ICA Tutorial on Generalisation & Multiple Representation
2 July 2011 Paris

Lecture 6 : Multi-agents within automated generalisation (30 mins)

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The content of this presentation is partly based on a paper –under submission– written with G. Touya, J. Gaffuri, P. Taillandier, A. Ruas and J. Renard

Outline

- Multi-agent systems
- Why to use agent modelling for generalisation?
- Principles of agent modeling for generalisation
- Overview of existing agent-based generalisation models

Multi-agent systems

- Agent: an entity

  [Weiss 1999]

  – Guided by a goal to reach
  – Situated in some environment
  – Having capacities of perception, deliberation, action, communication

  ≈ object + expert system

- Multi-agent system: system composed of several interacting agents

Multi-agent systems: applications

- Simulation of complex phenomena
  - Ant colonies, human cells, town development, pedestrian moves…
- Complex problem solving
  - Among which constraint-based problems
- General idea:
  - Each agent is rather simply modelled
    - Perceives a part of the « world », a part of the problem
    - Simple behaviour / knows a part of the solution
  - Interactions between agents => emergent properties

Outline

- Multi-agent systems
- **Why to use agent modelling for generalisation?**
- Principles of agent modeling for generalisation
- Overview of existing agent-based generalisation models

Giving autonomy to objects

- Generalisation =
  - complex problem
  - distributed over the map space
  - local, context dependent decisions to make

  => good candidate for multi-agent approaches
- 1990s
  - Multi-agent paradigm growing
  - Step by step, local approach uses OO + expert systems

  => agents = natural evolution of this approach

Step by step, local approach

- Objects progressively transformed by generalisation algorithms

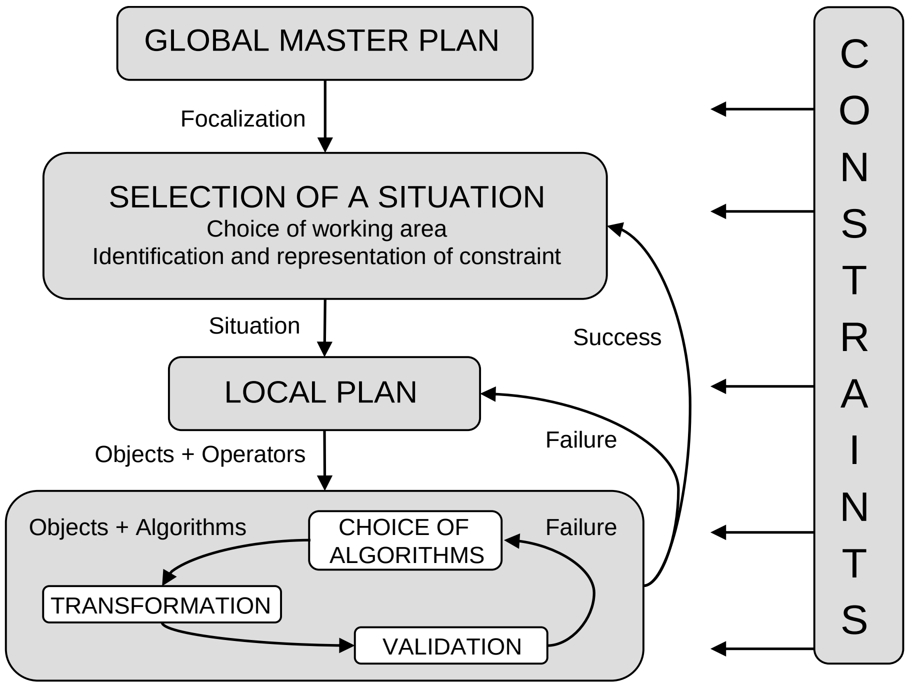
[Brassel & Weibel 1988; McMaster & Shea 1988]

- Algorithms chosen locally according to conflicts

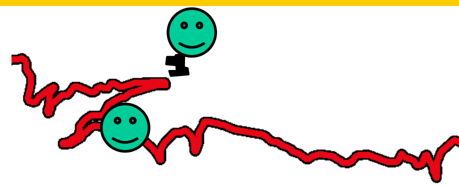
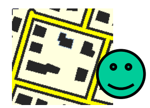
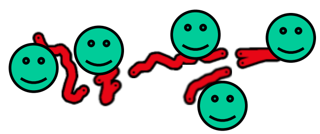
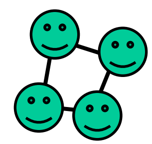
- Specifications represented as constraints

[Beard 1991]

- Operate at different levels; cycles [Ruas & Plazanet 1996]



Who are the agents in generalisation?

- Objects 
- Groups of objects 
- Parts of objects 
- The points of the objects 

…depending on the models

=> The geographic information « generalises itself » (Ruas 1999)

Outline

- Multi-agent systems
- Why to use agent modelling for generalisation?
- **Principles of agent modeling for generalisation**
- Overview of existing agent-based generalisation models

Architecture of a generalisation agent

Capacities/Mechanisms

Representation of the world

Knowledge

What I can do

How I see myself and the rest of the world

What I know about « how to behave »

Shared resources

- Map specifications
- Spatial analysis tools
- Generalisation algorithms

Available to all agents

Architecture of a generalisation agent

Capacities/Mechanisms

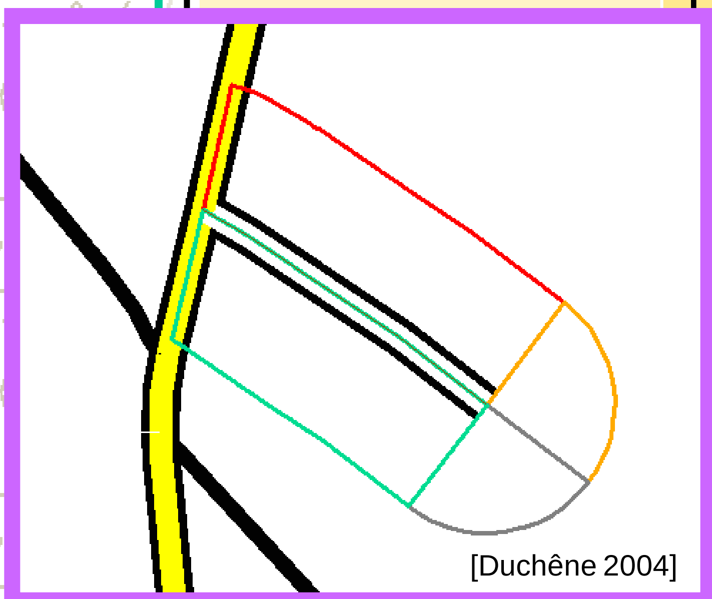
Perception

Representation of the world

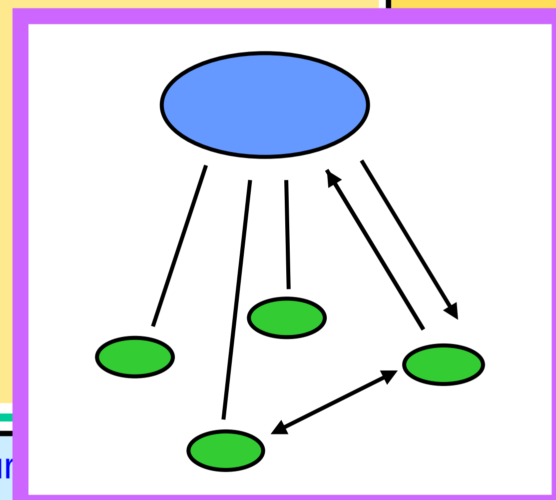
The space around me

The agents I know

Knowledge



[Duchêne 2004]



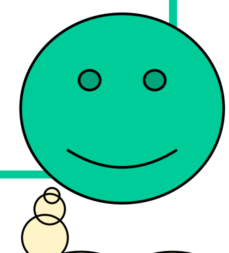
esour

Map specifications

uses

Spatial analysis tools

Generalisation algorithms



I can see a part of the world (including myself)

Architecture of a generalisation agent

Capacities/Mechanisms

- Perception
- Auto-evaluation

Representation of the world

- The space around me
- The agents I know
- My constraints/ their satisfaction
- My global happiness

