Multi-Target & Multi-Detector People Tracker for Mobile Robots

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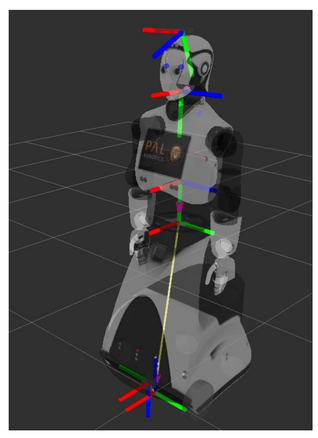
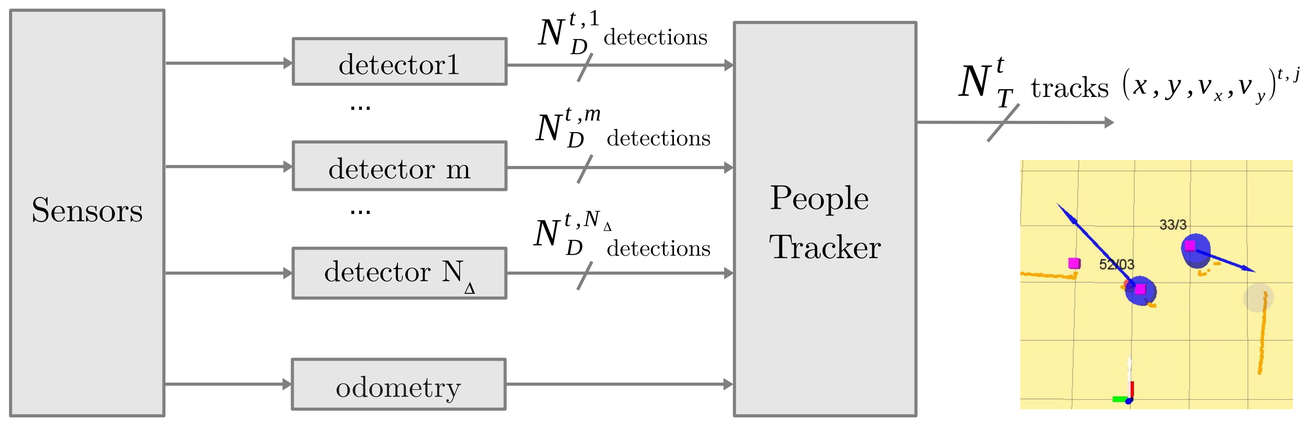
ECMR 15

MOTIVATION & OVERVIEW





TRACKER

MAIN LOOP:

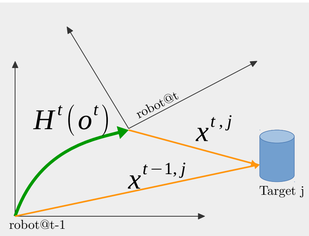
- FOR each target
  - **Prediction**:
    - People Motion (Person motion model)
    - Platform Motion (Odometry)
  - END
- **Occlusion Prediction**
- **Data Association** (Detections vs Targets)
- FOR each target
  - FOR each detector
    - FOR each associated detection
      - FOR each particle
        - **Correction**
      - END
    - END
  - END
- END
- **Resampling**
- END
- **Target Management**
- **Publish**

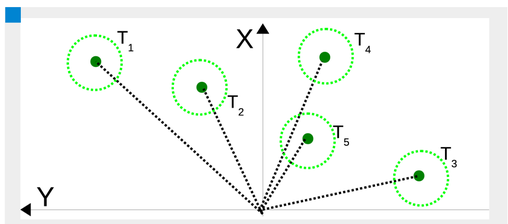
END MAIN LOOP

$$\mathbf{s}_j^{t,n} = \begin{bmatrix} 1 & 0 & \tau & 0 \\ 0 & 1 & 0 & \tau \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \mathbf{s}_j^{t-1,n} + \begin{bmatrix} \sigma_{\mathbf{x}} \\ \sigma_{\mathbf{x}} \\ \sigma_{\mathbf{v}} \\ \sigma_{\mathbf{v}} \end{bmatrix}$$

