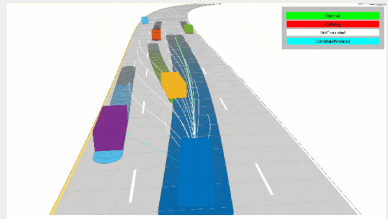


MOTION PLANNING FOR AUTONOMOUS VEHICLES

FRENET FRAME TRAJECTORY PLANNING

GEESARA KULATHUNGA

MARCH 25, 2023



<https://www.mathworks.com/help/nav/ug/highway-trajectory-planning-using-frenet.html>

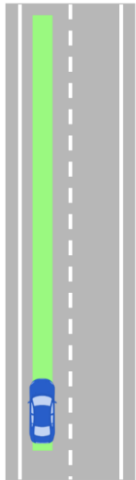
FRENET FRAME TRAJECTORY PLANNING

CONTENTS

- Frenet frame
- Curve parameterization of the reference trajectory
- Estimate the position of a given Spline
- The road-aligned coordinate system with a nonlinear dynamic bicycle model
- Frenet frame trajectory tracking using a nonlinear bicycle model
- Transformations from Frenet coordinates to global coordinates
- Polynomial motion planning
- Frenet frame trajectory generation algorithm
- Calculate global trajectories

DIFFERENT SCENARIOS

Lane Following



Lane Change



Obstacle Avoidance



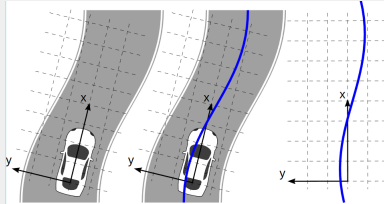
Pull Over



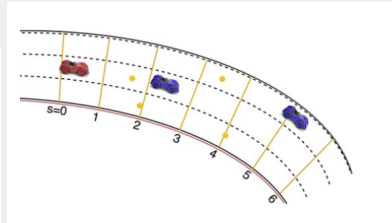
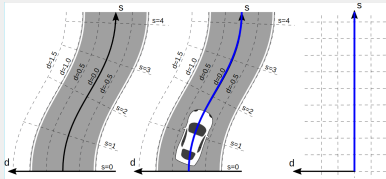
https://autowarefoundation.github.io/autoware.universe/main/planning/behavior_path_planner/

FRENET FRAME

World frame W



Frenet frame F



https:

[//raw.githubusercontent.com/fjp/frenet/master/docs/images/cart_refpath.svg?sanitize=true,](https://raw.githubusercontent.com/fjp/frenet/master/docs/images/cart_refpath.svg?sanitize=true)

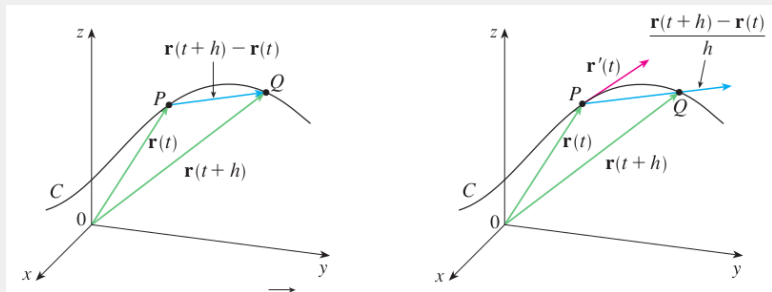
<https://caseypen.github.io/posts/2021/01/FrenetFrame/>

CURVATURE

Let $\mathbf{r}(t) = x(t)\mathbf{i} + y(t)\mathbf{j} + z(t)\mathbf{k}$ be a vector-valued function. That is, for every t , there is unique vector in \mathbf{V}_3 denoted by $\mathbf{r}(t)$ whose components are $x(t)$, $y(t)$, and $z(t)$.

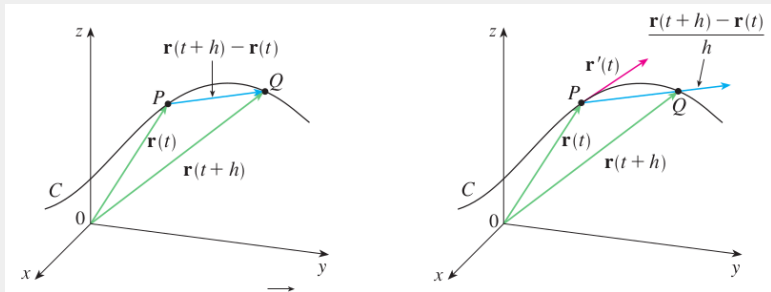
The derivative $\mathbf{r}'(t)$

$$\frac{d\mathbf{r}}{dt} = \lim_{h \rightarrow 0} \frac{\mathbf{r}(t+h) - \mathbf{r}(t)}{h}$$



CURVATURE

The vector $\dot{\mathbf{r}}(t)$ is called tangent line to the defined curve \mathbf{r} at point P, provided that $\dot{\mathbf{r}}(t)$ exists and $\dot{\mathbf{r}}(t) \neq 0$



Unit tangent vector

$$T(t) = \mathbf{t}' = \frac{\dot{\mathbf{r}}}{|\dot{\mathbf{r}}|}$$

Example 01

Show that if $|\mathbf{r}(t)| = c$ (a constant), then $\dot{\mathbf{r}}(t)$ is orthogonal to \mathbf{r} for all t .

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Show that if $|\mathbf{r}(t)| = c$ (a constant), then $\dot{\mathbf{r}}$ is orthogonal to \mathbf{r} for all t .

$$\mathbf{r}(t) \cdot \mathbf{r}(t) = |\mathbf{r}(t)|^2 = c^2$$

$$0 = \frac{d}{dt}[\mathbf{r}(t) \cdot \mathbf{r}(t)] = \dot{\mathbf{r}}(t) \cdot \mathbf{r}(t) + \mathbf{r}(t) \cdot \dot{\mathbf{r}}(t) = 2\dot{\mathbf{r}}(t) \cdot \mathbf{r}(t)$$