DE LA RECHERCHE À L'INDUSTRIE

A FUZZY SPATIO-TEMPORAL APPROACH FOR ACTIVITY RECOGNITION

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SeCoGIS

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OUTLINE

Context of this work

What is CEA ?
What is Egidium Technologies ?
What is the goal of this work ?

A brief introduction to fuzzy logic

Activity recognition

Focused activities

CONTEXT

CONTEXT

What is CEA ?

- Atomic Energy and Alternative Energies Commission
- Fundamental and applied research
- Major actor in research and innovation

What is CEA Tech ?

- Technological Research Division at CEA
- RTO
- Work is funded by private companies

What is Egidium Technologies

- Surveillance software editor
- Joint lab Egidium Technologies / CEA Tech

CONTEXT

Goal

- Improving the surveillance software
- Characterizing activities of geolocalized entities

Examples

- Agents situation awareness
- Monitoring of autonomous robots
- Crowd in public space
- Fleet of vehicles

Constraints

- The product of our work must be customisable for many applications
- Using Egidium’s GIS

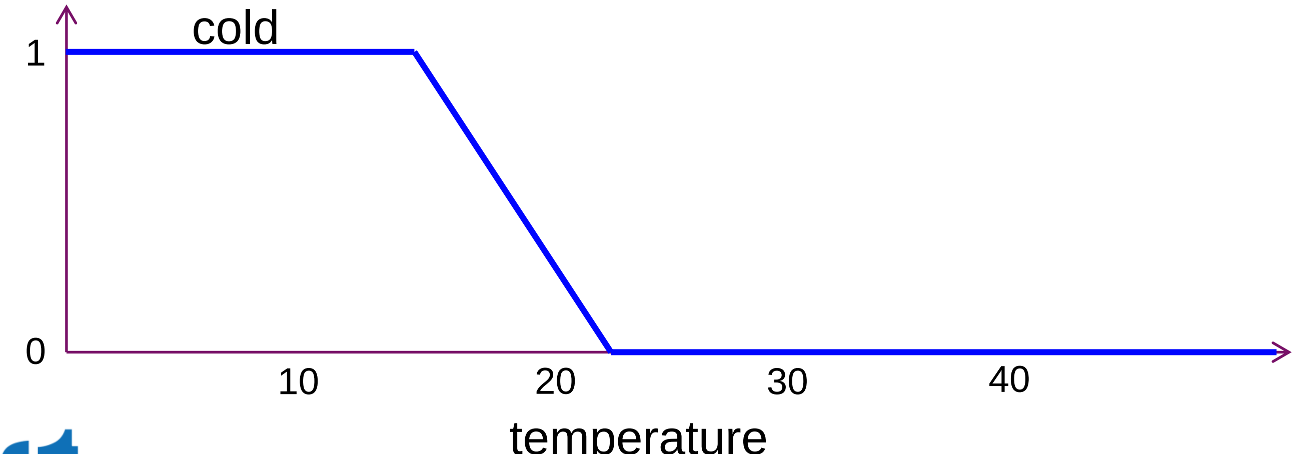
A BRIEF INTRODUCTION TO FUZZY LOGIC

Definition

- Introduced by Zadeh in 1965
- Many-valued logic
- Truth values range between 0 and 1

Membership functions and linguistic variables

- Membership functions measure how an object belongs to a set
- Linguistic variables introduce vocabulary to characterize a physical variable



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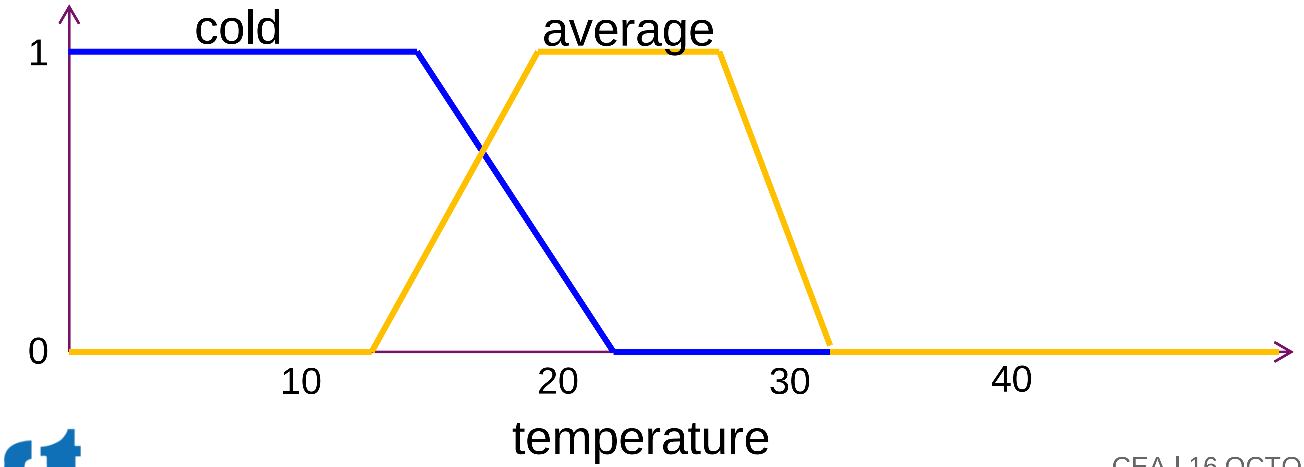

