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Optimal Object Categorization Under Application Specific Conditions

Submitted for Doctoral Consortium of VISIGRAPP 2014

PhD – candidate :

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Steven Puttemans

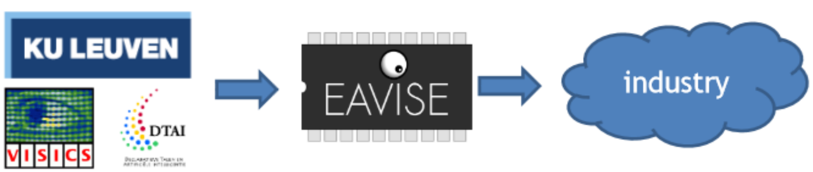
Embedded & Artificially intelligent VISion Engineering

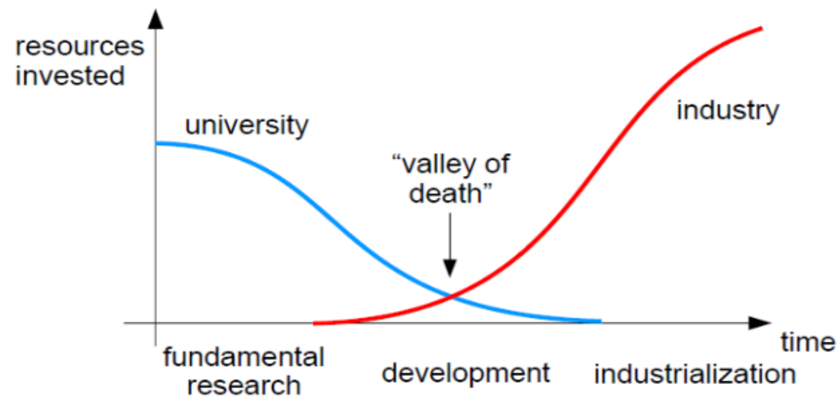
- Research assistant at EAVISE
  - **E**mbedded **A**rtificially intelligent **VIS**ion **E**ngineering
  - Research group that focusses on industry introduced problems that can be solved by computer vision algorithms and artificial intelligence.
- PhD student
  - Background = MSc Engineering (Electronics) + MSc Artificial Intelligence
  - Subject = optimal object categorization under application specific object and scene constraints.
    - Focussing on a new object categorization framework
    - Using an innovative active learning strategy
- Current research project: IWT-TETRA TOBCAT
  - Industrial applications of object categorization techniques
  - Technology transfer from academia to industry

EAVISE – a small introduction

- Research goal
  - **Translating** state-of-the-art image processing algorithms and artificial intelligence techniques to solutions for **industry-specific application** problems
  - Implementing advanced image processing on **embedded systems**
  - Optimize vision algorithms to **real-time performance**

- Trying to focus on the valley of death





Goal of PhD research

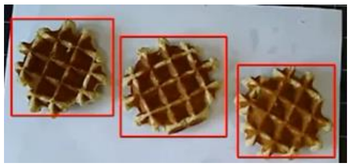
- State-of-the-art object categorization algorithms focus on:
  - Increasing complexity, making it robust to as much variation as possible that can occur in the scene
  - In the wild detections are the main goal
  - Artificially created datasets → eg. Pascal VOC challenge

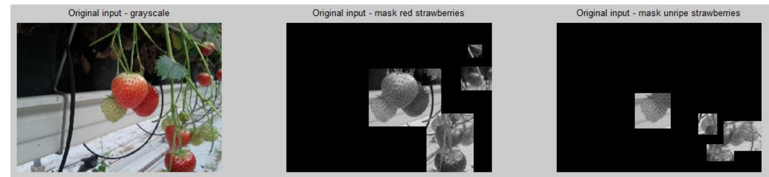
Table 1: Comparison of robustness against degrees of freedom of existing object categorization algorithms. (**Illumin.** = Illumination differences / **Locati.** = Location of objects / **Scale** = Scale changes / **Orient.** = Orientation of objects / **Occlu.** = Occlusions / **Clutt.** = Clutter in scene / **I.C.V.** = Intra-class variability)

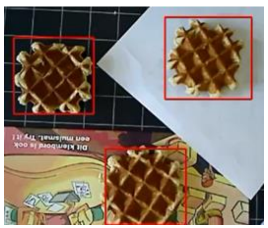
Technique	Example	Degrees of freedom						
		Illumin.	**Locati.**	**Scale**	**Orient.**	**Occlu.**	**Clutt.**	**I.C.V.**
NCC - based pattern matching	(Lewis, 1995)	X	X	–	–	–	–	–
Edge - based pattern matching	(Hsieh et al., 1997)	X	X	X	X	–	–	–
Global moment invariants for recognition	(Mindru et al., 2004)	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**

