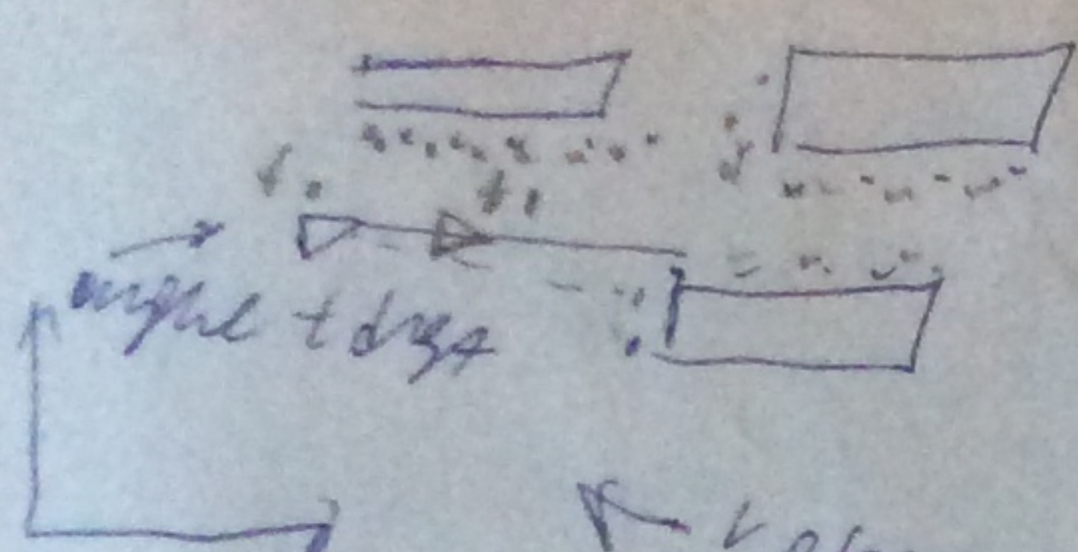
Linear interpolation

31.05.2022 Lab experience

I

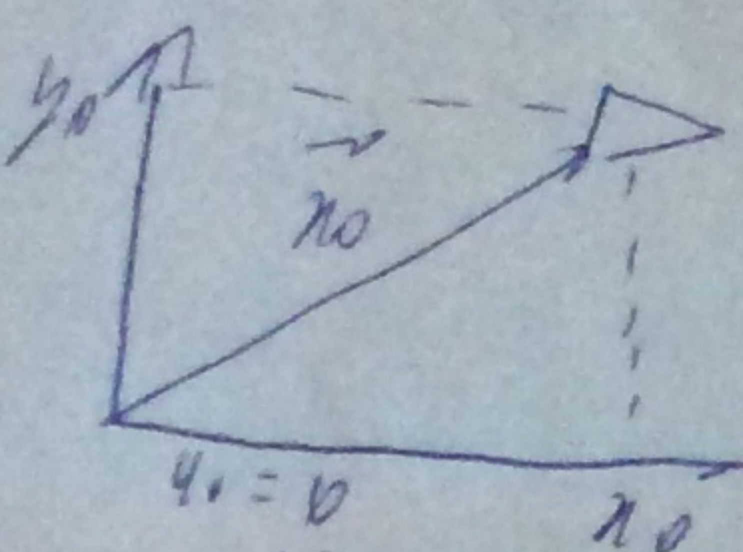


reference system

car moves → new scan

$\underline{x_0}$ - pause

$\underline{x_0}$ $[x_0, y_0, \psi_0]$



orientation

$x_1 = [x_1, y_1, \psi_1]$

Rigid body transform. to be found (estimated)

$x_1 = T(\underline{x_0})$ ← find the function

Z - scans ← pause

Lidar

$Z_0 = \begin{cases} \theta_1, r_1 \\ \dots \\ \theta_n r_n \end{cases}$

scan ← set of points

$x_i | x_{i-1}$

$P(\cancel{x_i|x_{i-1}}, u, m, z)$ ← SLAM tries to estimate it.

models how you move between the pauses

model of the environment

Condition your pause given something

pause, motion, measurement

$$P(x_i | x_{i-1}, u, m, z) \sim \underbrace{P(\underline{z}|\underline{x}_i, m)}_{\text{measurement given the position and scenario}} \, P(x_i | x_{i-1}, u)$$

scenario

How my lidar is sensing

How you move (given prev. pose and dynamic)

Motion model - const. velocity (simplest)

$$\begin{cases} x_i = x_{i-1} + v_{i-1} \cdot \cos\psi_{i-1}\, dt \\ y_i = y_{i-1} + v_{i-1} \cdot \sin\psi_{i-1}\, dt \end{cases}$$

← from GPS (given)

$P(z|x_i, m)$ ← difficult part

$$\begin{cases} v_i = v_{i-1} + \sigma_v \cdot \text{randn} \\ \psi_i = \psi_{i-1} + \sigma_\psi \, \text{randn.} \end{cases}$$

noise compensates for the acceleration and etc.

