Large Scale Environment Partitioning in Mobile Robotics Recognition Tasks

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Outline

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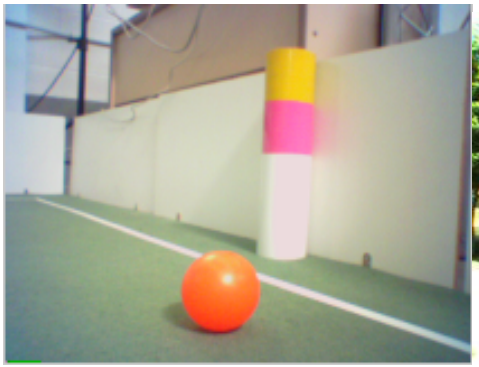
Localization

- Mobile robots
- Sensors + Maps
- Localization

Vision-based localization

Environments

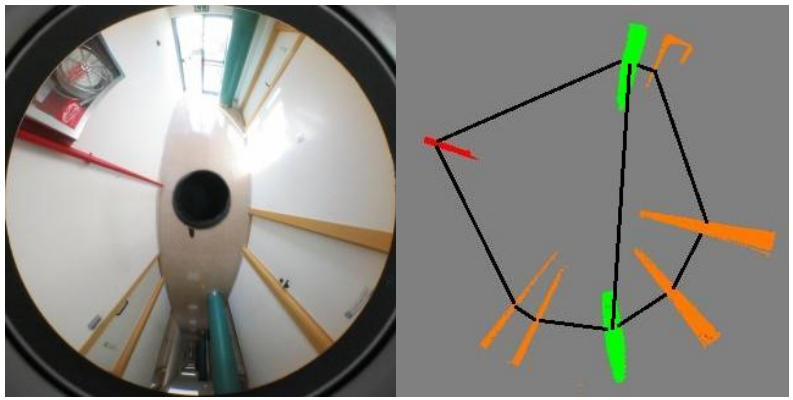
- Ad-hoc
- Natural
  - Indoor
  - Outdoor

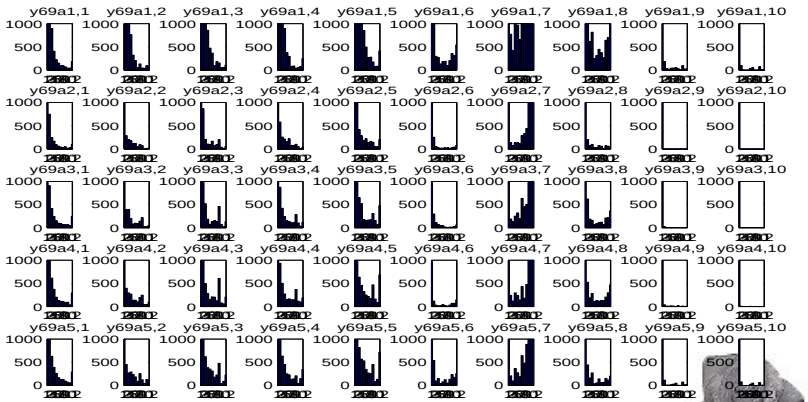


Appearance based visual recognition

Visual recognition approaches

- Structural-description
  - Structure from *high level features*
- **Appearance-based**
  - Images or *low level features*





Omnidirectional images

Omnidirectional images

- Local views with 360º visibility
- Independence of the direction of the route.
- Convenient representation for rotation-invariant recognition

