Towards VOC2010 Object Classification Challenge

Boosting Classification with Exclusive Context

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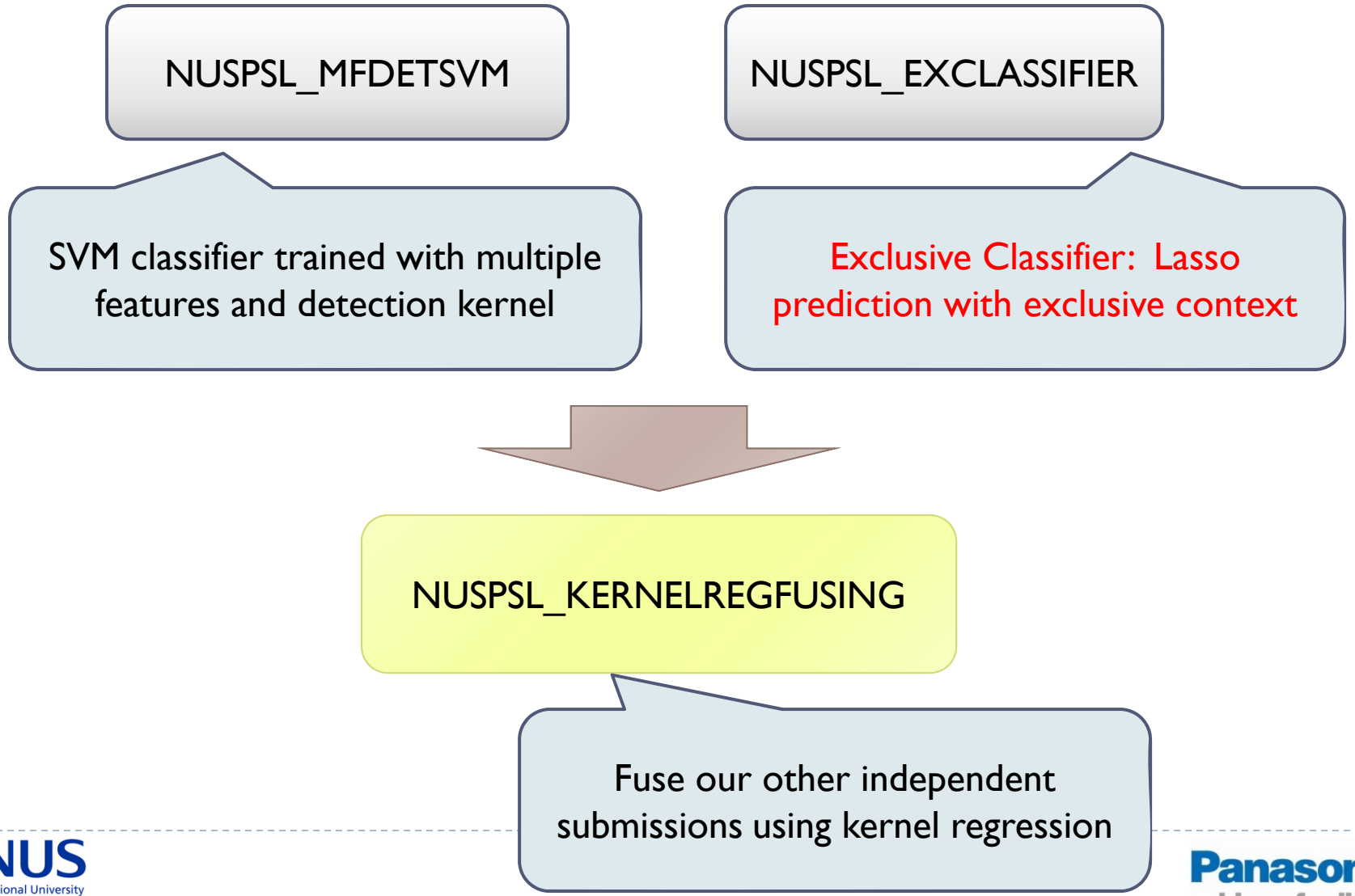
NUS-PSL Submissions



Framework

Visual Features

Low level features

+

Patch level features

BoW representations (Holistic)

Detection Results (Localized)