Knowledge

Shared resources

- Map specifications
- Spatial analysis tools
- Generalisation algorithms

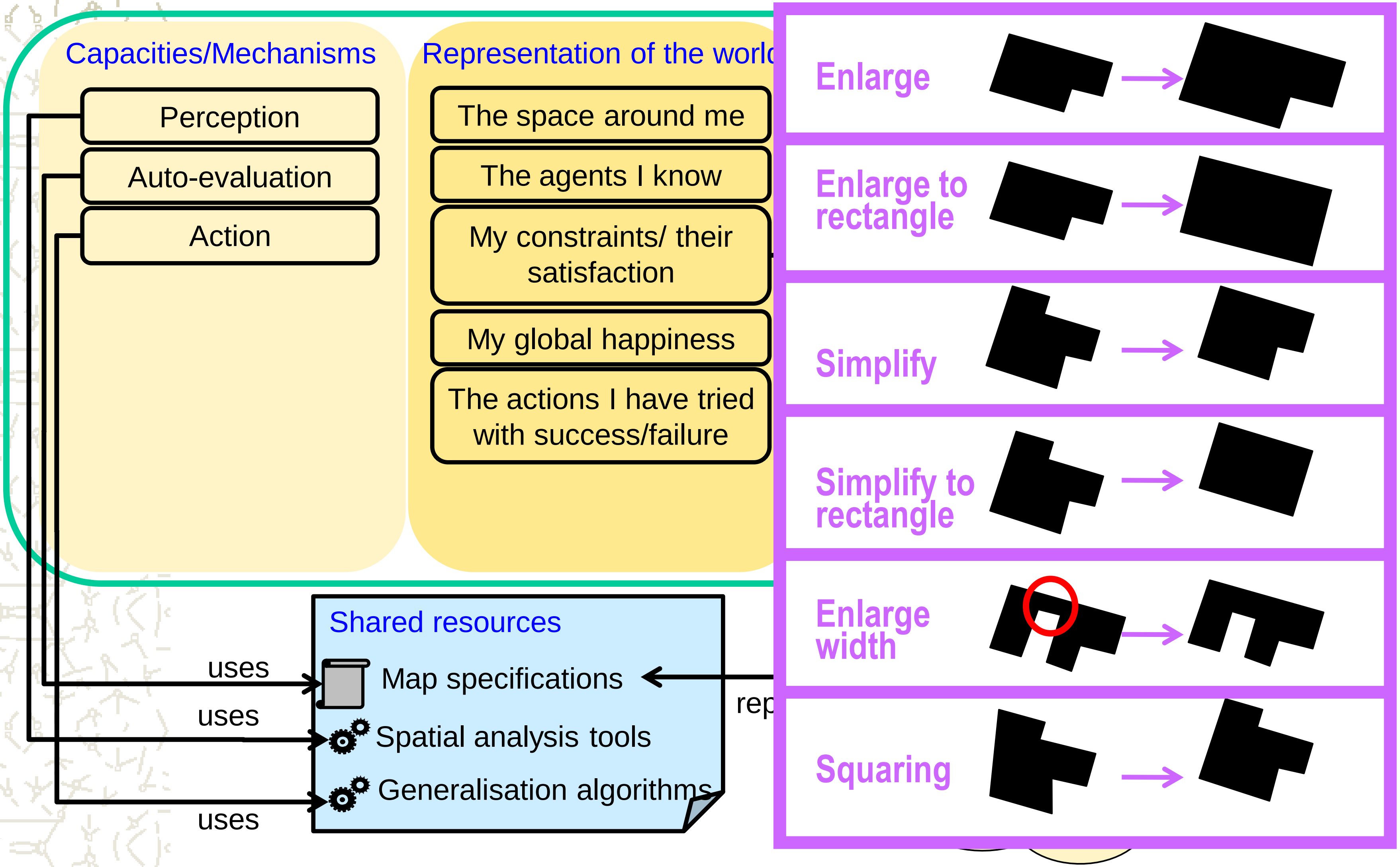
uses

uses

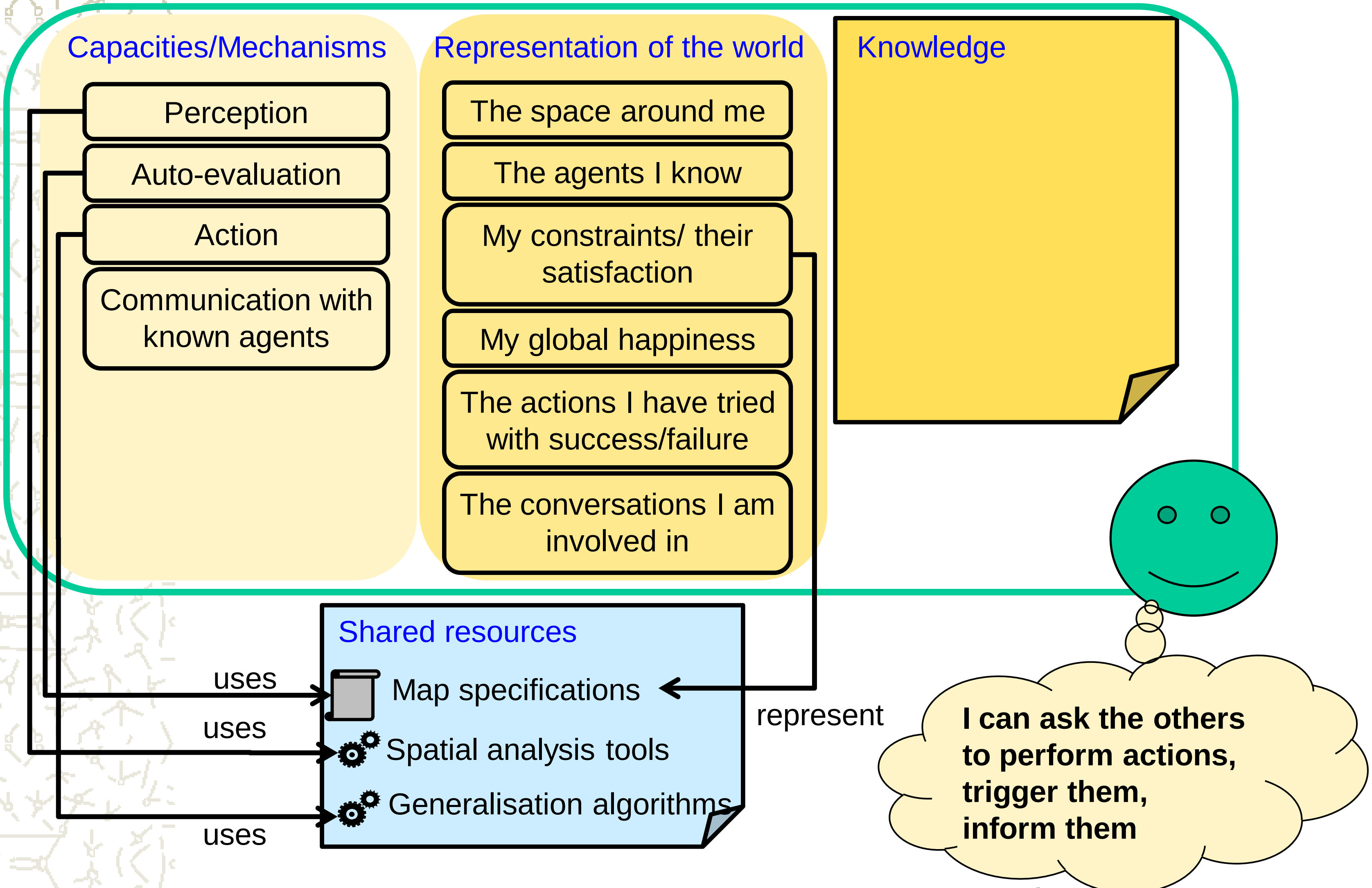
represent

I can assess if I respect the map specifications

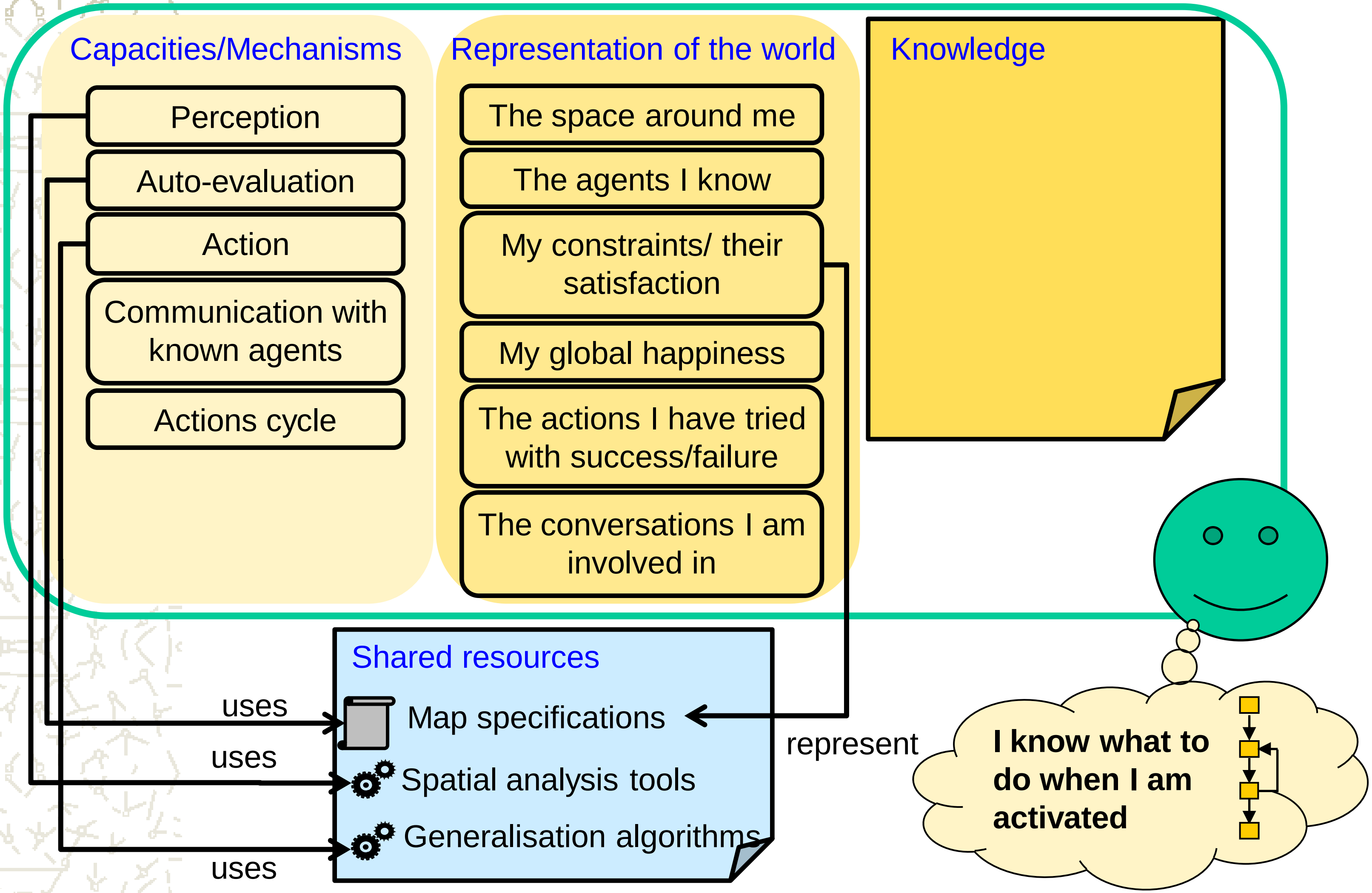
Architecture of a generalisation agent



Architecture of a generalisation agent



Architecture of a generalisation agent



Architecture of a generalisation agent

Capacities/Mechanisms

- Perception
- Auto-evaluation
- Action
- Communication with known agents
- Actions cycle

Representation of the world

- The space around me
- The agents I know
- My constraints/ their satisfaction
- My global happiness
