泛亚汽车技术中心

阶段性报告

地图模块

忻斌健

协助
丁稼毅 鞠一鸣 钱士才 李亚光

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摘要： 本文讨论了地图模块的接口设计和主要的功能模块以及车辆和目标在地理坐标系下的定位 · · · .

关键词： 地图；RTK；数据融合；路径规划；微波雷达；SRR, ESR.

HD Map implementation by RTK deployment for Path Planning with Vehicle and Object localization

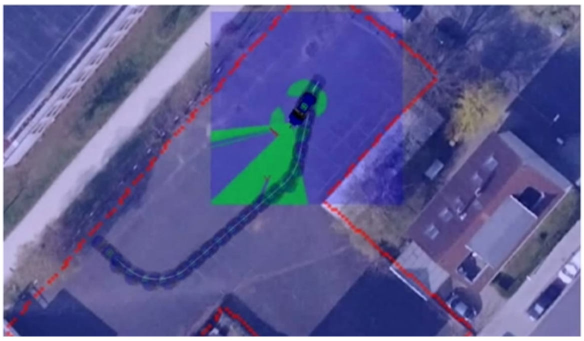
Xin Binjian

Abstract: This document has discussed the implementation of HD Map and the vehicle and objects localization in geographic coordinate system with RTK.

Key words: HD Map; RTK; Sensor Fusion; isomorphism; Fourier transform.

1　项目假设

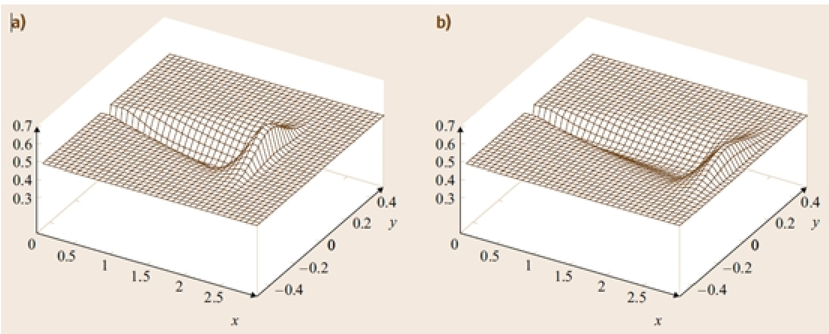
RTK，高精度地图，4 个 SRR，1 个 ESR；若干地标物（landmark, beacon, 交通标示）道路模型（局部地图）需要处理未知，占据和非占据信息。接口静态的占据格栅图地图 OGM+ 动态的目标列表。根据静态地标占据格栅图用来更新本车姿态，叠加动态的障碍物，局部地图：障碍物列表，车道，静态地标，RTK 车辆定位--> 路径规划。



2　2D 世界模型

2D 占据格栅图

$$p(m|x_{1:t}, z_{1:t}) = \prod_{l=1}^{L} p(m_l|x_{1:t}, z_{1:t}) \tag{1}$$




```
nction [veh_pose, veh_vel] = slam_ekf_patac (innerLine, middleLine, outerLine,...
I⌒⌒I⌒⌒I⌒⌒I    landmarks, ...
                 odo_motion_x, odo_motion_y, odo_motion_yaw, ...
                 rtk_gps_lat, rtk_gps_lon, rtk_gps_yaw, rtk_gps_ts,...
                 sensor_data_raw,...
                 proximity)
der.extrinsic('EKF_prediction');
der.extrinsic('draw_ellipse');
g;%randn('state', 0);
```

```
determines execution and display modes
der.inline('never');
lobal configuration sensor;

rsistent sensor configuration step veh_origin_pose map ground; %step = 0;
hi2 = chi2inv(configuration.alpha,1:1000);
rsistent rtk_gps_lat_last rtk_gps_lon_last rtk_gps_ts_last;

 isempty(step)
  %adapt to applied sensors (SRR)!
  step = 1;

nfiguration = struct('ellipses',true,'tags',false,'odometry',true, ...
                    'noise',true,'alpha',0.99,'step_by_step',false,...
                    'people',false,'ground',1,'map',2,'observations',3,...
                    'compatibility',4,'ground_hypothesis',5,'hypothesis',6,...
                    'tables',7);

  sensor.range = 5;
  sensor.minangle = -pi/2;
  sensor.maxangle = pi/2;
  sensor.srho = 0.01;
  sensor.stita = 0.125*pi/180;

  rtk_gps_lat_last =rtk_gps_lat;
  rtk_gps_lon_last = rtk_gps_lon;
  rtk_gps_yaw_last = rtk_gps_yaw;
  rtk_gps_ts_last = rtk_gps_ts;
  % generate the ground data from hdmap and RTK
  ground = generate_rtk_ground(innerLine, middleLine, outerLine);

  % start with a fresh map
  [map, ground] = new_map(ground);

  % plot ground
  draw_ground(ground,landmarks, configuration);
  %%pause

