



# Multi-class Multi-scale Stacked Sequential Learning

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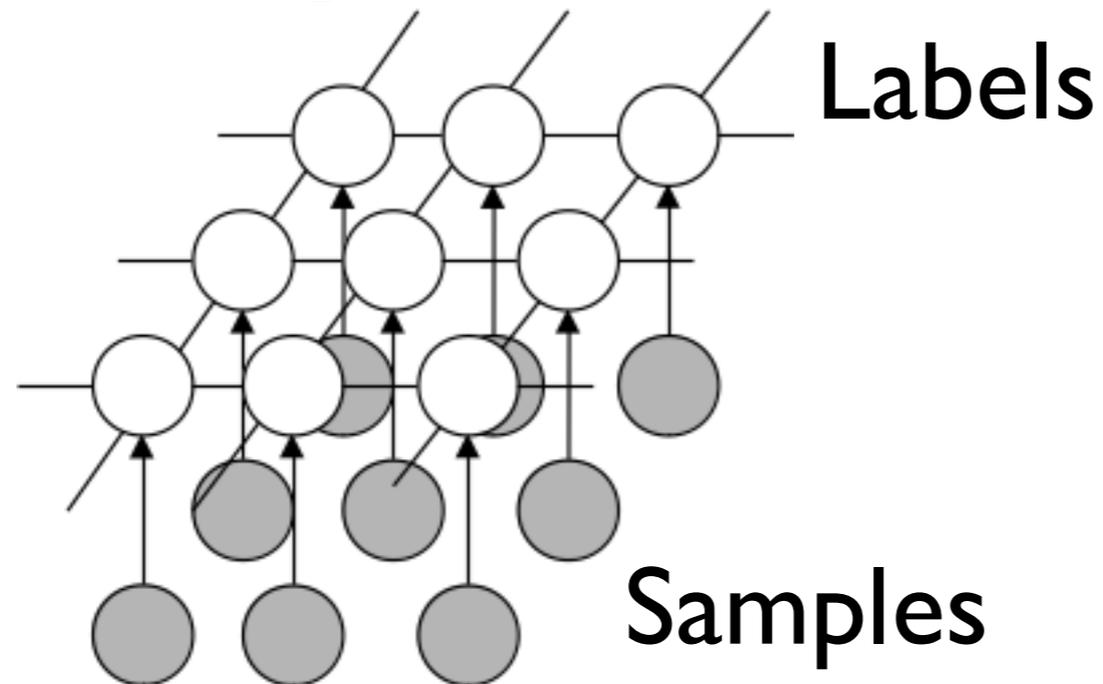
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# Outline

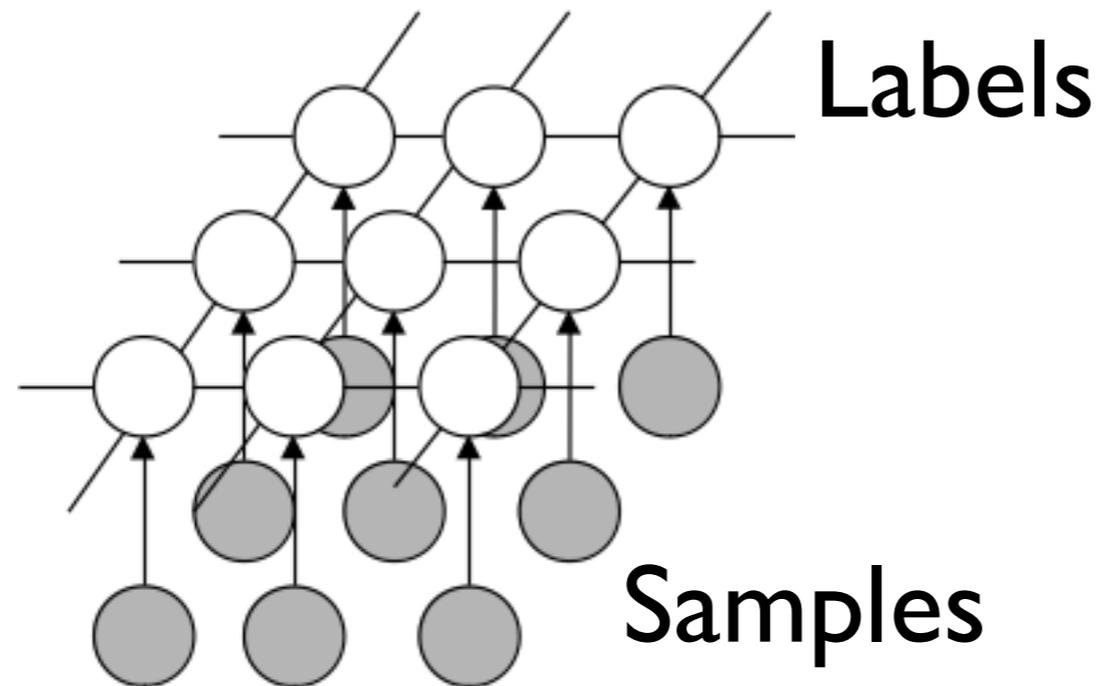
- Background:
  - Sequential Learning problem
  - Multi-scale Stacked Sequential Learning
- Multi-Class Multi-Scale Stacked Sequential Learning
- Experiments and results
- Conclusions and Future Work.

# Sequential Learning is...



- Classification Task.
- Neighboring labels have some kind of relationship,
- but neighboring samples does not provide any information about this relationship.

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## Example Application: Object classification inside images:

Each pixel is a sample. Each sample belongs to an object.