Omnidirectional images

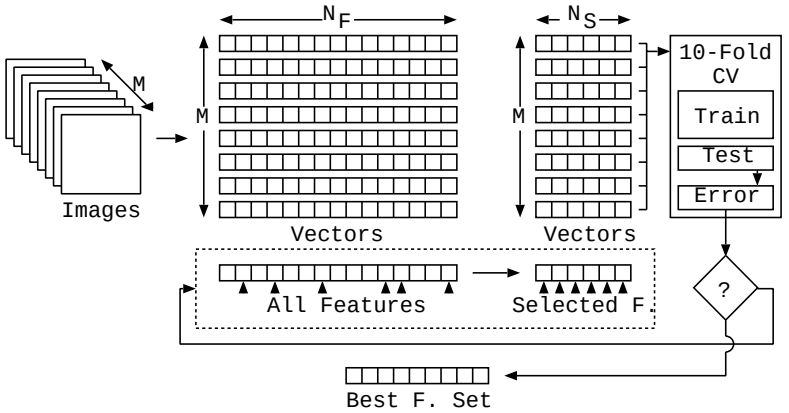
Feature selection approach

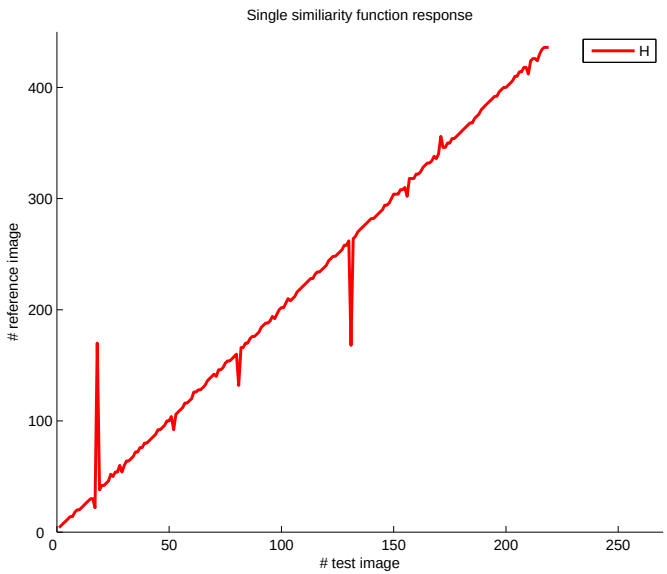
Low level filters

- Nitzberg
- Canny, Gradient
- Color Filters

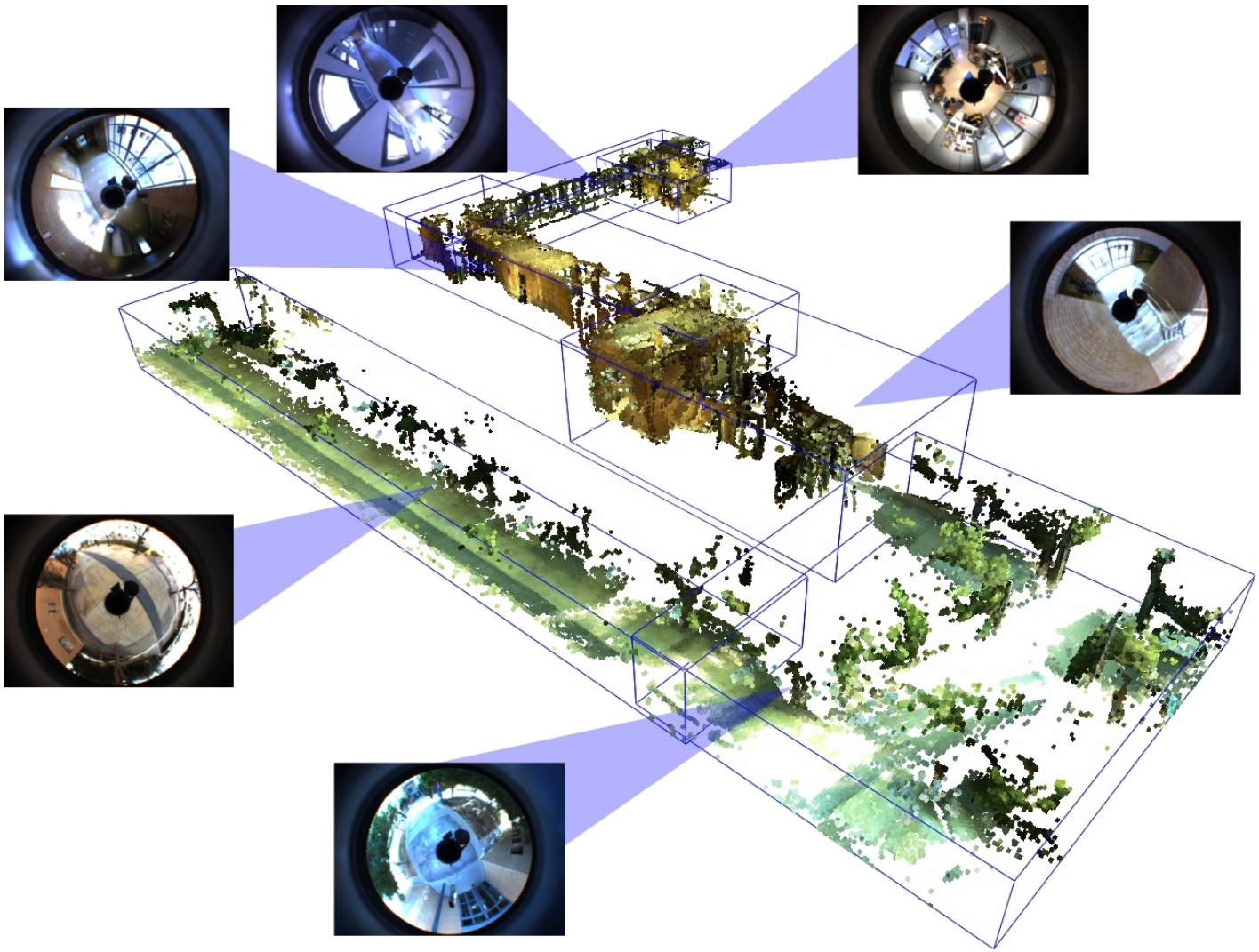
Histograms comparison

- 2,4, and 12 bins discretization



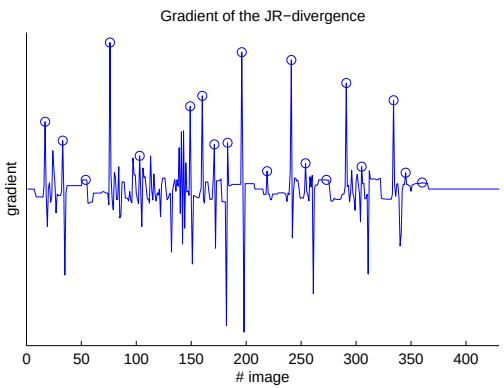


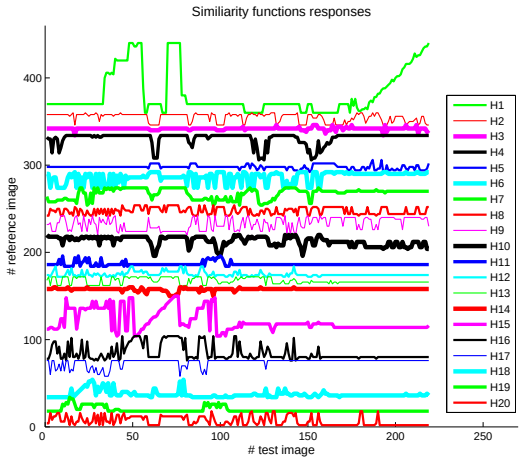
Large environments

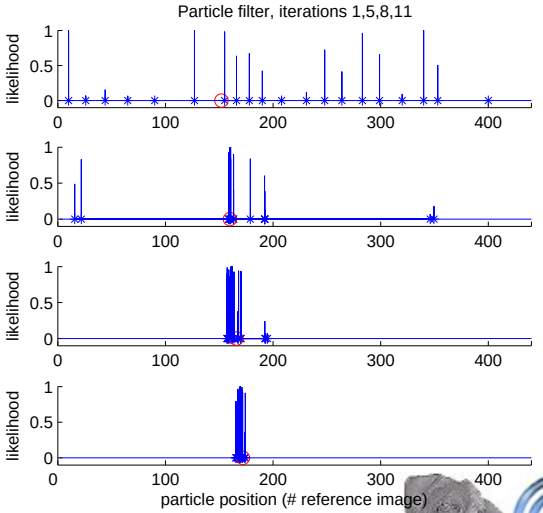


Approach

- Unsupervised partitioning of the environment
- Localization in each partition $\longrightarrow$ multiple hypotheses
- MCL to select a single hypothesis







Outline

Sequence of images

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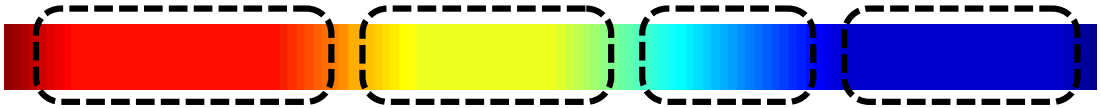
Divide the problem

How to divide the problem?

- Try all possible partitions
- Clustering algorithms



- Look for local variations in the information

Jensen-Rényi divergence

Information-theoretic divergence measures

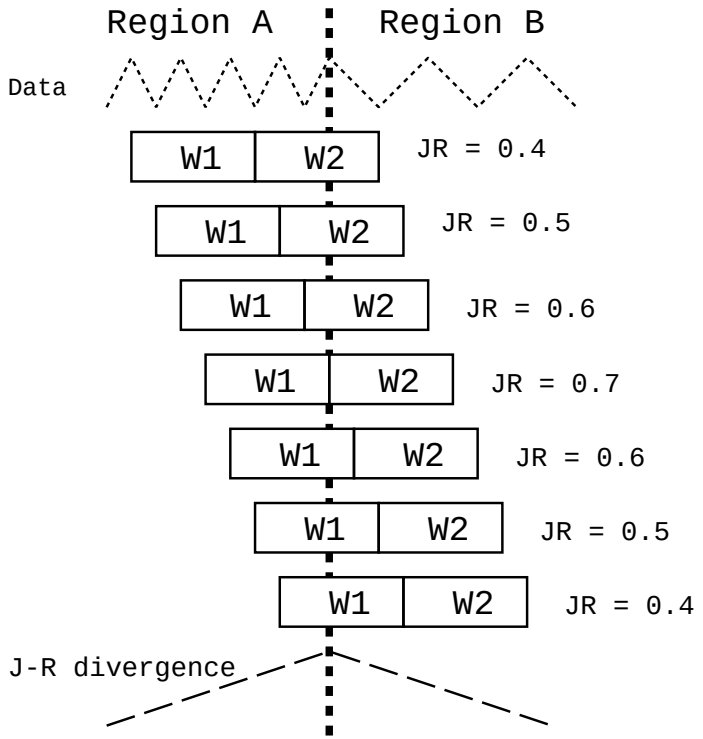
- entropy based
- unfeasible for multidimensional data

Jensen-Rényi divergence

- α-entropy based
- feasible estimation in high-dimensional spaces (Hero and Michel, 2002)

J-R divergence applications

- may be defined between any number of probability distributions
- may be used to detect “edges” with a sliding window



