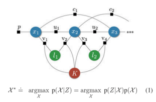
What we will do today ..

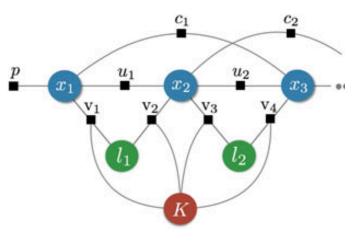


- Examples of Equation (1) in [Cadena 2016]
- Introduction to robot odometry (u_i in Fig. 3 of [Caneda 2016])
  - Coordinate frames
  - Spatial transforms (3D and 2D)
  - Wheel odometry
  - Odometry with inertial measurement unit (IMU) odometry
  - LiDAR odometry (Wednesday)
  - Visual odometry (later)
- Wednesday (9/18), we will talk about cameras and loop closure (c_i)
- Assignment No. 1, Wednesday (9/18)

Reading Assignments

- (9/4) SLAM Survey: [Caneda 2016], pp. 1-12 (1309-1320) and pp. 17-18 (1326- 1327)
- (9/16) Basic linear algebra and coordinate transformations: http://ais.informatik.uni-freiburg.de/teaching/ss11/robotics/slides/02-linear-algebra.ppt.pdf
- (9/16) Mobile robot kinematics (differential drive): http://ais.informatik.uni-freiburg.de/teaching/ss11/robotics/slides/03-locomotion.ppt.pdf
- (9/16) RTAB-MAP: [Labbe 2019], pp. 1-12 (416-427)

SLAM Solution



$$\mathcal{X}^\star \doteq \underset{\mathcal{X}}{\operatorname{argmax}}\ p(\mathcal{X}|Z) = \underset{\mathcal{X}}{\operatorname{argmax}}\ p(Z|\mathcal{X})p(\mathcal{X}) \quad (1)$$

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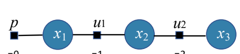
$$\mathcal{X}^\star = \underset{\mathcal{X}}{\operatorname{argmax}}\ p(\mathcal{X}) \prod_{k=1}^{m} p(z_k|\mathcal{X})$$

$$= \underset{\mathcal{X}}{\operatorname{argmax}}\ p(\mathcal{X}) \prod_{k=1}^{m} p(z_k|\mathcal{X}_k) \quad (2)$$

$$p(z_k|\mathcal{X}_k) \propto \exp\left(-\frac{1}{2}||h_k(\mathcal{X}_k) - z_k||^2_{\Omega_k}\right) \quad (3)$$

$$\mathcal{X}^\star = \underset{\mathcal{X}}{\operatorname{argmin}} -\log\left(p(\mathcal{X}) \prod_{k=1}^{m} p(z_k|\mathcal{X}_k)\right)$$

$$= \underset{\mathcal{X}}{\operatorname{argmin}} \sum_{k=0}^{m} ||h_k(\mathcal{X}_k) - z_k||^2_{\Omega_k} \quad (4)$$



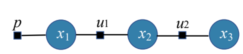
We can solve this toy problem by solving

(1) a system of linear equations

(2) linear least square

(3) MLE, or

(4) MAP



1. What is m?
2. What are z_1 through z_m?
3. What are $\mathcal{X}$, and $\mathcal{X}_1$ through $\mathcal{X}_m$?
4. What are h_1 through h_m?

$$p(z_k|\mathcal{X}_k) \propto \exp\left(-\frac{1}{2}||h_k(\mathcal{X}_k) - z_k||^2_{\Omega_k}\right) \quad (3)$$

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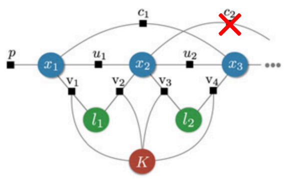

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RTAB-Map [Labbe et al. 2019]

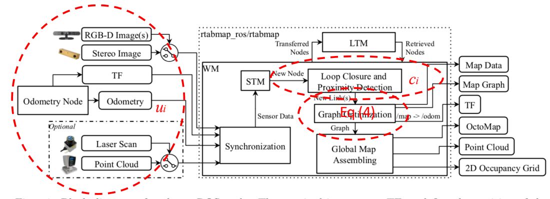

Fig. 1: Block diagram of *rtabmap* ROS node. The required inputs are: TF to define the position of the sensors in relation to the base of the robot; Odometry from any source (which can be 3DoF or 6DoF); one of the camera inputs (one or multiple RGB-D images, or a stereo image) with corresponding calibration messages. Optional inputs are either a laser scan from a 2D lidar or a point cloud from a 3D lidar. All messages from these inputs are then synchronized and passed to the graph-SLAM algorithm. The outputs are: Map Data containing the latest added node with compressed sensor data and the graph; Map Graph without any data; odometry correction published on TF; an optional OctoMap (3D occupancy grid); an optional dense Point Cloud; an optional 2D Occupancy Grid.

No v_i!