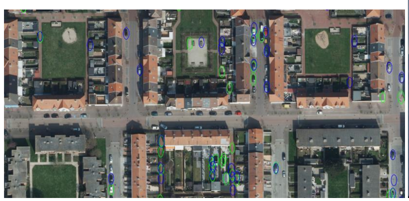
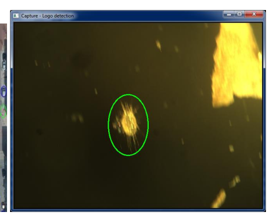
Goal of PhD research

- However, is this really what we expect in industrial applications?














Definition of applications interesting for our research

- DEFINITION: *applications where vision-based detection of objects is needed and which are subjected to:*

*(1) A large **intra class variability**. The objects can change within the same class in shape, colour, texture, …*

*(2) The fact that some of the **application specific knowledge** can be transformed into constraints for the algorithm, like a constant scale, lighting conditions, background, …*

Main purpose/goals of this PhD

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The purpose of this PhD study is threefolded:

1. We try to achieve a detection rate of 99,9% or even higher
2. We try to reach a minimal manual intervention by the user by smartly selecting the training samples using active learning
3. We focus on real time processing using CPU and GPU optimalizations whenever possible

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Why do we want to perform this PhD research?

1. Academic ←→ Industrial
2. Continuous evolution in object detection techniques
3. Integration of knowledge rather than pre- and postprocessing
4. Known forms of variation can be abused!
5. Current detection rate is not always high enough

5 Reasons for the PhD study

1. Contrast between academic – industrial research
   - Online test benches contain weird data sets
   - Eg. Pascal VOC challenge

Figure 1: Examples of typical object categorization test classes used in academic research: chairs, bikes, airplanes, dogs and children.

Figure 2: Examples of industrial object categorization applications: robot picking and object counting of natural products.

2. Clear evolution
   1. More and more variation is encapsulated
   2. But is this really necessary to reach in the wild super performance?

5 Reasons for the PhD study

3. Integrating knowledge in existing frameworks
   - Scene and object knowledge needs to be exploited!
   - Already some examples → ChnFtrs framework of Dollár

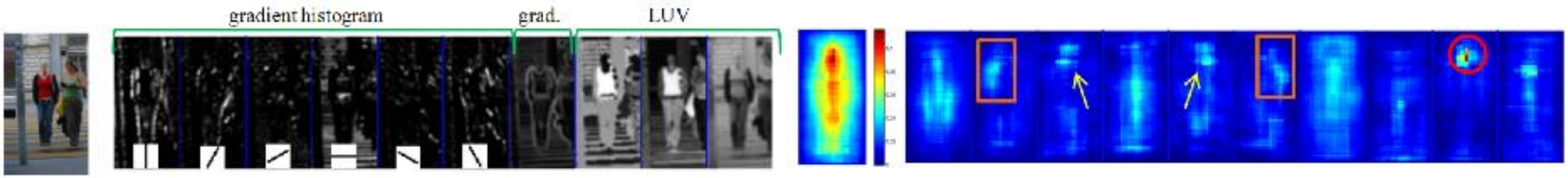
4. Focusing on 4 forms of variation
   - Lighting, color and texture
   - Orientation and rotation
   - Scale and position
   - Background clutter and occlusion

5. Detection rate is far not enough for the industry

   → whish= 99,9% or higher

Suggested approach for PhD

- Use application specific knowledge during model training for achieving an optimal detector model.
  - Inspired by the ChnFtrs framework (Piotr Dollàr)
  - From many possible feature channels, select the usefull ones
  - Boosting (bv. AdaBoost) to select features which give highest success rate



- Split research in blocks

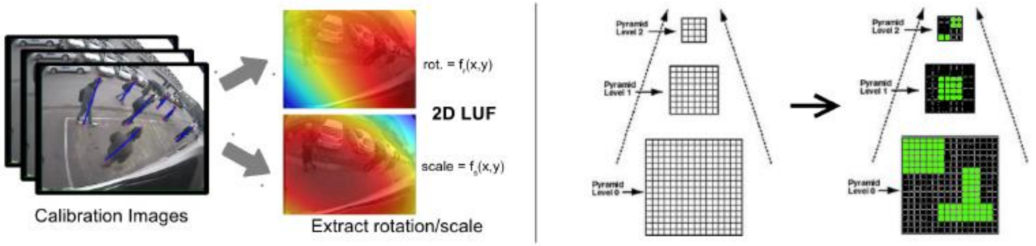
  WP1: Integrating the variation in model training and detection