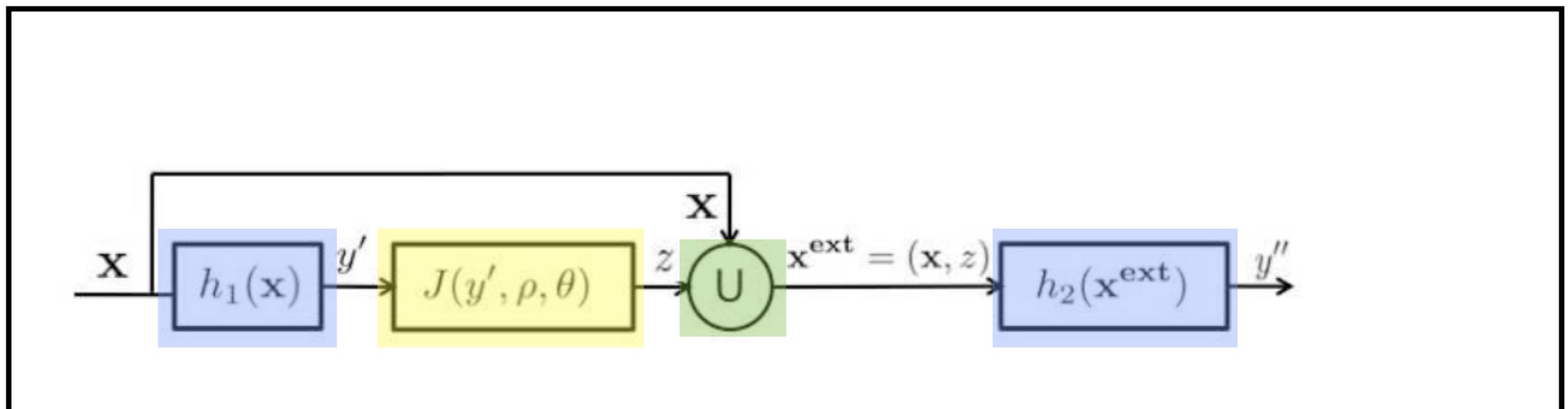
Exist a spatial relationship between labels of neighboring samples.



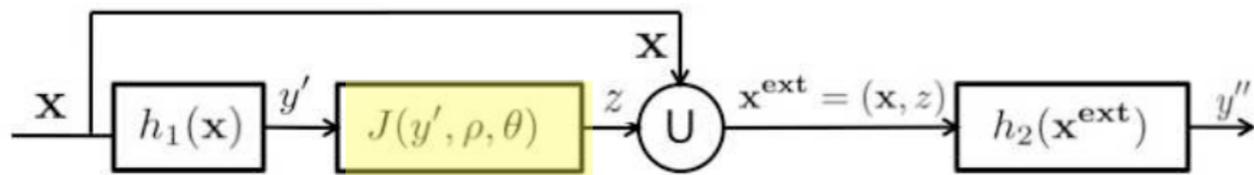
How to exploit relationship between labels for improving classification?

# Stacked Sequential Learning Generalization

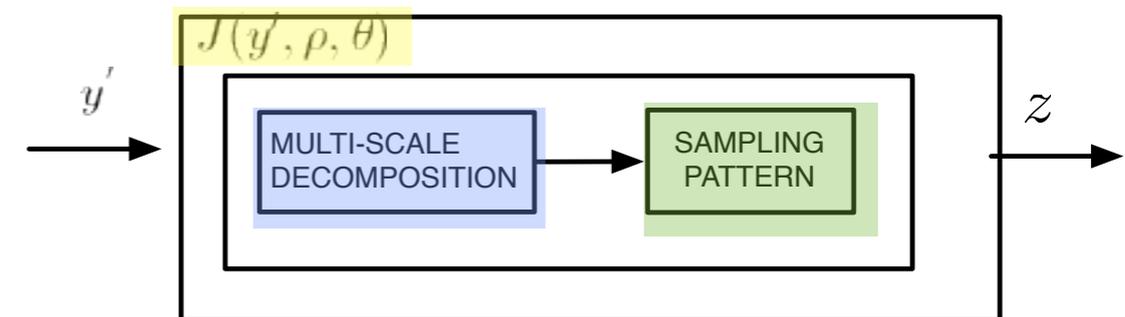
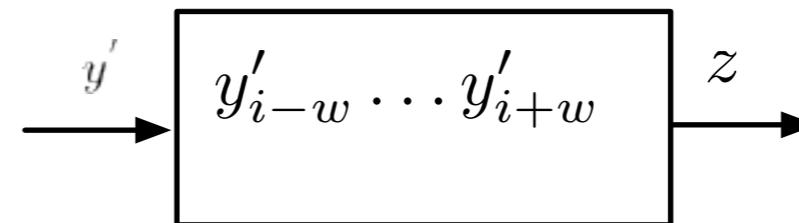
- Stacked Learning scheme of 2 classifier.
- Neighborhood relationship function.
- Extended data set. Combine the input space with a vector of extended features.