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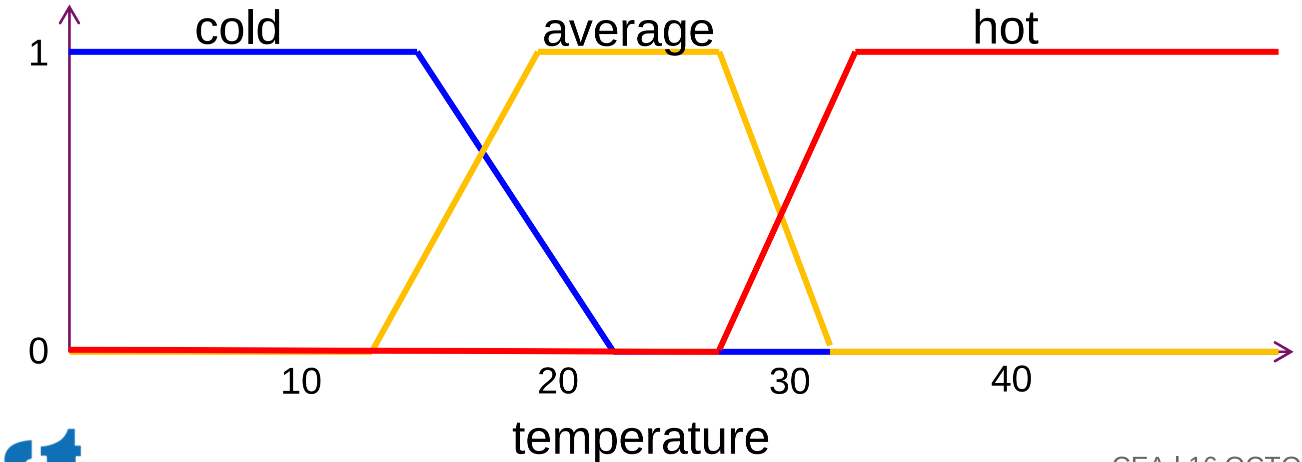


Denotation

- $\mu_{cold}(t)$ denotes membership function cold applied to t

Fuzzy expressions

- Fuzzy proposition: X is A, ex.: temperature is cold
- Expressions can be built with t-norms and t-conorms
- Not : 1's complement
- Zadeh's t-norm and t-conorm (most used): min / max

