Use Cases of Pervasive Artificial Intelligence for Smart Cities Challenges

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Summary

- Smart city : source of big data
- Pervasive AI
- Use cases
  - Energy production
  - Energy saving
  - Well-being

Smart city : source of big data

Sustainability

Transportation

Governance

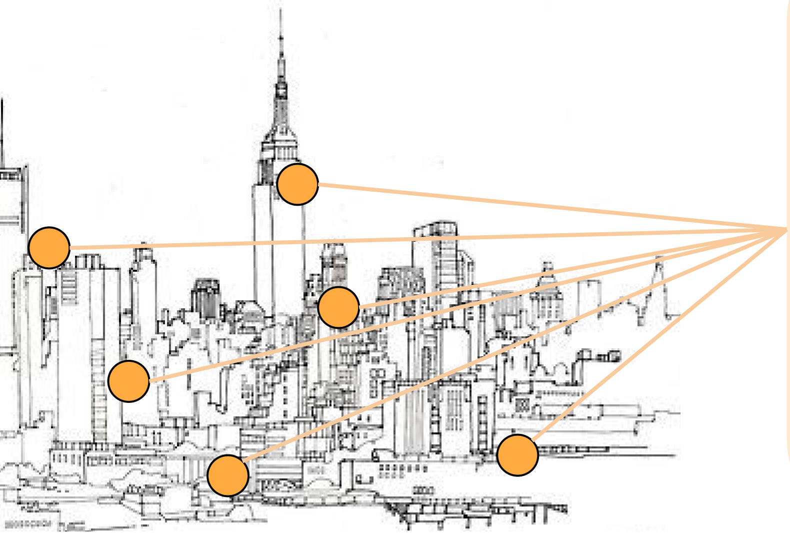
...

Data

- Many definitions of what is a “smart city.
- Focus on the ability of smart cities to provide a large amount of data.

Smart city : source of big data

Low-cost sensors allow to equip cities



Data

- Large amount of data
- Real-time data
- Useless data
- Redundant data

AMOEBA : Agnostic MOdEl Builder by self-Adaptation

Multi-Agent System

- System composed of interacting agents
- Efficient to handle complexity

AMAS

- Adaptive Multi-Agent System
- Bottom-Up approach
- Self-adaptive systems

Julien NIGON, Marie-Pierre GLEIZES et Frédéric MIGEON : ***Self-adaptive model generation for ambient systems. Procedia Computer Science****, 83: 675–679, 2016.*

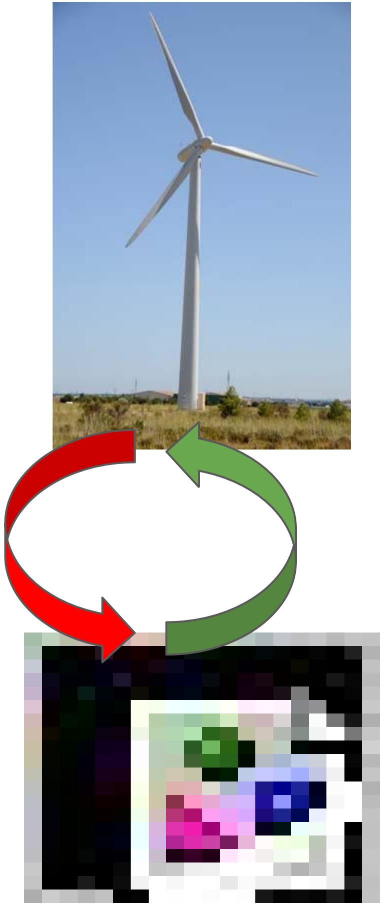
Use Case 1 : Energy production

Energy production

Use case 1

- Smart cities need to be sustainable
- **Renewable energies** are an interesting choice (inexhaustible, low ecological footprint), but...

- Most of renewable energies (including wind and solar power) are **intermittent**
- It is therefore important to forecast energy production

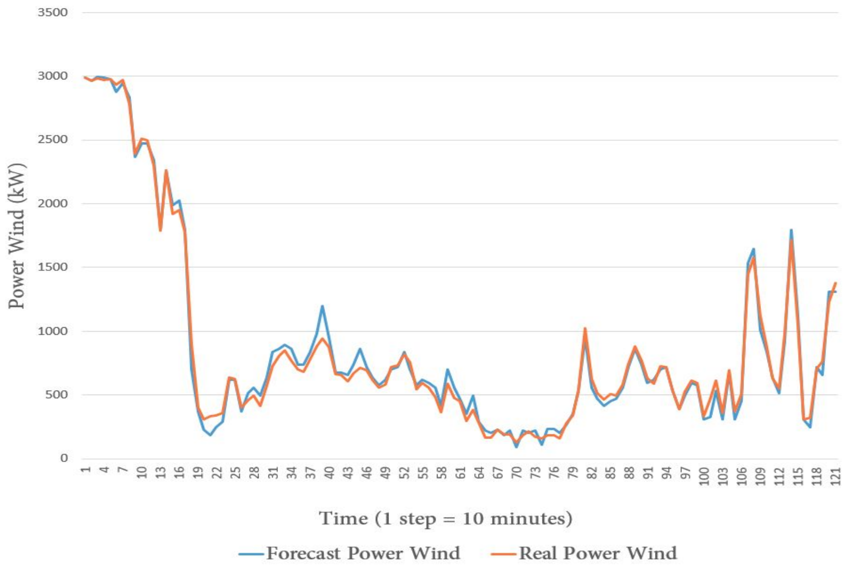


Pervasive AI for energy production

Use case 1

- Use meteorological forecast
- AMOEBA builds correlations between forecast and energy production

- Interesting results using real wind power
- Far less accurate using meteorological forecast



Perspectives for energy production

- At this point, AMOEBA is not sufficiently accurate using meteorological forecast
- These forecasts are too unstable

- But even using these forecasts, AMOEBA accuracy is comparable to more classical approaches (like neural networks)

Use Case 2 : Energy saving

Energy saving

Use case 2

- Connected buildings allow to monitor many data
- Theoretically, this allows the detection of **uncommon situations**
- Detecting these situations allows to optimizes energy consumption, but...