- The actions I have tried with success/failure
- The conversations I am involved in

Knowledge

- Which problem to handle first
- Which algo to solve which conflict
- When to stop searching
- …

Shared resources

- Map specifications
- Spatial analysis tools
- Generalisation algorithms

uses

uses

uses

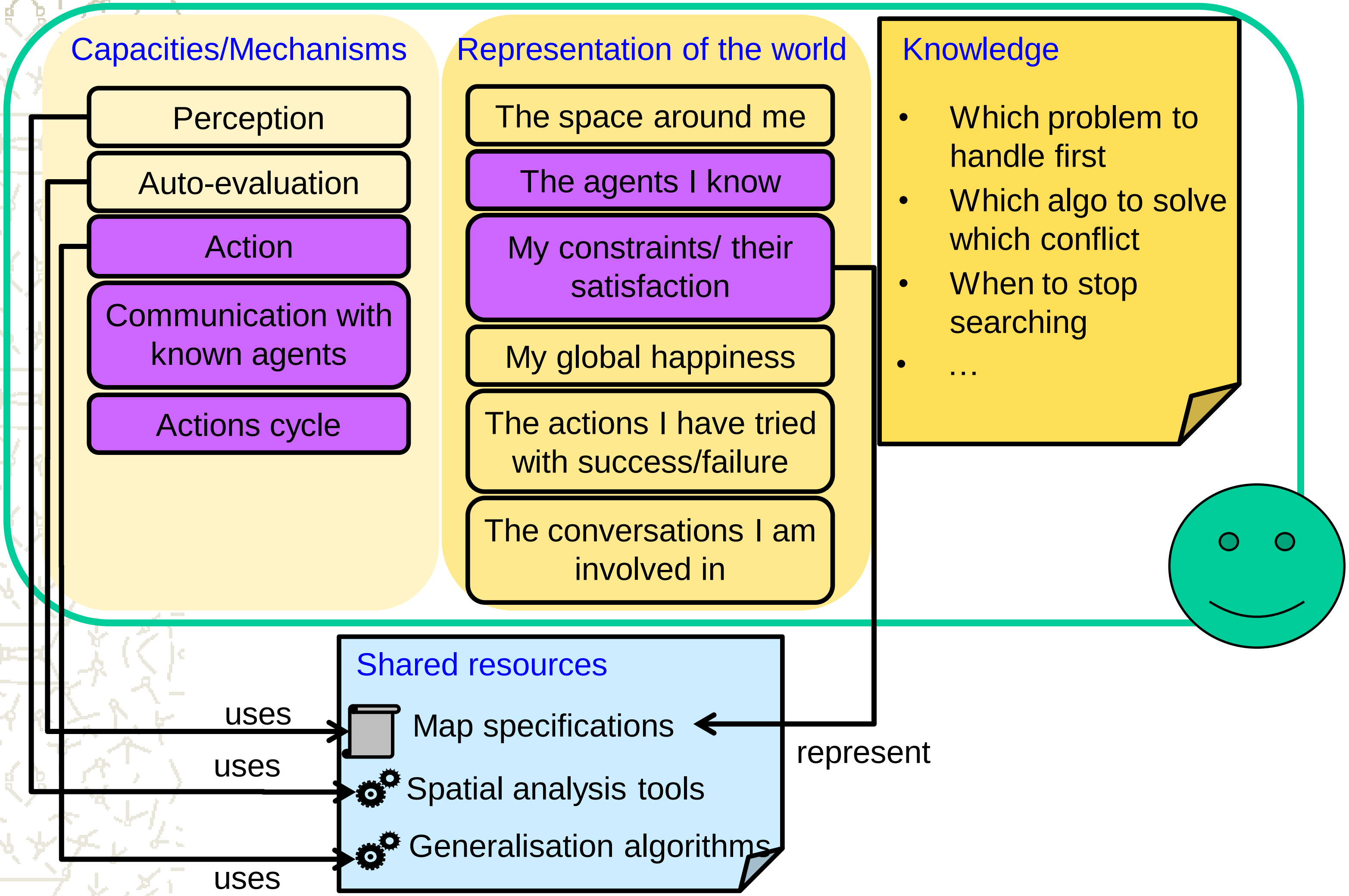
represent

I can make decisions

Outline

- Multi-agent systems
- Why to use agent modelling for generalisation?
- Principles of agent modeling for generalisation
- **Overview of existing agent-based generalisation models**

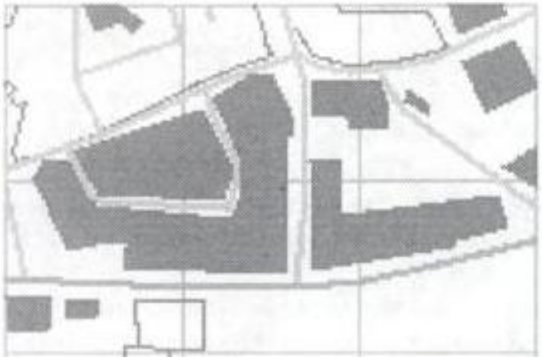
Architecture of a generalisation agent



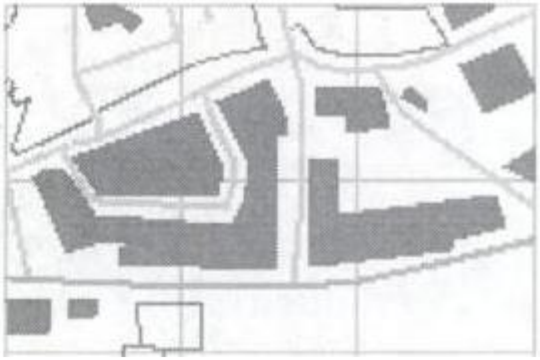
The model of [Baeijs 1998]