# Neighborhood relationship function

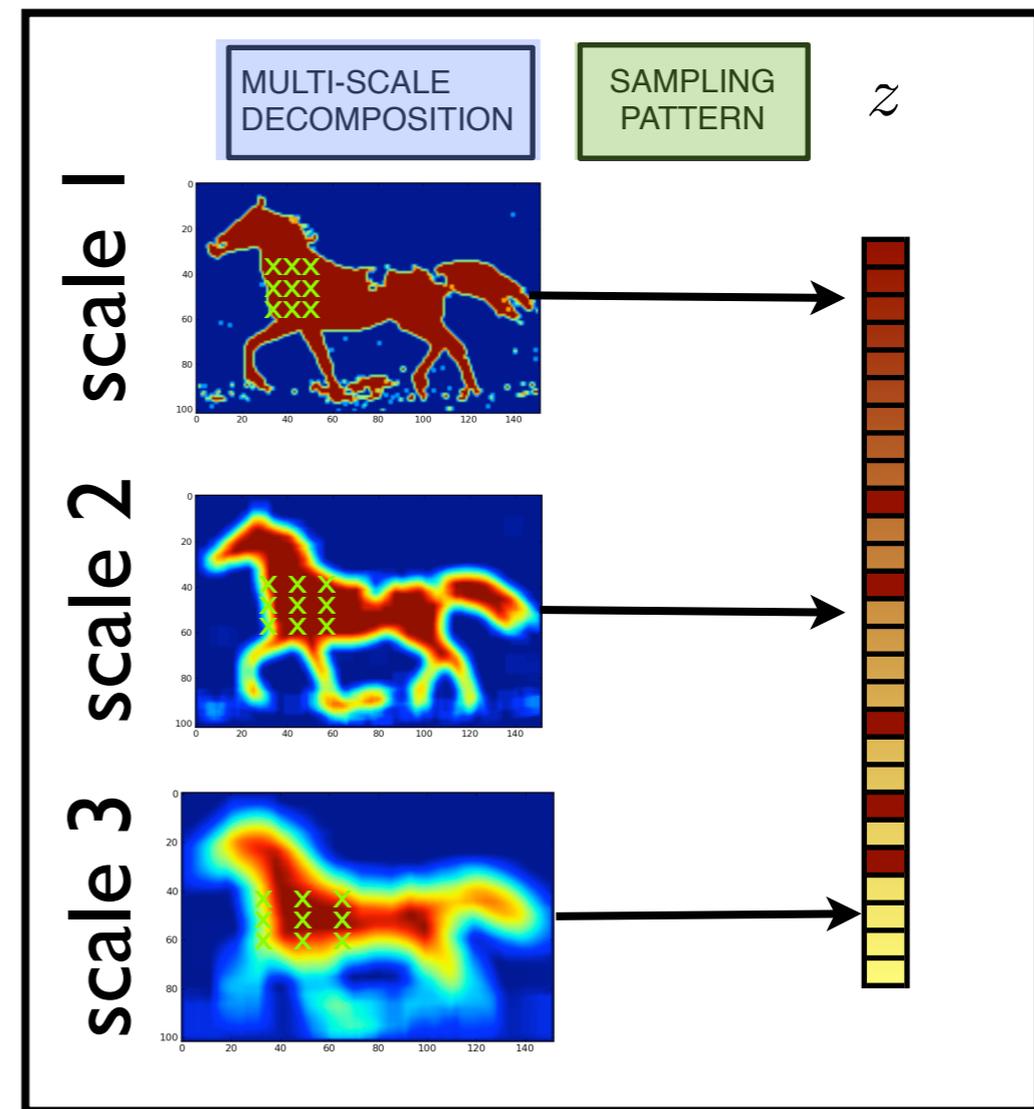
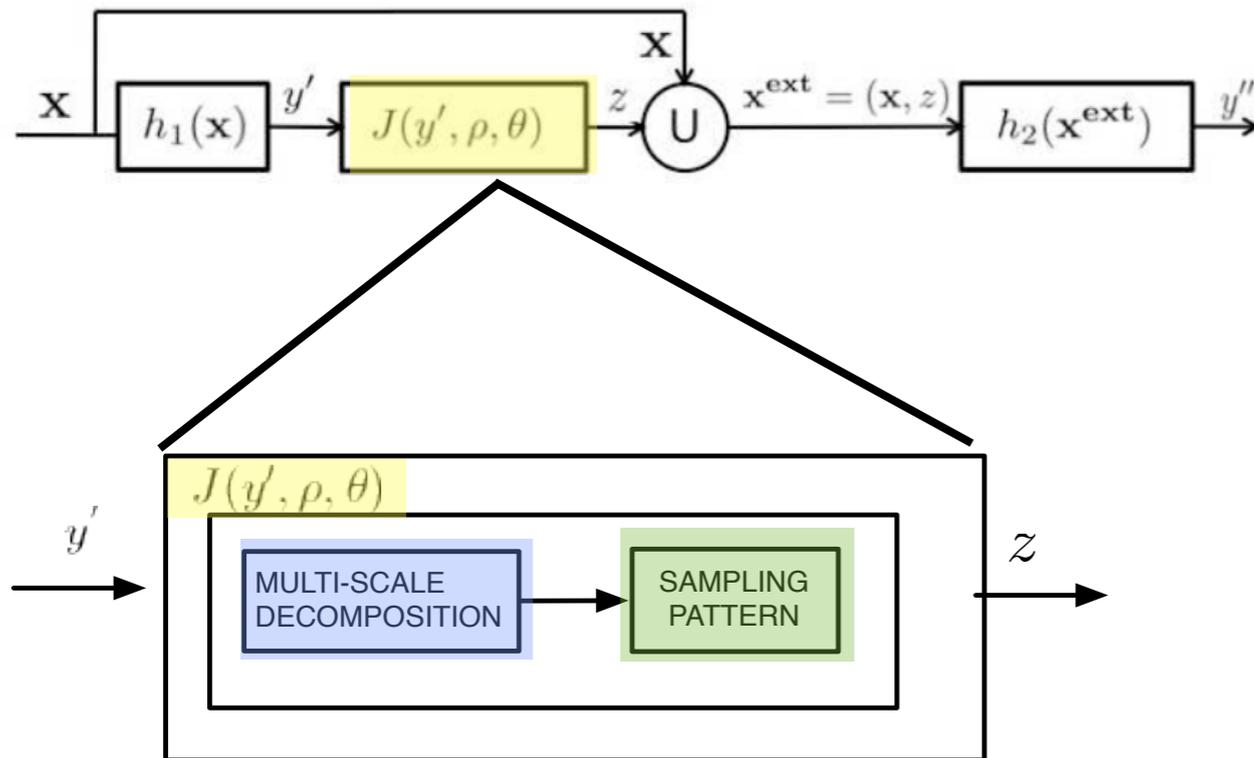


- Sliding Windows.
- Multi-scale decomposition using Gaussian Filters. (1)
- Set of reduced features able to capture long-distance relationships.



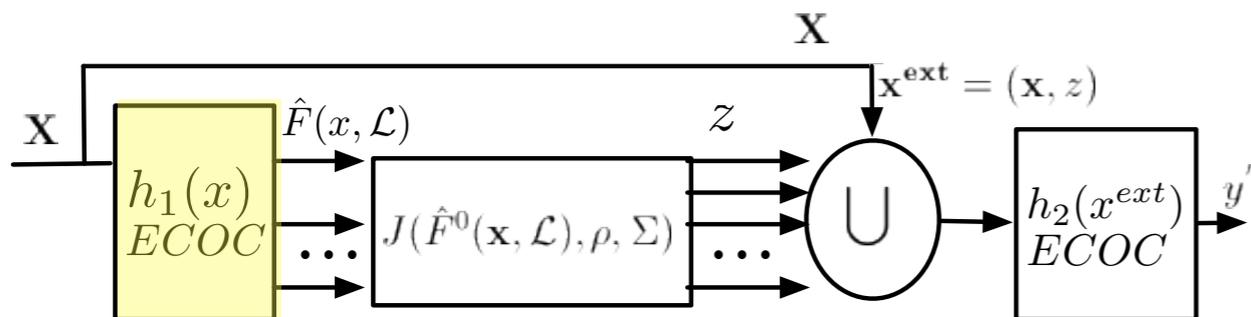
(1) C. Gatta, E. Puertas, O. Pujol, Multi-scale stacked sequential learning. Pattern Recognition (2011).

