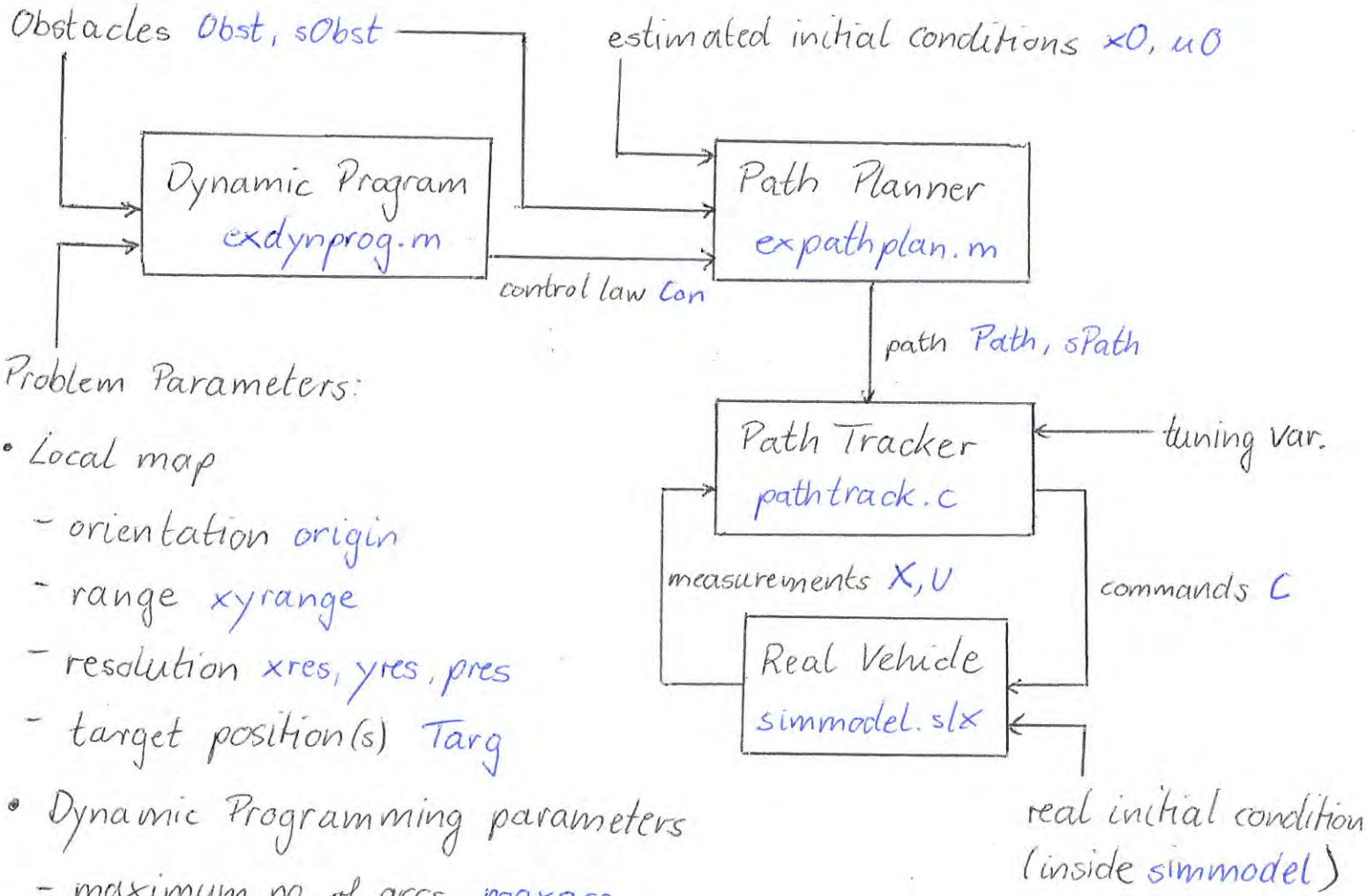
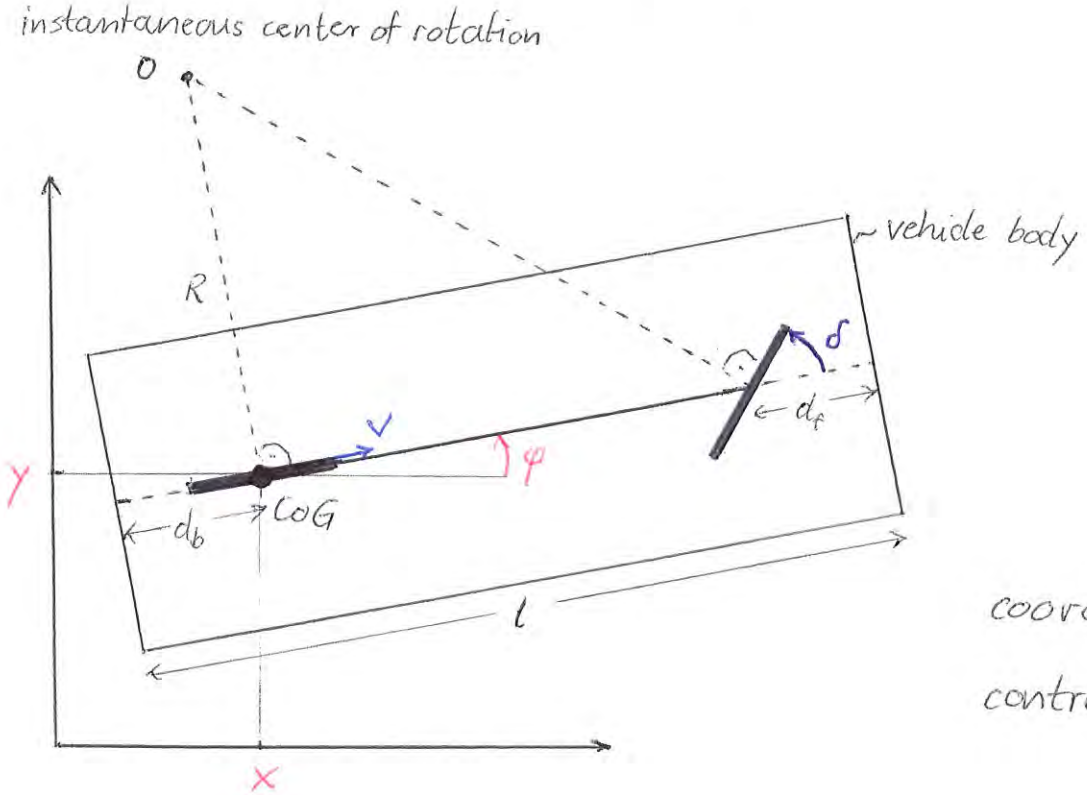
29-May-2015