Max pooling

Kernel

Nonlinear Kernel

+

Linear Kernel

Classification

SVM

Regression

Lasso prediction with Exclusive Context

Post Processing

Kernel Regression

Confidence Refinement with Exclusive prior

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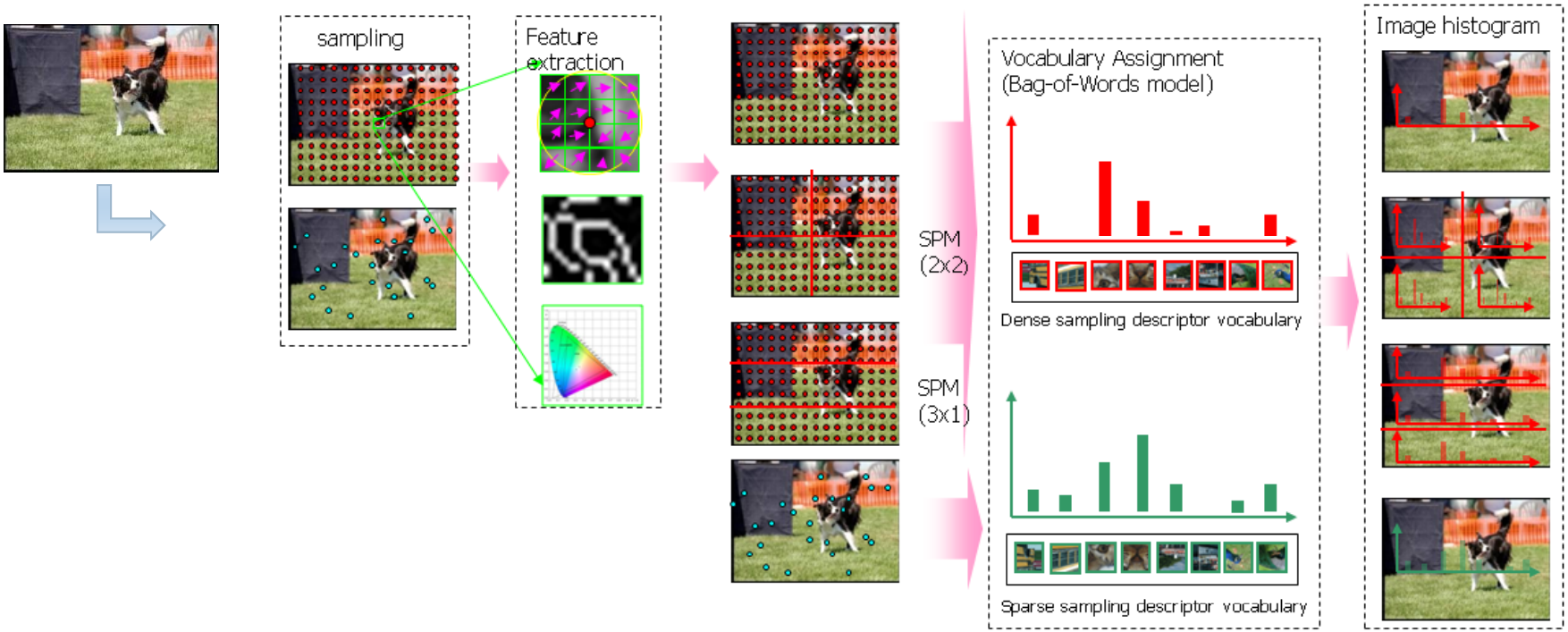
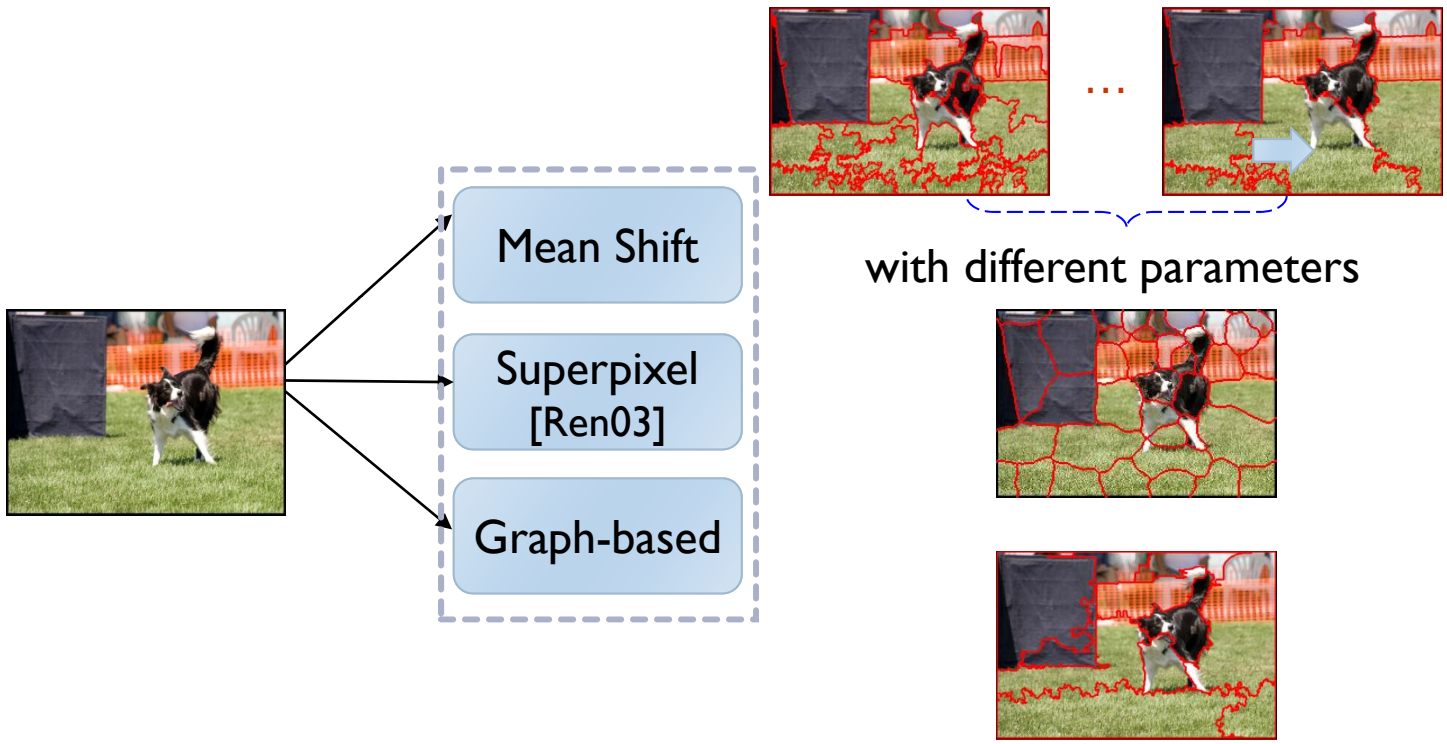
Low Level Features