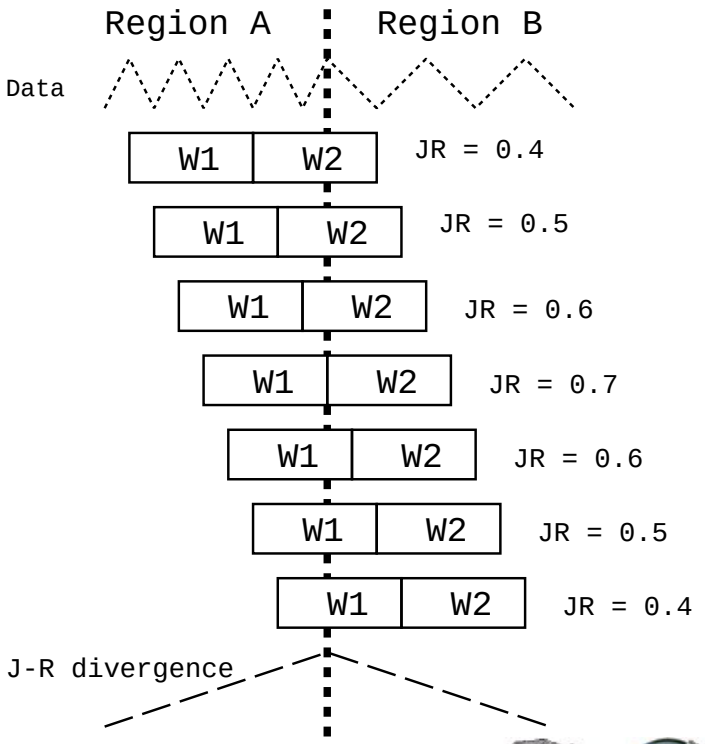
Jensen-Rényi divergence

J-R divergence simplified for two equally weighted distributions

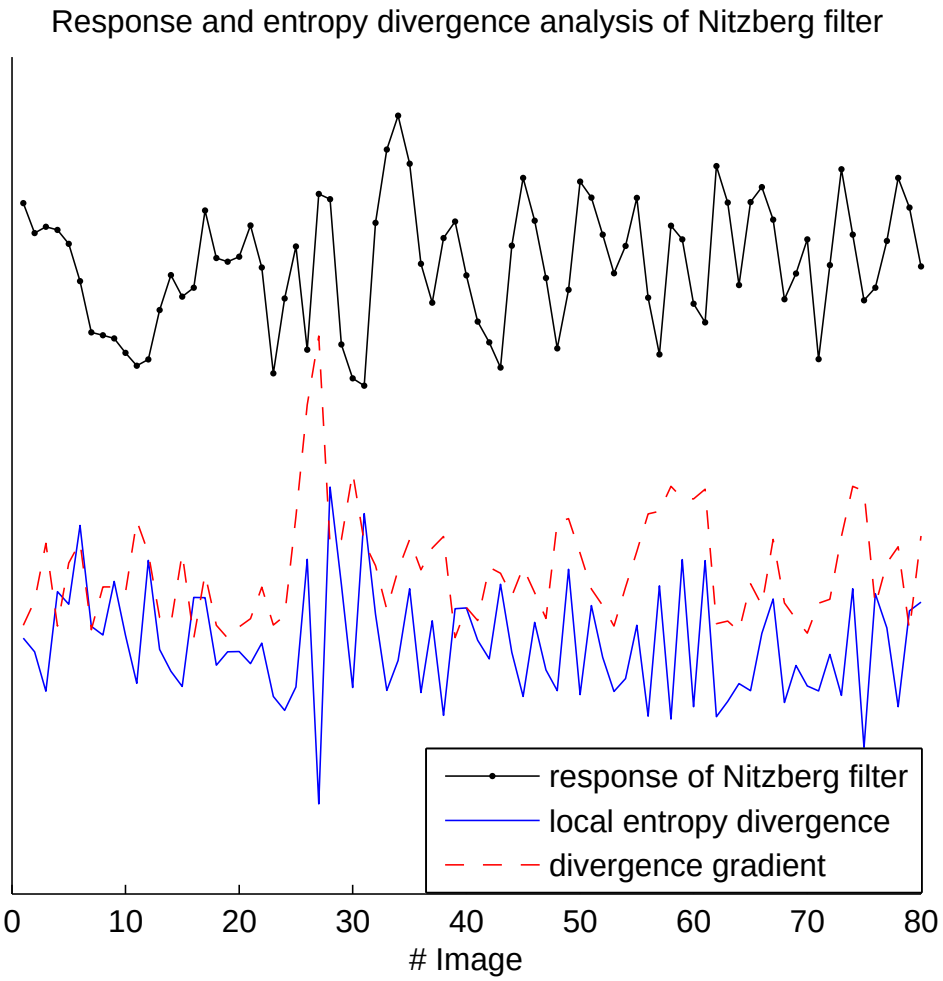
$$JR_\alpha(p_1, p_2) = \\ = H_\alpha\left(\frac{p_1 + p_2}{2}\right) - \frac{H_\alpha(p_1) + H_\alpha(p_2)}{2},$$

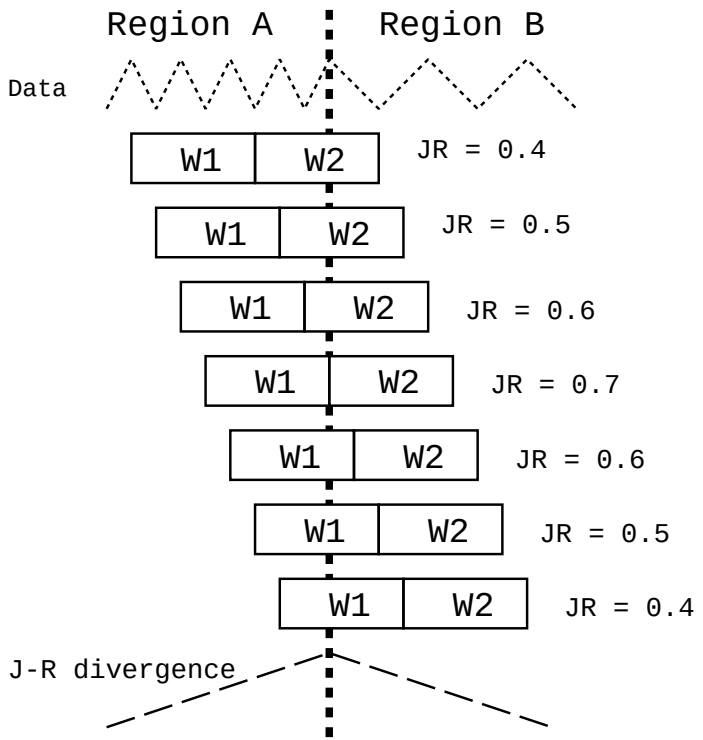
where

- Rényi entropy H_α is estimated with Hero and Michel's method (based on *minimal spanning trees*)
- complexity depending on the number of samples $O(N \log N)$

