FACTOR GRAPHS

(Large) problems may involve | 1000s camera poses

thousands and thousands of nodes .....

INFORMATIONAL,

boiled down to a solution of a linear system ⇒ thousands of poses $SE(3)$ problem ≡ (6 thousands of variables .....

⇓

6000 × 6000 matrices .....

bring an inversion in hell......

But

H matrix, in certain class of problems, #non-zero blocks <<<<< #matrix blocks (grows quadratically)

if add measurement, only add 1/linear block to matrix

e.g. FOV 180° | would only observe the things in the room

| new things depends on the motion

is upper bound ⇒ #factors/observations that correspond to new poses are at most M

⇓

$M \times N$ new non-∅ blocks inserted in the matrix

huge state vector

LOCALITY → measurements only depend on relatively small set of variables in our state

FACTOR GRAPHS → NOT METHOD is a formalization to formulate flexible problems

$e^{[k]}$ → is what we want to minimize ⟶ it is only a means to an end

$X^{[k]}$ = subset of variables affecting $z^{[k]}$

e.g.

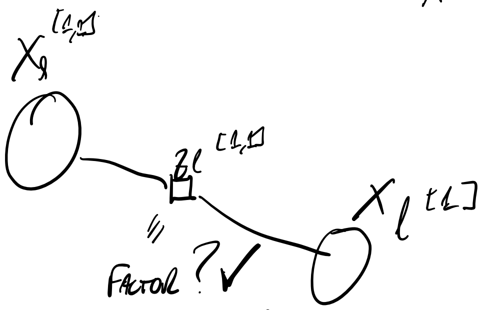
X^r, X^l → $z^{[r,l]}$ → only depends on robot pose X_r and landmark pose X_l

actual function

another examples

odometry

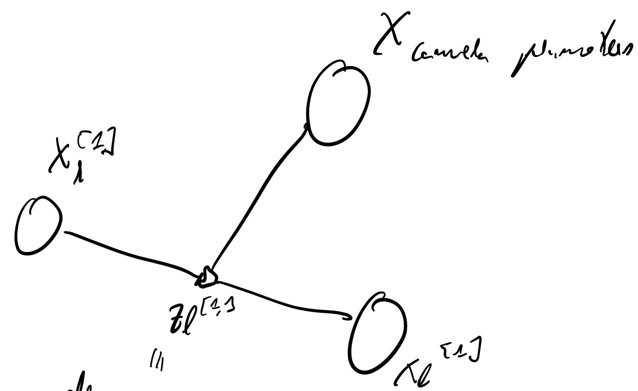
X^t, X^{t+1} → odometry measurement



FACTOR? ✓

(a node that encodes information = edge)

OR



this FACTOR now has 3 dependencies!

$$q^2 = 1_q$$ in the dimension of a factor

Cholesky decomposition gives numerically stable solution if H is symmetric

$$Ly = -b$$ → solve triangular solution (much easier!!!)

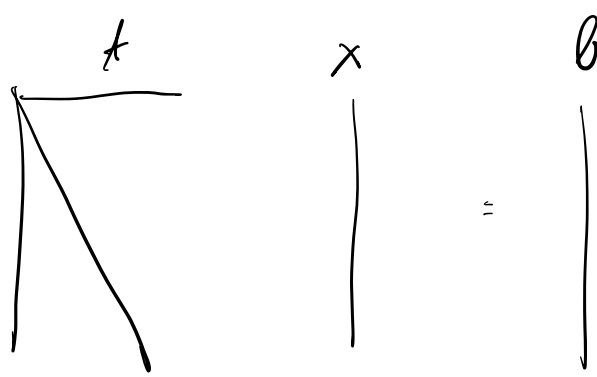
2 steps

⇓

$$L^T \Delta x = y$$

H sparse does not mean L sparse!

Bor



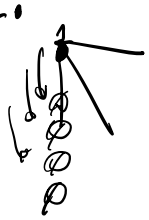
↓

↳ upon depend on non-0 elements in H ④

strongly influenced by older!

To solve, triangularize

1.



→ this line and store it subsequently to the lines below

eliminate these values

and over and over...

by doing ~~triangulation~~ ⇒ we end up with a dirty linear system

2.

what if we swap the first and last columns?

We may end up with a sparse matrix (just by swapping lines and columns)

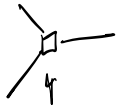
SPECIAL CASE OF ORTHOGONAL MATRIX ($A^{-1}=A^T$)

permutation matrix multiplies by left and right only (just shuffles the values) to swap variables

CRUCIAL "RIGHT" ORDERINGS OF THE MATRIX COEFFICIENTS (we need to know the ordering)

CODING EXERCISE (PART II)

in general



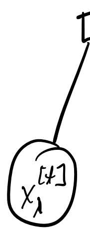
all variables of the state that predict that measurement

measurement may connect several variables

what if we had a GPS?

≡

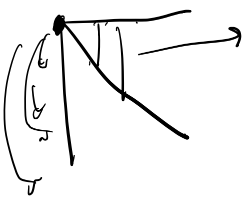
sensor that depends on current robot position (with the, sensor...)



→ error factor only dependent on the current robot position

E.g.

1. choose row w/ least elements / lower degree / blocks non-zero
2. eliminating this would result into filling-in all the elements below and above that row...



→ would have fill in in this part

→ Total Least Squares (same methodology while also taking into account sparse structure)

Pose-Pose (3D)

Pose-Landmark (3D)

Pose-Landmark (Projection: 2D)

→ State: collection of SE(3) objects (robot pose)

and collection of SE(3) points (landmarks)

given that we are missing and rotating things, position ROBOT → WORLD is more intuitive?...

K camera matrix

π = homogeneous division of ICP projective

Pose-Landmark (3D)

Pose-Landmark (3D)

≡

Pose⊕ Landmark

≈ pose-point

≡

only robot position

z_l = zeros (3,20)

z_φ = zeros (3,20) → comment to not disappear the repeated measurements!