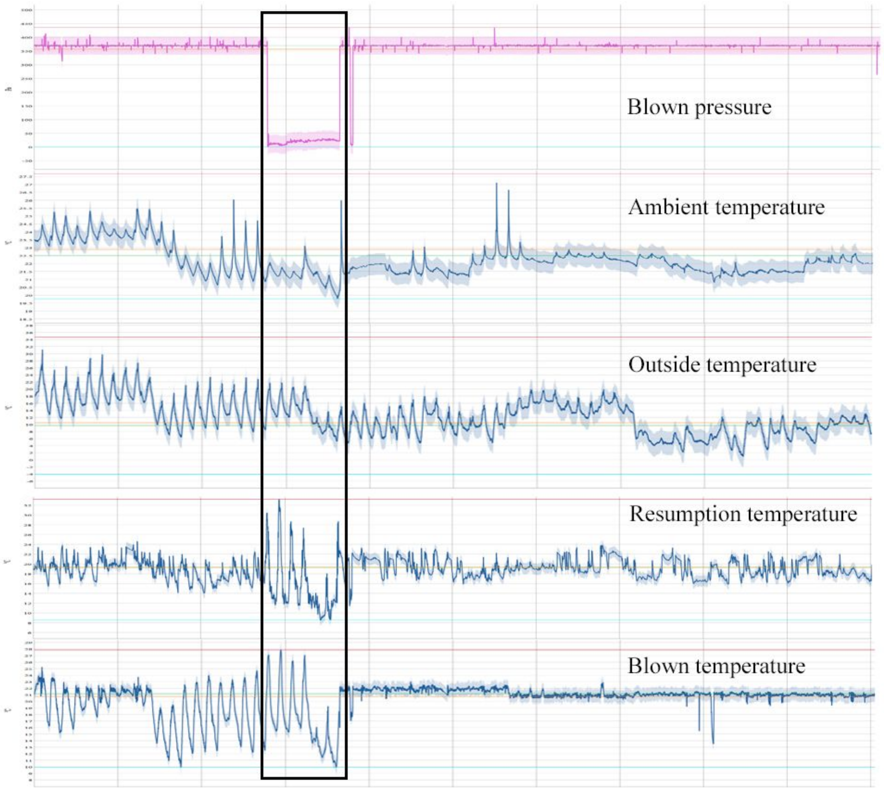
- Smart cities provide too many data to only rely on human technician
- It is therefore important to automatically detect uncommon situations

Pervasive AI for energy saving

Use case 2

- Use data annotated by an expert

- AMOEBA builds correlations between all data sources and informations from the expert



Perspectives for energy saving

Use case 2

- First results are promising
- Low error rate

To do :

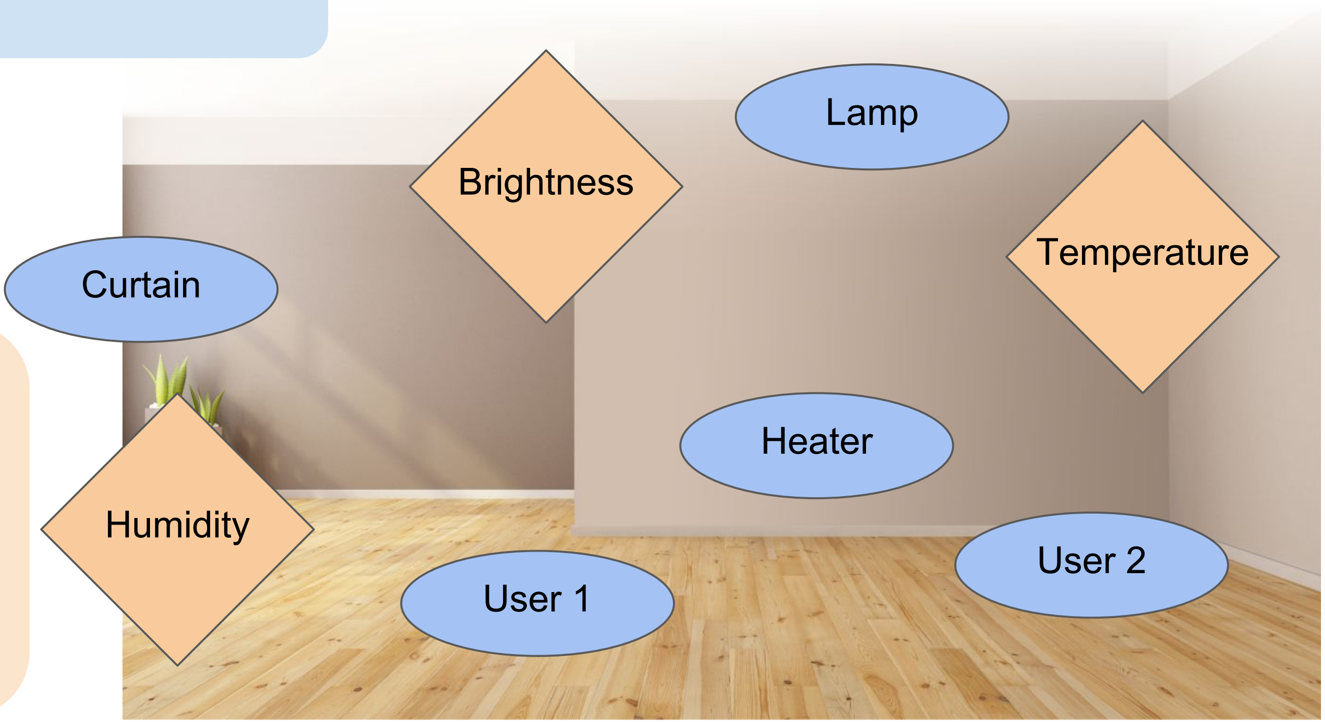
- Working with harder to detect uncommon situations
- Evaluating the confidence of uncommon situations detection

Use Case 3 : Well-being

Well-being

- Many connected devices

How to use them efficiently to improve well-being?