$$\mathbf{H}_n^{t,t-1}(\mathbf{o}^t) = \mathbf{H}_n^t = \begin{bmatrix} \cos\theta_n^t & -\sin\theta_n^t & r_n^t \cos\frac{\theta_n^t}{2} \\ \sin\theta_n^t & \cos\theta_n^t & r_n^t \sin\frac{\theta_n^t}{2} \\ 0 & 0 & 1 \end{bmatrix}$$

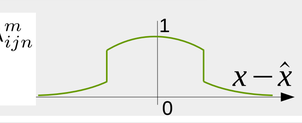
$$\begin{bmatrix} \mathbf{x} \\ 1 \\ \mathbf{v} \\ 0 \end{bmatrix}_{j,n}^{t} = \begin{bmatrix} (\mathbf{H}_n^t)^{-1} & \mathbf{0}_3 \\ \mathbf{0}_3 & (\mathbf{H}_n^t)^{-1} \end{bmatrix} \begin{bmatrix} \mathbf{x} \\ 1 \\ \mathbf{v} \\ 0 \end{bmatrix}_{j,n}^{t-1}$$



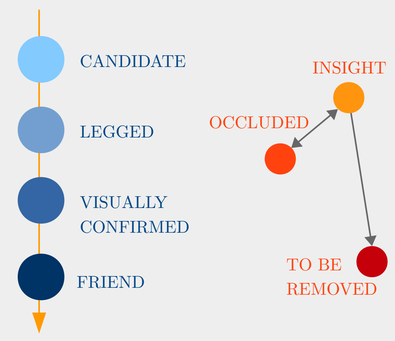


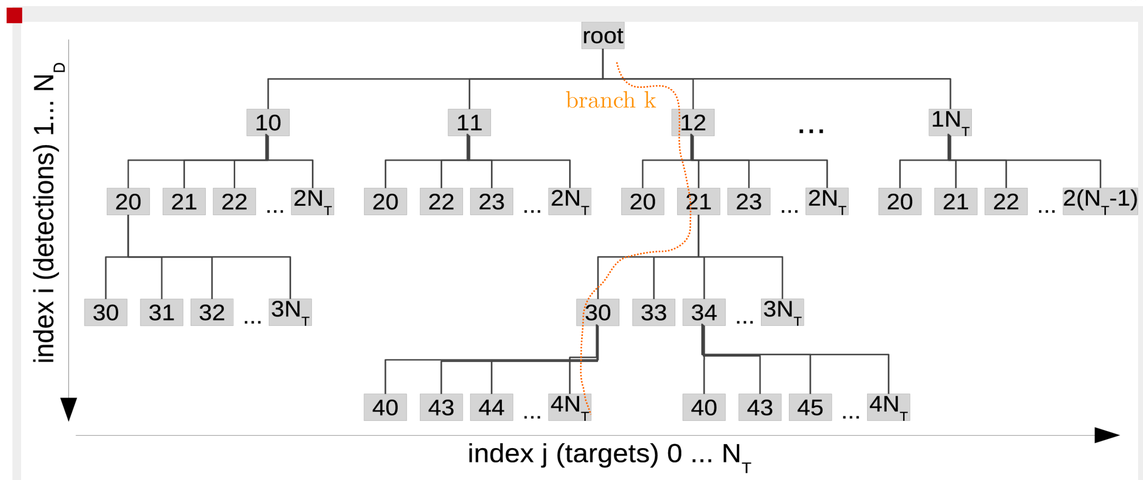
$$\lambda_{ijn}^m = \lambda(D_i^m, \mathbf{s}_j^n) : \mathbf{s} \to \mathbb{R} \in [0,1]$$

$$w_j^{t,n} = \prod_{\substack{m=1..N_\Delta^t \\ (i,j)\in\mathfrak{B}}} \lambda_{ijn}^m$$