```

```
% ok, here we go

%%observations = get_observations(ground, sensor, step);
[x1,y1,utmzone,utmhemi] = wgs2utm(rtk_gps_lat,rtk_gps_lon,51,'N');
veh_origin_pose.x = x1;
veh_origin_pose.y = y1;
veh_origin_pose.yaw = rtk_gps_yaw;
veh_origin_pose.ts = rtk_gps_ts;
veh_pose = veh_origin_pose;
veh_vel = [0; 0]; % Start point with 0 velocity.
observations = get_observations (ground, landmarks, veh_pose, ...
                                 sensor_data_raw, sensor, proximity);
draw_observations (observations, configuration, step);

  GT = zeros(1, size(sensor_data_raw,1));
   H = zeros(1, size(sensor_data_raw,1));

map = add_features(map, observations);
% plot map
draw_map (map, ground,configuration,step);

% steps = length(ground.motion);
se

step = step+1;
disp('-----------------------------------------------------------');
  disp(sprintf('Step: %d', step));

% EKF prediction step
odometry.x = [odo_motion_x, odo_motion_y,odo_motion_yaw]'; ;%odo_motion.x;
odometry.P = diag([0.25 0.1 5*pi/180].^2);


map = EKF_prediction (map, odometry);

% sense
[x1,y1,utmzone,utmhemi] = wgs2utm(rtk_gps_lat,rtk_gps_lon,51,'N');
veh_pose.x = x1;
veh_pose.y = y1;
```

```
veh_pose.yaw = rtk_gps_yaw;
veh_pose.ts = rtk_gps_ts;

[x2,y2,utmzone,utmhemi] = wgs2utm(rtk_gps_lat_last,rtk_gps_lon_last,51,'N');
veh_vel = [x1-x2; y1-y2]/(rtk_gps_ts - rtk_gps_ts_last)/1000;%ms-->s

rtk_gps_lat_last =rtk_gps_lat;
rtk_gps_lon_last = rtk_gps_lon;
rtk_gps_ts_last = rtk_gps_ts;


motion.x = [x1 y1 rtk_gps_yaw]';
motion.P = diag([0.02 0.02 2*pi/180].^2); % expectation of std of RTK
ground = move_vehicle (ground, motion, step);

observations = get_observations(ground, landmarks, veh_pose, ...
                                sensor_data_raw, sensor, proximity);

% individual compatibility
prediction = predict_observations (map, ground);
compatibility = compute_compatibility (prediction, observations);

disp(compatibility.HS);
disp(compatibility.AL);

disp(' ');

% ground truth
% your algorithm here!
% 1. Try NN
% 2. Complete SINGLES and try it
% 3. Include people and try SINGLES5
% 4. Try JCBB

H = NN (prediction, observations, compatibility,configuration);

draw_map (map, ground,configuration, step);
draw_observations (observations, configuration, step);

```

```
    draw_compatibility (prediction, observations, compatibility,configuration);

    disp(' ');

    draw_hypothesis (prediction, observations, H, 'NN:', 'b-',configuration);

    % update EKF step
    map = EKF_update (map, prediction, observations, H, step);


    % only new features with no neighbours
    new = find((H == 0) & (compatibility.AL == 0));

    if nnz(new)
      map = add_features(map, observations, new);
    end

    draw_map (map, ground, configuration, step);
d
h_pose = map.x(1:3);
```

以下给出六种典型的数列空间和函数空间的定义，文字叙述和符号表示依照文献 [1].

定义 1 (空间 l^p $(p \geq 1)$). 一切满足 $(\sum_{i=1}^{\infty} |\xi_i|^p)^{1/p} < +\infty$ 的数列 $x = (\xi_1, \xi_2, \cdots)$ 的全体记为 l^p. 容易验证

$$\| x \|_p = (\sum_{i=1}^{\infty} |\xi_i|^p)^{1/p} < +\infty$$

是 l^p 上的范数.

...

3 追踪列表（动态）

```
int main() {
printf("hello, world");
return 0;
}
```

```
typedef struct{
int id;
// set to 1 in the very first cycle onl that an object is output, 0 in all other cycles.
bool newObj;
//one of GCS (WGS84/UTM), LCS, CCS, VCS, SCS, ACS, ENUM tbd
int coordinate_system;
PatObjState objState;
PatObjSize objSize;
// Pedestrian/vehicle_car/vehicle_truck/unknown/... ---> ENUM tbd.
int objClass;
//1 if the object is moving;0 if it's still;
bool moving;
//tracking when the object is seen by which exteroceptive sensor;
PatTime lastSeenBySensor[NUM_SENSOR_EXTEROCEPTIVE];
//0 for invalid; 1 for valid;
float existenceProbability;
}PatObject;

//maximally 256 tracked objects by all sensors around the vehicle;
PatObject object_list[128];
```

3.1 l^p 和 $L^p(\mathbf{E})$

l^p 和 $L^p(\mathbf{E})$ 都可分. $\cdots$

4 SLAM（同时定位与生成地图）

4.1 函数空间与函数空间、数列空间与数列空间之间的联系

$\cdots$

4.2 函数空间与数列空间的联系

引理 1 (Riesz-Fiesher 定理)**.** 设 $\{e_n\}$ 是 *Hilbert* 空间 **H** 中一就范正交系，$(c_1, c_2, \cdots) \in l^2$，则存在唯一的 $x \in H$ 使 $(x, e_n) = e_n, \quad n = 1, 2, \cdots$ 并且 $(x, x) = \sum_{n=1}^{\infty} |c_n|^2$.

文献 [4] 给出了 $1 \le p \le 2$ 时的 $L^p(\mathbf{E})$ 上的 Fourier 变换的构造过程，并指出当 $p > 2$ 时在广义函数的意义下 $L^p(\mathbf{E})$ 仍可导入 Fourier 变换. 问题在于 $p \neq 2$ 时 Fourier 变换能否构成 $L^p(\mathbf{E})$ 与 l^p 之间的保范同构.

问题 1. 完备距离空间 $S(\mathbf{E})$ 与 s，*Banach* 空间 $M(\mathbf{E})$ 与 m 之间是否有同构关系？更进一步， *Fourier* 变换及其反演公式能否推广到完备距离空间 $S(\mathbf{E})$ 与 s，*Banach* 空间 $M(\mathbf{E})$ 与 m

References

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