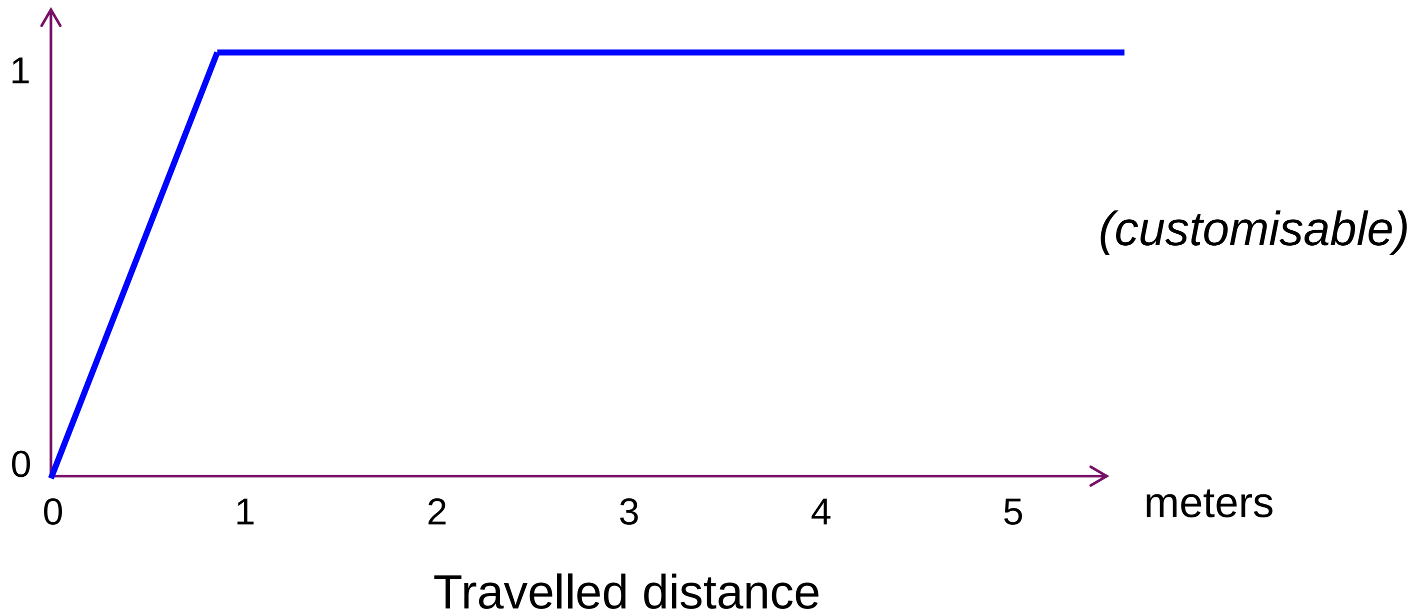
Advantages

- Deals with uncertainty and vagueness
- Simple computation

ACTIVITY RECOGNITION

e is moving

- e is moving ⇔ the distance from the last position is greater than 0
- Let P_1 = the distance is greater than 0



e is moving

- e is moving at time t:

$$\mu(p_1, t) \vee \operatorname*{mean}_{t' \in I^*} \mu(p_1, t')$$

e is moving

- e is moving at time t:

$$\underbrace{\boxed{\mu(p_1, t)}}_{\text{present time}} \vee \operatorname*{mean}_{t' \in I^*} \mu(p_1, t')$$

e is moving

- e is moving at time t:

$$\mu(p_1,t) \vee \boxed{\operatorname*{mean}_{t'\in I} \mu(p_1,t')}$$

recent past (I)

e is moving

- e is moving at time t:

$$\mu(p_1, t) \vee \boxed{\underset{t' \in I}{\text{mean}}^{*} \mu(p_1, t')}$$

recent past (I)

- Mean can be a weighted average (the most recent, the most important)
  Ex. the last few seconds are more important than the last minute

e is moving

- e is moving at time t:

If the entity has just begun to move…

$$\mu(p_1, t) \vee \underbrace{\boxed{\operatorname*{mean}_{t' \in I^*} \mu(p_1, t')}}_{0}$$

…it only considers the very present

e is moving

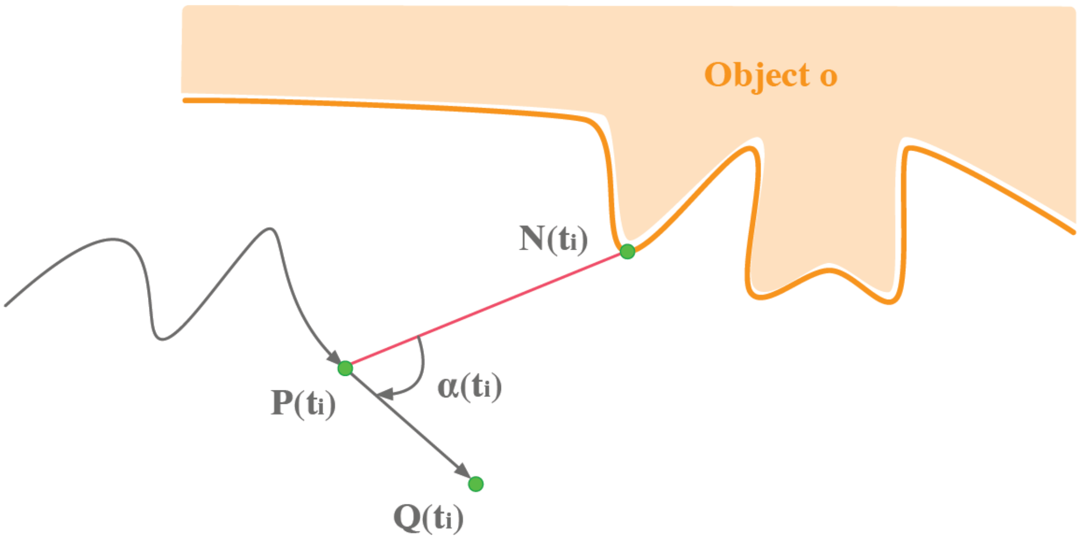
- e is moving at time t:

If the entity has just stopped…

$$\underbrace{\boxed{\mu(p_1, t)}}_{0} \vee \underset{t' \in I^*}{\mathrm{mean}}\, \mu(p_1, t')$$

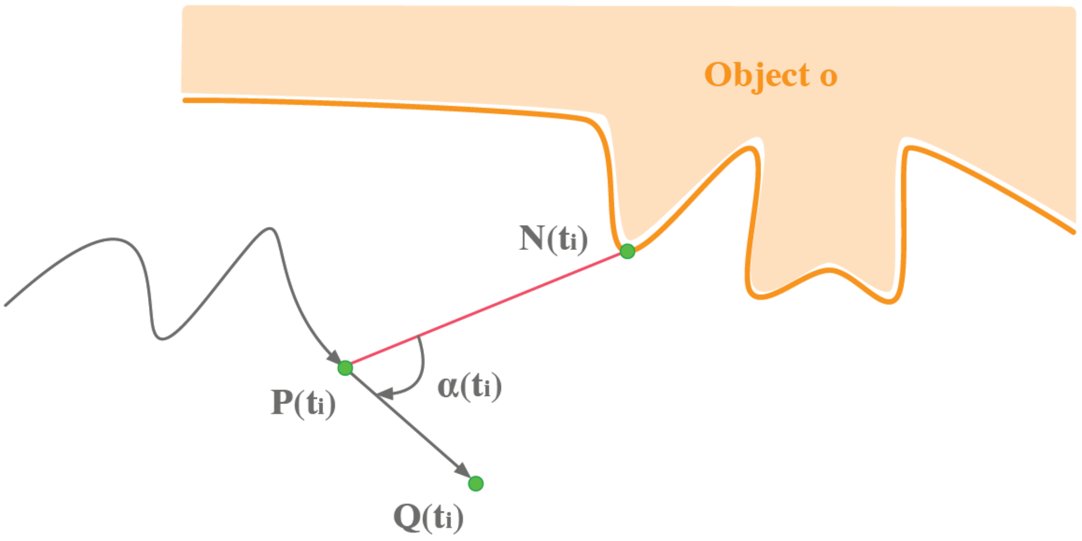
…it decreases more and more regarding the past (customisable)

e is coming close to the object o (polyline)



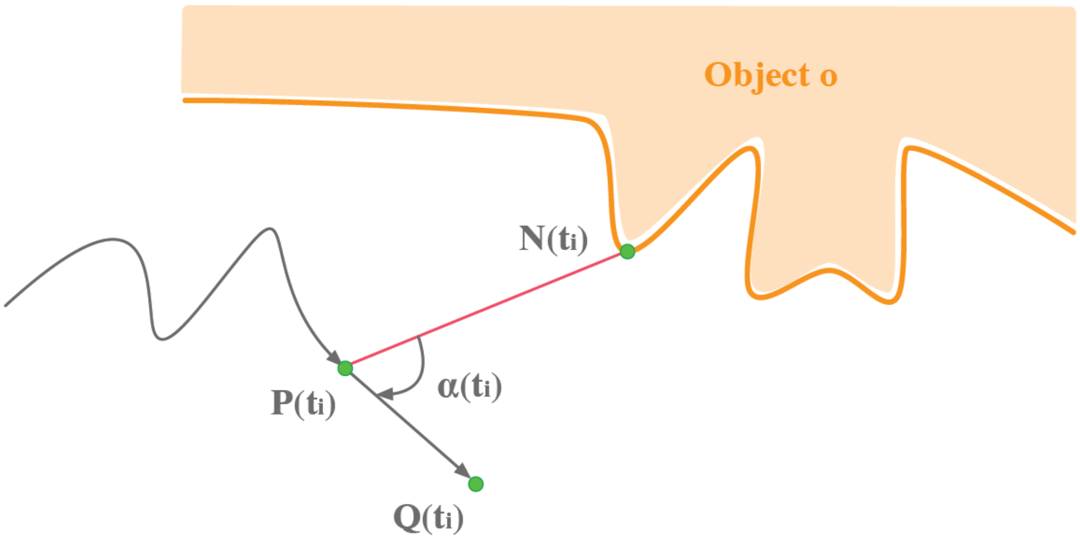
- P is the current position of e
- N is the closest point from e to o
- $\overrightarrow{PQ}$ is the direction of e

e is coming close to the object o (polyline)