Linear interpol...

(II)

Observation model

m can't be measured completely => they assume the following

$p(z_i | x_i, m) \rightarrow p(z_i | x_i, z_{i-1})$ ← previous scan

You don't know the real m (want it with SLAM), use the previous scan → MAP IT

Correlate the new scan and the previous scan => => estimate $T(\cdot)$ (scan by scan) ← translation + rotation

Correlation = all possible rotation and translation to maximize it.

Practical implementation

$\underline{x}_1 = T(\underline{x}_0)$ ← rigid body transformation

correlate to find roto-transl. which changes your pose

$$\begin{bmatrix} x_i \\ y_i \\ \psi_i \end{bmatrix} = \begin{bmatrix} \cos\psi & -\sin\psi & \delta_x \\ \sin\psi & \cos\psi & \delta_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_{i-1} \\ y_{i-1} \\ \psi_{i-1} \end{bmatrix}$$

New pos. every 500 ms ?

Motion model — GPS Data : $\left[x_j, y_j, h_j, v_j \right]_{N}^{j=1}$ (heading) $T_{GPS} = 500\,ms$ sampling

Lidar : $\left[z_k \right]_{M}^{k=1} \rightarrow T_{LIDAR} = 83\,ms \leftarrow \frac{1}{12}$ (12 Hz ← meter meas.) (12 rot per sec.)

* Different sampling rate !!! ← PROBLEM ← more scans than GPS samples

Syncronize the data → common sampling time => ← stick with the samp. time of the lidar

=> interpolate data of the GPS ← lat, long, direction, speed

2 GPS interpolation → $T_{GPS}^{interp} = T_{LIDAR}$

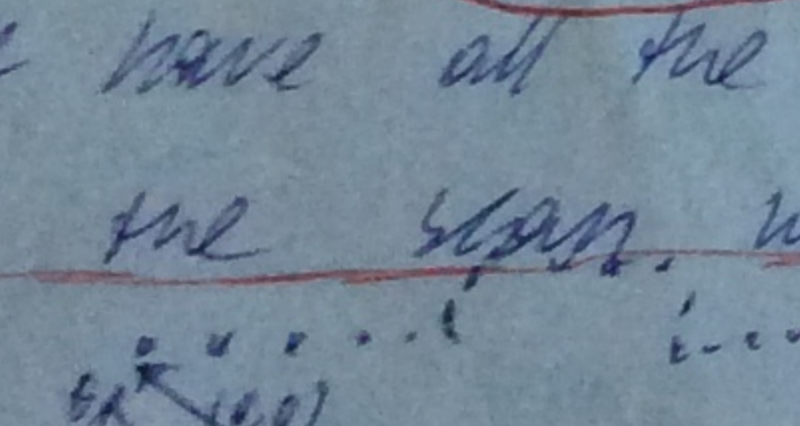
*(1) Transform GPS data from latitude + longitude to cartesian (UTM) ← 2D

↘ you have all the poses

next

Match the scan with positions

Z_k :



$R, \theta \longrightarrow$ global

overlap scan to GPS

$T(Z_k^{local}) = Z_k^{global}$

* Origin of the local is the lidar itself (polar R, θ)

$\begin{cases} \text{heading for } \psi. \\ x, y \rightarrow x, y \end{cases}$

Linear interpol...

III

3 a) $Z_k^{polar} \rightarrow Z_k^{xy}$ ← using $T(.)$ ← roto translation

b) $\left(Z_k^{xy}\right)^{local} \rightarrow \left[Z_k^{xy}\right]^{G}$ add GPS pos extract before

using the matrix roto-translation

⇒ you will have for each point the position of the building

Exact position of the lidar is given.