Dynamic Programming for Parking



- Local map
  - orientation origin
  - range xyrange
  - resolution xres, yres, pres
  - target position(s) Targ
- Dynamic Programming parameters
  - maximum no. of arcs maxarc
  - tolerance for angle at switching points phitol
  - path discretization distance for constraint checking condis
- Model vehicle parameters auto
- Real vehicle parameters car

Kinematic Bicycle Model [Rajamani pp. 20 ff.]



coordinates: x y φ

control inputs: δ v

- CoG (coordinate reference point) is located on rear axis
- Constant steering ($\delta = const$) $\Rightarrow$ circular movement of the vehicle around O with radius R

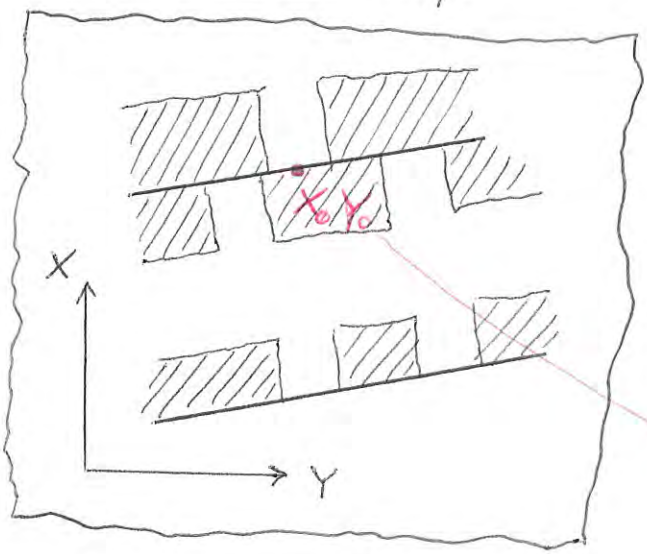
$$\tan(\delta) = \frac{d}{R} \Rightarrow R = \frac{d}{\tan(\delta)} \quad \text{where } d := l - d_f - d_b$$