- Agents = points of the objects; groups of agents
- Known agents = others of the group
- Constraints translated as forces
- Actions = small displacements
- Life-cycle = compute forces, compute displacement, apply displacement

The model of [Baeijs 1998] - results



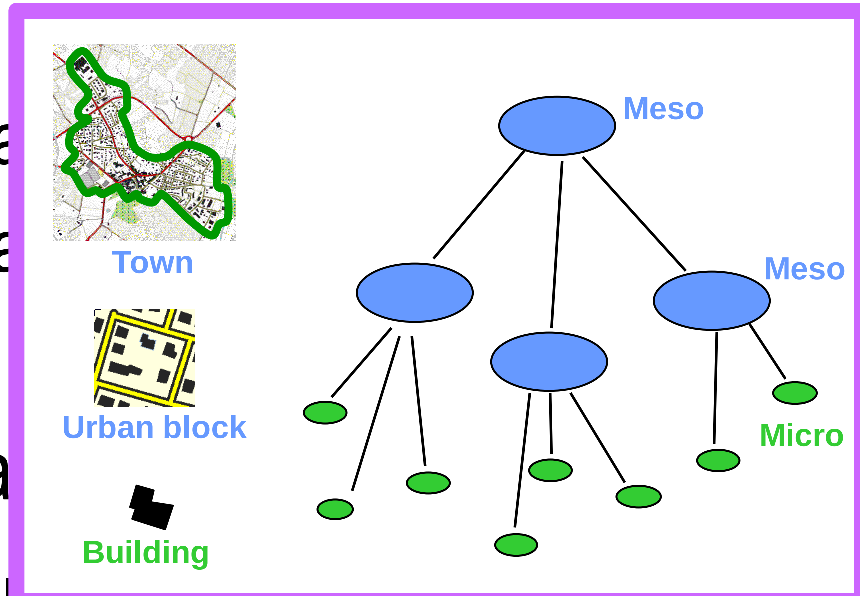
Before



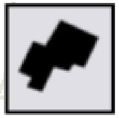
After

The AGENT model [Ruas 1999]

- Agents:
  - Micro a… ment, building)
  - Meso a… oad network)
  - Macro … s)
- Known a… osants
- Constraints: represented as objects, internal to agents
- Actions: generalisation algorithms
- Communication: hierarchical



The AGENT life-cycle v1



Building constraints:

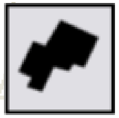
SIZE
measure name: “area”
current value:
goal value: 0.2mm²
importance: strong
priority:
satisfaction:
advice:

GRANULARITY
importance: strong
priority:
satisfaction:
advice:

SQUARENESS
importance: medium
priority:
satisfaction:
advice:

CONCAVITY
importance: medium
priority:
satisfaction:
advice:

The AGENT life-cycle v1



Characterise and Evaluate

Building constraints:

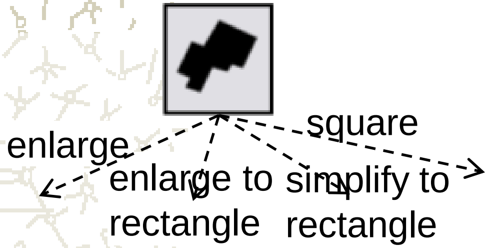
SIZE
measure name: “area”
current value: **0.12mm²**
goal value: 0.2mm²
importance: strong
priority: **strong**
satisfaction: **low**
advice:

GRANULARITY
importance: strong
priority: **medium**
satisfaction: **low**
advice:

SQUARENESS
importance: medium
priority: **low**
satisfaction: **low**
advice:

CONCAVITY
importance: medium
priority: **-**
satisfaction: **perfect**
advice:

The AGENT life-cycle v1



Characterise and Evaluate

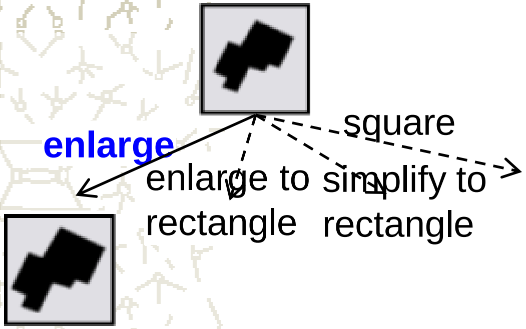
↓

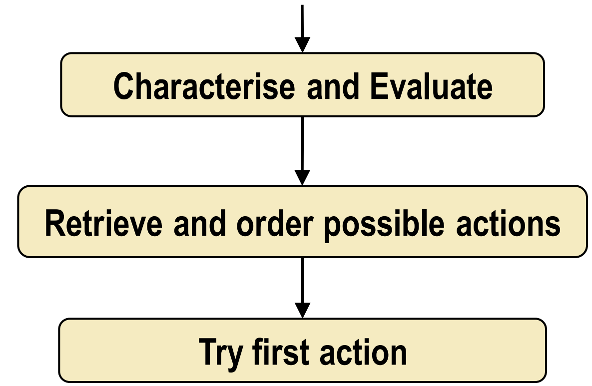
Retrieve and order possible actions

Building constraints:

SIZE	GRANULARITY	SQUARENESS	CONCAVITY
measure name: “area”			
current value: $0.12mm^2$			
goal value: $0.2mm^2$			
importance: strong	importance: strong	importance: medium	importance: medium
priority: strong	priority: medium	priority: low	priority: -
satisfaction: low	satisfaction: low	satisfaction: low	satisfaction: perfect
advice: **enlarge, enlarge to rectangle**	advice: **simplify to rectangle**	advice: **square**	advice: -

The AGENT life-cycle v1

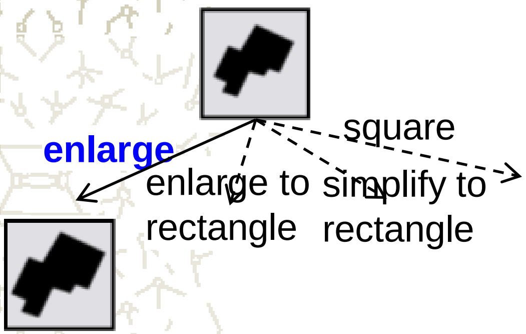


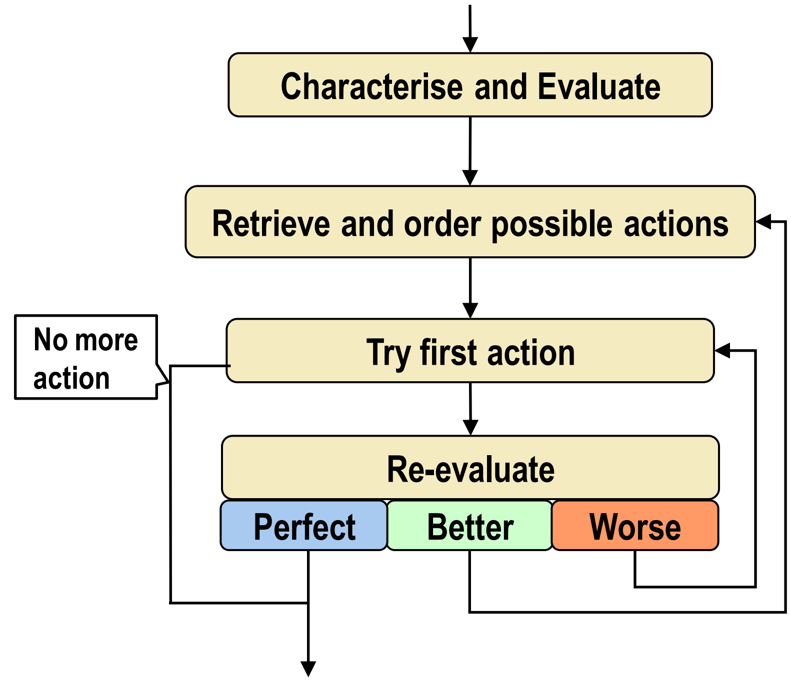


Building constraints:

	SIZE	GRANULARITY	SQUARENESS	CONCAVITY
measure name:	“area”			
current value:	$0.12mm^2$			
goal value:	$0.2mm^2$			
importance:	strong	strong	medium	medium
priority:	strong	medium	low	-
satisfaction:	low	low	low	perfect
advice:	**enlarge, enlarge to rectangle**	**simplify to rectangle**	**square**	-