(result error < 10 cm)

Scan to scan matching

GEOPLOT(X,Y) ⇒ building

Brute force:

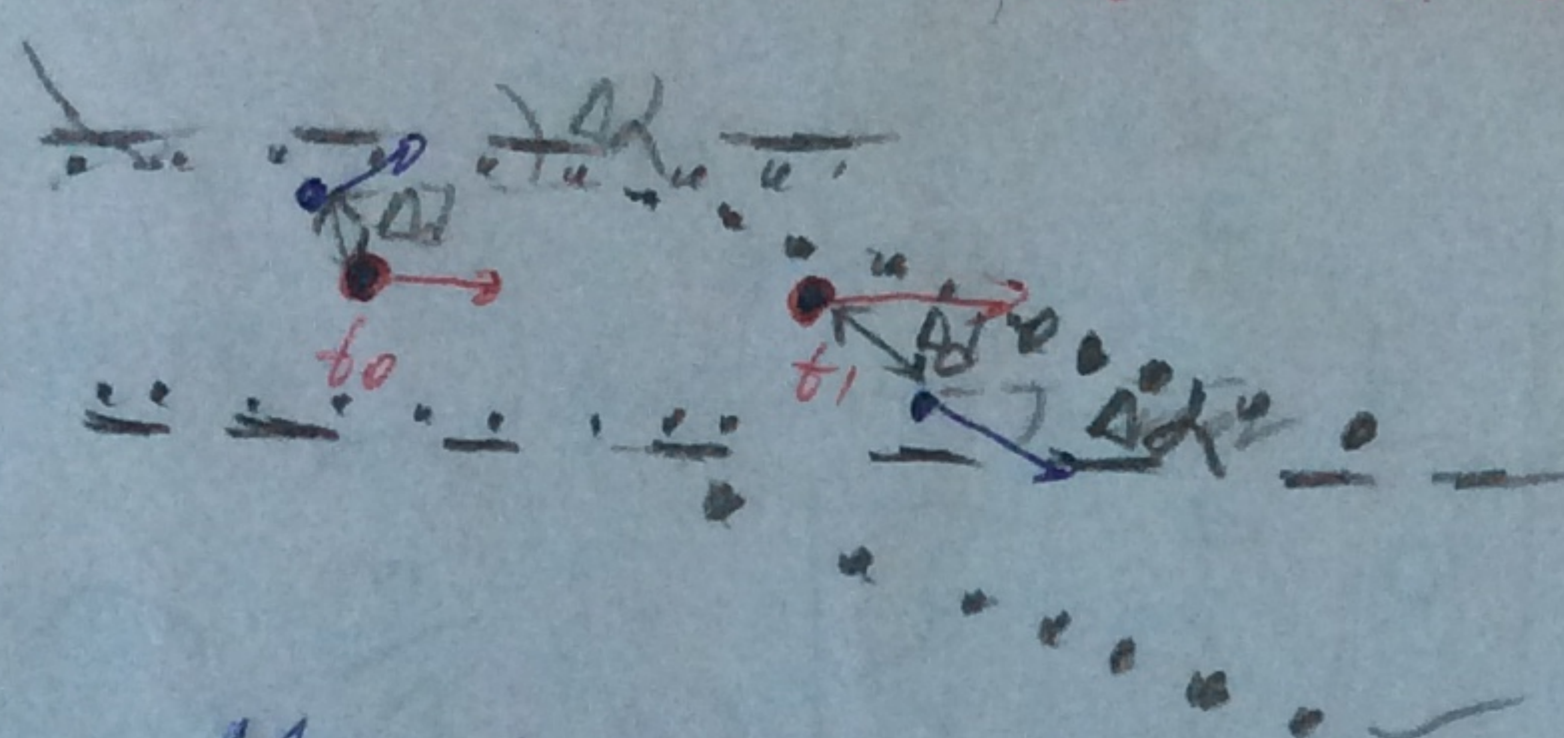
4 we have from GPS $\left[\hat{x}_{k+1}, \hat{y}_{k+1}, \hat{h}_{k+1}\right]^{-4}$ ← after interpolation

$\left(Z_{k+1}^{xy}\right)^{glob}$ ← conv. at. step 3b

has errors

scan for $\boxed{\text{initial guess}}$ $\hat{T}^{k \rightarrow k+1}$ (we care about diff. and heading)

scan → match scan with the previous scan



• - true

• - GPS

We have GPS with an error, reduce the error to make perfect overlaps

rotated because of errors

Map based on the assumption of the previous correctness

Two scans are close to each other. Correct the translation using 3D correlation.