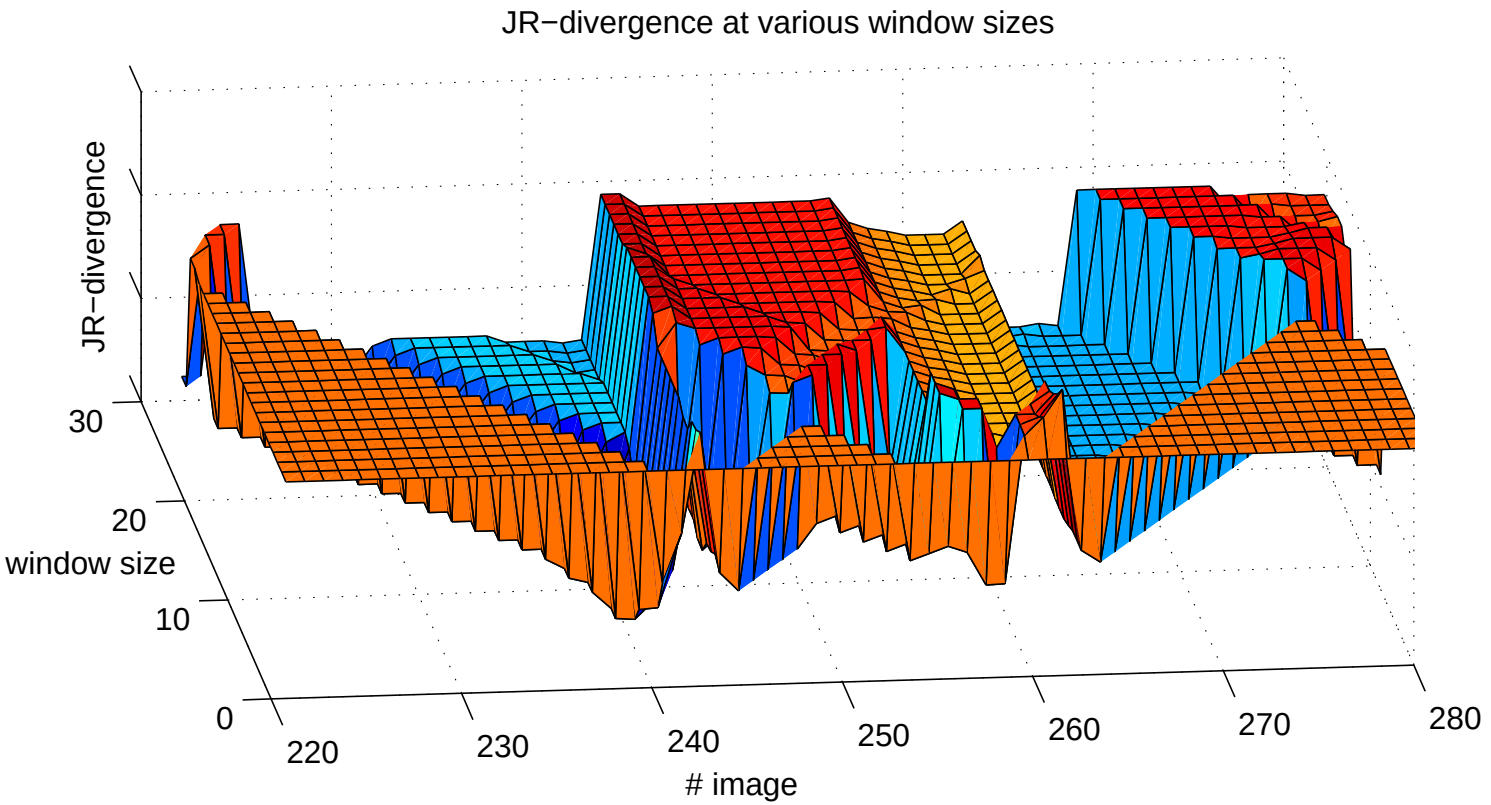


Jensen-Rényi divergence





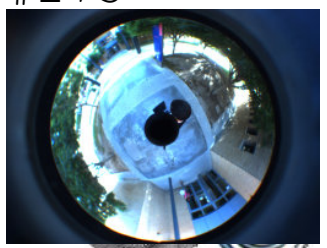
Multiscale Jensen-Rényi divergence



#241

#254

#273



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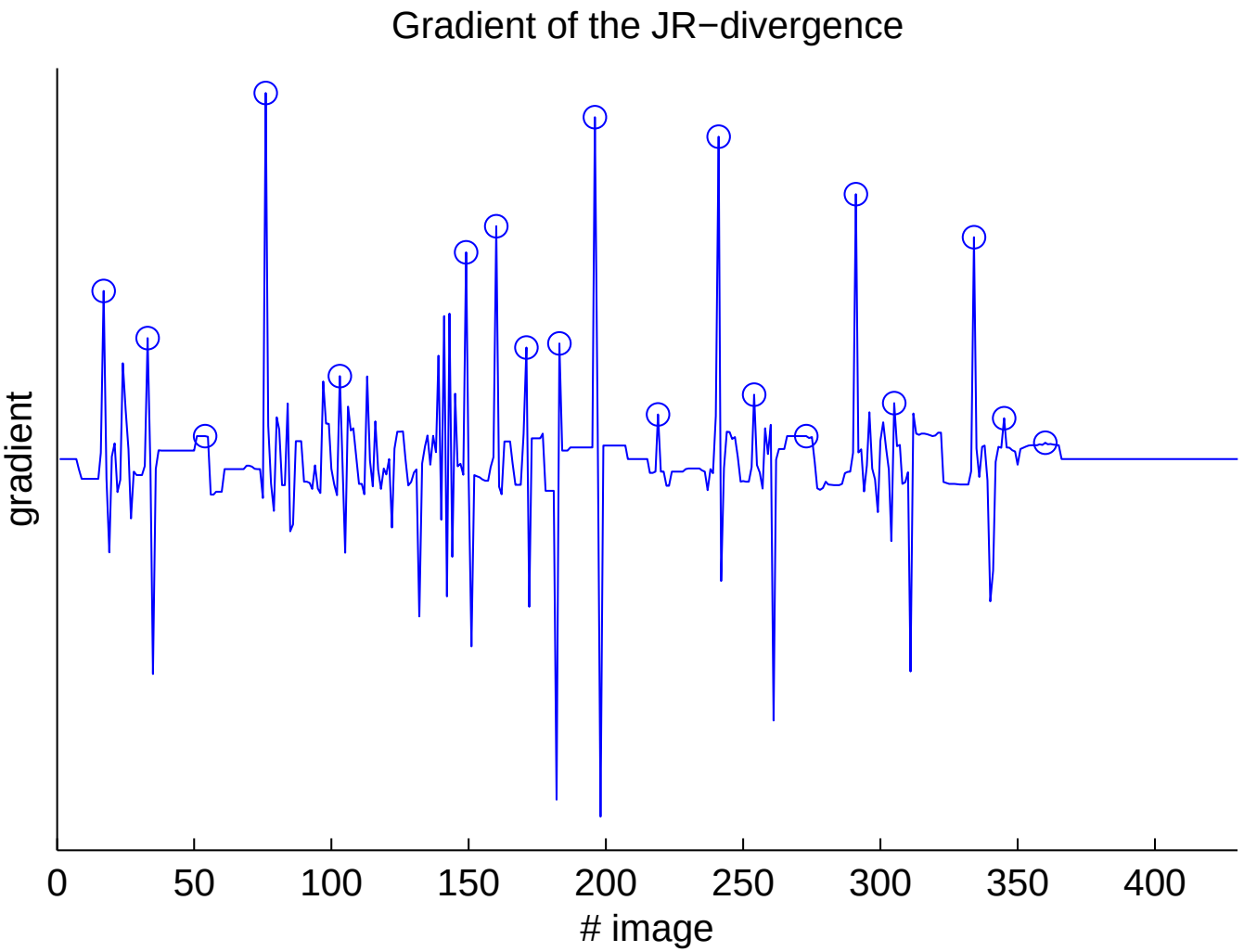
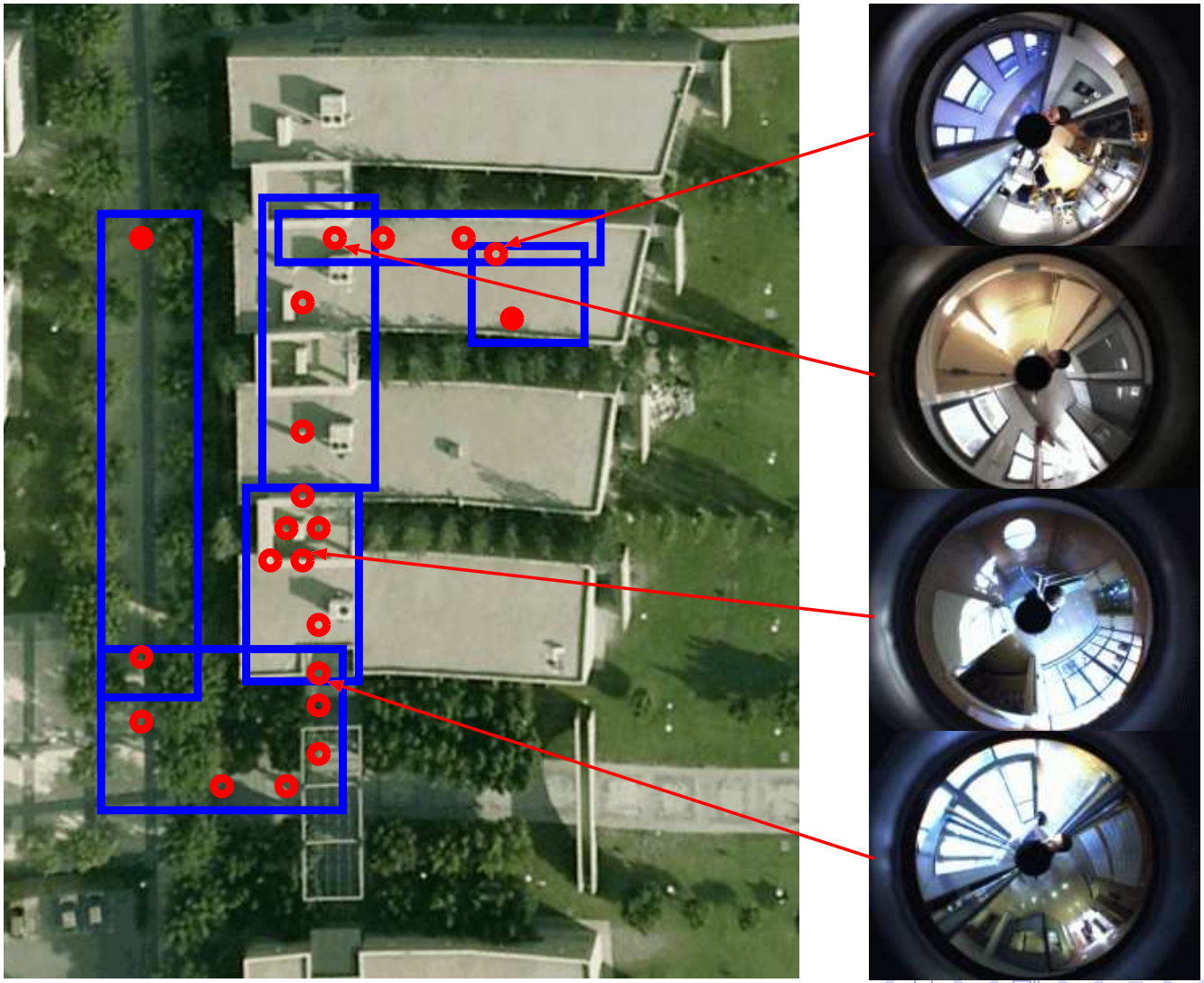
Resulting partitions