TARGET STATUS





Best association event

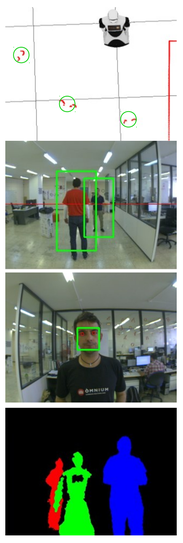
Branch k maximizing P_k

$$p_{i0} = \prod_{\substack{k=1..N_D \\ k\neq 0}} (1-\lambda_{ik}), \forall i = 1..N_D$$

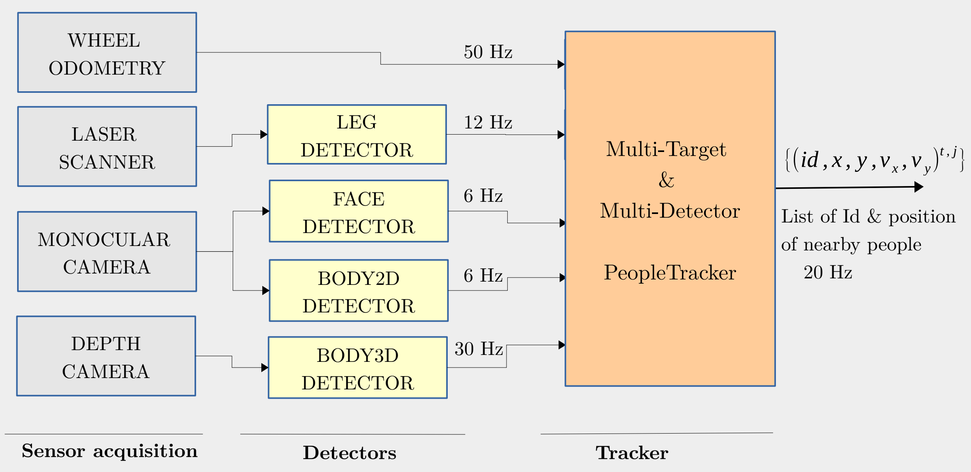
$$p_{ij} = \lambda_{ij} \cdot (1-p_{i0}) \cdot \prod_{\substack{k=1..N_T \\ k\neq j}} (1-\lambda_{ik}) \cdot \prod_{\substack{k=1..N_D \\ k\neq i}} (1-\lambda_{kj})$$

