An Evaluation of Local Shape Descriptors in Probabilistic Volumetric Scenes

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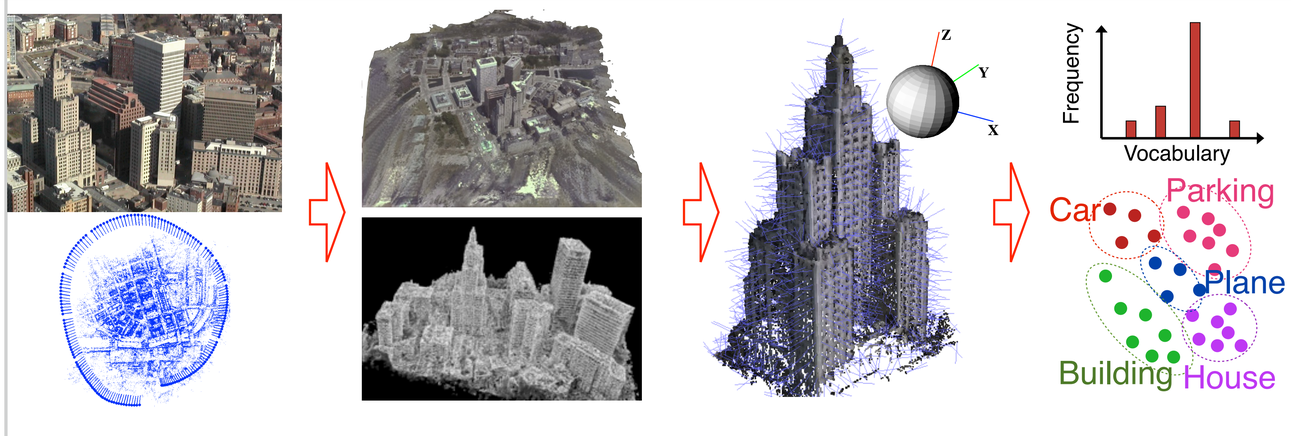
Introduction and Framework Overview

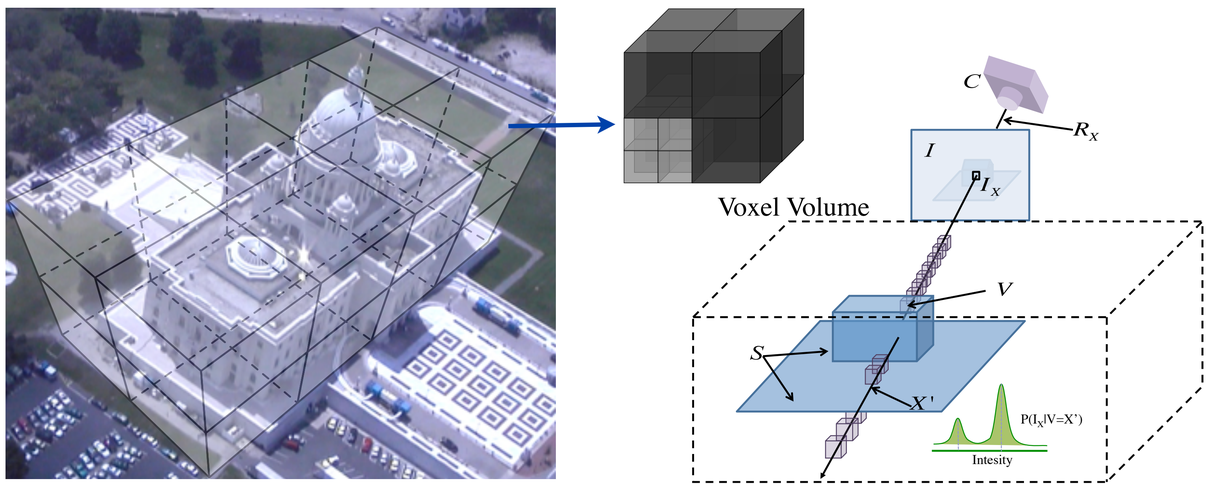
- Characterization of the Probabilistic Volumetric Models (PVM) as a new representation for 3-d scene understanding.
- The first evaluation of the performance of several local shape descriptors extracted from the PVM in terms of accuracy for object classification.
- Histogram-based descriptors are of particular interest as they are the most popular and most successful for many image indexing applications.
- The performance of many 3-d shape descriptors has been studied in point cloud data, but it is unclear that their descriptiveness and robustness to noise successfully extends to the diffuse surface probability distributions of the PVM.