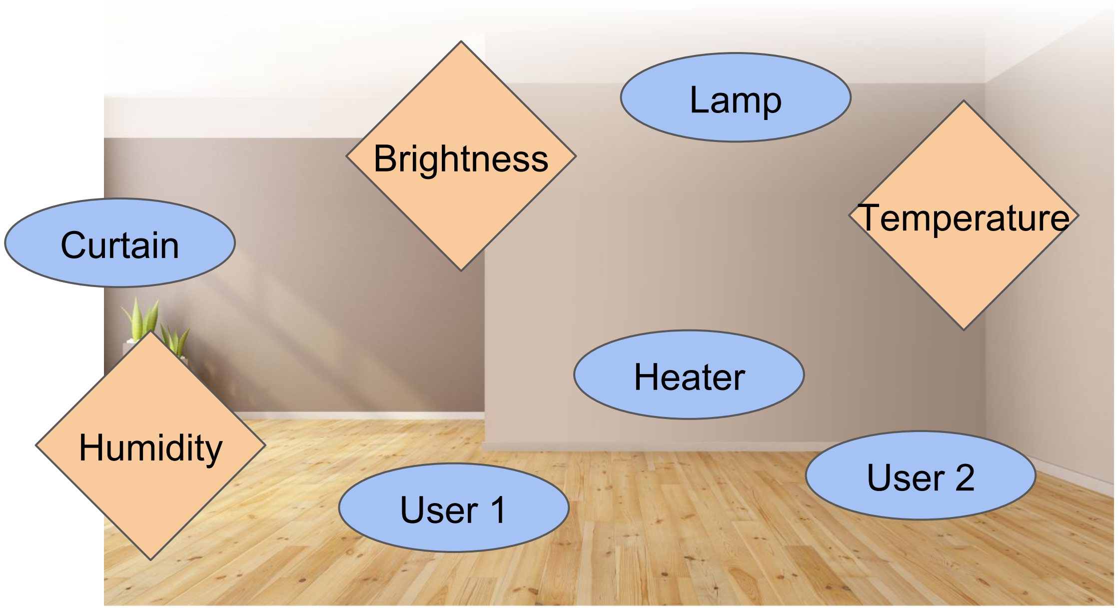
Pervasive AI for well-being

Use case 3

AMOEBA builds dynamic models of behaviour

Allow to :

- Forecast impact of actuators
- Forecast users actions



Perspectives for well-being

- AMOEBA was designed in order to handle well-being problematics, but we need real world experimentations.

- Previous work using similar approach already achieved good results.

Valerian Guivarch, Valérie Camps, André Péninou, and Pierre Glize. ***Self-adaptation of a learnt behaviour by detecting and by managing user's implicit contradictions.***

Conclusion

- Smart cities need a generic approach to handle data
- AMOEBA is a **dynamic**, **bottom-up** approach designed for this purpose

Perspectives

- Detecting useless data
- Detecting lack of data
- Giving confidence on AMOEBA forecast
- Experimentating on neOCampus

Thank you for your attention.

Plan

1. Ambiant Systems and Complexity

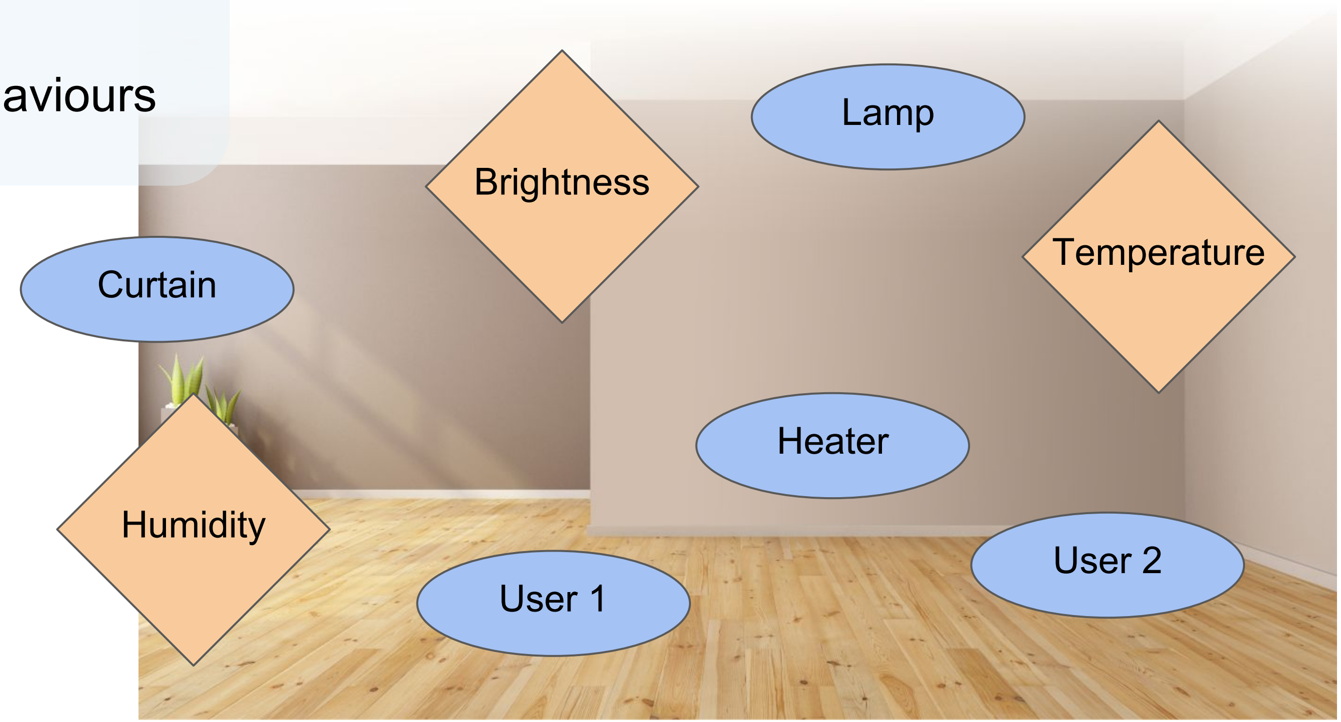
2. Model Generation

3. Agnostic MOdEl Builder by self-Adaptation (AMOEBA)

4. Conclusion

Ambiant Systems and Complexity

- distributed information
- non-linear dynamics
- noisy data
- unpredictable behaviours



Challenges

1 : How can I adjust the temperature in such an environment ?