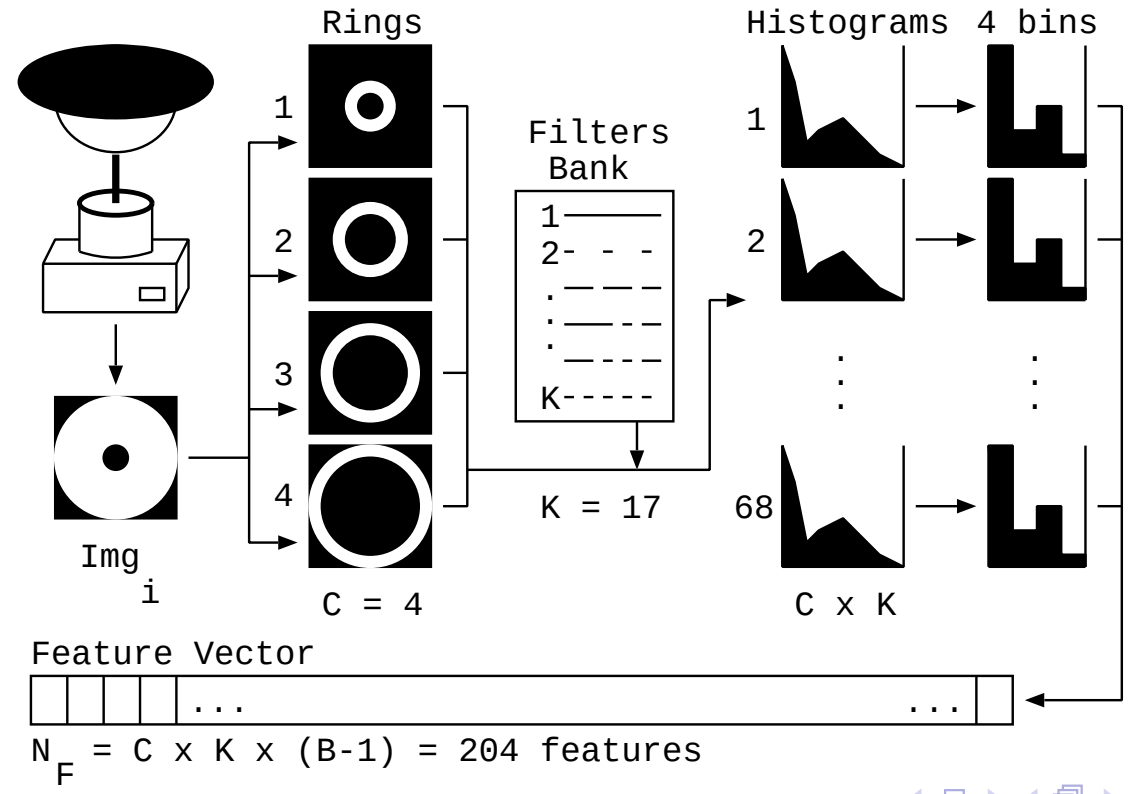


Resulting partitions



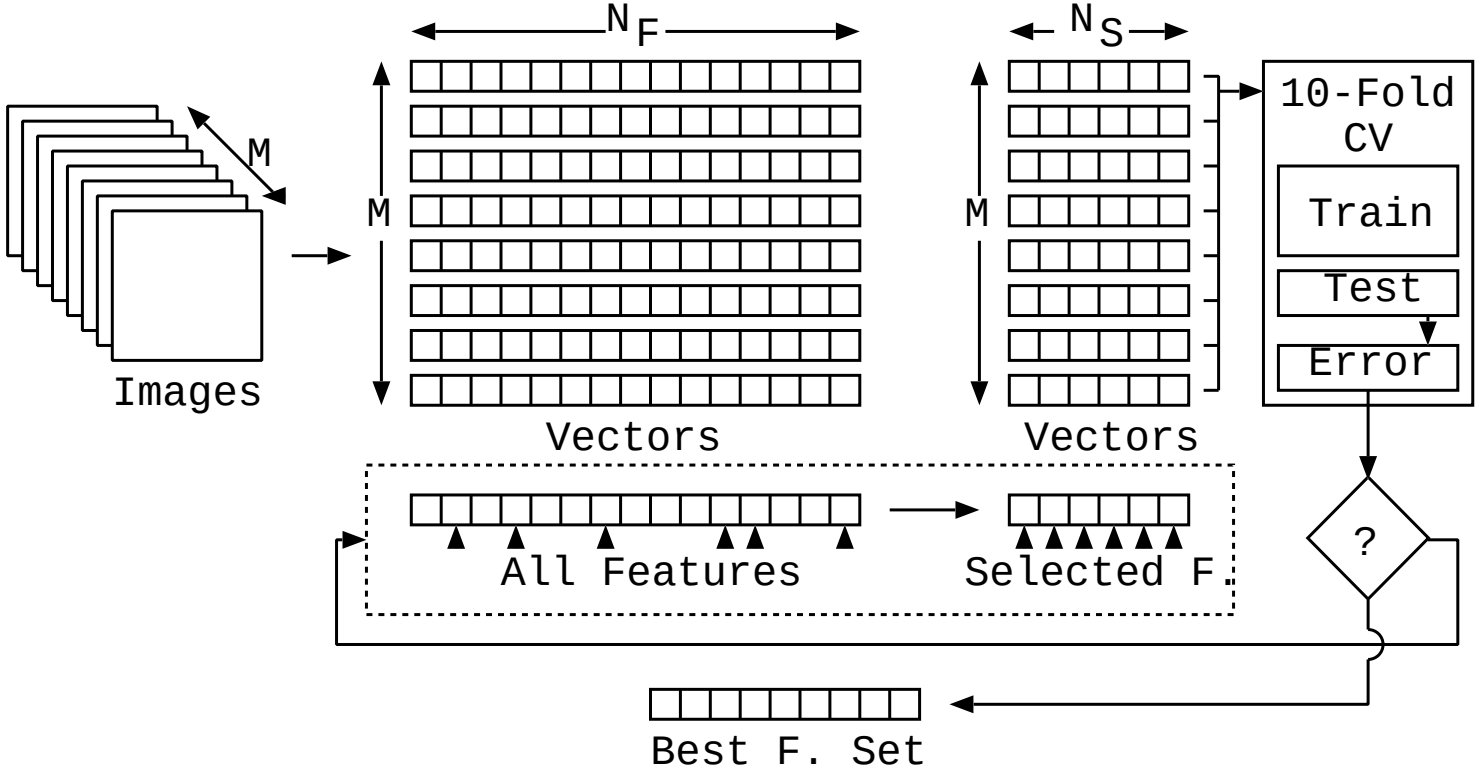
Feature extraction

Extraction of global features



