Notes on “NTD Transform: a new approach to laser scan matching”

5/11/2017

WHY NDT?

- Purpose: Alternative method of building correspondence between features.No bother to brain twisting on explicit correspondences between primitives.

- Why NDT is able to achieve the purpose? Point cloud are transformed to piecewise continuous and differentiable, which enable us to utilize more powerful mathematics tool to model and solve the problem.

How to do?

- Break down SLAM and trace back to the very first conception, the primitive of SLAM: Matching one scan to another scan
- Let's first figure out the basic theory behind on this primitive application
- Then it is much easier apply same matching scheme to different superior application, such as position tracking and SLAM.

Zoom out and check the core of NTD out (the theory behind the matching scheme)

- establish the motion model:

$$T : \begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} t_x \\ t_y \end{pmatrix}$$

- The problem turns to be: we know (x,y) (x' y'), we need to solve what is /phi and t though the equations

$$\mathbf{p} = (p_i)_{i=1..3}^{t} = (t_x, t_y, \phi)^t;$$

Zoom out and check the core of NTD out (the theory behind the matching scheme)

- How to solve the equations?

- First step, select meaningful and effective cost function, choose the P which can maximize the cost function.

$$\mathbf{score(p)} = \sum_i \exp\left(\frac{-(\mathbf{x_i'} - \mathbf{q_i})^{\mathbf{t}} \mathbf{\Sigma_i^{-1}} (\mathbf{x_i'} - \mathbf{q_i})}{2}\right).$$

- Second step, since the cost function is continuous and differentiable, we are able to use Newton algorithm to solve

- Third step, define a criteria for Newton algorithm used to determine when to stop iteration.

Key algorithm design point: why to choose this score?

- physical meaning: prjecting the corresponding coordinates of same points from one scan to another = maximize the joint probability of the points appearing on same grid.

- practical meaning: maximizing the joint probability of the points appearing on same grid = finding the corresponding coordinates of the points in one scan from another scan.

- mathematical meaning: Nomal distribution can trasform discrete irregular points into piecewise continuous and differentiable objects.

Application of point tracking

Application of SLAM

$$T' : \begin{pmatrix} x' \\ y' \end{pmatrix} = \mathbf{R}_i^t(\mathbf{R}\begin{pmatrix} x \\ y \end{pmatrix} + \mathbf{T} - \mathbf{T_i})$$