# Multi-Scale Stacked Sequential Learning

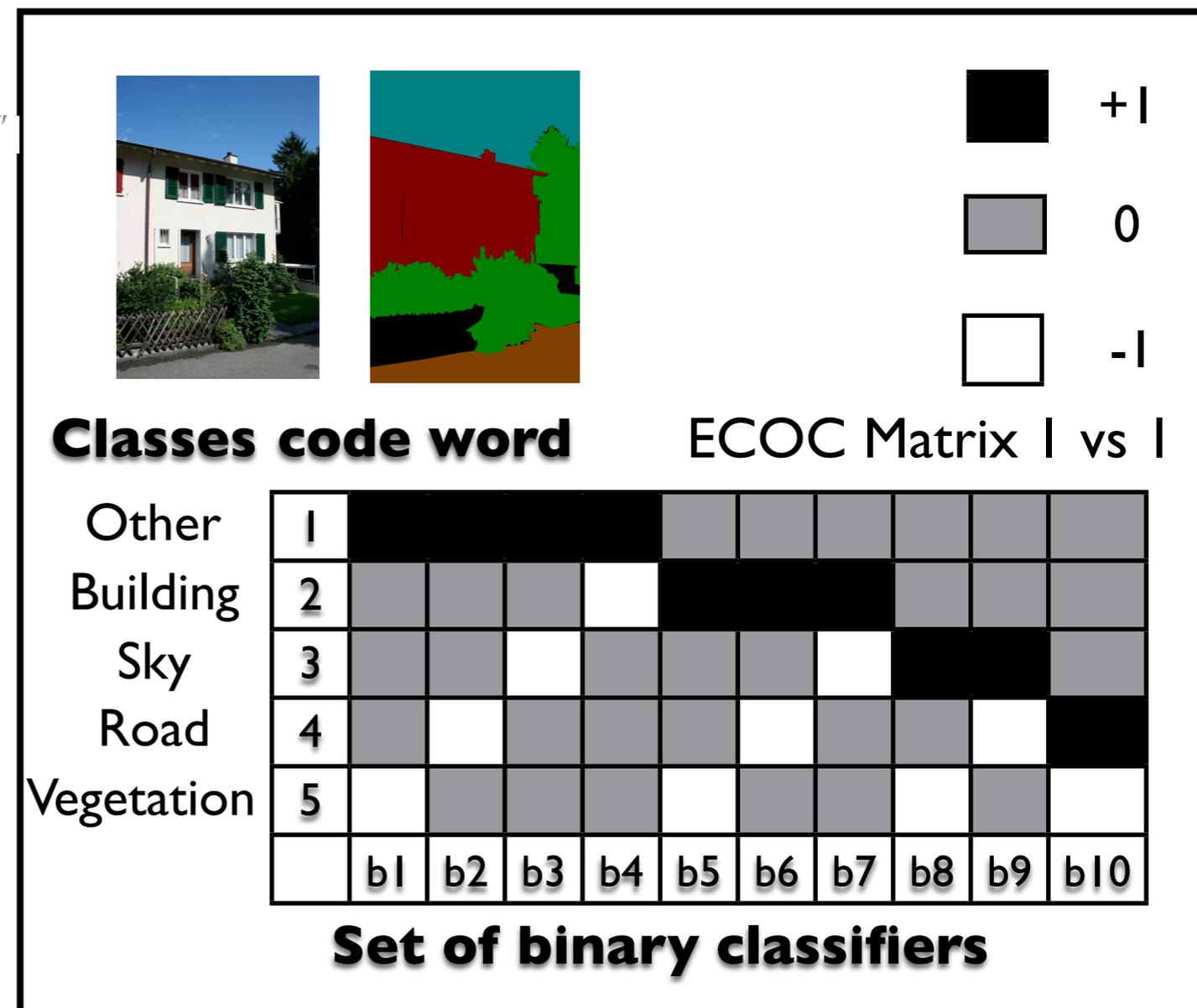


size:  $(2w + 1)^d \times |\Sigma|$

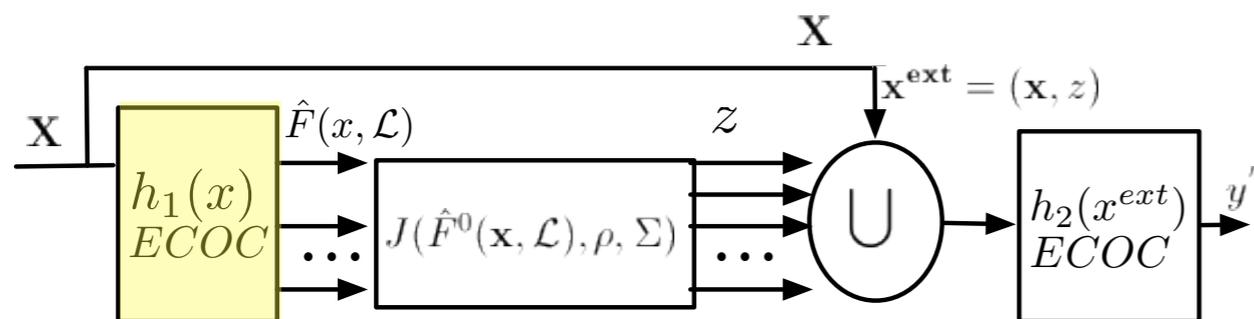
# Multi-Class Multi-Scale Stacked Sequential Learning