The AGENT life-cycle v1

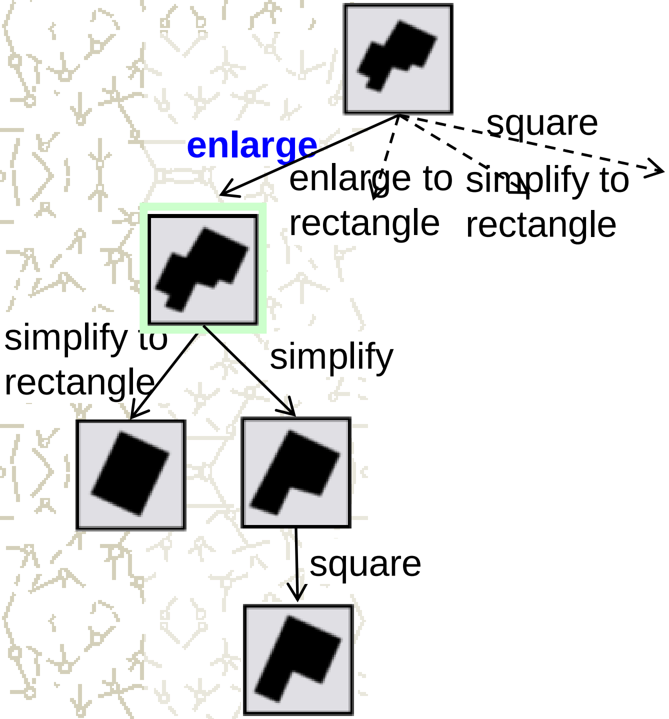


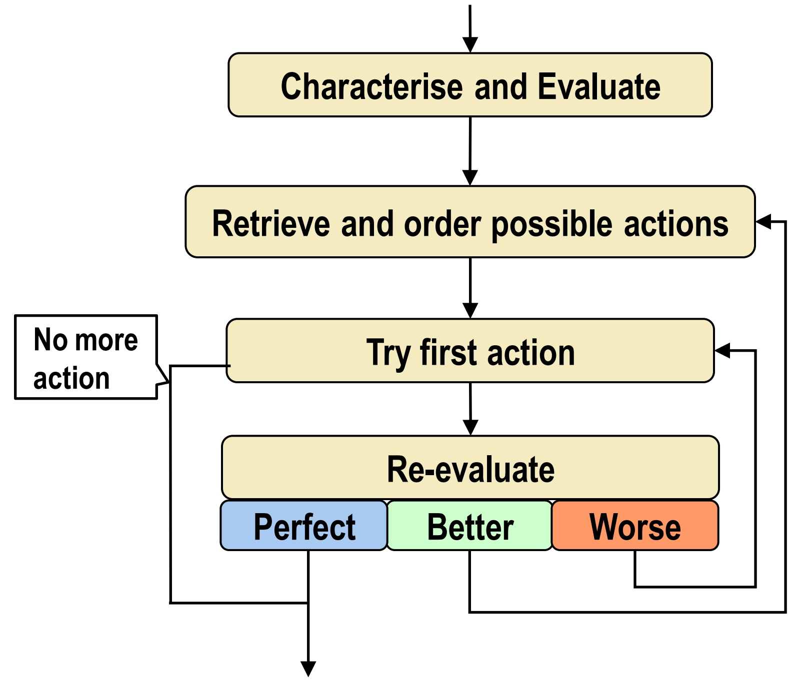


Building constraints:

SIZE	GRANULARITY	SQUARENESS	CONCAVITY
measure name: "area"			
current value: **0.2mm²**			
goal value: 0.2mm²			
importance: strong	importance: strong	importance: medium	importance: medium
priority: -	priority: **strong**	priority: **medium**	priority: -
satisfaction: **strong**	satisfaction: **medium**	satisfaction: **low**	satisfaction: **perfect**
advice: enlarge, enlarge to rectangle	advice: simplify to rectangle	advice: square	advice: -

The AGENT life-cycle v1





Building constraints:

SIZE
measure name: “area”
current value: **0.2mm²**
goal value: 0.2mm²
importance: strong
priority: -
satisfaction: **strong**
advice:

GRANULARITY
importance: strong
priority: **strong**
satisfaction: **medium**
advice:

SQUARENESS
importance: medium
priority: **medium**
satisfaction: **low**
advice:

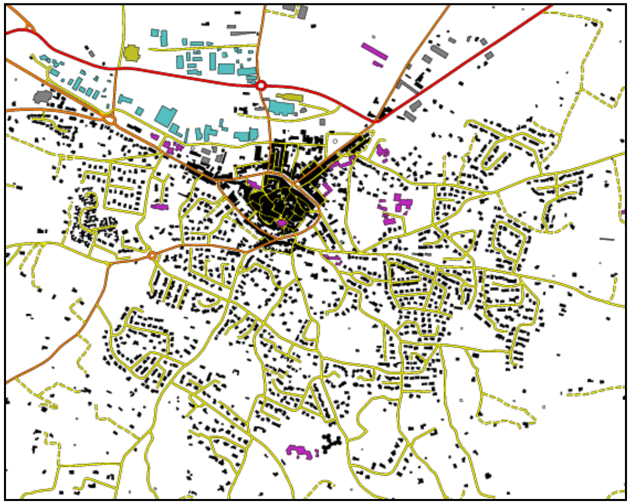
CONCAVITY
importance: medium
priority: -
satisfaction: **perfect**
advice:

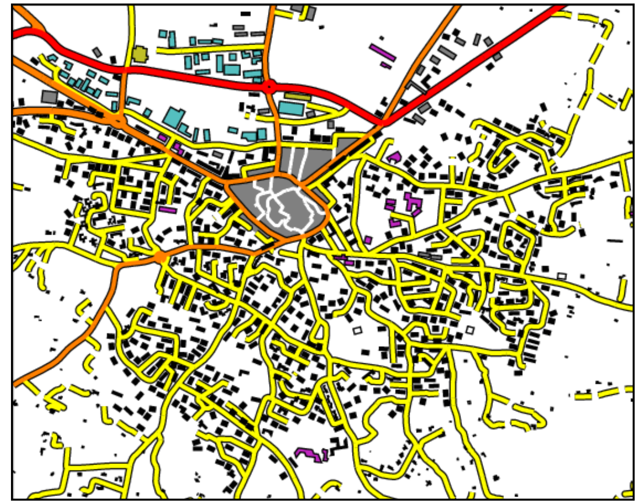
The AGENT project [Barrault et al. 2001]

- Dates: December 1997-December 2000
- Project partners:
  - IGN France
  - University of Edinburgh
  - University of Zürich
  - Polytechnical University of Grenoble
  - 1Spatial (formerly Laser-Scan)
- Used and refined the AGENT model
  - New implementation
  - Rich prototype with lots of generalisation algorithms
  - Improvement of life-cycle [Regnauld 2001]
  - Application to urban space and roads – intensive testings
- => AGENT model well adapted for hierarchical data

