The Kernel:
An Expert System for Image Processing

RMA - Dept CISS
Goal

- Vectorization of scanned maps
  - Service Géo: provider of geo-data to Defense
  - 1000+ scanned maps, limited time frame and resources
  - Computer-based solution as a support
Challenges

• Scene analysis
  • Experts still better than computers
  • Why: real-world knowledge reasoning on uncertain/incomplete data, etc

• Strategies
  • Propose suitable image processing strategies
  • Need to accurately describe context
Proposed solution

• The Kernel:
  • An **expert system** dedicated to image processing
  • Use of high-level knowledge to mimic human expert reasoning
Expert systems (1/3)

Expert systems...

- Store expert knowledge as *rules*
- Apply rules onto observable *facts*, i.e. data
- Derive new facts and conclusions from the fired rules
- Model uncertain/incomplete data (fuzzy logics)
Expert systems (2/3)

Applied to Image processing:

ex: pools detection:

- pool: rectangular shape, water, near a house
- facts: regions in an image (ex: segmentation)
- rule:
  “IF a region has a rectangular shape, the reflectance of water and is located near a house THEN it is likely to be a pool”
Expert systems (3/3)

Advantages:

- Decoupling knowledge from reasoning
  - Generic system
    Ex: vehicle detection => other rules, same system
  - Knowledge can be re-used through projects
- System controls the order in which rules are firing
  => discovers situations not envisaged by user
User request:

- Data:
  - Geo extent
  - Spatial res
  - Time span

Score 1
Score 2
Score 3

Geo extent
Spatial res
Time span

(a) ontology for structural knowledge

“IF (Object is_inside Road)
  OR (Object overlaps Road)
  OR (Object is_near Road)
  THEN Object is_a Car”

(b) rules for procedural knowledge

Domain-specific knowledge

Available programs

Metadata

Feature extraction
Segmentation
Filtering
Registration

Knowledge Warehouse

Resource Manager

User Interface

Processing Toolbox

Data Warehouse

Edition services
Search engine

User request:

Data:

Score 1
Score 2
Score 3

Score
Scene analysis (1/2)

Detection of vehicles on VHR optical images

- 1\textsuperscript{st} approach: detecting line patterns

**RULES:**

- “IF 2 or more lines have same direction THEN group them”
- “IF 2 groups have perpendicular directions THEN vehicle detected”
Scene analysis (2/2)

Detection of vehicles on VHR optical images

- 2\textsuperscript{nd} approach: detecting color patterns

**RULES:**
- “IF 2 or more touching polygons have same hue THEN group them”
- “IF 2 groups with same hue separated by a 3\textsuperscript{rd} group AND group(1,2,3) has rectangular shape THEN vehicle detected”
Strategy elaboration (1/3)

Creating a low-level processing chain

1. Image
2. Edge detection
3. Line identification
4. Expert system
5. Vehicles

How to assemble processing units?
Strategy elaboration (2/3)

Creating a low-level processing chain

• Backwards reasoning:
  I need to detect vehicles
  => “A vehicle has a rectangular shape”
  => I can detect lines
  => I can use Hough transform program
  => I need an edge-detected image
  => I need an input image (will ask the Data Warehouse)

• Reasoning on “application concepts” => ontology
Strategy elaboration (3/3)

Ontology:
Intended use

- @ Dept CISS:
  - In-house: system for documentation, discovery, test and re-use of developed programs
  - New projects: Re-use of architecture and/or knowledge
- @ Service Geo:
  - Support to map vectorization