(New scan → correlate)

$\hat{h}_{k+1} = 90^\circ \rightarrow 90^\circ - 10$
$\qquad\qquad\qquad 90^\circ + 10$

$\hat{y}_{k+1} = 100 \rightarrow 90 : 110$

$\hat{x}_{k+1} = 200 \rightarrow 190 : 210$

complicated

Max value → exact h, y, x

apply to the new scan.

for h ..

for x ...

for y ...

correl

end

end

end

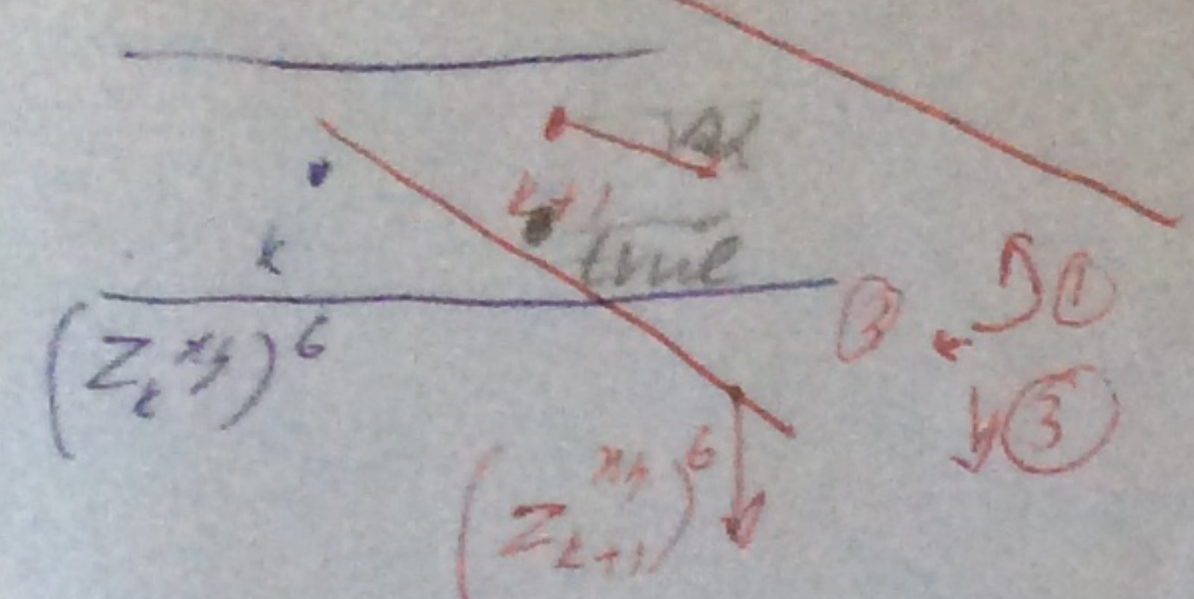
← least square

Brute force search

linear interpolation

grid resol = = accuracy

GPS traject + SLAM ← gps data trajectory



$$T = \begin{pmatrix} \cos\theta_h & -\sin\theta_h & \delta_x \\ \sin\theta_h & \cos\theta_h & \delta_y \\ 0 & 0 & 1 \end{pmatrix}$$

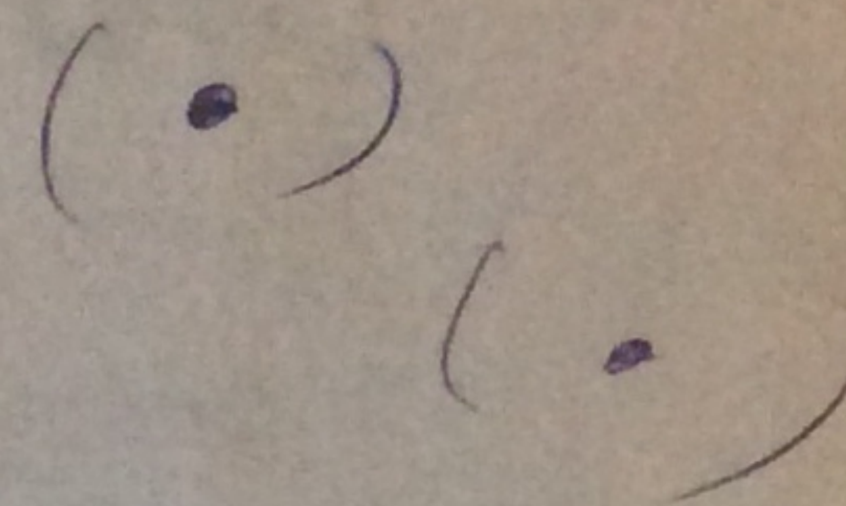
Friday 10th 4pm.