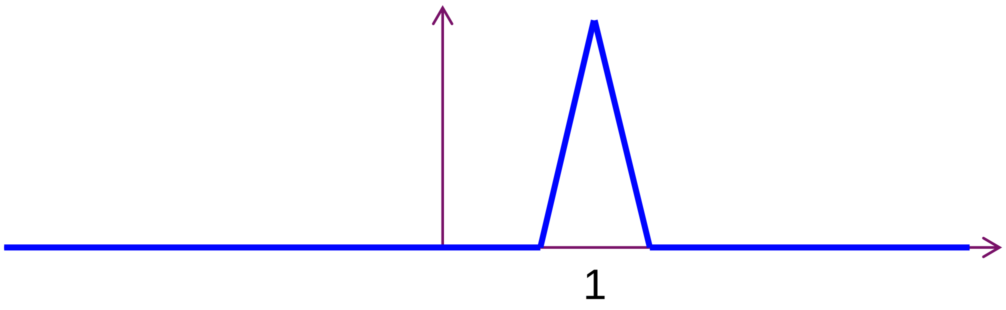


- e must be moving
- cos(α) must tend to 1
- the past orientations must be directed toward the object too

e is coming close to the object o (polyline)



- Let p_2 denote: $\cos(\alpha)$ tends to 1



e is coming close to the object o (polyline)

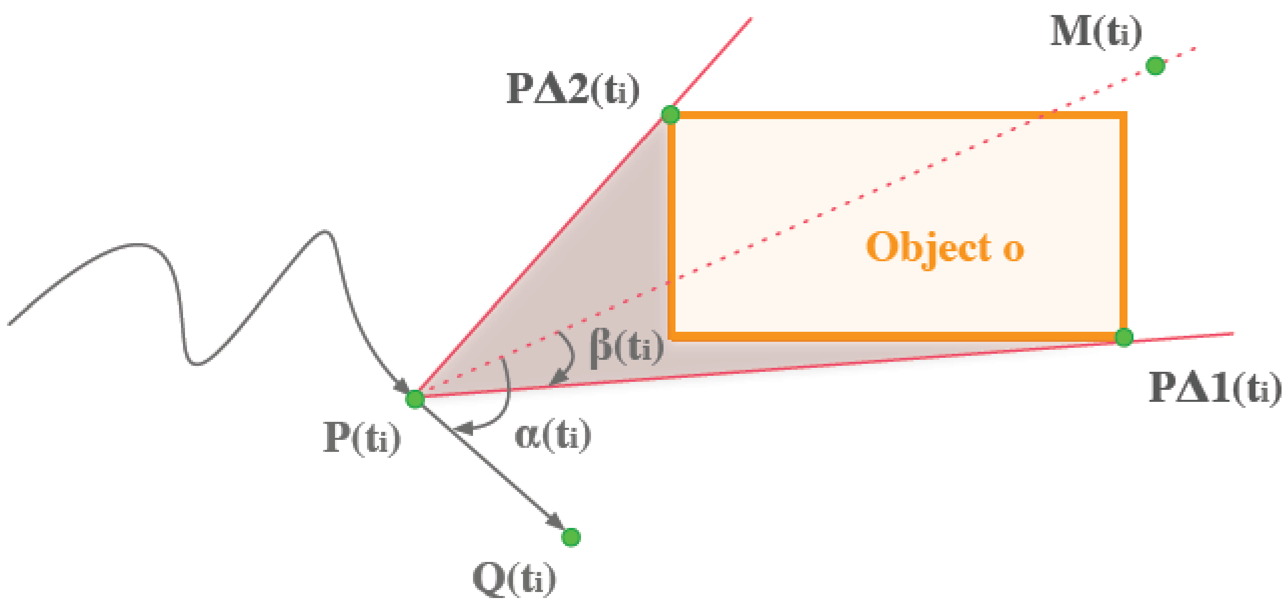
- e is coming close to the object o is defined by:

$$IsMoving(e,t) \wedge \left(\mu(p_2,t) \vee \underset{t' \in I^*}{\mathrm{mean}}\, \mu(p_2,t') \right)$$

