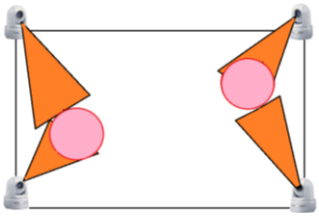
Tokyo Institute of Technology

3-D Visual Coverage



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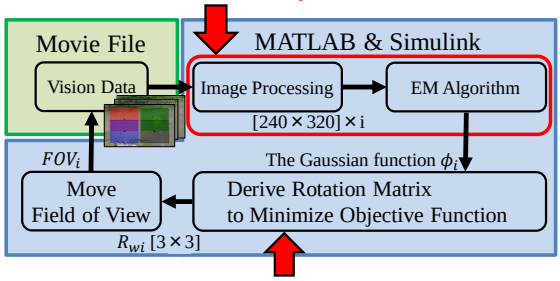
Outlines

- Main Points
- Application of EM Algorithms
- Density Function
- Objective Function
- Coverage for Multiple Cameras
- Simulation & Future Work

Main Points

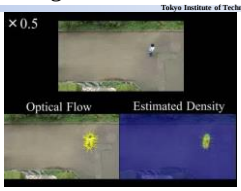
It doesn't matter what scenario you choose here.



Multiple cameras' fields of view are properly dispersed to cover important places.

Application of EM Algorithms

K=2



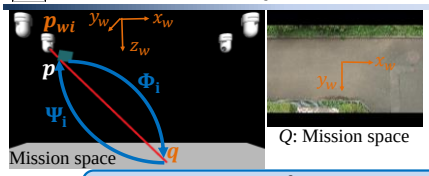
An example of EM algorithm

EM algorithm approximates a probability distribution of data by a Gaussian mixture model with k components.

$$\phi_i(p^{im}) = \sum_{j=1}^{k} \alpha_j \exp\left(-(p^{im} - \mu_j^{im})^T \Sigma_j^{im} (p^{im} - \mu_j^{im})\right)$$

$$\Sigma_j^{im} = \frac{1}{2} S_j^{im\,-1}$$ S_j^{im}: Covariance matrix μ_j^{im}: Matrix of means

Density Function



Q: Mission space

$$p = \begin{bmatrix} p^{im} \\ \lambda_i \end{bmatrix} \quad \mu_j = \begin{bmatrix} \mu_j^{im} \\ \lambda_i \end{bmatrix} \quad \Sigma_j = \begin{bmatrix} \Sigma_j^{im} & 0 \\ 0 & 0 \end{bmatrix}$$

Density function

$$\phi \circ q_{wl}(R_{wi}) = \psi \circ \Psi_i \circ g_{wi}^{-1}[k](q)$$

$$\psi(p) = \begin{cases} \bar{\phi} & \text{if } g_{wi} \circ \Phi_i(p) \notin Q \\ \bar{\psi} - \sum_{j=1}^{k} \alpha_j \exp\left(-(p-\mu_j)^T \Sigma_j (p-\mu_j)\right) & \text{otherwise} \end{cases}$$

$\psi(p) > 0 \quad \bar{\phi} > \bar{\psi}$

There is a larger penalty $\bar{\phi}$ when watching outside of mission space.

Objective Function

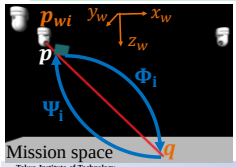
Objective function (to be minimized)

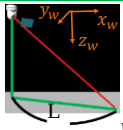
$$H_i(R_{wi}) = \sum_{l \in \mathcal{L}_i} w_{il}\left(f_i \circ q_{wl}(R_{wi})\right)\left(\phi \circ q_{wl}(R_{wi})\right)$$

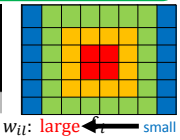
Define the set of pixels of camera i by $\mathcal{L}_i$.

Sensing performance function

$$f_i \circ q_{wl}(R_{wi}) = \frac{1}{\lambda_i}(q - p_{wi})^T W (q - p_{wi}) \quad W = \mathrm{diag}([w\ w\ 1])$$

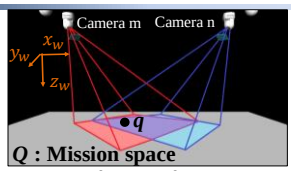






w_{il}: large ← small

Coverage for Multiple Cameras



Overlaps of Field of View (FOV)

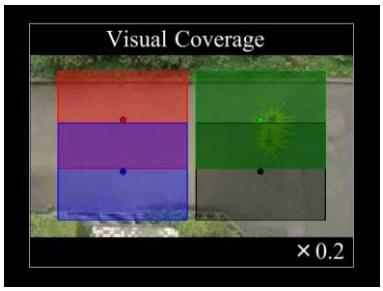
Define the set of sensors capturing a point q within the FOV as

$$\mathcal{V}(q;R_\mathcal{V}) = \{i \in \mathcal{V} | q \in FOV_i(R_{wi})\} \quad : \; R_\mathcal{V} = (R_{wi})_{\,i\in\mathcal{V}}$$

$$SFOV_i^c(R_\mathcal{V}) = \left\{ q \in FOV_i(R_{wi}) \middle| i \notin \arg\min_{j\in\mathcal{V}(q;R_\mathcal{V})} f_j(q) \right\}$$

What pixel l captures a point in $SFOV_i^c(R_\mathcal{V})$ is identified with what it captures a point outside of Q whose cost is $\bar{\phi}$.

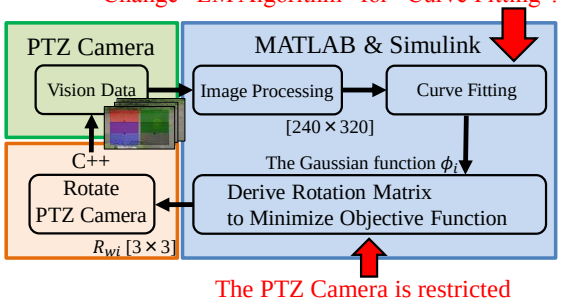
Simulation Result



http://www.fl.ctrl.titech.ac.jp/paper/2014/sim.wmv

Future Work : Experiment

Change “EM Algorithm” for “Curve Fitting”.



The PTZ Camera is restricted by the actuator configurations.