real scan is around the true position

2) from gps at 10 and 20, extract gps at 11.25 → say it is lidar

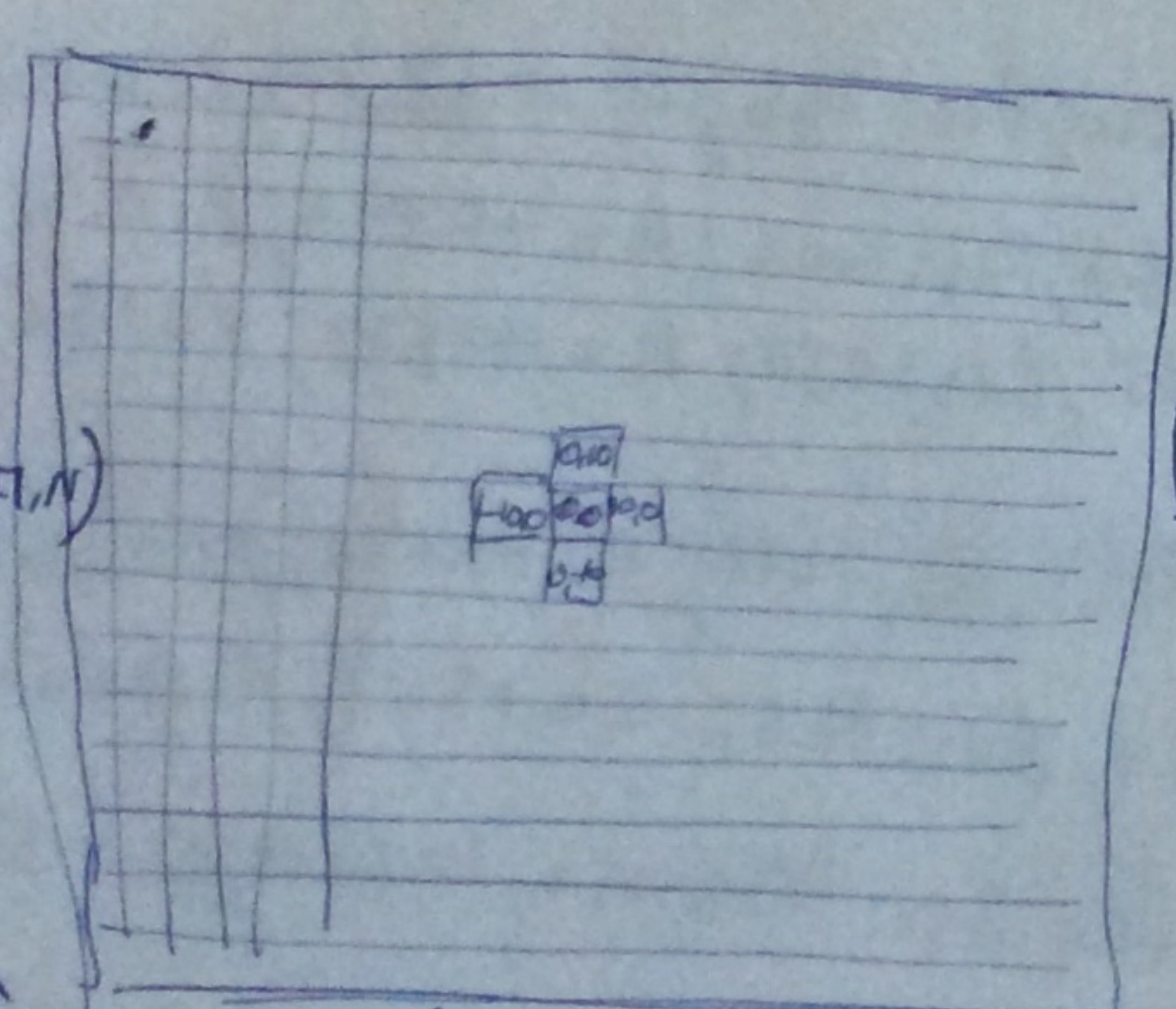
m-heading

unwrap - between 0 and 2π



$$AngSpace = -5 : \frac{1}{720} : 5 ;$$

$$phi\_s = \left(AngSpace + h[i]\right) \cdot \frac{pi}{180} ;$$



bin size 10

$x_{min} = -R_{max} - 1$

$[X_F, Y_F] = \text{meshgrid}(x_{min} : 10cm : x_{max},\ y_{min} : 10cm : y_{max})$

vec. of points at the grid

$P_F = [X_F(:) ; Y_F(:)] \rightarrow$ $P_F \Rightarrow$ size $\rightarrow 2 \times \left(\frac{2R_{max}+2}{10cm}\right)^2$

For each point in the frame:

$d = \text{pdist2}(P_F, \text{2xr\_loc}(P))$

$[v, \text{idx\_min}] = \min(d)$;

$[r, c] = \text{ind2sub}([M\ N], \text{idx\_min})$

binary $\rightarrow F_R(r, c] = 1 ; \rightarrow F_R(r, c) = F_R(r, c) + I ;$