  WP2: Using an innovative active learning strategy for minimal manual input

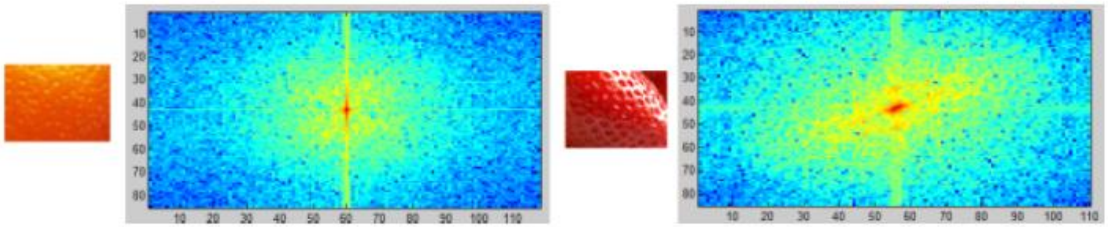
  WP3: Optimize the code through GPU/CPU

Suggested approach for PhD

- WP1: Integrating the variation in model training and detection

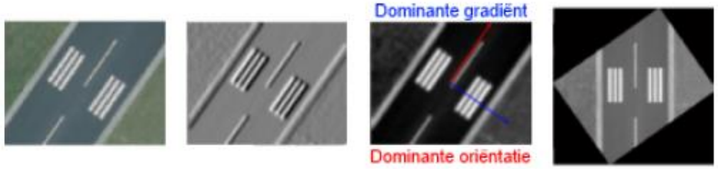


Figuur 8: [Links] Voorbeeld van een schaal-locatie lookup-functie voor de dodehoekcamera van een vrachtwagen [Rechts] Voorbeeld van een gefragmenteerde schaalpyramide.



Figuur 10: Textuurvariatie op basis van het Fourier powerspectrum van een sinaasappel en een aardbei.

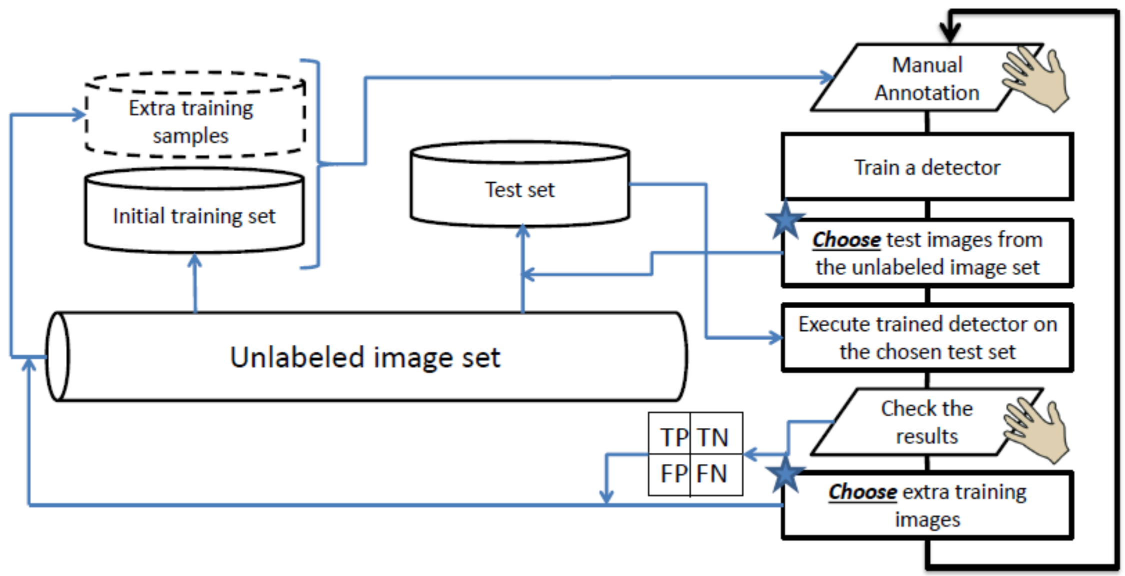
Figuur 11: Voorbeeld van achtergrondvariatie en occlusie in (a) academische cases en (b) industriële cases



Figuur 12: Voorbeeld van rotatienormalisatie door gebruik te maken van de dominante gradiënt techniek.