$$P_k = \prod_{\substack{\forall nodes \\ \in branch\ k}} p_{ij}$$

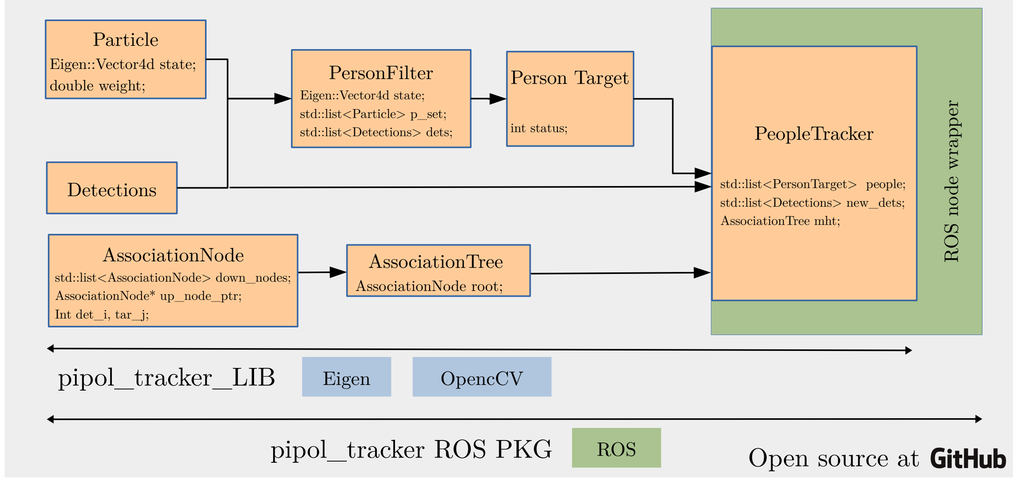
IMPLEMENTATION



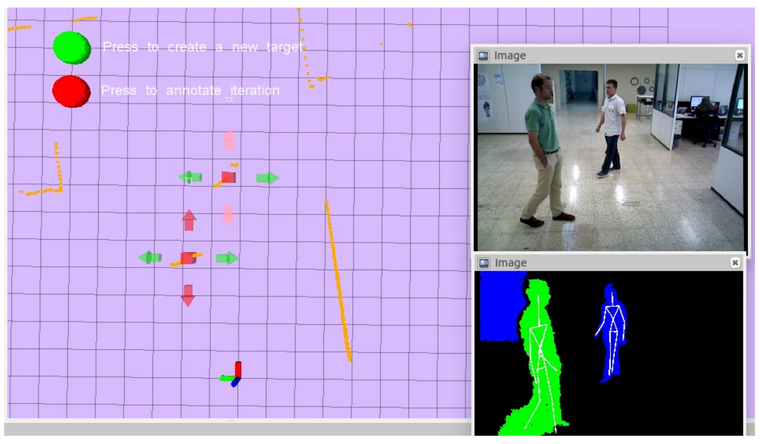
PROCESS DIAGRAM



TRACKER: CLASS HIERARCHY & DEPENDENCIES



EXPERIMENTAL RESULTS



Ground Truth Anotation with ROS Interactive Markers

SENSOR FUSION EXPERIMENT

	Dataset A			Dataset B			Dataset C		
	ALL	LBF	LS	ALL	LBF	LS	ALL	LBF	LS
MOTP	0.14	0.11	0.15	0.15	0.18	0.14	0.16	0.14	0.16
MOTA	0.69	0.63	0.71	0.31	0.15	0.32	0.66	0.32	0.61

DATA ASSOCIATION EXPERIMENT

	Dataset A		Dataset B		Dataset C	
	MHT	NN	MHT	NN	MHT	NN
MOTP	0.14	0.15	0.15	0.15	0.16	0.15
MOTA	0.69	0.34	0.31	0.21	0.66	0.56

ALL: all detectors
L: Leg detector
B: Body 2D detector
F: Face detector
S: Skeleton (NiTE) detector
MHT: Multi-Hypothesis Tree
NN: Nearest Neighbor

FUTURE WORKS

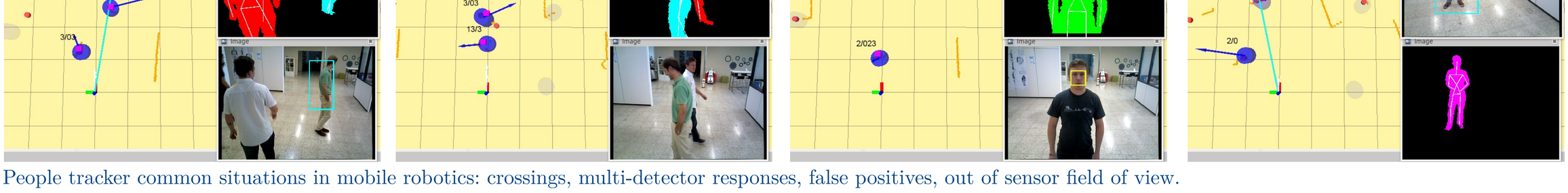
People Motion

Social Constraints

Windowed Optimization

Tracking Appearance

New data sets
Experimentation
Partnerships



People tracker common situations in mobile robotics: crossings, multi-detector responses, false positives, out of sensor field of view.