2 : Is it possible to replace the data of a deficient sensor?

Model Generation

Generating a model ?

Linking events and entities composing the studied system

Opening curtain + **Sun** = **Increase brightness**

Empirical model

Statistical model

Physical model

Model Generation

Models designed by experts

- Long to develop
- Can not take into account all unexpected events

Adaptive models generated automatically

- Need to learn
- As accurate as experts models ?

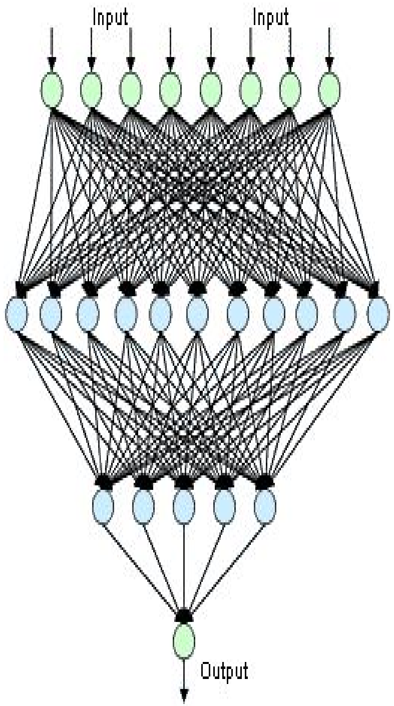
Model Generation

Existing approaches

Neural Networks / Deep learning
Schema learning
Bayesian networks
Support vector machines

Difficult to learn in real time

Difficult to adapt to new applications (topology…)



AMOEBA

Agnostic MOdEl Builder by self-Adaptation

Multi-Agent System

- System composed of interacting agents
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AMAS

- Adaptive Multi-Agent System
- Bottom-Up approach
- Self-adaptive systems

AMOEBA

AMAS

- self-organisation
- self-adaptation

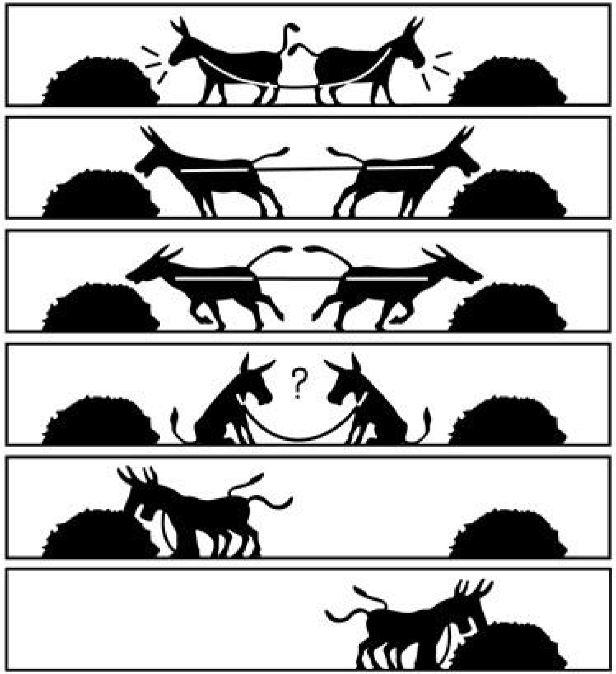
Driven by cooperation

Interactions between agents could be :

