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Stichting NIOC (www.nioc.nl) stelt zich conform zijn statuten tot doel: het realiseren van congressen over informatica onderwijs en voorts al hetgeen met een en ander rechtstreeks of zijdelings verband houdt of daartoe bevorderlijk kan zijn, alles in de ruimste zin des woords.

De stichting NIOC neemt de archivering van de resultaten van de congressen voor zijn rekening. De website www.nioc.nl ontsluit onder "Eerdere congressen" de gearchiveerde websites van eerdere congressen. De vele afzonderlijke congresbijdragen zijn opgenomen in een kennisbank die via dezelfde website onder "NIOC kennisbank" ontsloten wordt.

Op dit moment bevat de NIOC kennisbank alle bijdragen, incl. die van het laatste congres (NIOC2023, gehouden op donderdag 30 maart 2023 jl. en georganiseerd door NHL Stenden Hogeschool). Bij elkaar bijna 1500 bijdragen!

We roepen je op, na het lezen van het document dat door jou is gedownload, de auteur(s) feedback te geven. Dit kan door je te registreren als gebruiker van de NIOC kennisbank. Na registratie krijg je bericht hoe in te loggen op de NIOC kennisbank.

Het eerstvolgende NIOC vindt plaats op donderdag 27 maart 2025 in Zwolle en wordt dan georganiseerd door Hogeschool Windesheim. Kijk op www.nioc2025.nl voor meer informatie.

Wil je op de hoogte blijven van de ontwikkeling rond Stichting NIOC en de NIOC kennisbank, schrijf je dan in op de nieuwsbrief via

www.nioc.nl/nioc-kennisbank/aanmelden nieuwsbrief

Reacties over de NIOC kennisbank en de inhoud daarvan kun je richten aan de beheerder:

R. Smedinga kennisbank@nioc.nl.

Vermeld bij reacties jouw naam en telefoonnummer voor nader contact.

NIOC 2013

Ground-truth creation for end-user trainable machine vision systems

Applied to antibiotic disc print reading

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NHL Hogeschool
Kenniscentrum Computer Vision

This research is part of a project for BD Kiestra

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Contents

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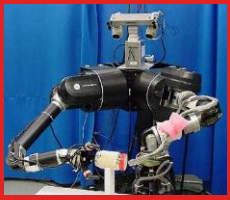
NHL University of Applied Sciences

Institute: Techniek
- Department: Engineering
  - Center of Expertise Computer Vision
  - Bachelors
    - Information Science
    - Technical Information Science
    - Electrical Engineering
    - Mechanical Engineering

Computer Vision

Automation of visual inspections



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Cameras

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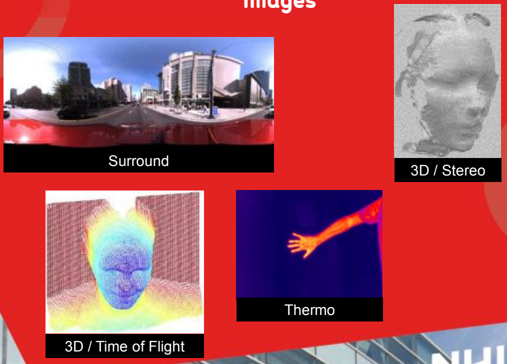
Images