- Low level features: SIFT and its variants, LBP, HOG.
- Dense sampling and interest point detector;
- Represented as Bags of Words;

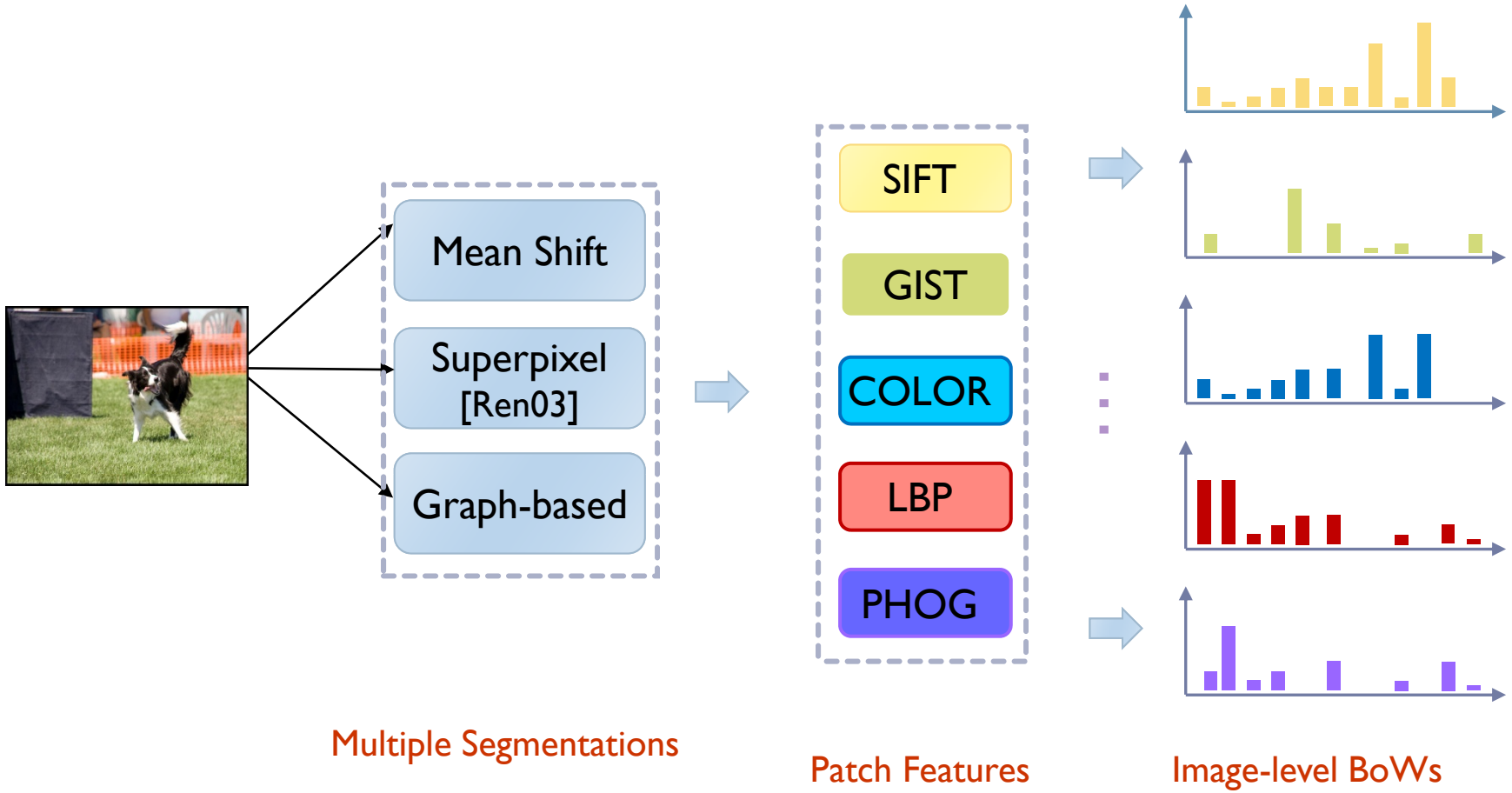


Patch Level Features

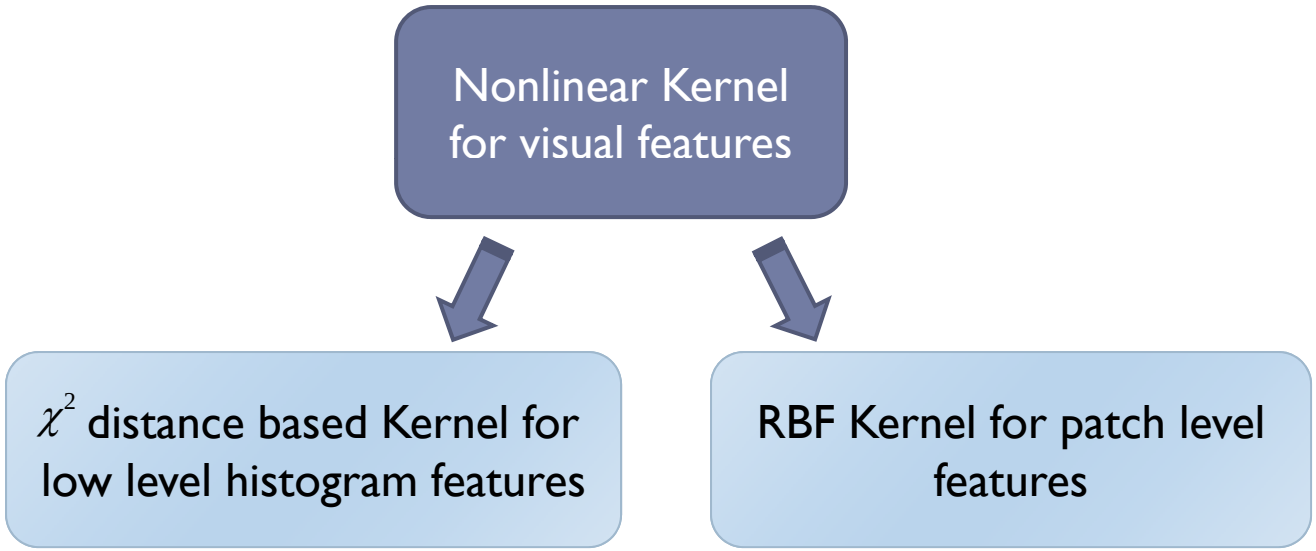


Multiple Segmentations

Patch Level Features



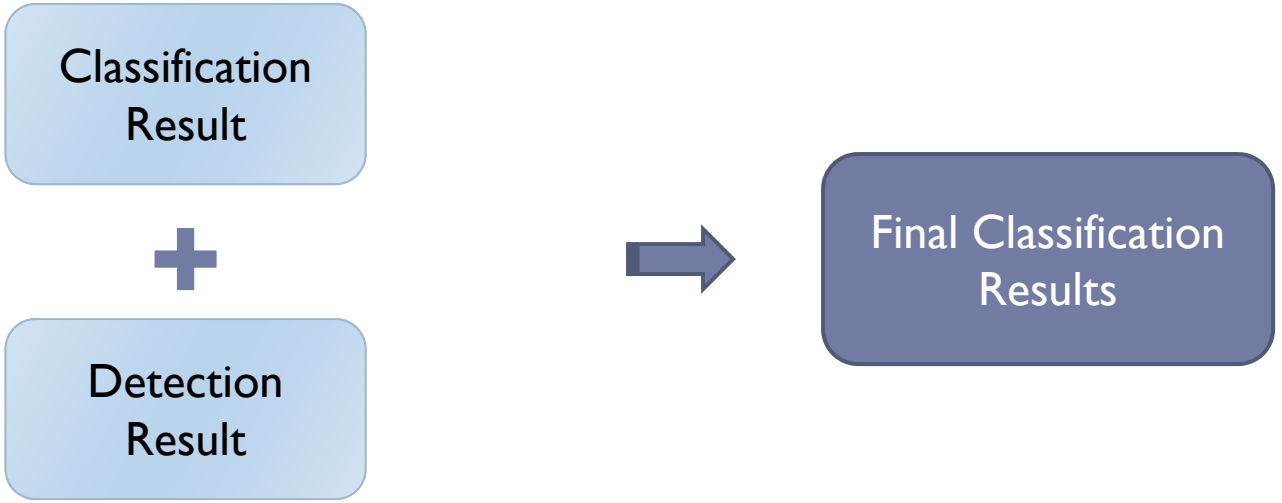
Kernel


Nonlinear Kernel for visual features
χ^2 distance based Kernel for low level histogram features
RBF Kernel for patch level features

Detection Kernel

- How to encode the detection result into the classification framework?

✓Detection result are often combined with classification as post processing.