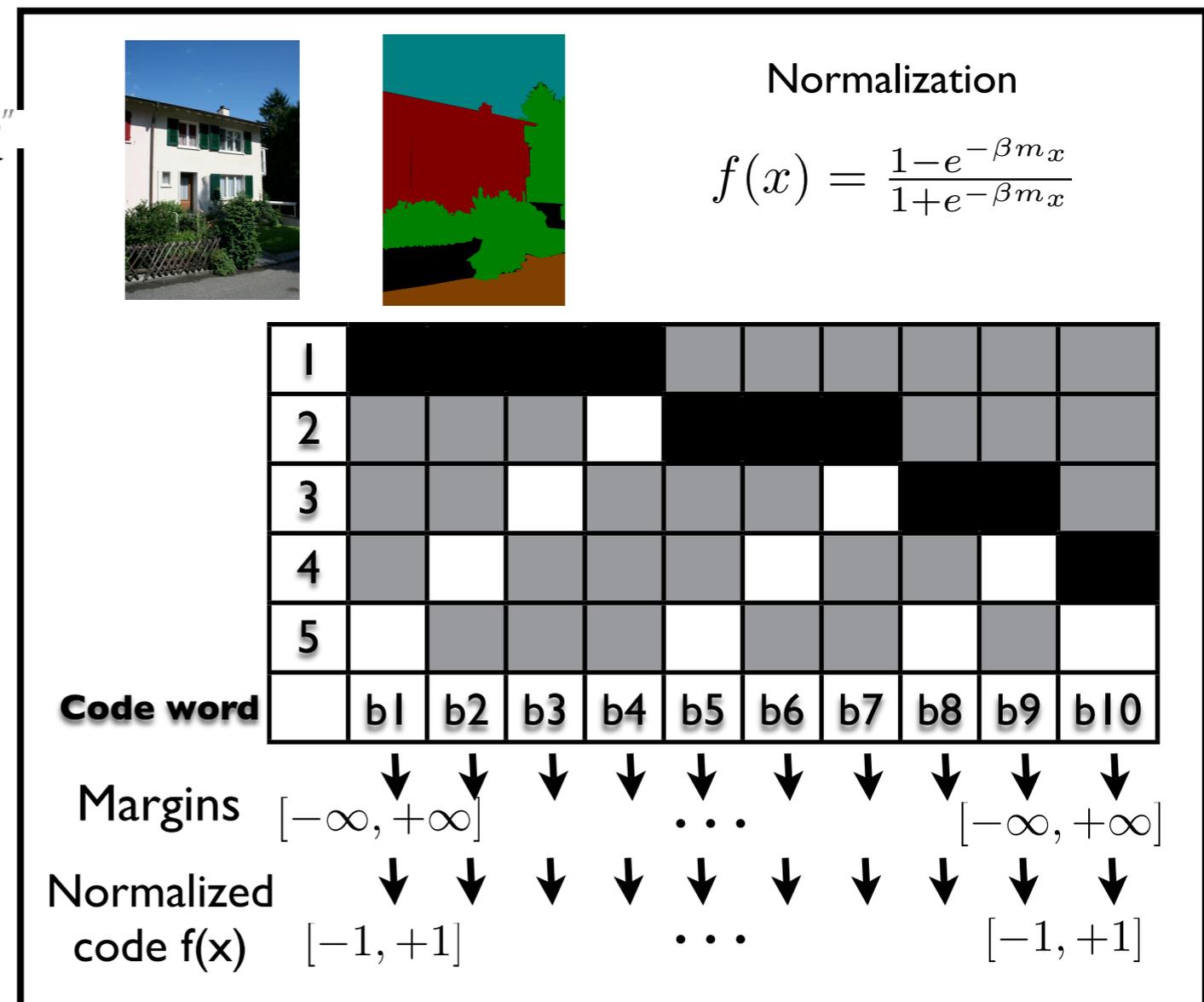
1. Multi-class classifiers using Adaboost + ECOC.
2. Use Adaboost margins as confidence values.
3. Confidence map for each class.
4. Multi-scale decomposition of each Confidence map.



# Multi-Class Multi-Scale Stacked Sequential Learning

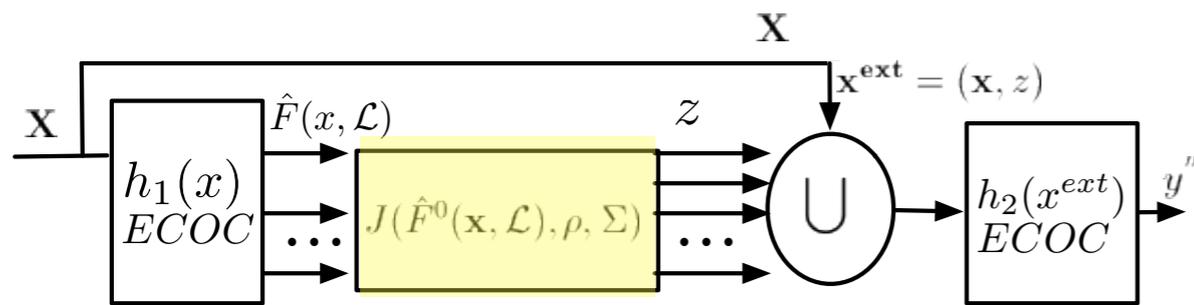


1. Multi-class classifiers using Adaboost + ECOC.
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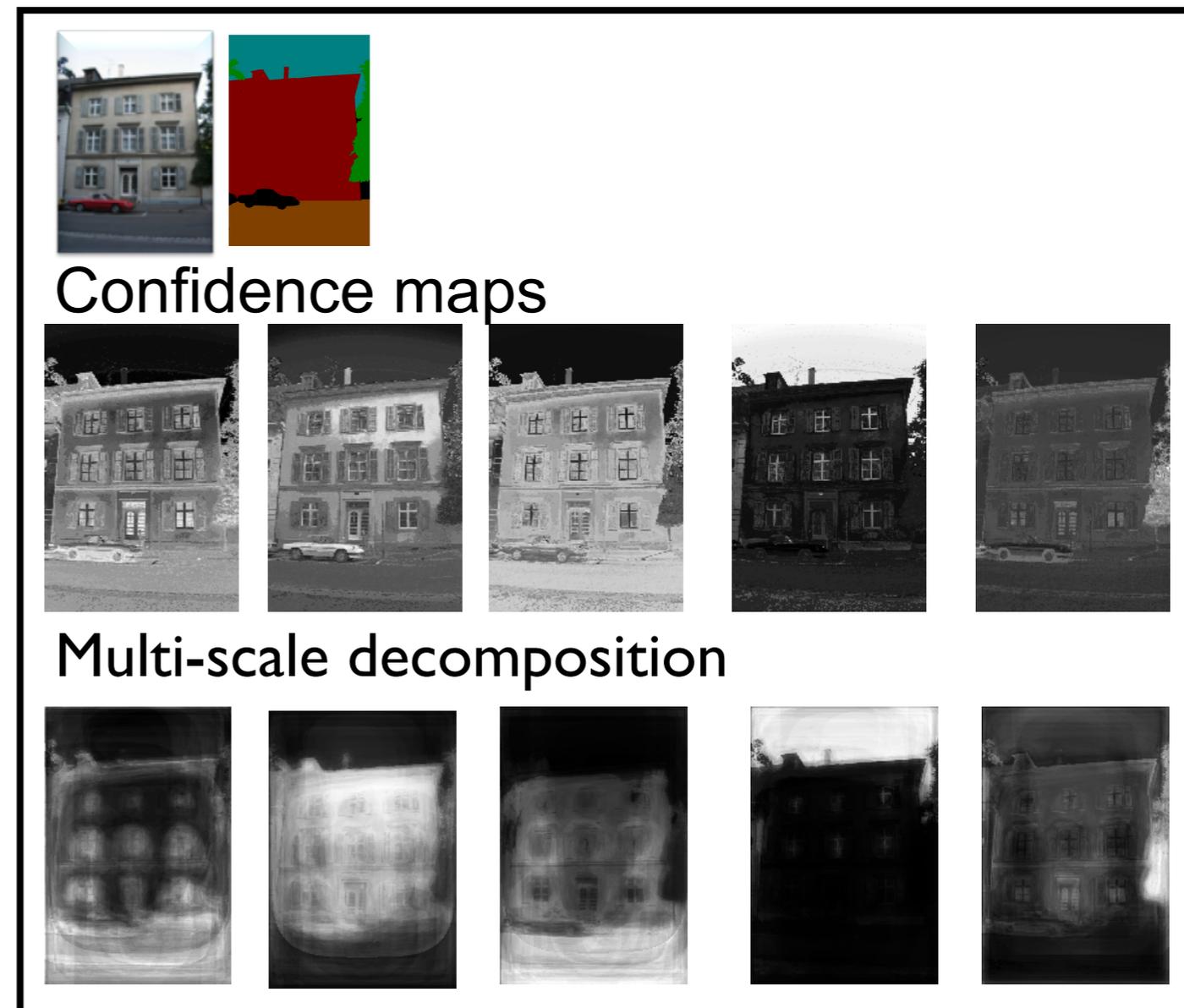