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Illumination
Lenses
Ringlight
Backlight
Dome
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NHL Center of Expertise Computer Vision
Background:
• Founded 1996
• 4,5 FTE
• 170 industrial projects, > 3.000.000 euro
• Course Computer Vision
Goals
• Extending knowledge and expertise
• Professional networks and market exploration
• Transfer of knowledge to companies
• Education
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Microbiology
AI
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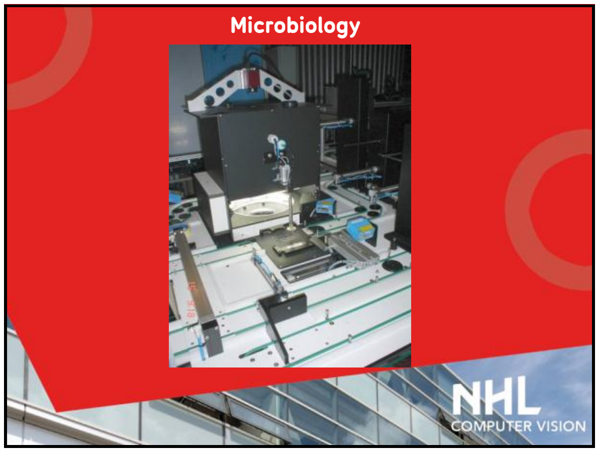
Microbiology
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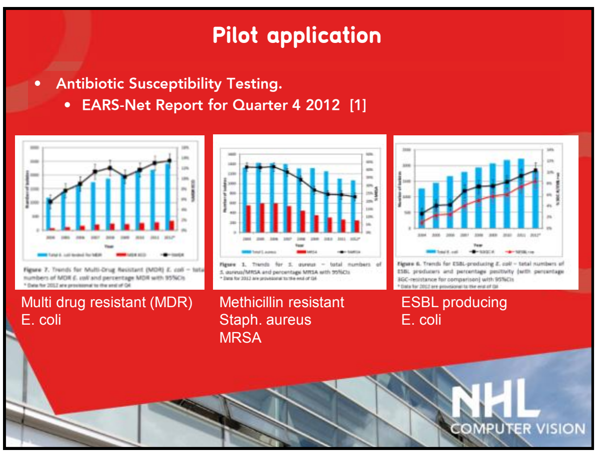
Pilot application
• Antibiotic Susceptibility Testing.
• EARS-Net Report for Quarter 4 2012 [1]
Multi drug resistant (MDR) E. coli
Methicillin resistant Staph. aureus MRSA
ESBL producing E. coli
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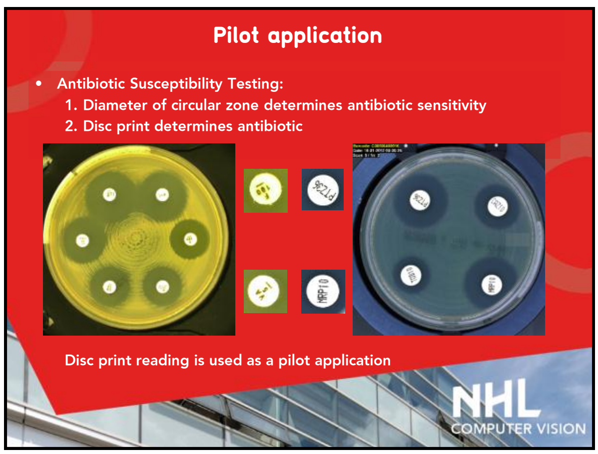
Pilot application
• Antibiotic Susceptibility Testing:
1. Diameter of circular zone determines antibiotic sensitivity
2. Disc print determines antibiotic
Disc print reading is used as a pilot application
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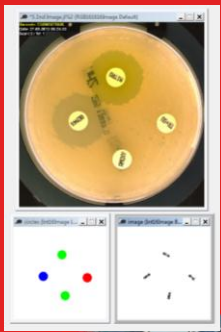
Blob matching demo



Motivation / Problem definition

Domain expert != Technical expert

- Two strategies for automating classification applications:
  1. Domain expert trained in technical knowledge
     - End-user software engineering (EUSE) [2]
       - Application Specific Language
       - Programming by Example
       - Visual Programming
       - Natural Programming
  2. Technical expert trained in domain knowledge
     1. Investigate demands
     2. Software design
     3. Train algorithms on ground-truth input

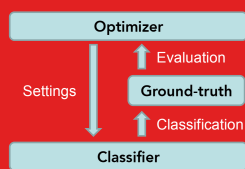
Aims and Objectives

- End-user trainability
  - Minimize domain knowledge needed by technology expert
  - Minimize technical knowledge needed by domain expert
  - Maximize classifier's performance
- Roles
  - Technical expert: Limit the solution space by specifying *which* classification algorithm to use
  - Domain expert: Make a ground-truth to specify *what* the system needs to do
  - Artificial Intelligence: Find technical parameters evaluated using only the ground truth to determine *how* this is done.

Optimization framework

- Classifier is used to classify objects
- Optimizer is used to converge to more optimal classifiers
- Ground-truth is used to evaluate classifiers

General framework:



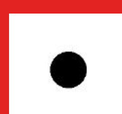
Rules for an end-user trainable machine vision system

- Steps by the *technical expert*:
1. Choose algorithms using the following criteria:
   a) Few parameters, to limit possible solutions.
   b) Robust, which limits dependence on parameters.
   c) Heuristics, determine rules for setting the parameters.
   d) Prior knowledge, to limit solution space.
2. For remaining parameters choose an optimization method with:
   a) Few parameters and for all others use heuristics.
- Steps by the *domain expert*:
1. Create a ground-truth.
   a) Entice the end-user, to minimize errors.