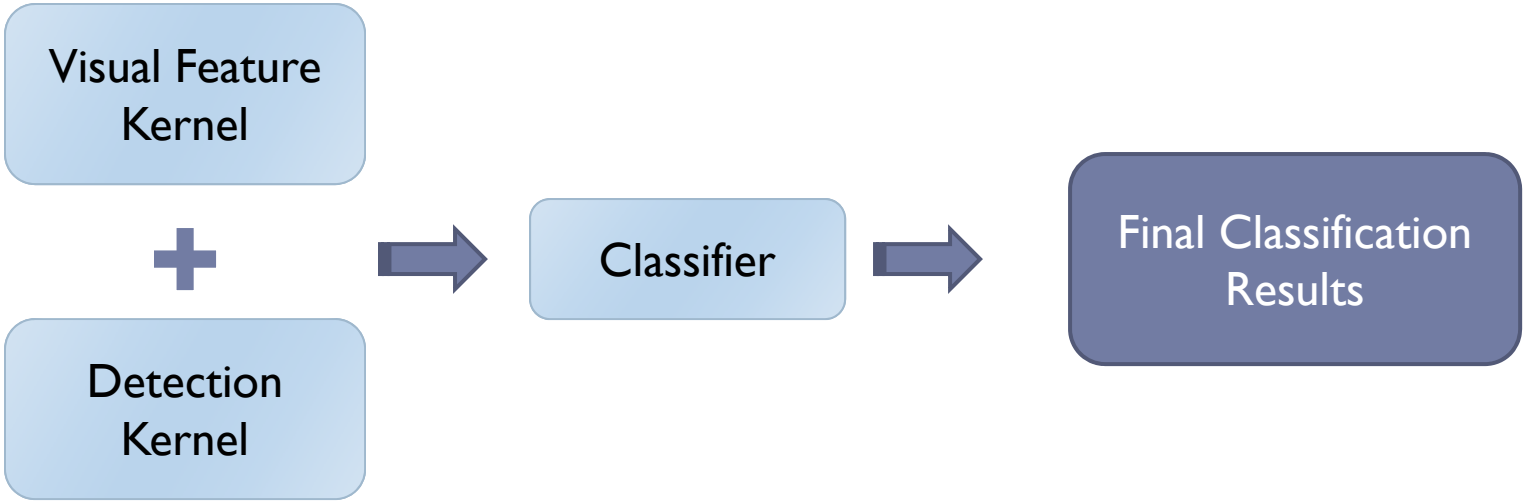


Detection Kernel

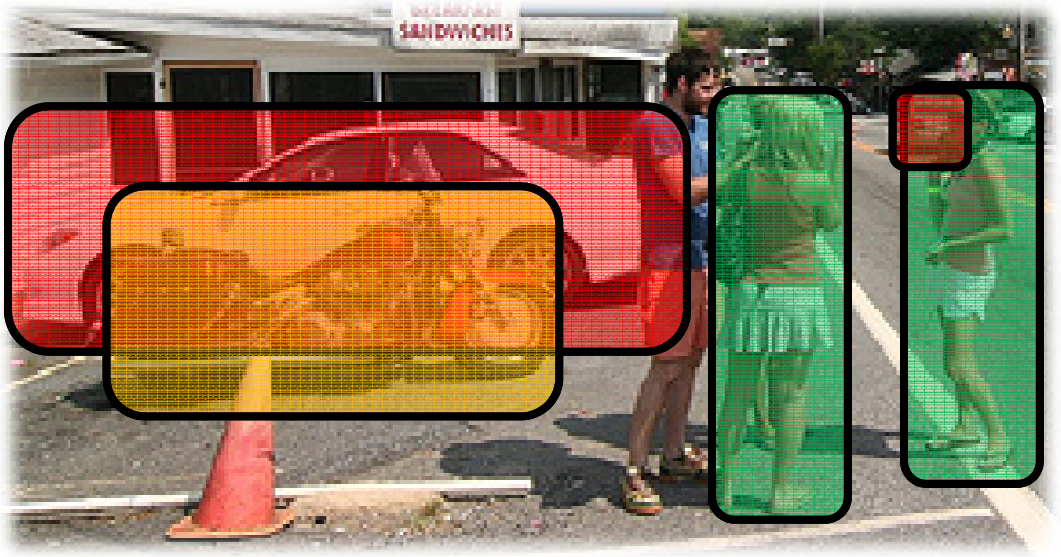
- How to encode the detection result into the classification framework?

✓Detection result are often combined with classification as post processing.

✓We combine the detection result at the feature level.

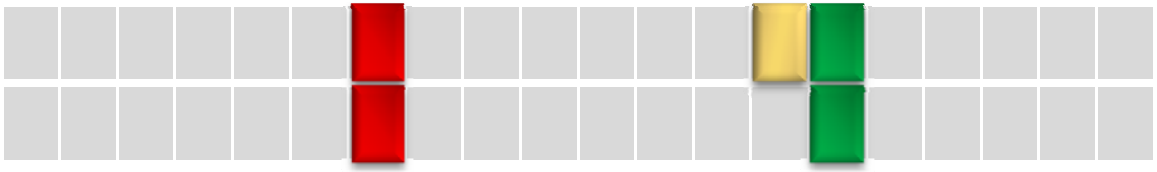


Detection Feature for Classification



Part-based Detector for 20 Objects

[Felzenszwalb et al. 2010]