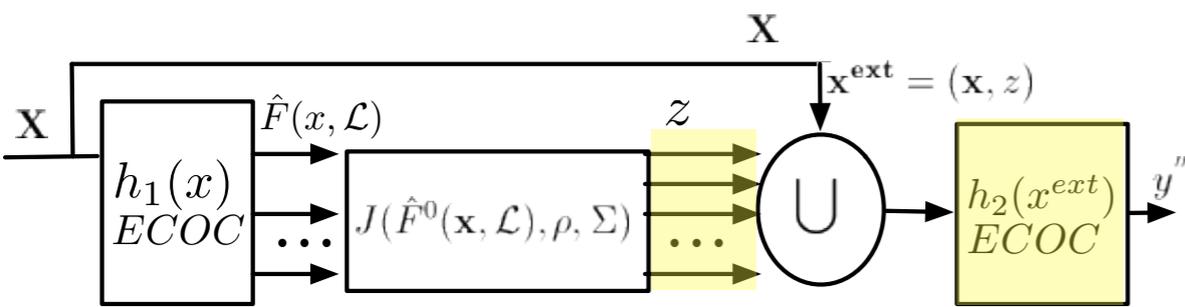
# Multi-Class Multi-Scale Stacked Sequential Learning



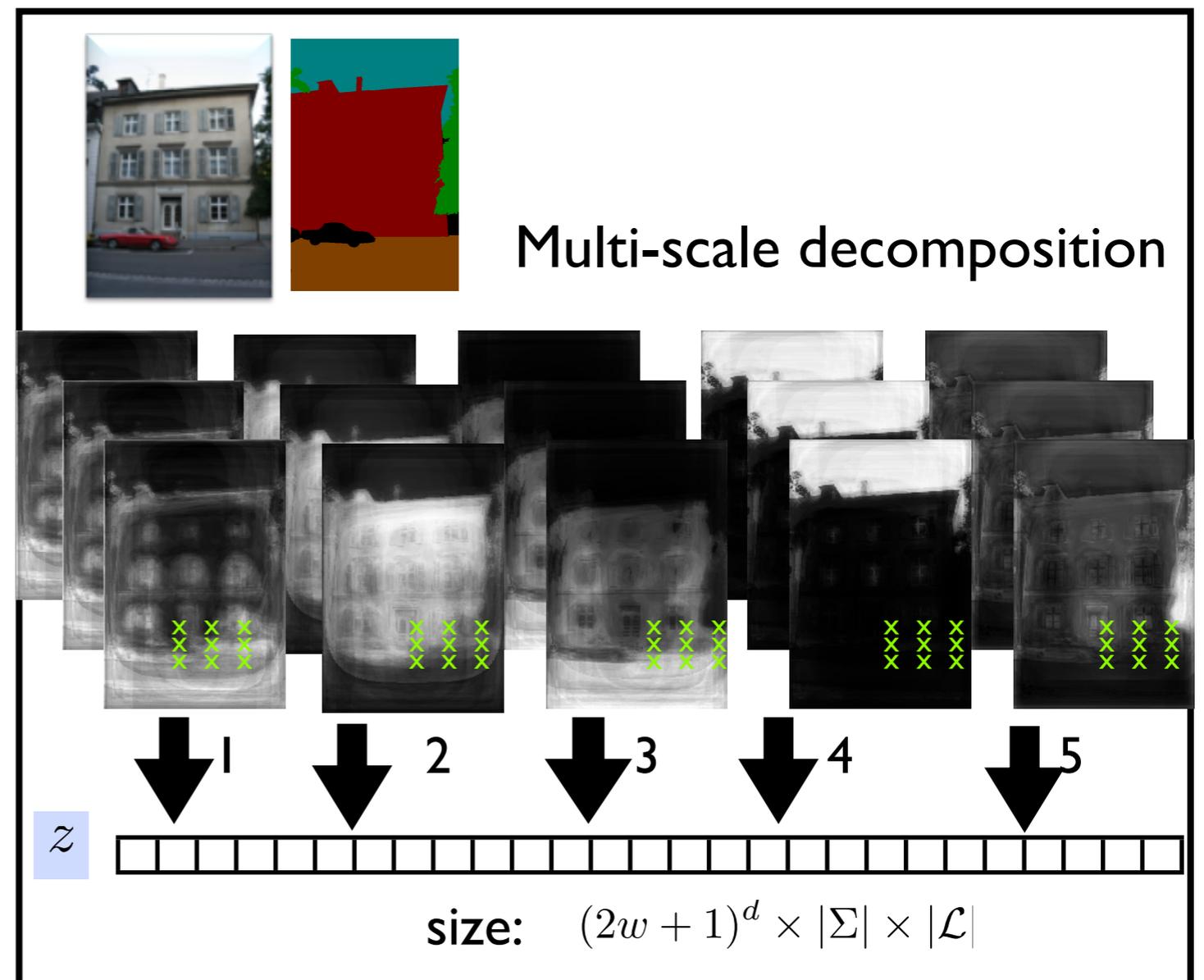
1. Multi-class classifiers using Adaboost + ECOC.
2. Use Adaboost margins as confidence values.
3. Confidence map for each class, from ECOC decoding
4. **Multi-scale decomposition of each Confidence map**



