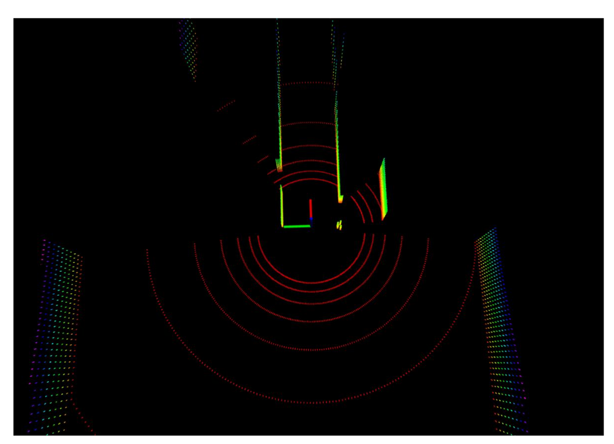


Fig.3 Environment expressed in raw point cloud.

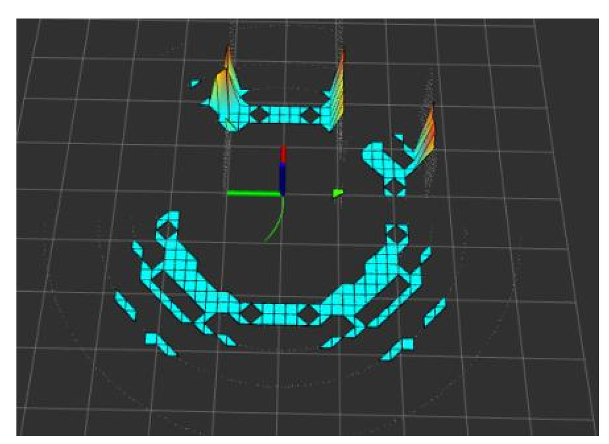


Fig.4 Environment converted into grid map.

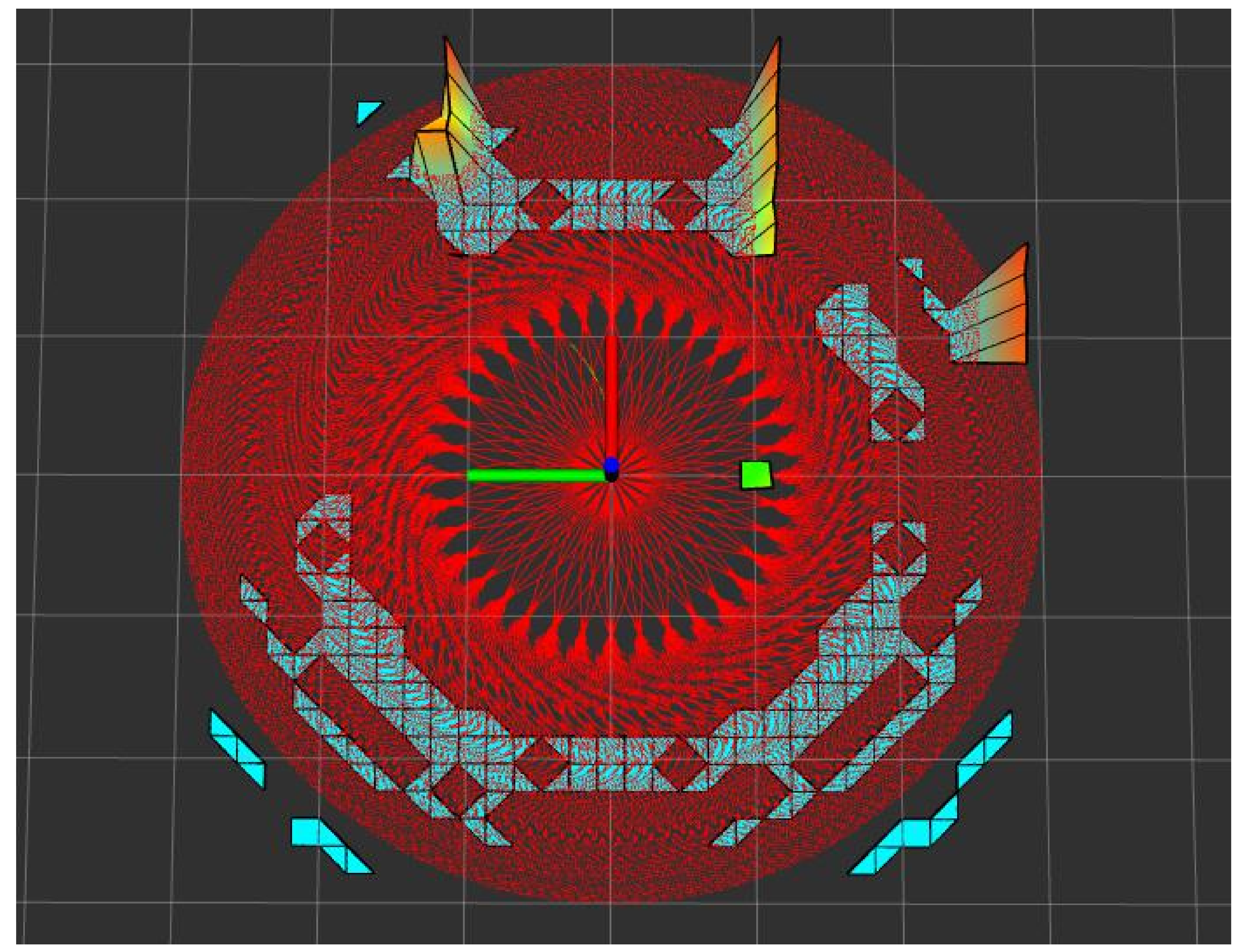


Fig.5 Path Evaluation example.

Future Work

1. Simulation has been done in ROS base to verify the capability.
2. Experiments are going to be conducted.
3. More semantic layers are going to be added into grid map to perform higher level decision making.

Reference

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