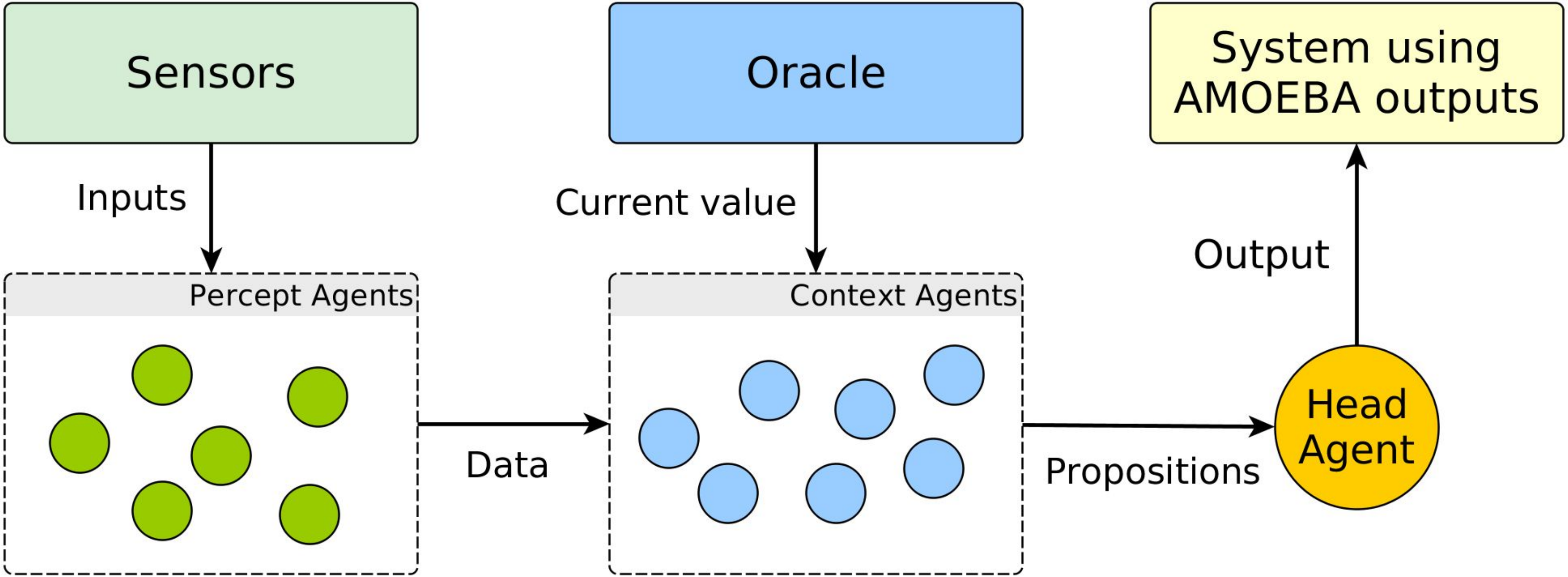
Cooperative +

Neutral =

Antinomic -



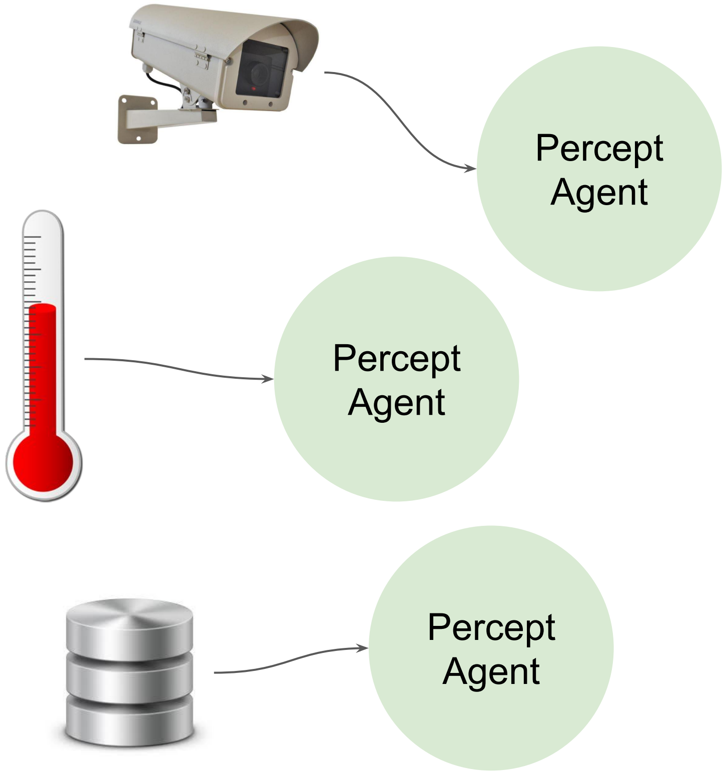
AMOEBA


Sensors
Oracle
System using AMOEBA outputs
Inputs
Current value
Output
Percept Agents
Context Agents
Data
Propositions
Head Agent

AMOEBA

Percept Agents

- Connected to the data sources
- Manage inputs
- Transmits the data to relevant agents



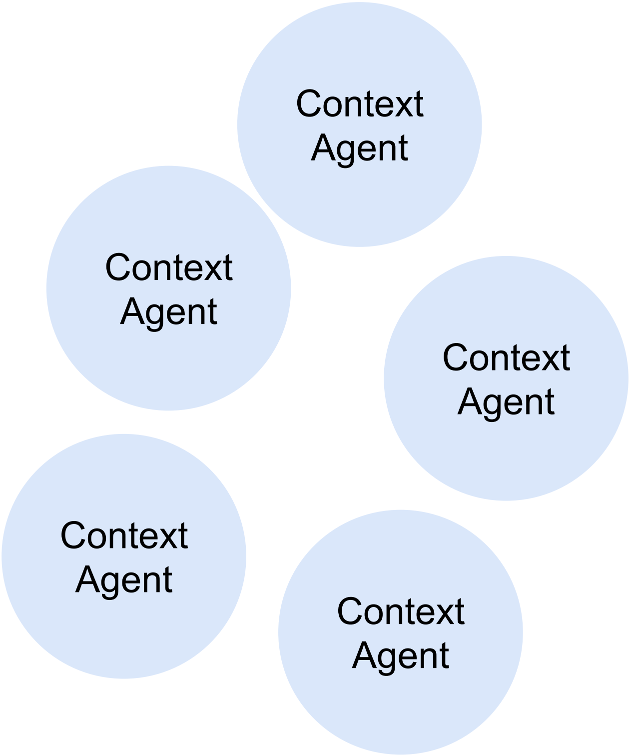
AMOEBA

Context Agents

- Absent at the beginning of the learning
- Responsible for the proposal of a good output value for a range of situations

Tripartite structure

context	local model	confidence



AMOEBA

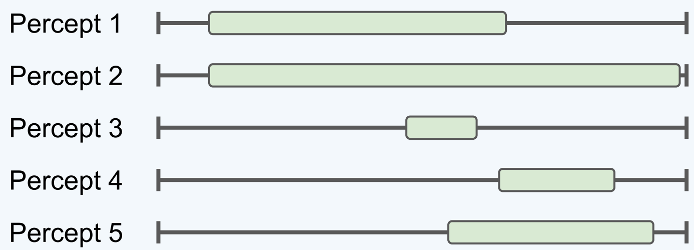
Confidence

Local Model

Context

context

- Set of intervals called validity ranges.
- One Percept Agent associated with each validity range.



- Agent is **valid** if all ranges are valid.