- Minimum turning radius: $R_{min} := \frac{d}{\tan(\delta_{max})}$
- Kinematic equations of motion:

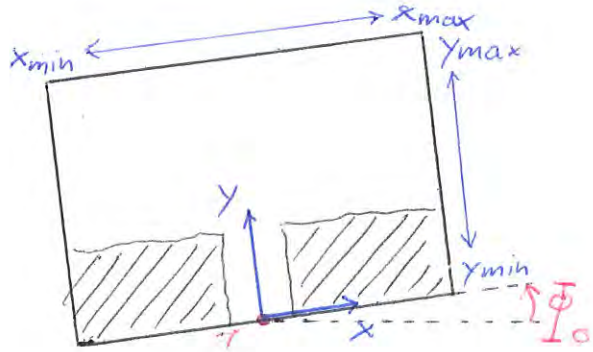
$$\dot{x} = v \cos(\varphi)$$
$$\dot{y} = v \sin(\varphi)$$
$$\dot{\varphi} = \frac{v}{R} = v \frac{\tan(\delta)}{d}$$

Global and Local Map

Global Map



Local Map



X, Y: GPS coordinates

x, y: DP coordinates

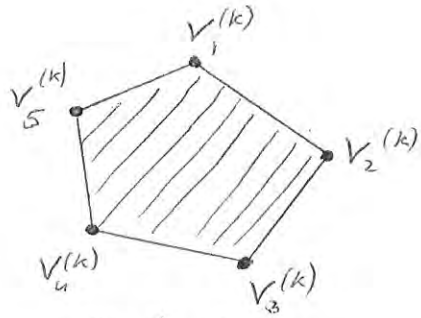
- origin = $[X_0, Y_0, \Phi_0]$
- xyrange = $[x_{min}, x_{max}, y_{min}, y_{max}]$
- Targ = $[X_1, Y_1, \Phi_1, X_2, Y_2, \Phi_2 \ldots]$ — list of star target positions in global map

(Tar = conversion of target positions in local map)

- Coordinate conversion:
  - global → local map:
    $$x = (X - X_0)\cos\Phi_0 + (Y - Y_0)\sin\Phi_0$$
    $$y = -(X - X_0)\sin\Phi_0 + (Y - Y_0)\cos\Phi_0$$
  - local → global map:
    $$X = X_0 + x\cos\Phi_0 - y\sin\Phi_0$$
    $$Y = Y_0 + x\sin\Phi_0 + y\cos\Phi_0$$

Obstacle Description

- In addition to the restricted local map by xyrange, obstacle limit the path of the controlled vehicle
- Obstacles are defined as polygons (list of vertex points, in the global coordinate system, in clockwise direction)



Obstacle k

- Variable definitions:
  - nObs = number of obstacles
  - sObs = $[\underbrace{n^{(1)} \; n^{(2)} \; n^{(3)} \; \dots \; n^{(k)} \; \dots}_{nObs}]$ number of vertex points for each obstacle $k = 1, \dots, nObs$
  - Obst = $\begin{cases} [\, x_1^{(1)} \; y_1^{(1)} \;\; x_2^{(1)} \; y_2^{(1)} \;\; x_3^{(1)} \; y_3^{(1)} \; \dots \\ x_1^{(2)} \; y_1 \;\; x_2 \; y_2 \;\; x_3 \; y_3 \; \dots \\ \dots \,] \end{cases}$ (nObs rows) row k: list of vertex points for obstacle k, in global coordinates, in clockwise direction

(- Obs: conversion of obstacle positions in local map)