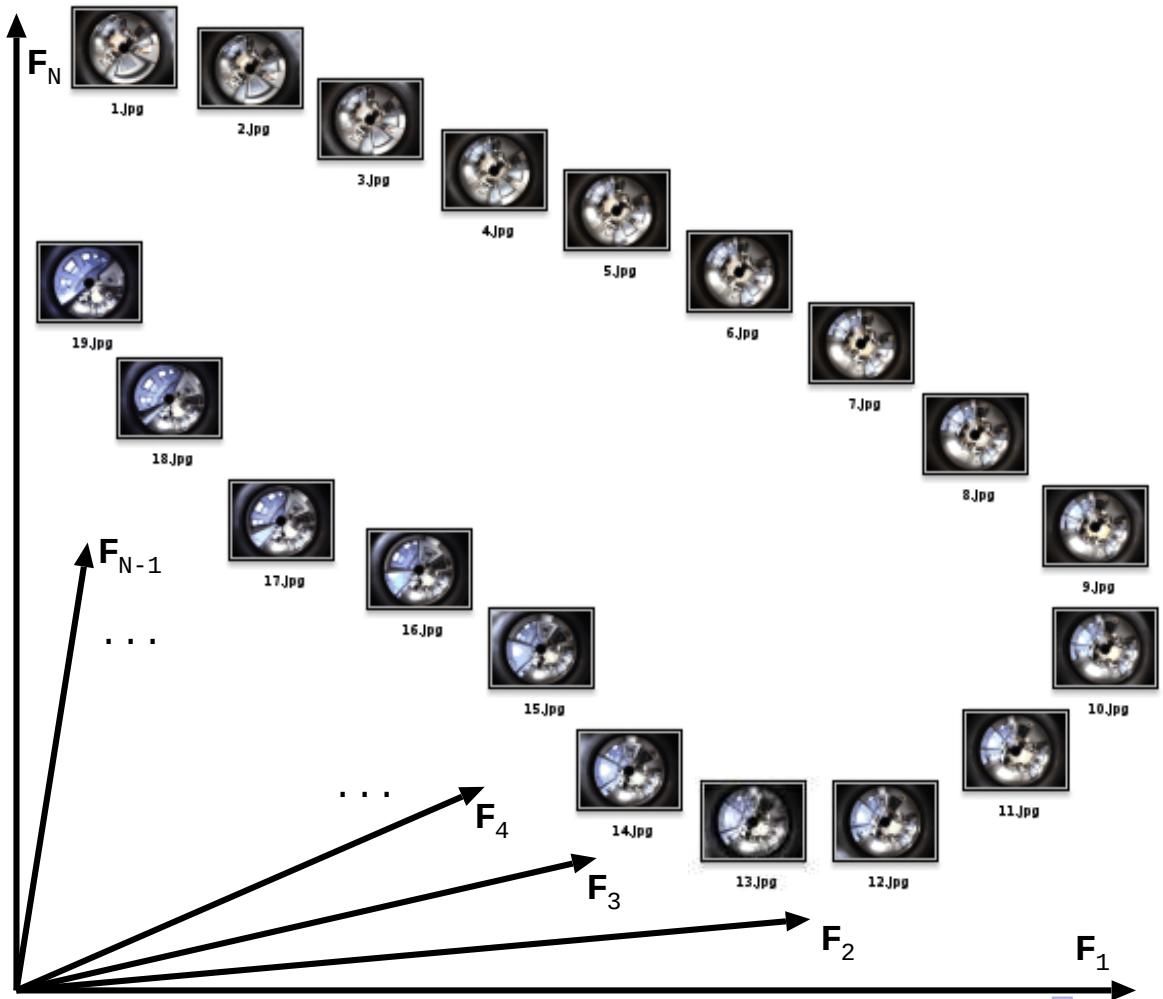
Training

Selection of features



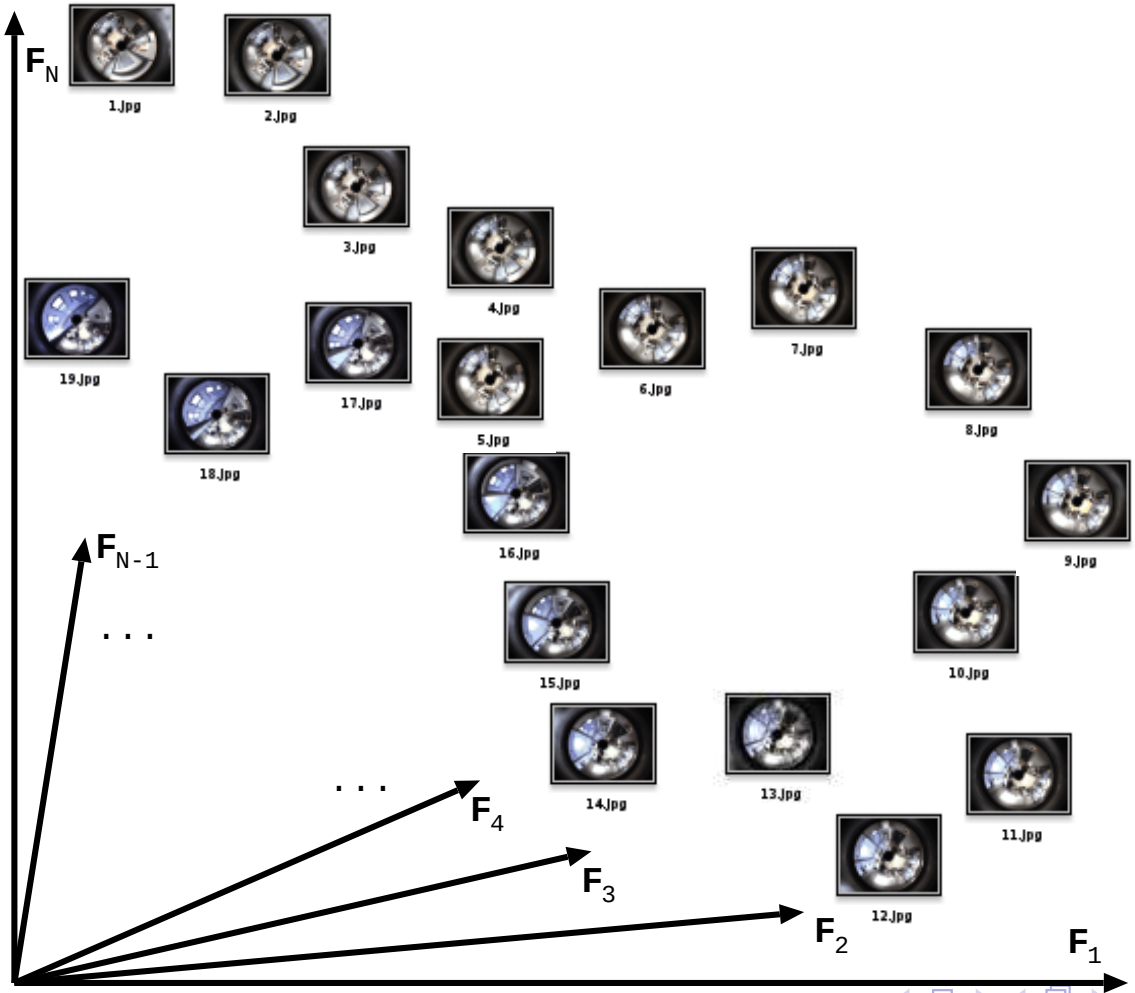
NNs in the feature space

The ideal case:



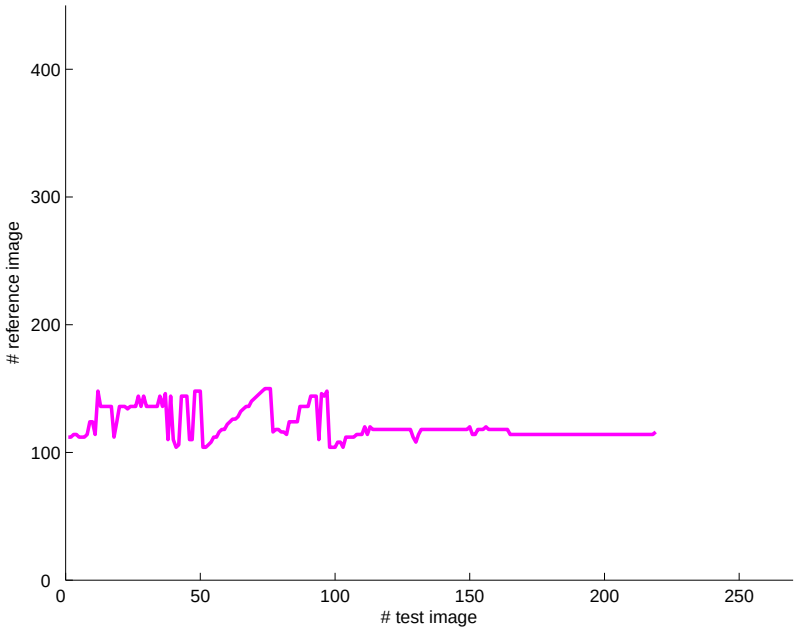
NNs in the feature space

The wrong case:

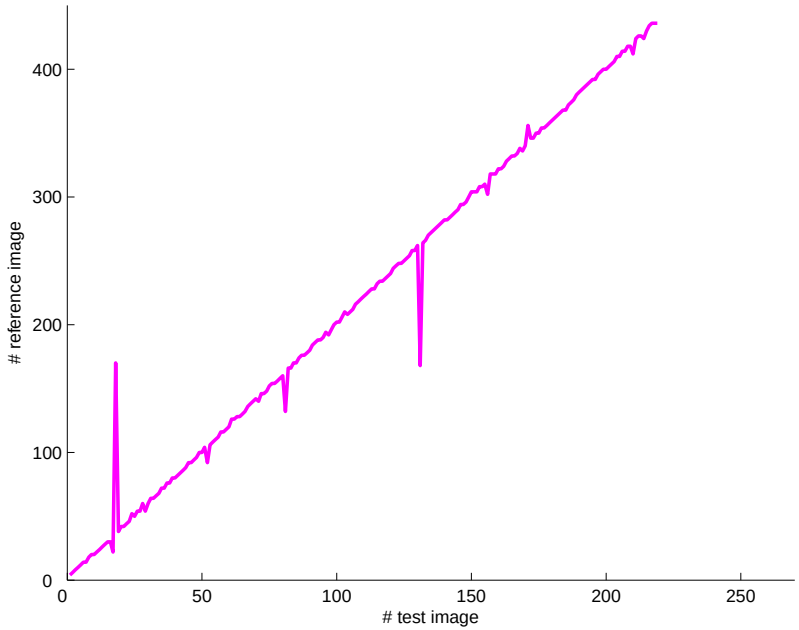


Response on the test set

- Classifier trained for images 104 – 148



- Classifier trained for images 001 – 440



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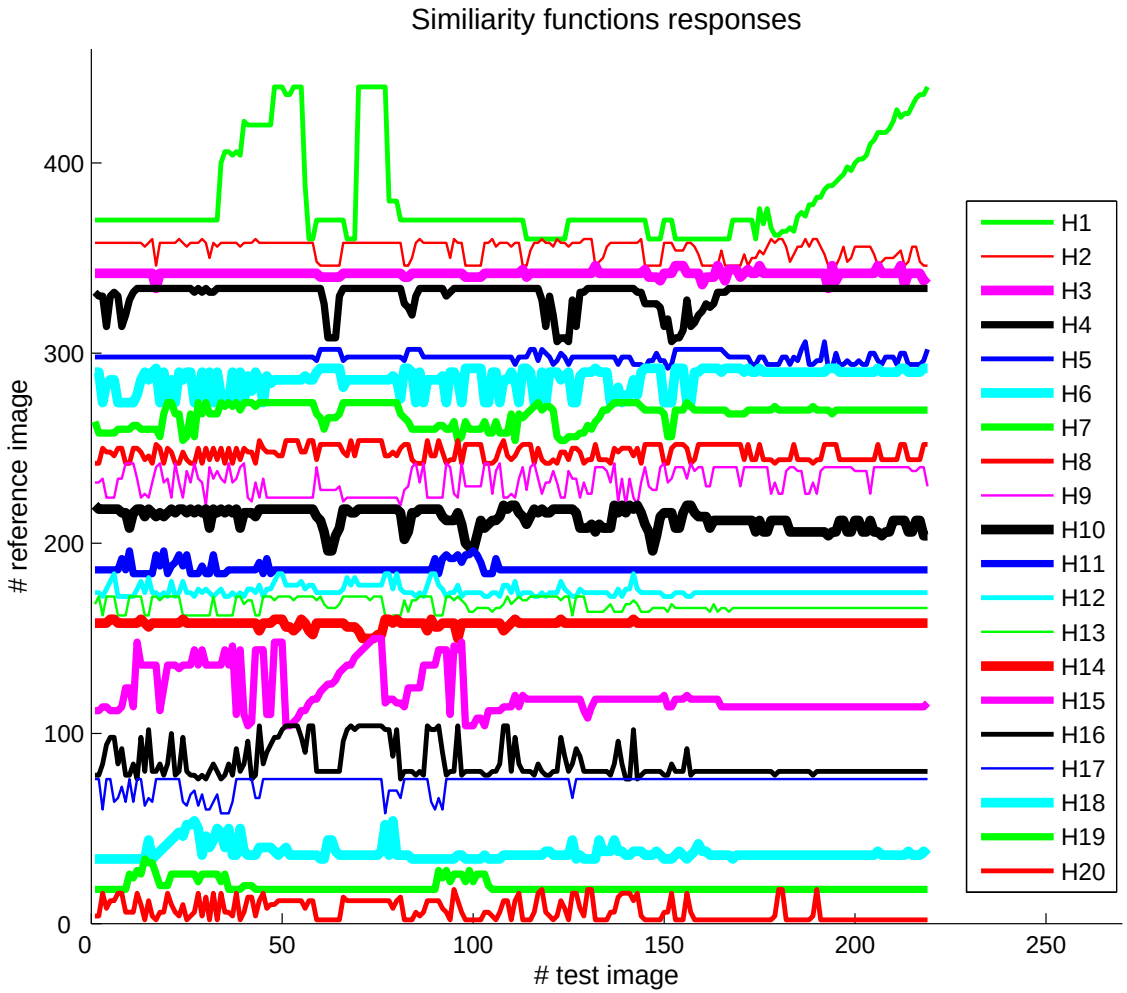
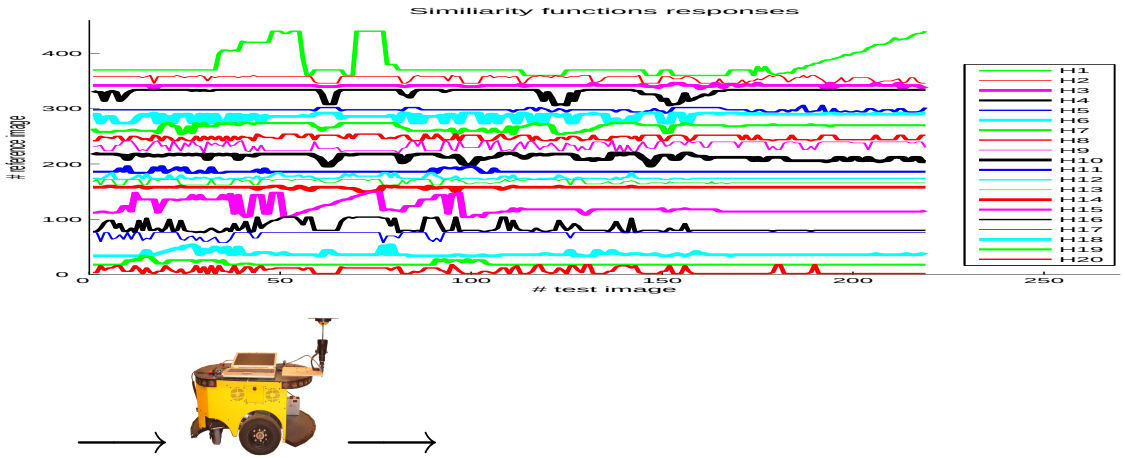
Several localization hypotheses