AMOEBA

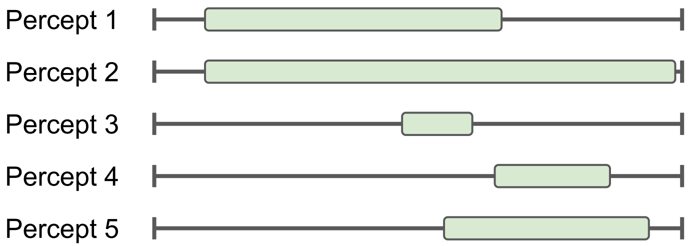
Confidence

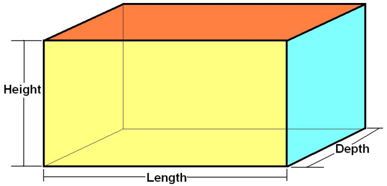
Local Model

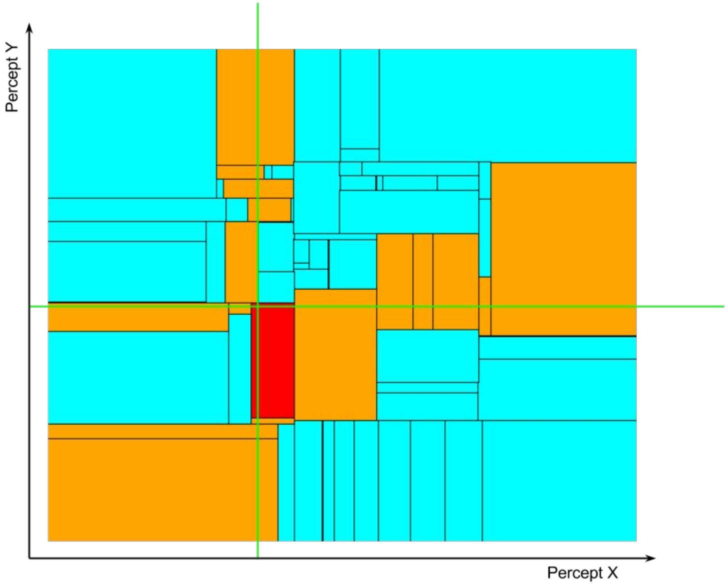
Context

context

- A simple way to visualize this structure is to represent the context of a Context Agent such as n-orthotope (or hyperrectangle)







AMOEBA

Confidence

Local Model

Context

Local Model

- Function which, according to current Percept Agent values, provides an output
- Fixed value, linear function, algorithm, etc ...

Confidence

- Confidence value on the quality of its proposal

AMOEBA

Confidence

Local Model

Context

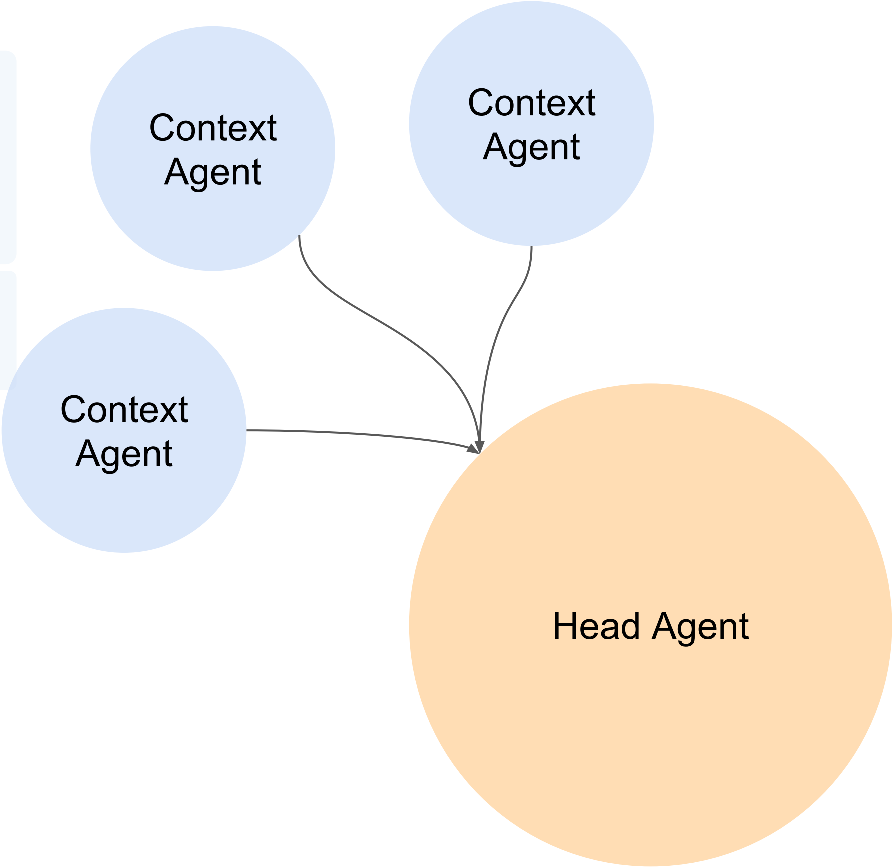
Adaptation

When a Context Agent finds that it provides incorrect information, it adapts the different components of its tripartite structure to improve results.

AMOEBA

Head Agent

- Receive propositions from valid Context Agents
- Select the best one



Conclusion

To handle ambiant systems complexity :

- static models are limited

- AMOEBA propose a dynamic, self-adaptive approach

Perspectives

Works underway :
- meteorological predictions
- learning in a connected campus
- anomaly detection

Extensive comparison with other approaches

Conclusion

Thank you for your attention.