Suggested approach for PhD

➢ WP2: Using an innovative active learning strategy for minimal manual input



- ✓ Reduce the needed training data set (pos & neg samples)
- ✓ Iteratively annotate a small set
- ✓ Select new examples smartly using the constraints

Suggested approach for PhD

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- WP3: Optimize the code through GPU/CPU
  - Extra functionality means extra processing time
  - Real time processing is essential for the industry
  - Using parallel approaches and multicore systems
  - Using general purpose GPU's based on the CUDA or OpenCL architecture

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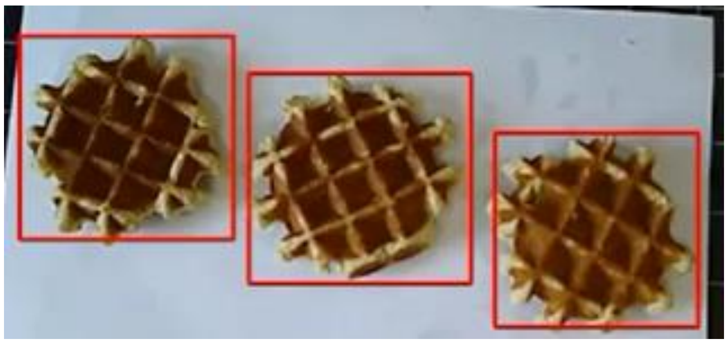
Current PhD research results

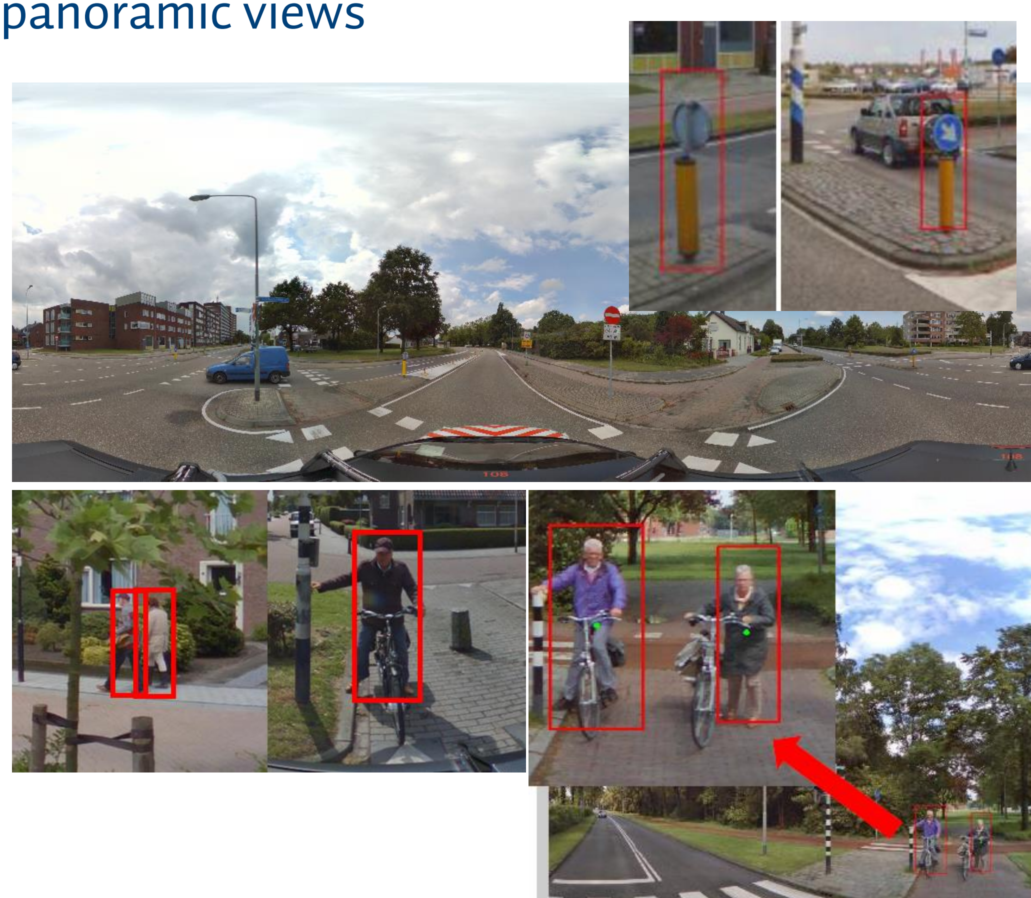
Based on the OpenCV implementation of the Viola & Jones object detection framework

