Position paper:

How to exploit scene constraints to improve object categorization algorithms for industrial applications?

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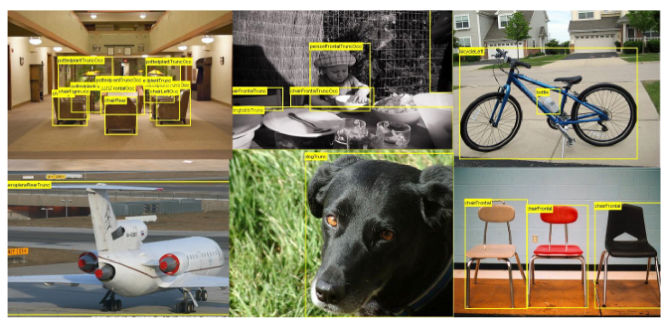
Problem statement

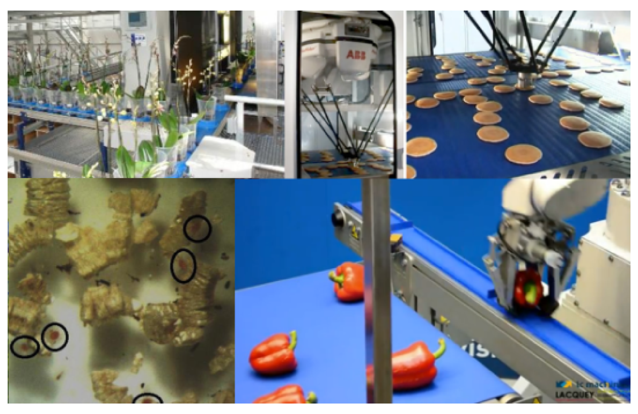
Object categorization algorithms

- No single object instances
- General class model
- Cope with intra-class variability and other scene variations
- Object model trained on a large number of training images



Academic context = fundamental research

- Typical classes : bikes, pedestrians, airplanes, chairs, ...
- Complex scenery : street views, airports, shops, …
- Try to cope with a lot of variance in scenes and objects



Industrial context = practical implementation

- Need for robust and performant detection algorithms
- Need for meaningful test classes
- Very controlled environments
  → less scene variations

Goal of research

- Exploit scene constraints
- Create a new set of object categorization algorithms
  - Less training data needed
  - Faster performance, up to real-time
  - More accurate and robust detections

Evolution in object categorization

Algorithms need to be robust

- Scene variations = degrees of freedom
- Add degrees of freedom for each new algorithm
- Incremental approach

Technique	Example	Degrees of freedom						
		Illumination	Location	Scale	Orientation	Occlusion	Clutter	Intra Class Variability
NCC - based pattern matching	(Lewis, 1995)	X	X	–	–	–	–	–
Edge - based pattern matching	(Hsieh et al., 1997)	X	X	X	X	–	–	–
Global moment invariants for recognition	(Mindru et al., 2004)	X	X	X	X	–	–	–
Object recognition with local keypoints	(Bay et al., 2006)	X	X	X	X	X	X	–
Object categorization algorithms	(Gall and Lempitsky, 2009)	X	X	X	–	X	X	X
Industrial Applications	–	**–**	**–**	**–**	**X**	**X**	**–**	**X**

Cope with degrees of freedom

- Normalization → Rescale each window towards default size
- Invariance → Convert image to illumination invariant form

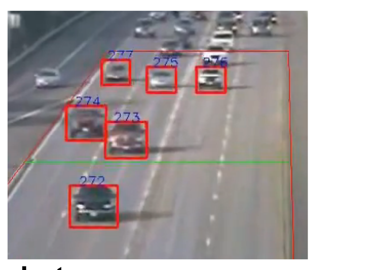
Industrial cases however do not need this

- Many degrees of freedom are controlled
- **Intra-class variability** remains
- Not supported by earlier techniques
- Computational expensive algorithms can be improved a lot

Use of Scene Constraints

Focus of research and scene constraints

- Machine vision applications
- Random object picking & object counting



Two possible approaches to apply constraints

- Use existing algorithms → reduce training samples using constraints
- Adapt existing algorithms → remove internal constraint functionality

Illumination Changes

Highly controlled in industrial applications

- Much less illumination variance
- Able to use color information
- Remove illumination invariant processing
- Amount of training examples drops

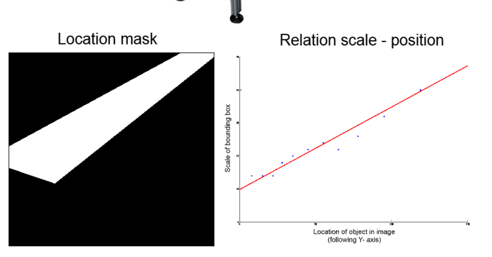
Scale Changes & Localization

Static machine setup in industrial applications

- Camera position fixed
- Object solely on conveyor belt

Using scale information

- Reduce region of interest for object detection
- Known scale at each position



Due to setup → use movement for background subtraction

Orientation

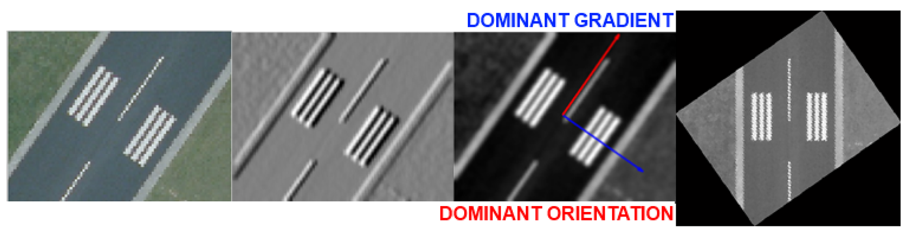
Classic detectors → expect fixed orientation