ANNEX

Agents in AMAS

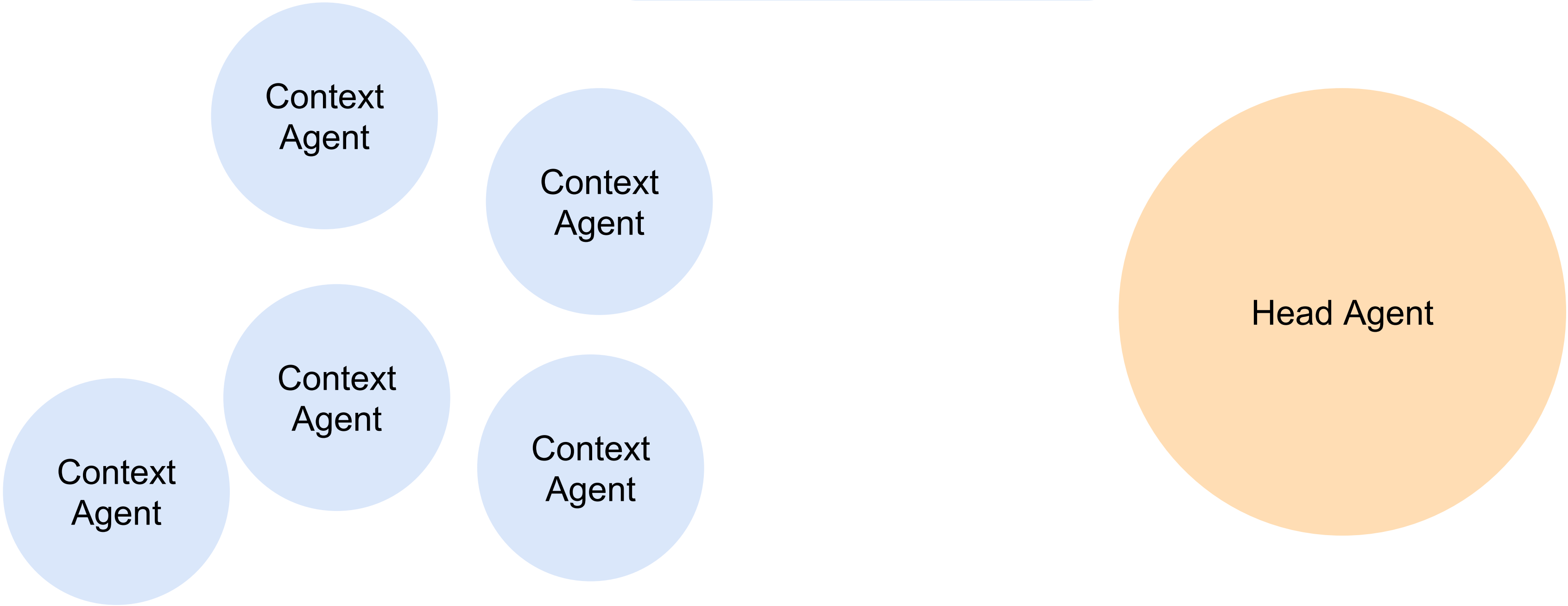
Agent is in **cooperative state** when :

- all its interactions are cooperative

In this state, the agent executes its **nominal behaviour**

Else, agent is in a **Non-Cooperative Situation (NCS)**.

Agents in AMAS4CL



AMOEBA

Head agent

Allow interactions between exploitation mechanism and other agents

No control over other agents

Able to detect and repair some NCS.

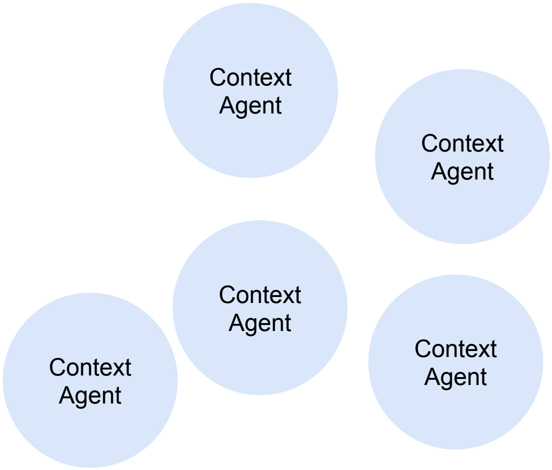
AMOEBA

Contexts agents

Start as an empty set
All created at runtime

Tripartite structure

context	action	appreciation



AMOEBA

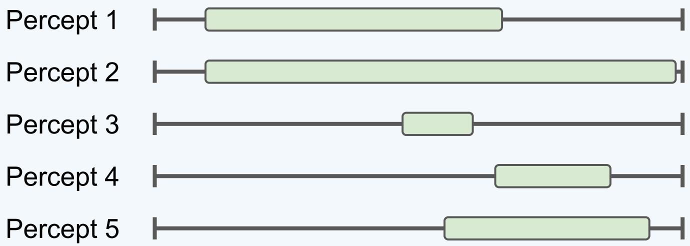
appreciation

action

context

context

Set of intervals called validity ranges.
One percept associated with each validity range.



Valid if all ranges are valid.

AMOEBA

appreciation

action

context

action

Modification of the environment

Domain dependant

Exemple : go forward, rotate right, etc...

appreciation

Estimation of the effect of the action

Exemple : new position, temperature change, etc...

AMOEBA

Perception

1 : receives perception values from environment
2 : receives feedback from exploitation mechanism

Decision and action

1 : checks its validity
2 : if valid, sends an *action* proposition (+*appreciation*) to the Head Agent

AMOEBA

Perception

1 : receives feedback from exploitation mechanism
2 : receives action propositions from Context Agents