The AGENT project [Barrault et al. 2001] - results

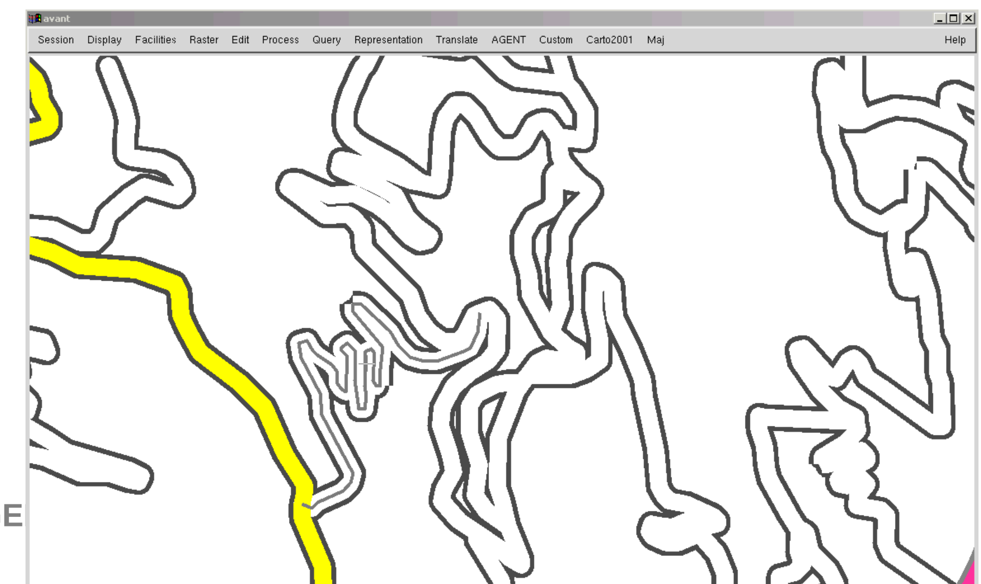
Urban space





Data: IGN France

Mountain roads

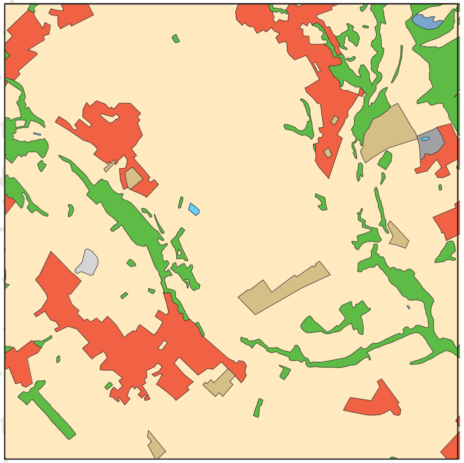


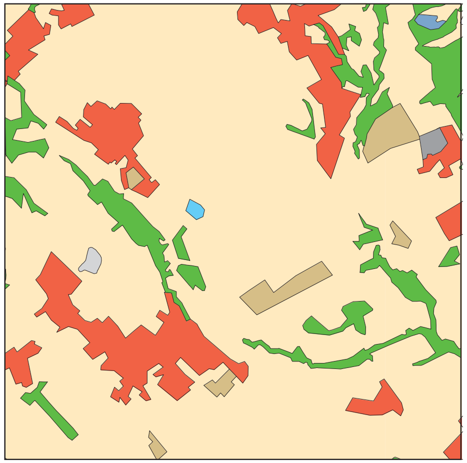
Adaptatations and uses of the AGENT model

Application to categorical data [Galanda 2003]

- Defines agents and algorithms suitable for land cover generalisation
- Among actions, a snakes based algorithm

  => step by step and continuous generalisation combined





Data: SwissTopo

Adaptatations and uses of the AGENT model

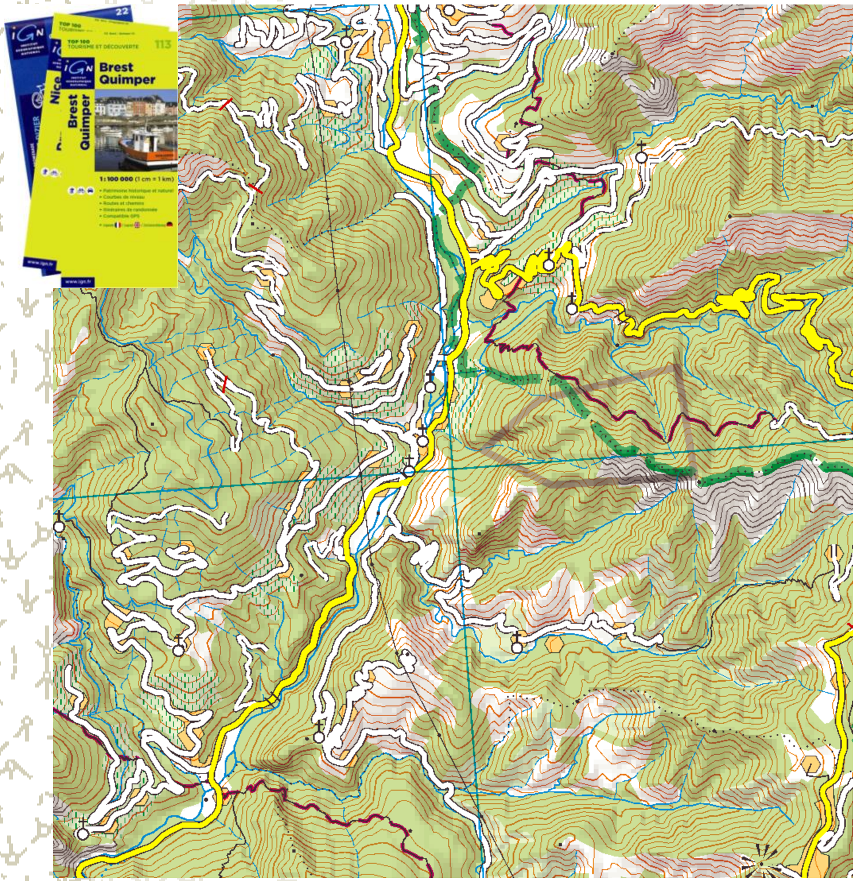
Industrialisation

- In the Clarity software (1Spatial)
- By customising Clarity in European NMAs:
  - IGN-France,
  - OSGB,
  - NMAs of German Länder,
  - KMS-Danemark

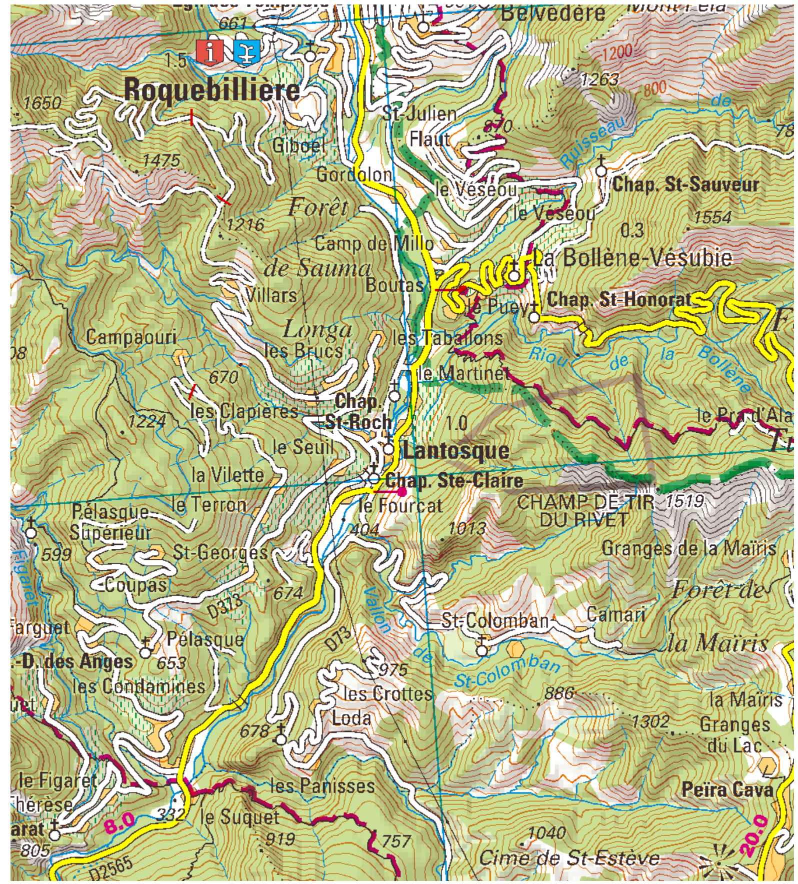
Demos this afternoon

Adaptatations and uses of the AGENT model

- Industrialisation at IGN-France [Lecordix et al. 2005]