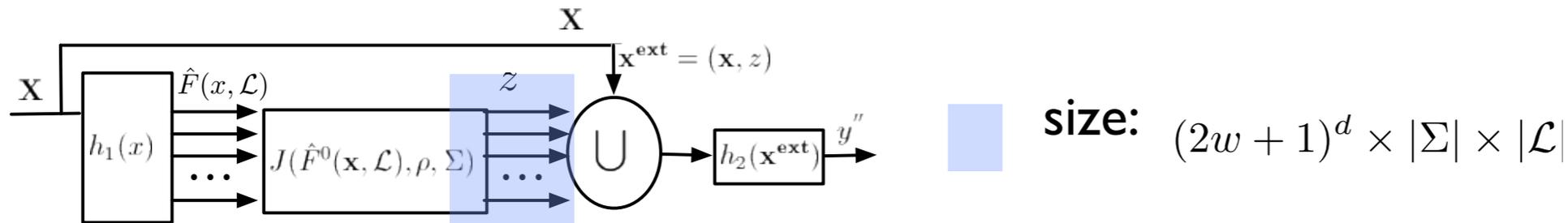
# Multi-Class Multi-Scale Stacked Sequential Learning



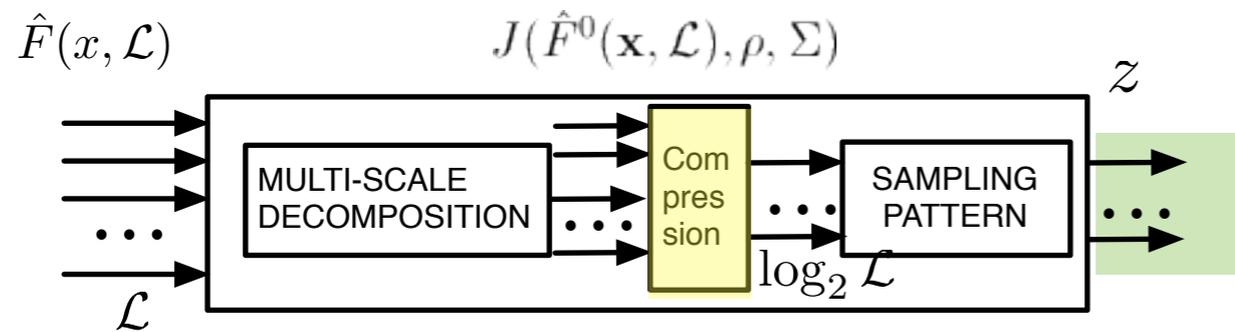
## 5. Sampling and vector of extended features formation.



# Drawback: The increase of Extended Features



## Extended data set grouping approach coding

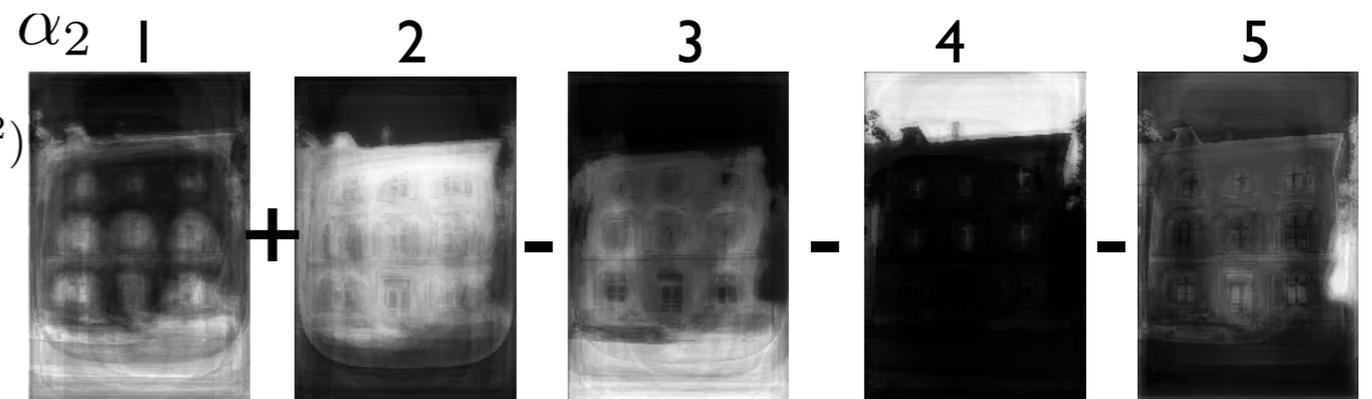


- 1 000
- 2 001
- 3 011
- 4 010
- 5 110

Compression Strategy:

$$\mathcal{F}^{s_j}(\{P^1, P^2\})_\alpha = \sum_i \hat{F}^{s_j}(\mathbf{x}, \lambda_i \in P^1) - \sum_i \hat{F}^{s_j}(\mathbf{x}, \lambda_i \in P^2)$$

size:  $(2w + 1)^d \times |\Sigma| \times \lceil \log_2 |\mathcal{L}| \rceil$



# Experimental settings

- Etrims 5 and 9 classes.
- 4 and 8 objects annotated per image.
- Simple Features (RGB)
- 6-folds, 50 train, 10 test.

60 annotated building images.