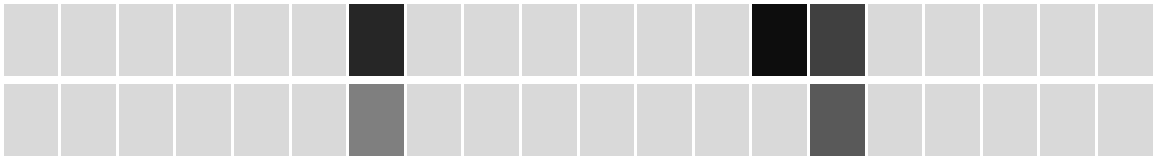
Maximum response

2nd maximum response

car

motor person

Sigmoid Response Mapping



Probability of Objects
(40 Dimension Feature)

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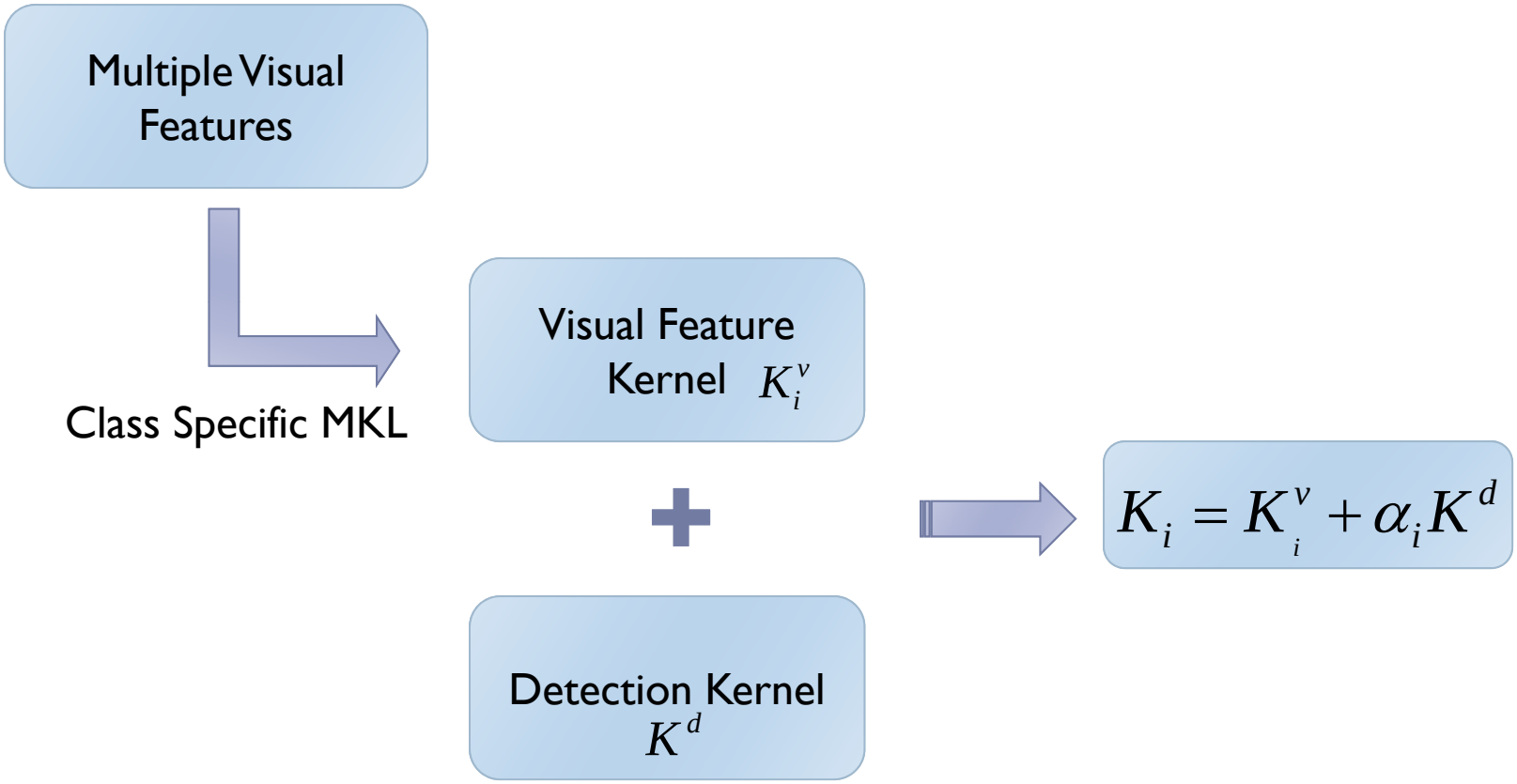
Kernel combination