BD Carto

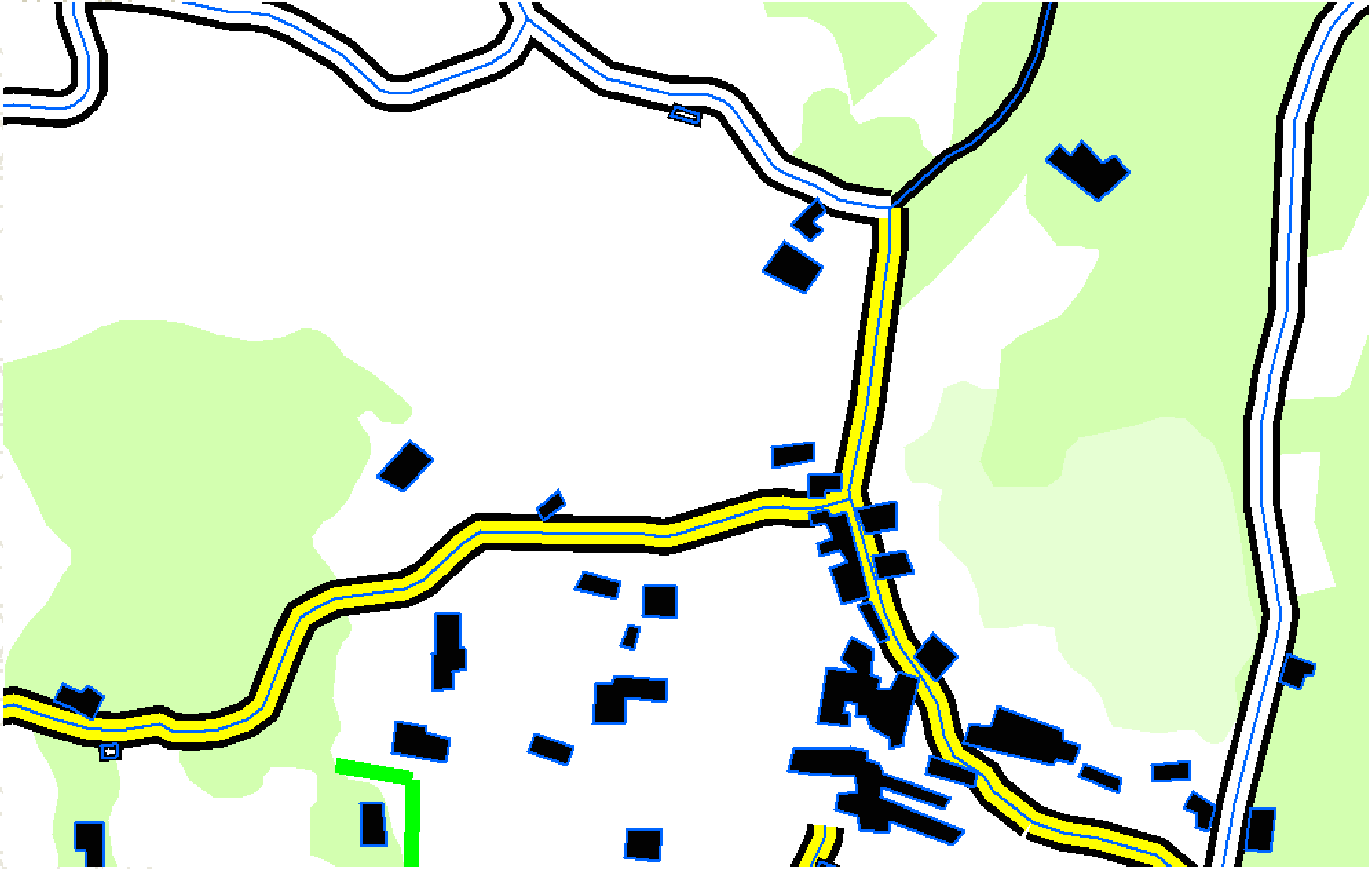


Top100 DB

The CartACom model [Duchêne 2004]

- Target data: low density, no obvious hierarchy
- Agents: only single objects (micro agents)
- Constraints: shared by two agents (relational c.)
- Known agents: neighbours sharing constraints
- Actions: generalisation algorithms, including displacement away from the neighbours
- Communication: each agent
  – informs the others of its own modifications
  – can ask the others to perform actions

The CartACom model [Duchêne 2004] - results

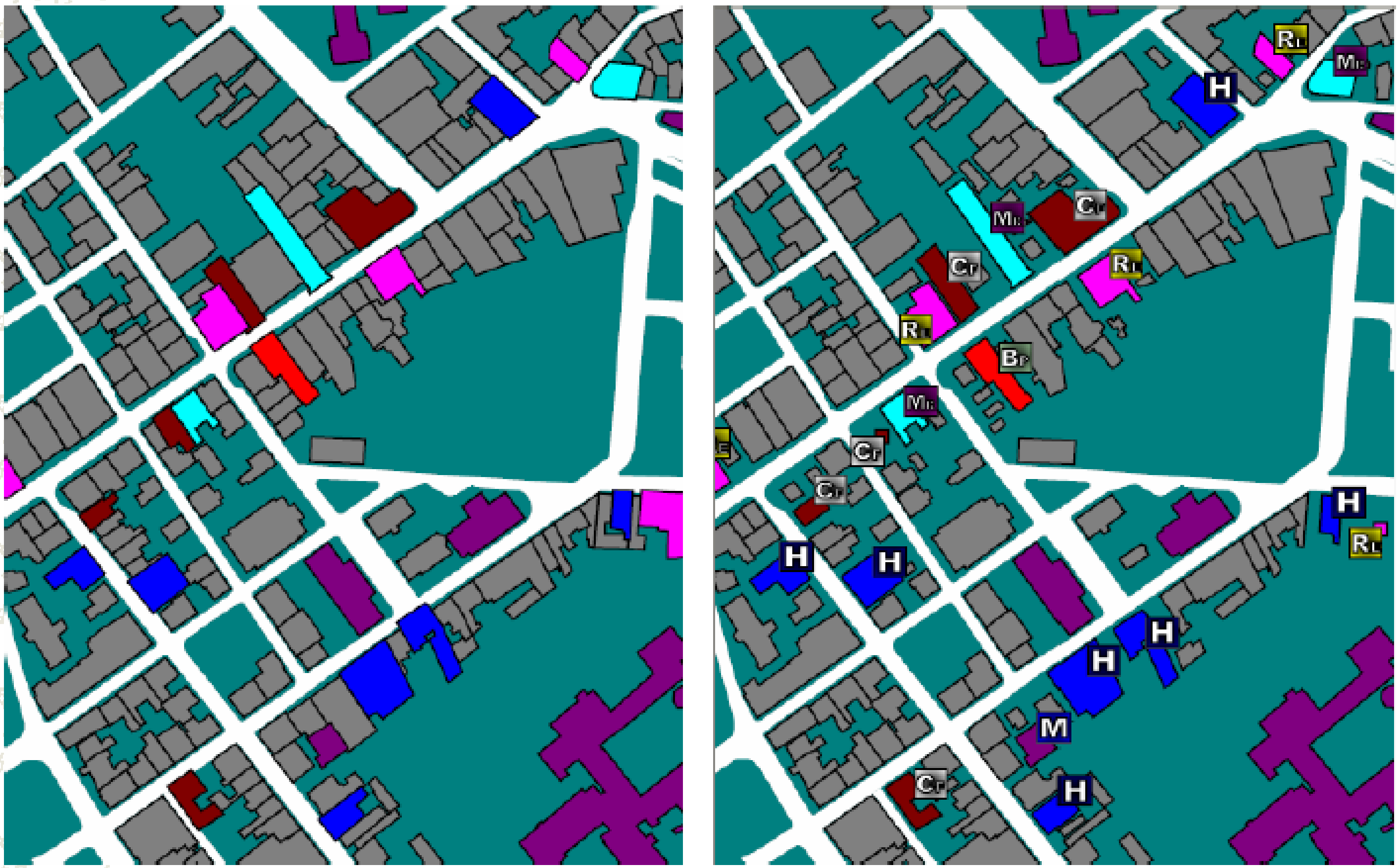


The model of [Jabeur 2006]

- Agents:
  - ~micro, meso + layers
  - Have a priority depending on the user's interest
- Constraints: size and proximity
- Known agents: neighbours, container/contained
- Actions: scaling, aggregation, displacement, removal
- Communication: ask for action, ask meso for help
- Agents with lower priority more easily eliminated

The model of [Jabeur 2006] - results

Has been applied to on-the-fly generalisation with small scale changes



Before After

[Jabeur 2006, p. 206]

The GAEL model [Gaffuri 2008]

- Agents: micro/meso + fields decomposed into points (TIN)
- Constraints:
  - object/field + internal to field
  - translated into forces on points
- Known agents: sharing constraints + neighbouring points
- Actions: small displacements (points)
- Communications: ask for action; trigger neighbours