Same remarks as previous formula

e is coming close to the object o (closed object)

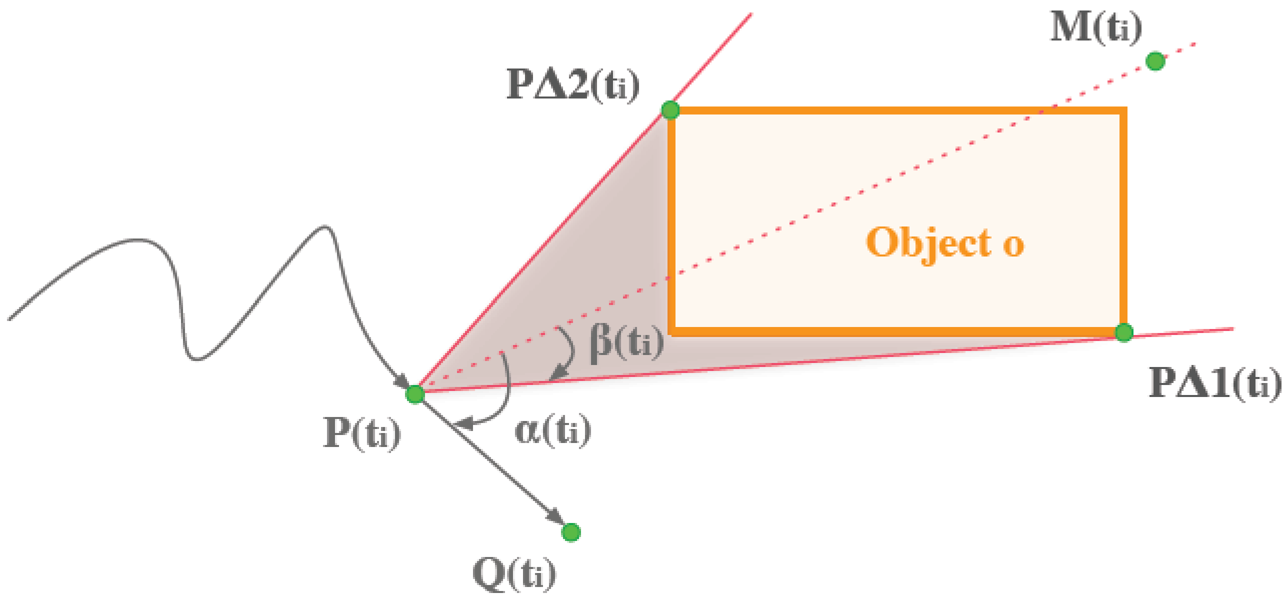
- More complicated



- This time $\cos(|\alpha - \beta|)$ must tend to 1
- e must be outside o

e is coming close to the object o (closed object)

- More complicated



- Let p_3 denote $\cos(|\alpha - \beta|)$ must tend to 1

e is coming close to the object o (closed object)

- e is coming close to the object o is defined by:

$$IsMoving(e,t) \wedge \bigwedge_{t'\in I_2} disjoint(e,o,t') \wedge \left(\mu(p_3,t) \vee \operatorname*{mean}_{t'\in I_3} \mu(p_3,t')\right)$$

Same remarks as previous formula

e is going away from the object o

- On the same basis, we can define this relationship
- $\cos(\alpha)$ or $\cos(|\alpha - \beta|)$ must tend to -1 instead

e is going along the object o

- Let p_6 be « e is near o »
- e is going along o if:
  - e and o are disjoint since a certain timespan I_2 (such as $t \in I_2$)
  - e is near o since a certain timespan I_2 (such as $t \in I_2$)
  - e is moving

$$IsMoving(e,t) \\ \wedge \bigwedge_{t' \in I_2} disjoint(e,o,t') \\ \wedge \bigwedge_{t' \in I_2} \mu(p_6, t')$$

CONCLUSION AND FUTURE WORK

CONCLUSION AND FUTURE WORK

- We now have more than a dozen of relationships
- More relationships are coming
- All implemented and interfaced with Egidium's software: distances, inclusions are computed by their GIS
- Test with a scenario at the end of the year
- GUI to simply customize the relationships and check the correctness

Thank you for your attention…

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