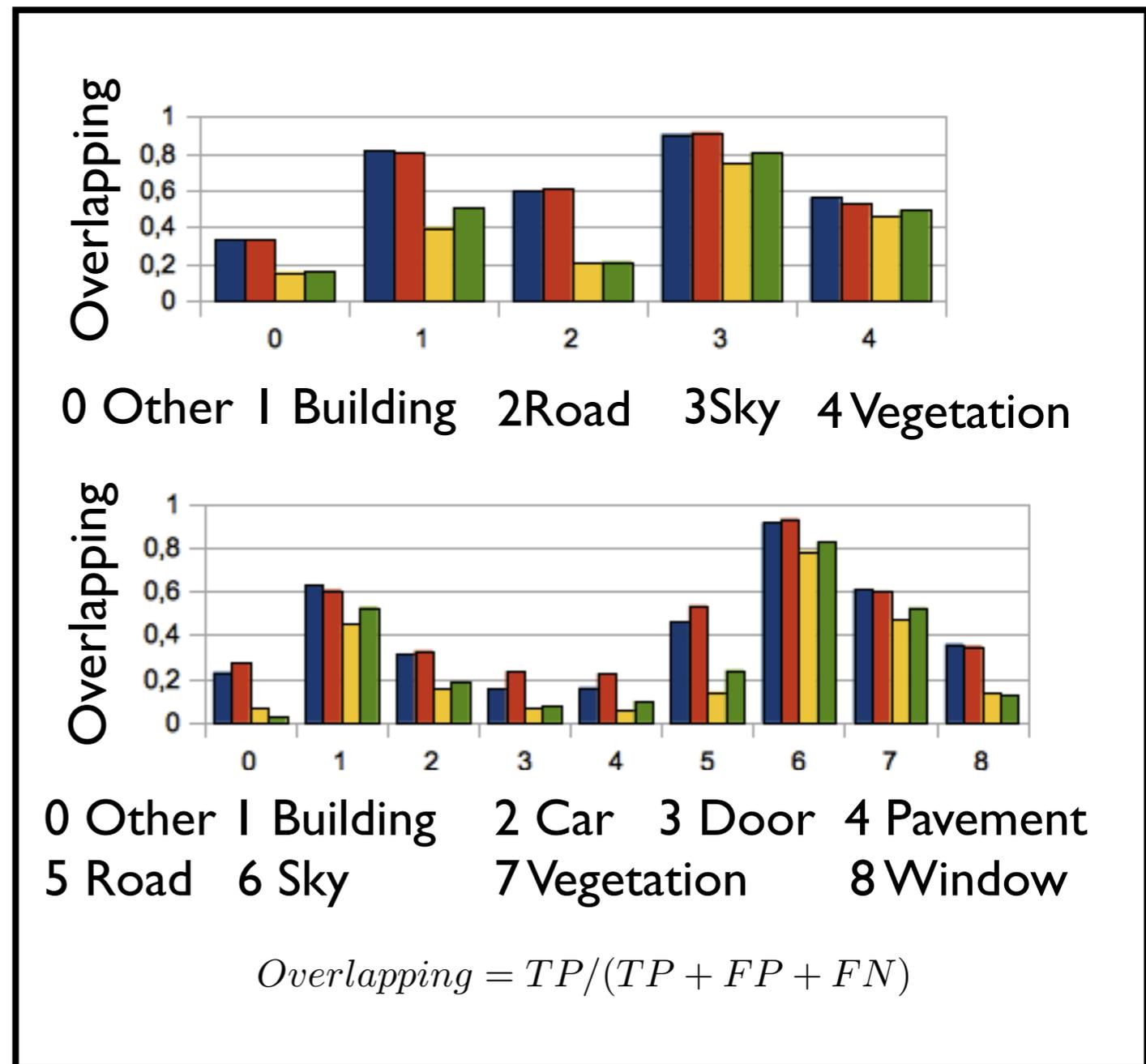
4-objects 8-objects



# Results

## Methods:

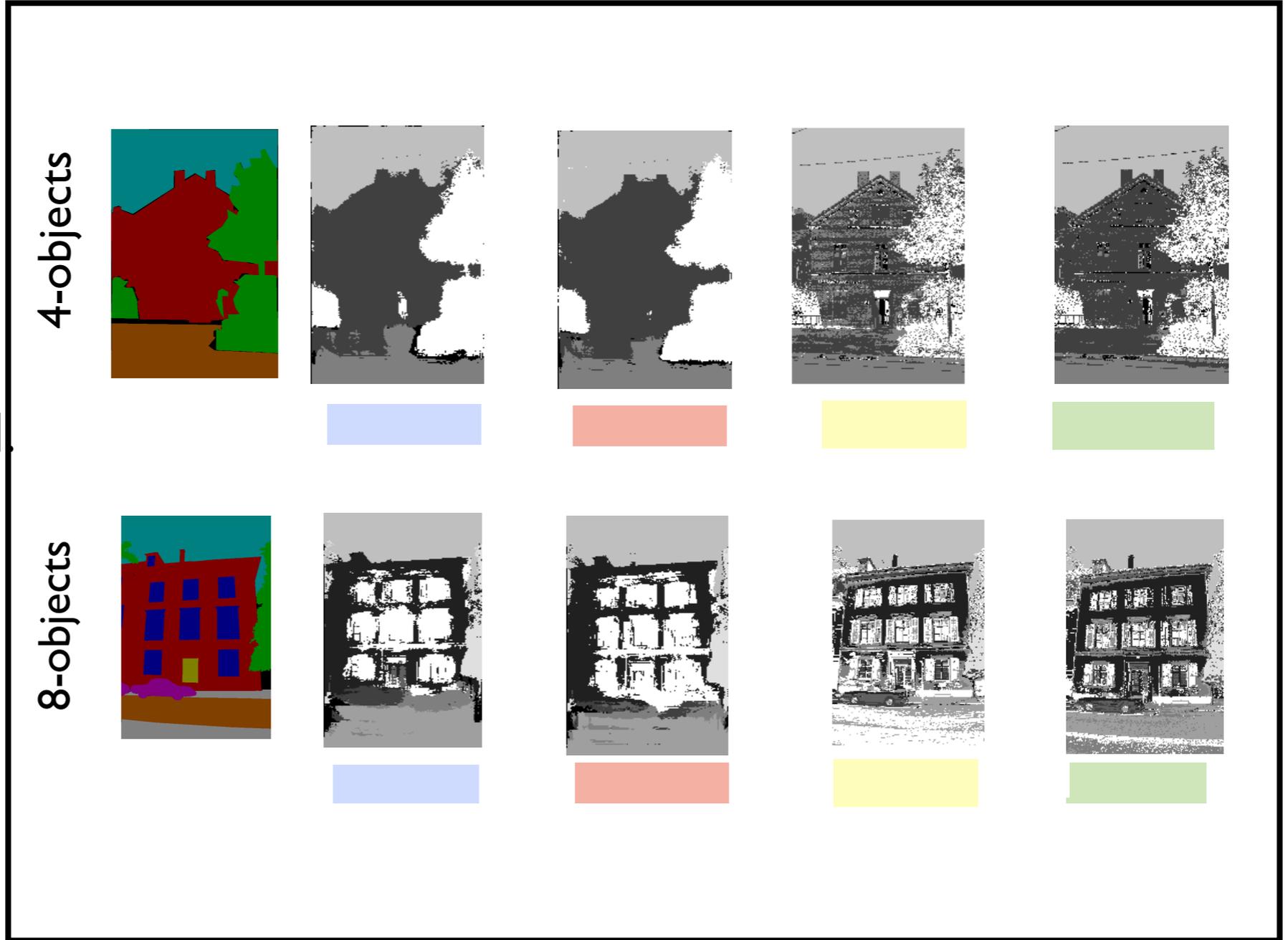
-  MMSSL standard,
-  MMSSL compressed.
-  Adaboost + graph cut alfa expansion.
-  Adaboost





# Results

- Methods:**
-  MMSSL standard,
  -  MMSSL compressed
  -  Adaboost + graph cut alfa expansion.
  -  Adaboost





# Conclusions

- **Multi-class** extension of Multi-scale stacked sequential learning
- **Confidence maps** obtained from binary classifiers and ECOC framework.
- **Compression strategy** for reducing the number of extended set features.



# Future Work

- Study alternative neighborhood relationship functions
- Find problem dependent compression coding strategies for the confidence maps
- Study compression strategies for neighborhood samplings and scales.

**Thanks!**