The GAEL model [Gaffuri 2008] – results

Scale 1:50 000

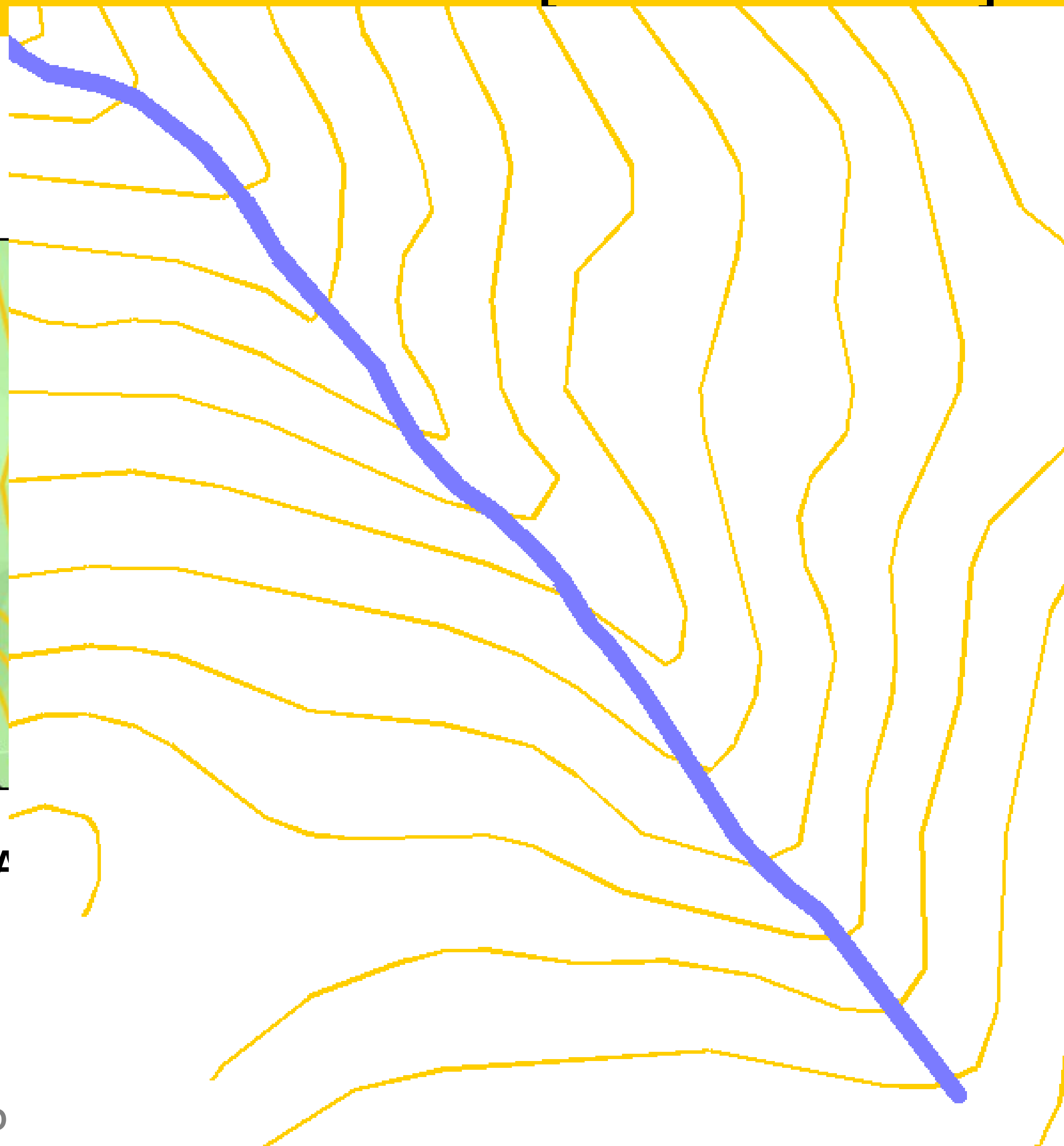
INITIAL STATE

AFTER BUILDINGS GENERALISATION

AFTER GAEL

The GAEL model [Gaffuri 2008] – results

Scale 1:50 000



INITIAL STA

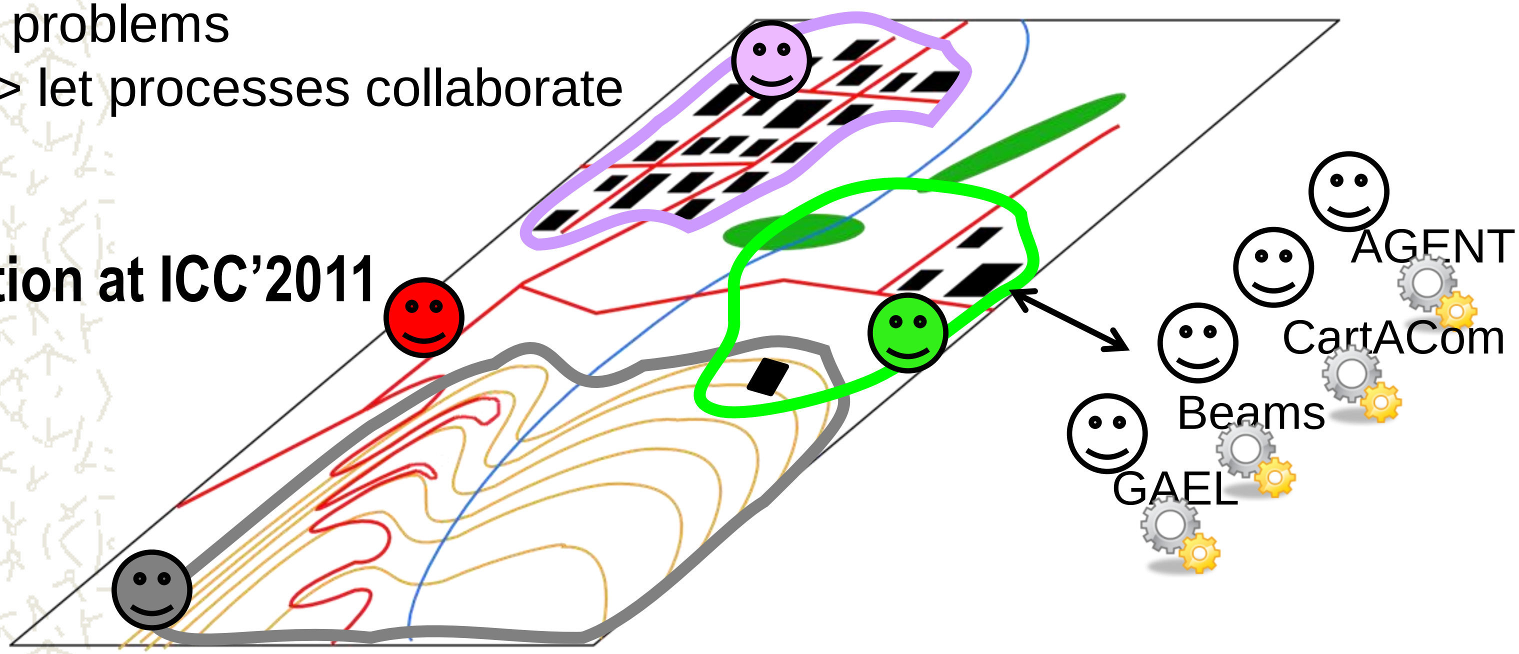
R GAEL

The CollaGen model [Touya 2011]

CollaGen = **Colla**borative **Gen**eralisation

Idea: some processes efficient on some problems, but none able to handle all problems
=> let processes collaborate

Presentation at ICC'2011



Conclusions

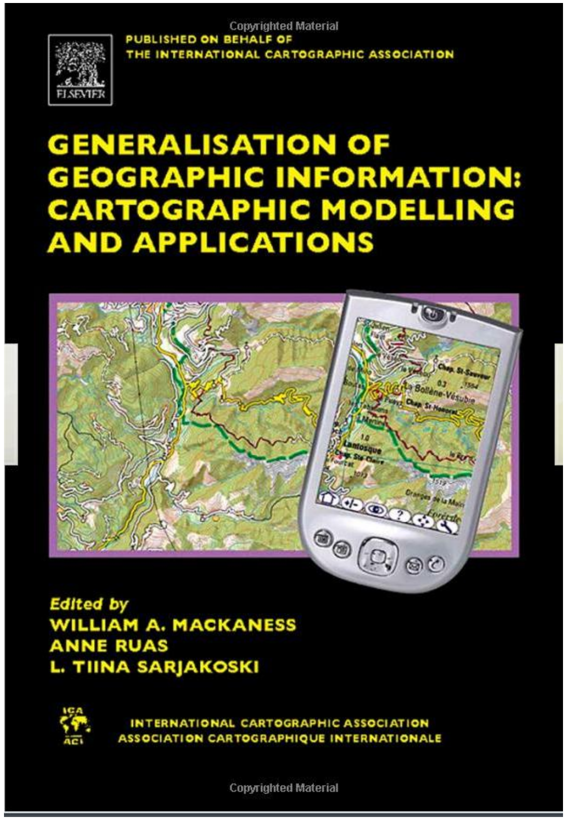
- Agent approaches: a distributed vision of generalisation
  - Geo agents know/interact with a part of the space (and other agents)
  - Their constraints are assessed locally
  - Close the OO modelling => « easy to think »
- … but behaviours/knowledge can still be generic
  - shared by types of agents, customised by specialisation

Conclusions

- Component-based => tolerant to local faults
- Dependent on component quality (algos…)
- Can embed other models

- Well suited for cases where decisions should vary locally according to spatial context

- Main disadvantage: complex to parameterise



Also on this topic

Chapter 14
A Prototype Generalisation System Based on the Multi-Agent System Paradigm
by A.Ruas and C.Duchêne

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