Input Image and Camera Sequence | Probabilistic Volumetric Modeling | Shape Descriptor Computation | Bag of Words Categorization

Framework Details

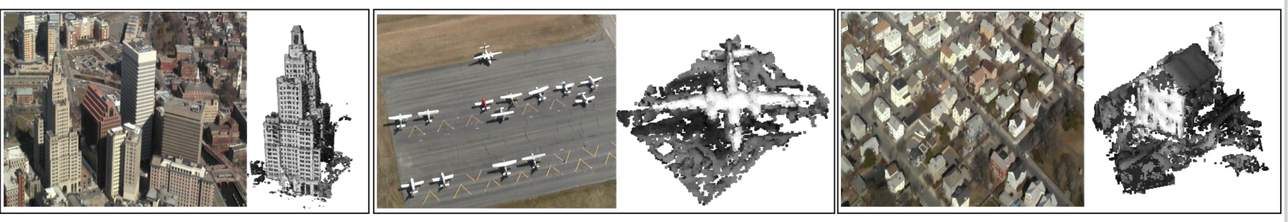
Probabilistic Volumetric Model



$$P^{N+1}(X \in S|I_x^{N+1}) = P^N(X \in S)\frac{p^N(I_x^{N+1}|X \in S)}{p^N(I_x^{N+1})}$$

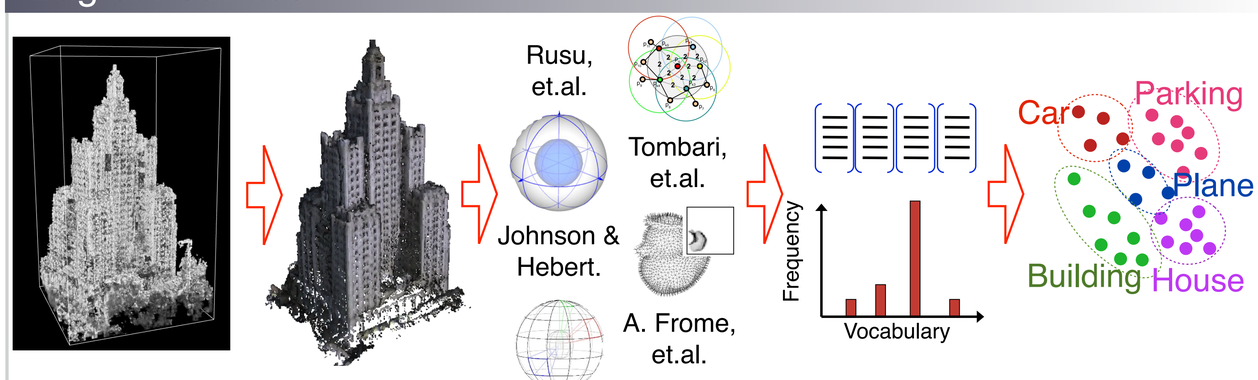
[Pollard and Mundy, 2007] [Crispell, Mundy and Taubin 2011] [Miller, Jain and Mundy 2011]

Sample Data



http://vision.lems.brown.edu/datasets/aerial-multiview

Bag of Features

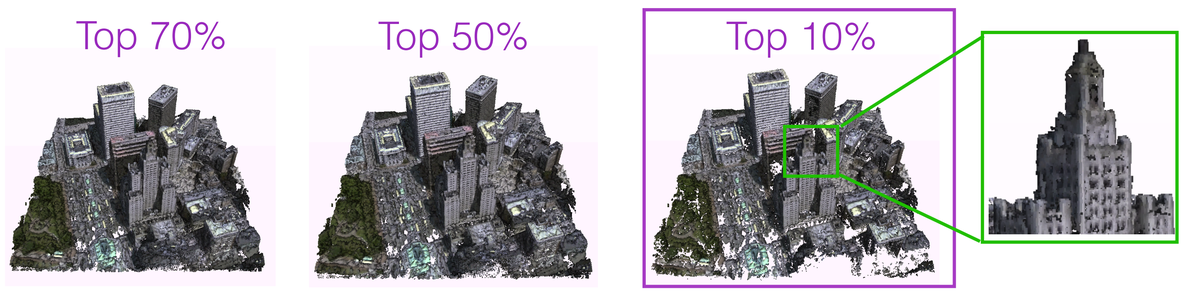


Input: PVM | Feature sampling: Dense, Max. *s(x)* | Descriptor: FPFH, SHOT, SI, SC | Vocabulary: K-means | Classifier: Naive Bayes, SVM, NN