Technical expert: Disc print segmentation

Original image

- Robust



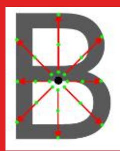
Hough circle Transform [3]

- Few parameters
- Heuristics

Local adaptive threshold [3]

Technical expert: Disc print classification using the Blob Matcher

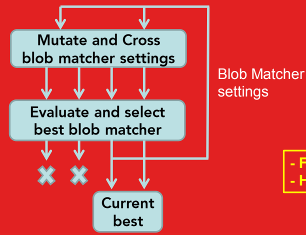
- Uses a single pattern as a model for the rest
- Exterior matching using the contour (less accurate, faster)
- Interior matching by sampling points (more accurate, slower)
- Matching error $e_{total} = e_{exterior} * f + e_{interior}$
- example: nr of rotations = 8, fill sample size = 3



- Prior knowledge

Technical expert: Blob Matcher optimization using a Genetic Algorithm

- Optimization algorithm based on natural selection [4]



- Few parameters
- Heuristics

Domain expert: Ground-truth creation using Surprise-Explain-Reward

- Making ground-truth more appealing:
  1. Tedious work
  2. Human error
  3. Inter-operator bias
  4. Intra-operator bias
- EUSE [2]
  1. *Surprise* end-user
  2. *Explain* what this means
  3. *Reward* the end-user

Entice the end-user

Demostration ground tool

Ground-truth creation using Surprise-Explain-Reward

1. End-user specifies disc print annotation
2. Current partial ground-truth is used to propose annotation
   - Surprise
3. Classification becomes better while *in the process* of ground-truth creation
   - Explain
4. Less annotation has to be specified by end-user and ground-truth creation becomes easier
   - Reward

Ground-truth creation using Surprise-Explain-Reward

1. Tedious work
   - Becomes less tedious because end-user is helped
2. Human error
   - Is reduced because blob matcher is able to detect geometrically different disc prints

   Prior knowledge
3. Inter-operator bias and intra-operator bias
   - Less prominent in this pilot application, because disc prints are not ambiguous

Ground-truth creation using Surprise-Explain-Reward

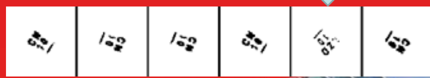
- Proposed annotation is accompanied by a confidence from the blob matcher:
  1. Proposed annotation has a high confidence
     - Annotation is automatically accepted
  2. Proposed annotation has a low confidence and is correct
     - Annotation should be accepted by end-user
  3. Proposed annotation is incorrect
     - Annotation is corrected by the end-user and single class optimization is performed on the incorrect class

Ground-truth creation using Surprise-Explain-Reward

- Single class optimization:

```
min_error_sum = infinity
For a = 0 to count(patterns) - 1
  For b = 0 to count(patterns) - 1
    error_sum += match(patterns[a], patterns[b]).error
  End
  If error_sum < min_error_sum
    best = a
    min_error_sum = error_sum
  End
End
```

Erroneous pattern is never chosen



Demonstration optimization

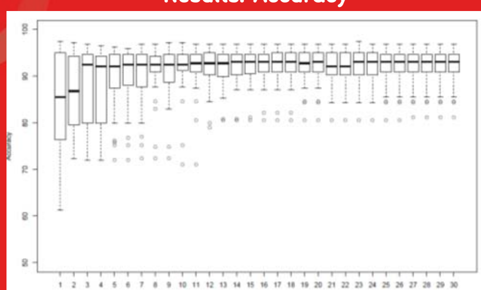
Results: Accuracy

37 different discs
17 samples per class
5 folds 5 repetitions

Results: Precision

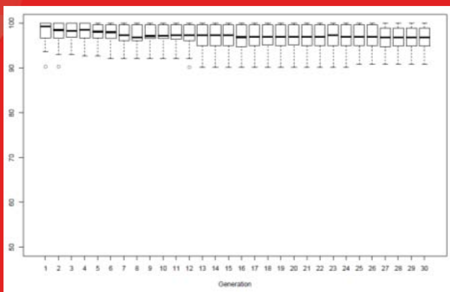
37 different discs
17 samples per class
5 folds 5 repetitions

Results: Accuracy



36 different discs and tablets
10 samples per class
5 folds 5 repetitions

Results: Precision



36 different discs and tablets
10 samples per class
5 folds 5 repetitions

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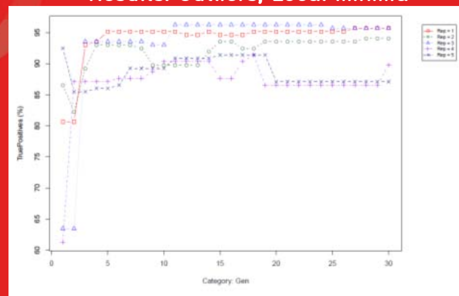
Results: Outliers, Local minima



36 different discs and tablets
10 samples per class
5 repetitions

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Results: Human error

Class: CN10
Confidence: 0.49

Class: LZD10
Confidence: 0.14

Part of training set

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Conclusions

- Ground-truth software using *Surprise-Explain-Reward*
- End-user trainable disc print application
- Optimization framework with rules for deciding on algorithms
- Error correction using prior knowledge

Future work

- End-user trainable basis for future applications
- Extend optimization
- Find heuristics for population size and generations
- Extend classification to regression analysis
- Measure quantitative performance

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