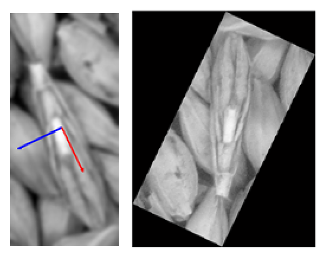
- Multiple detections for all orientations
- Or train for all orientations *(small variation)*

Structural change → orientation normalization

- Define dominant orientation
- Rotation towards fixed position
- Drastically reduce training examples

Experimental result on road printed traffic signs and harvested grain

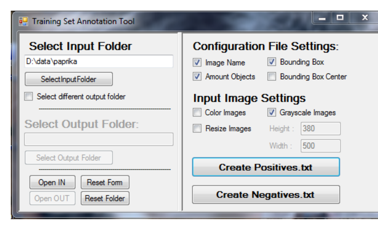




Simplifying The Training Process

Object categorization disadvantages

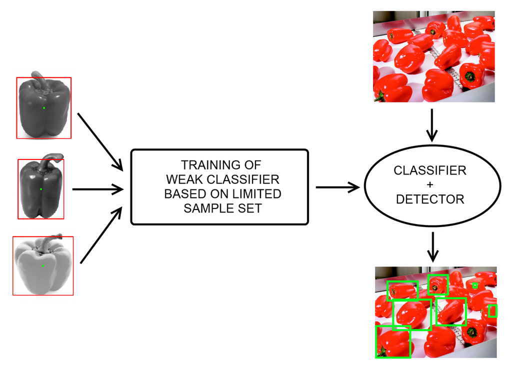
- Large training sets needed for model
- A lot of manual annotation
  → Results in large preprocessing step
  → Expensive & time consuming



Annotation Phase

Evolve towards semi supervised annotation

- Limited supervised set → Basic weak classifier
- Apply to whole set
- Accept or decline results



Interesting techniques to achieve better performance

- Boosting
- Online learning

Actual Training Phase

Current training algorithms

- Train all scene variabilities
- Requires large amounts of training samples

Adapt the training process

- Scene constraints help to remove positive training samples
- Amount of negative samples can also be reduced due to fixed scene

No guidance exists for defining size of training sets

- How many positive/negative samples are actually needed?
- When do you reach a robust classifier? *(Academic ↔ Industrial)*

Conclusion & Future Work

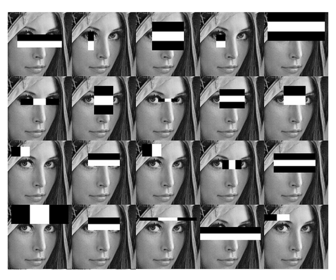
Conclusion

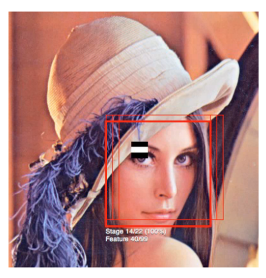
By exploiting scene constraints from industrial applications we will make object detection in these cases:

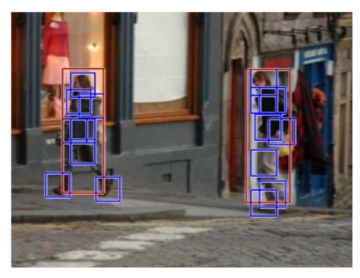
- Faster, up to real-time
- More reliable, reaching a high detection rate
- Easier to train, needing less training data

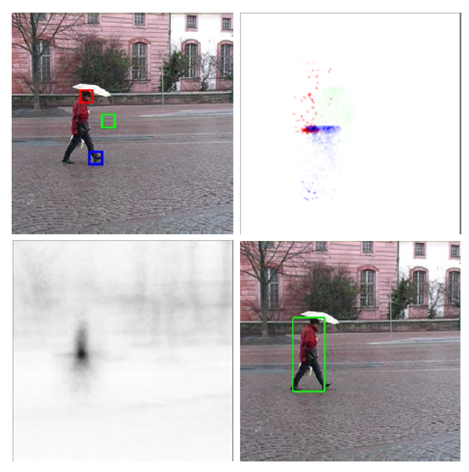
Adapt known algorithms and training procedures

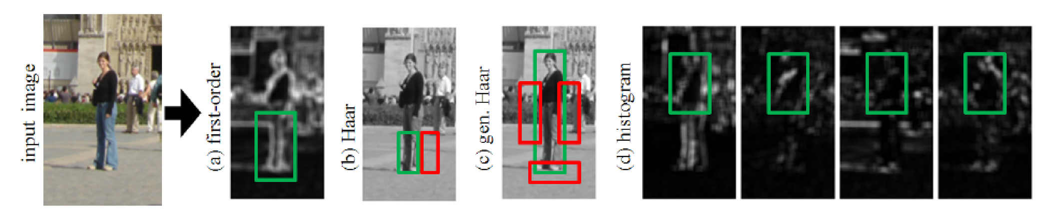
- Viola & Jones : Cascade weak learner object detection
- Felzenszwalb : Part based object detection
- Gall & Lempitsky : Class specific Hough Forests for object detection
- Dollár et al. : Using integral channel features to boost object detection











Future Work

If the suggested approach proves successful

- Optimize robustness for industrial applications
- Apply on other object categorization techniques
- Look for other fields of application
- Expand same approaches towards 3D object categorization

Embedded & Applied Vision Engineering

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