Location Sampling

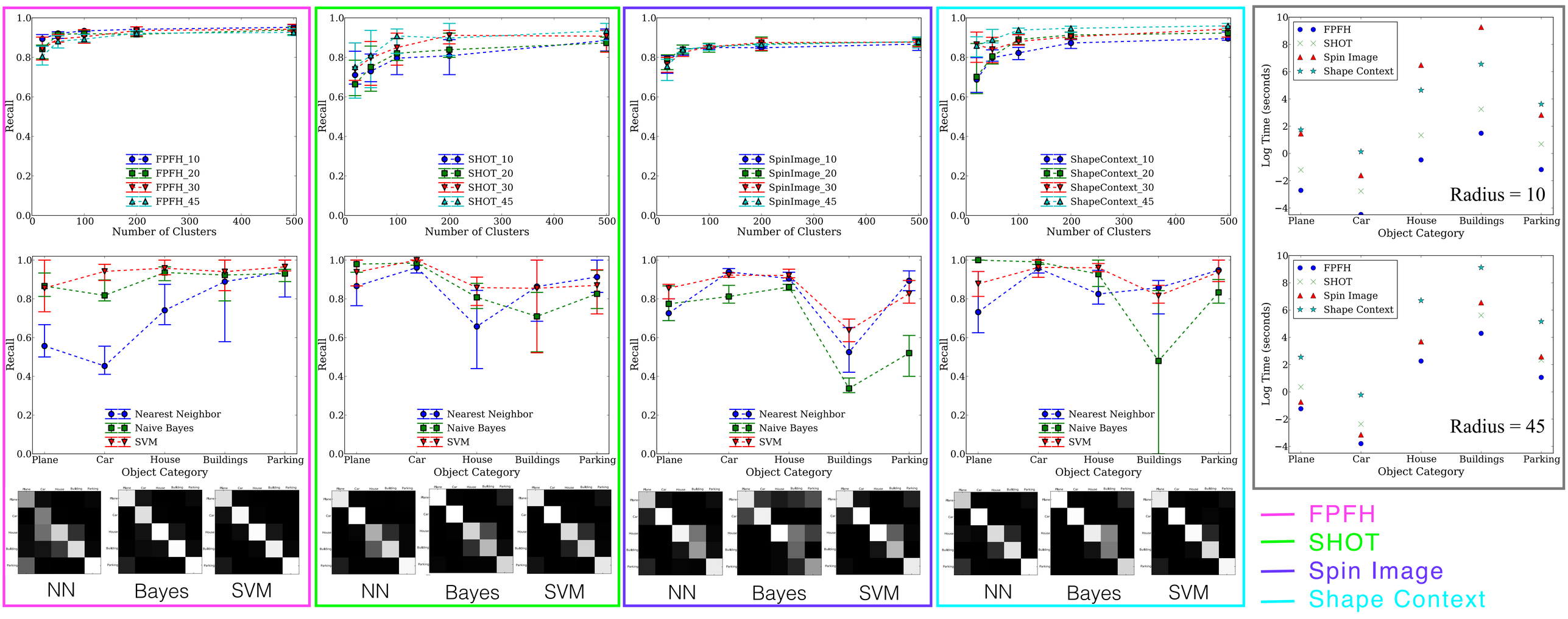
$$s(x) = \alpha(x) \times vis\_score(x) \times \|\nabla\alpha(x)\|$$

Probable Surfaces | Visible Surfaces | Stable Normals



Evaluation Results

- Top Row: Recall vs. K
- Middle Row: Recall vs. Category
- Bottom Row: Confusion Matrices
- Right Column: Average Running Time per Object



Conclusions

- FPFH obtained high recall while having the advantage of being compact and fast to compute.
- Spin Images under-performed, specially recognizing buildings.
- SVM was the more effective classifier.
- Distribution-based descriptors effectively characterize the shape information in the PVM for object categorization.