Several localization hypotheses

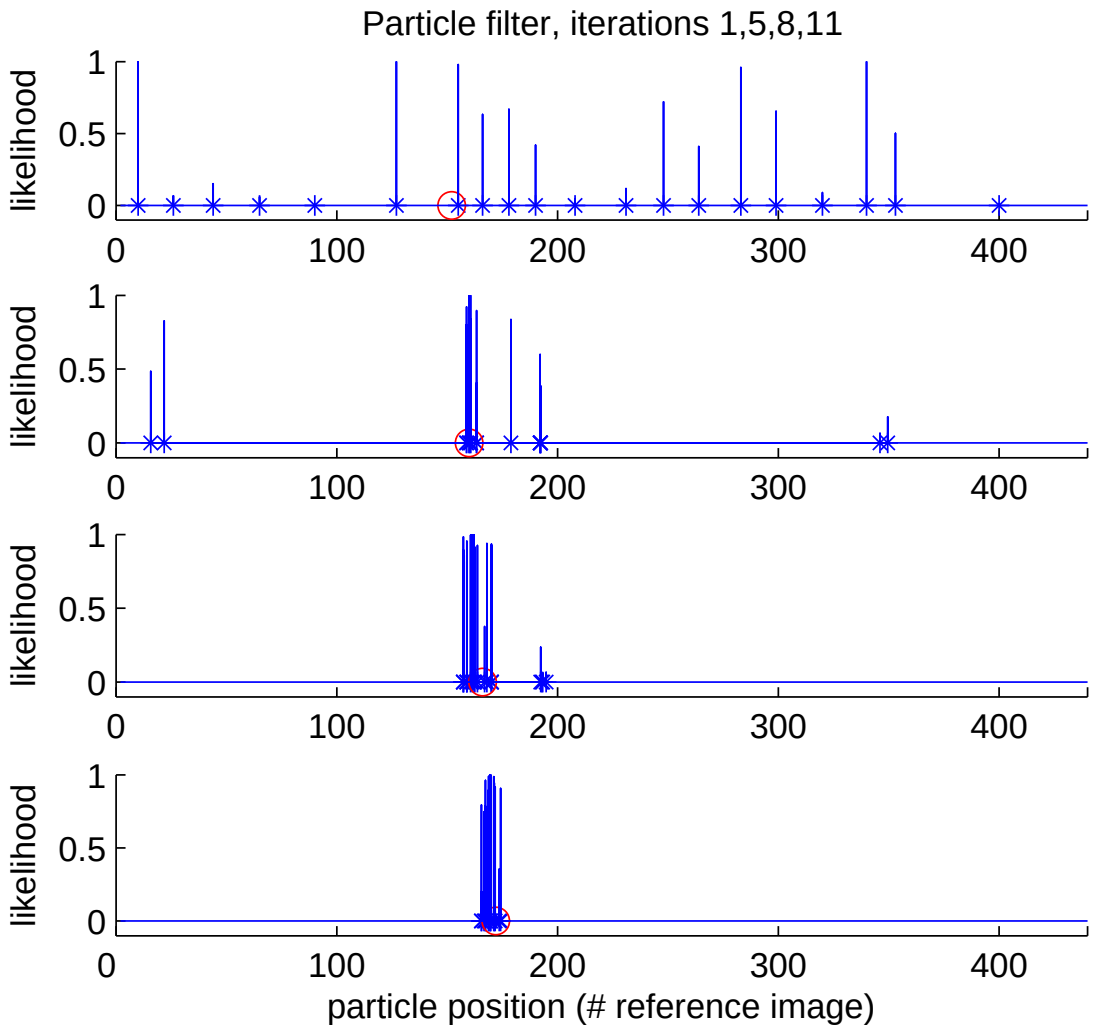


Monte Carlo Localization, given:

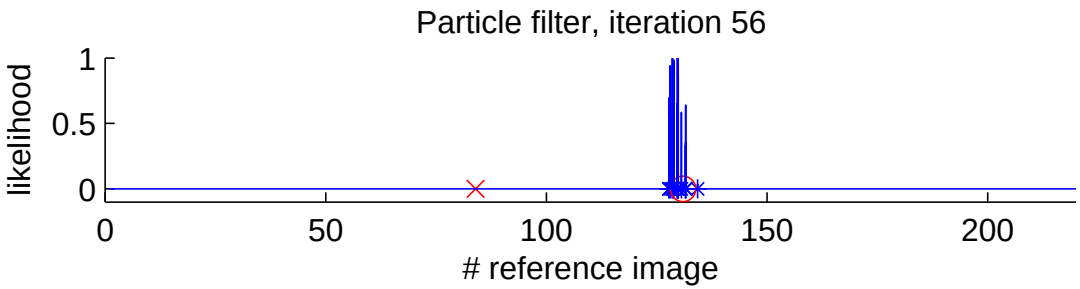
- A motion model
- A likelihood function for a given position

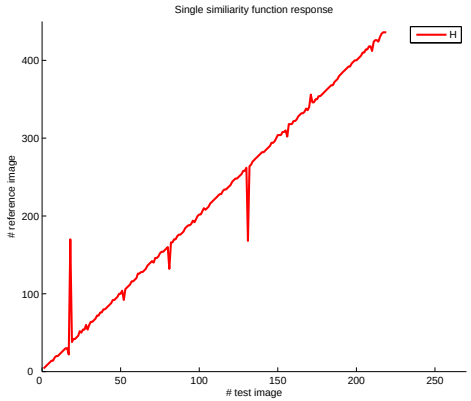
Outline

MCL algorithm for disambiguation



Single classifier





Outline

Conclusions

Visual localization approach

- Scalability
- Unsupervised IT-based partitioning
- Fast image recognition, $\approx$ 0.1sec
- Suitable for corridor-like scenarios

Future work

- Generalize to 2D scenarios

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