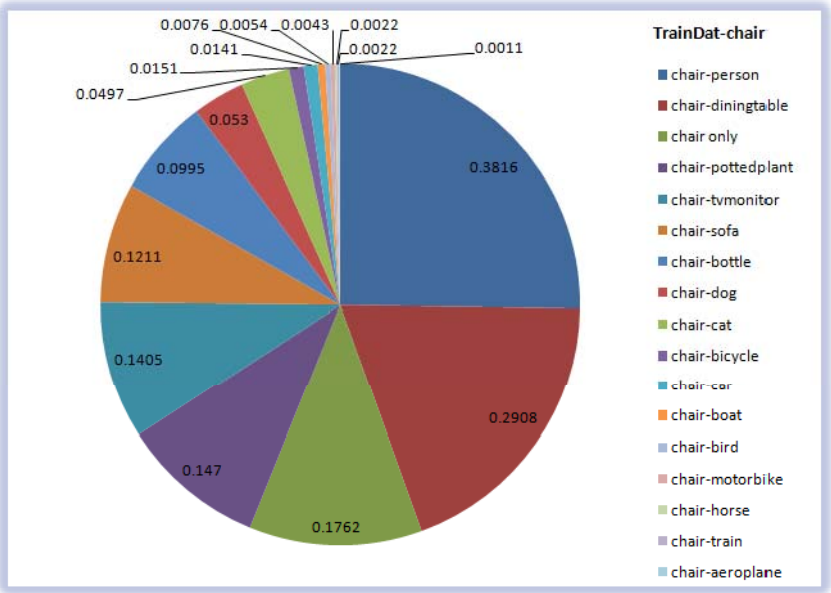


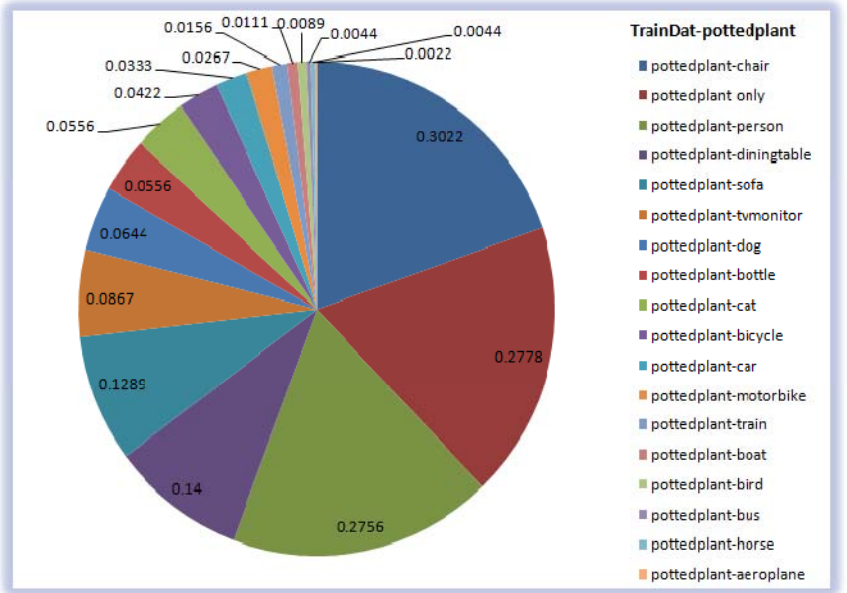
Classification

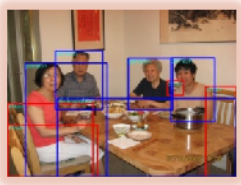
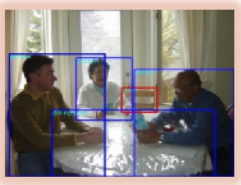
- SVM
- Regression
- Lasso Prediction with Exclusive Context

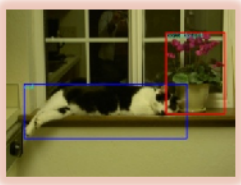
Exclusive Classifier:
Lasso Prediction with Exclusive Context

- Traditional label context: co-occurrence
  - focus on mutually increasing confidences







Exclusive Label Sets

- We focus on the exclusive label context.
  - For an exclusive label set, at most one label can appear.

Exclusive label sets

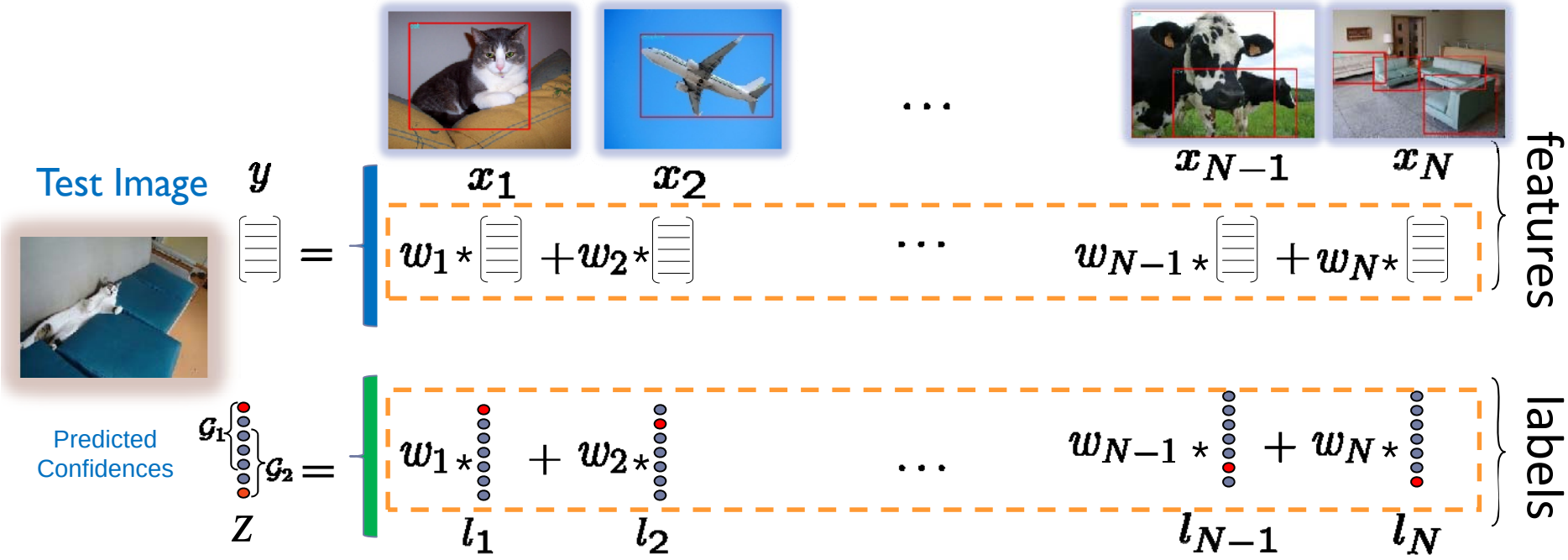
{train, tvmonitor, sheep, boat, dingingtable }
{boat, diningtable, horse, sofa}
{cat, aeroplane, horse, motorbike, train}
……
{sofa, aeroplane, bird, cow, horse, sheep}