Decision and action

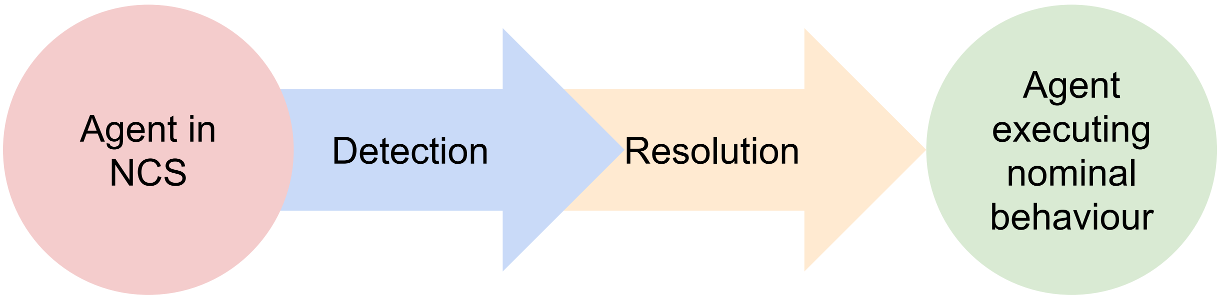
1 : gathers all propositions and send them to the exploitation mechanism
2 : forwards exploitation mechanism feedbacks to relevant Context Agents

AMOEBA

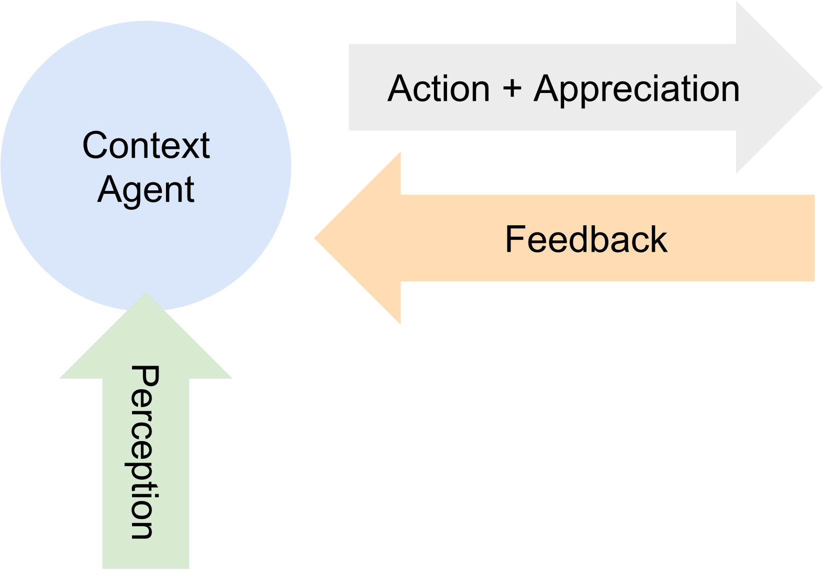
In several cases, these behaviours fail...

… and agents are no more cooperatives.

These situations are NCS



AMOEBA



NCS 1 : wrong appreciation

Using feedback, Context Agent know if its action was applied.

It evaluates its appreciation.

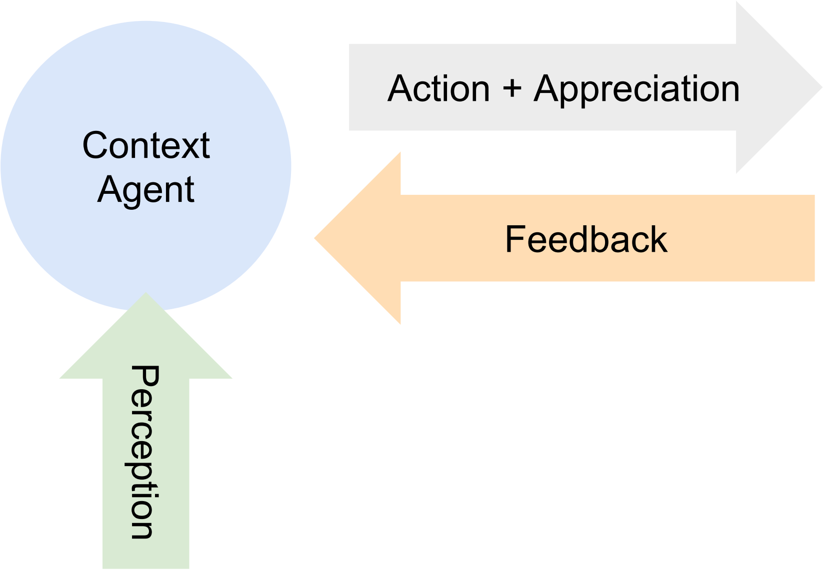
If its appreciation is wrong, the interraction is flawed.

Conflict NCS

Resolution :

Reduction of the validity ranges.

AMOEBA



NCS 2 : inexact appreciation

Using feedback, Context Agent know if its action was applied.

It evaluates its appreciation.

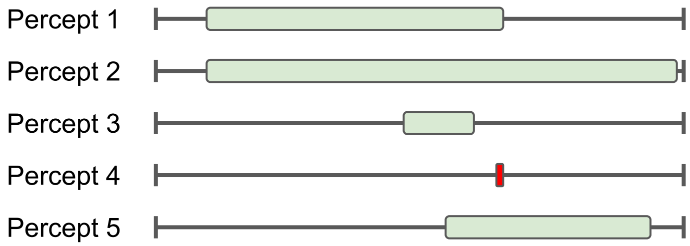
If its appreciation is inexact, the interraction is flawed.

Conflict NCS

Resolution :

Less harmful NCS.
Context Agent adjust its appreciation.

AMOEBA



NCS 3

After adjustement, ranges could be greatly reduced.

If range is inferior to a user-defined critical size, the agent consider itself useless.

Uselessness NCS

Resolution :

The agent self-destroys.

AMOEBA

Head Agent

Feedback

NCS 4

Feedback action was not proposed at the previous step.

No proposition was interesting
OR
No Context Agent was valid

Improductivity NCS

Resolution :

Extend last Context Agent range to include current context **or** Create new Context Agent

Conclusion

AMAS4CL

To handle real world complexity :
- good context understanding
- mapping context/information

Static mapping limited

AMAS4CL propose a dynamic, self-adaptive approach

Perspective

Works underway :
- networks control
- complex system models generation
- human user behaviour understanding

Formalisation of AMAS4CL

Comparison with other approaches