- Dummy examples like cookie or candy detector



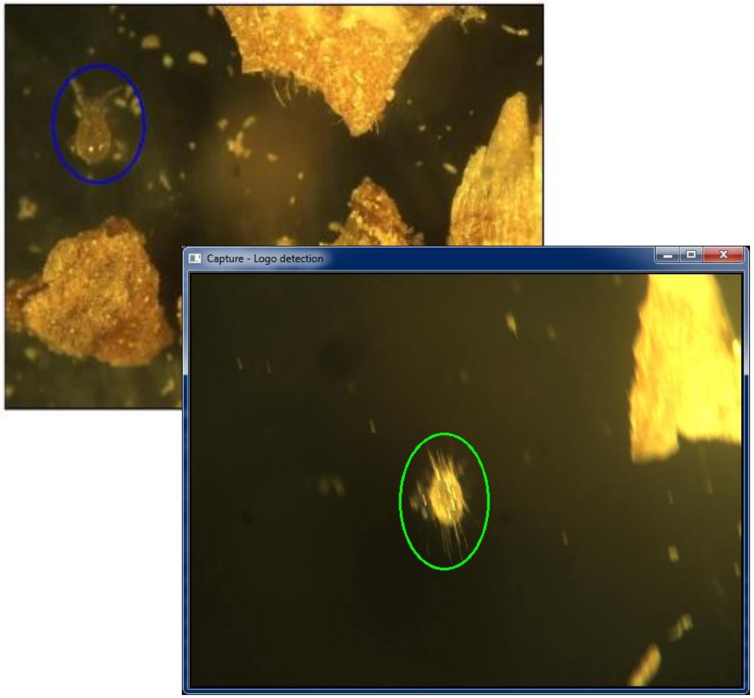
Current PhD research results

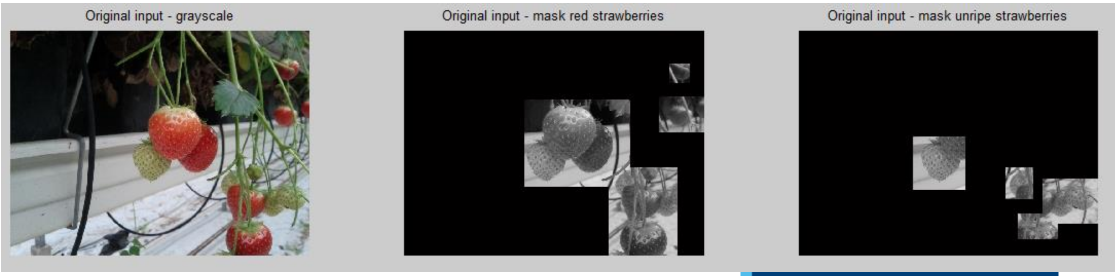
- But also more ‘industrial’ inspired tests where done
  - ✓ Detection of objects in aerial imagery
  - ✓ Detection of persons in 360° panoramic views



Current PhD research results

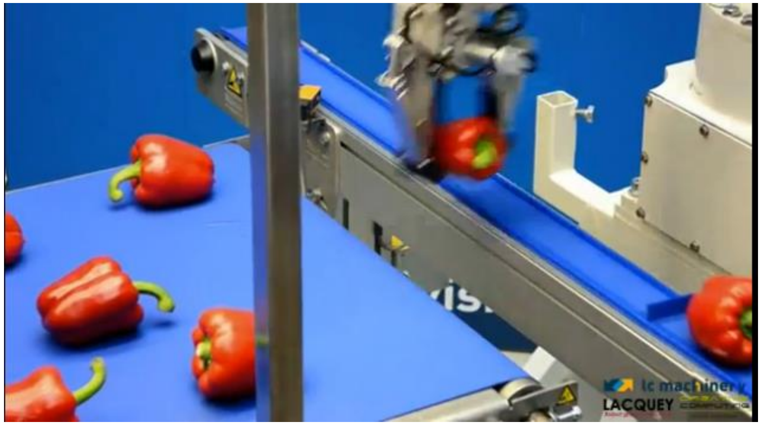
- But also more ‘industrial’ inspired tests where done
  - ✓ Detection of micro organisms under a microscope
  - ✓ Detection of filth in a grainery machine
  - ✓ Detection of strawberries





Current PhD research results

- But also more ‘industrial’ inspired tests where done
  - ✓ Detection of flower buds to decide on price category and type
  - ✓ Detection and picking of bell peppers



Current PhD research results

- But also more ‘industrial’ inspired tests where done
  - ✓ Detection of walking aids and elderly people for fall risk detection
  - ✓ Detection of traffic threads and dangerous situations

Questions

Thank you very much for your attention.

Any questions, suggestions or remarks?