- Construction for exclusive label sets $\mathcal{G} = \{\mathcal{G}_k\}_{k=1}^{K}$:

  Apply the approach: *Robust Graph Mode Seeking by Graph Shift* (*Liu H. and Yan S. ICML'10*)

Lasso Prediction with Exclusive Context

- Test label vector is penalized by exclusive constraint
  - $X = [x_1, ..., x_N]$: training feature set
  - $L = [l_1, ..., l_N]$: training label set (multiple label)
  - $\mathcal{G} = \{\mathcal{G}_k\}_{k=1}^{K}$: exclusive label sets



Objective: least reconstruction error while enforcing sparsity within exclusive label sets

Formulation

- Main Objective

$$\hat{w} = \arg\min_{w} \frac{1}{2}\|y - Xw\|_2^2 + \frac{\lambda}{2}\sum_{\mathcal{G}_k \in \mathcal{G}} \|z_{\mathcal{G}_k}\|_1^2,$$

$$s.t. \quad z = Lw$$

$$(\hat{w}, \hat{u}) = \arg\min_{w,u} \frac{1}{2}\|\phi(y) - \phi(X)w\|_2^2 + \frac{\lambda}{2}\sum_{\mathcal{G}_k \in \mathcal{G}} \|u_{\mathcal{G}_k}\|_1^2,$$

$$s.t. \quad u = Lw$$

(Kernel Version)

- Optimization: a thresholded Landweber algorithm combined with Accelerated Proximal Gradient Method

Note: This is unpublished work. Please contact Dr. Yan if you plan to make use of any of the ideas presented

Post Processing

- Kernel regression for fusing all confidences.
  - Learn a nonlinear mapping function from obtained confidence $C = [C_1^T \quad C_2^T \quad C_3^T]^T$ to ground truth L using validation set.
  - Objective:

$$\min_W \| L - W\phi(C) \|_2^2 + \lambda \| W \|_2^2$$

- Confidence Refinement using exclusive context.
  - High confidence label can depress other labels in the same exclusive set

The results

	SVM	Exclusive	Fusing	Our Best	Other's Best
aeroplane	91.9	91.3	93	93	93.3
bicycle	77.1	77	79	79	77
bird	69.5	70	71.6	71.6	69.9
boat	74.7	75.6	77.8	77.8	77.2
bottle	52.5	50.7	54.3	54.3	53.7
bus	84.3	83.2	85.2	85.2	85.9
car	77.3	77.1	78.6	78.6	80.4
cat	76.2	75.4	78.8	78.8	79.4
chair	63	62.5	64.5	64.5	62.9
cow	63.5	62.6	64	64	66.2
diningtable	62.9	62.7	62.7	62.9	61.1
dog	65	64.6	69.6	69.6	71.1
horse	79.5	77.9	82	82	76.7
motorbike	83.2	81.8	84.4	84.4	81.7
person	91.2	91.1	91.6	91.6	90.2
pottedplant	45.5	44.8	48.6	48.6	53.3
sheep	65.4	64.2	64.9	65.4	66.3
sofa	55	53.2	59.6	59.6	58
train	87	86.3	89.4	89.4	87.5
tvmonitor	77.2	77.1	76.4	77.2	76.2
MAP	72.095	71.455	73.8		

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Conclusions and Discussion

- Effective detection kernel.
- Exclusive classifier can boost the final classification results, more importantly, it is scalable and perfectly suitable for classification with large category number, e.g. ImageNET.

- Increasing the class size: a bad thing or good thing?
  - Bad thing: individual classification accuracy may drop down.
  - Good thing: more context (co-occurrence and exclusive) can be utilized.

Acknowledgement

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