A FUZZY SPATIO-TEMPORAL APPROACH FOR ACTIVITY RECOGNITION

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16 octobre 2012
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
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
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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[Diagram showing membership functions for cold and average temperatures]
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Membership functions and linguistic variables

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Denotation

- $\mu_{\text{cold}}(t)$ 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 \( \iff \) the distance from the last position is greater than 0

- Let \( P_1 = \) the distance is greater than 0

![Graph](customisable)
e is moving at time $t$: 

$$
\mu(p_1, t) \lor \text{mean}_{t' \in I} \mu(p_1, t')
$$
e is moving

\[
\mu(p_1, t) \lor \text{mean } \mu(p_1, t')
\]

present time
e is moving

\[ \mu(p_1, t) \vee \text{mean}_{t' \in I} \mu(p_1, t') \]

recent past (I)
e is moving

\[ \mu(p_1, t) \vee \text{mean}_{t' \in I} \mu(p_1, t') \]

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

\[ \mu(p_1, t) \lor \text{mean}_{t' \in I} \mu(p_1, t') \]

If the entity has just begun to move...

...it only considers the very present
e is moving

If the entity has just stopped...

\[
\mu(p_1, t) \lor \text{mean}_{t' \in I} \mu(p_1, t')
\]

...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
- $\cos(\alpha)$ 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)

\[ IsMoving(e, t) \land (\mu(p_2, t) \lor \text{mean}_{\mu(p_2, t')}_{t' \in I}) \]

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:

\[
IsMoving(e, t) \\
\land \land_{t' \in I_2} disjoint(e, o, t') \\
\land (\mu(p_3, t) \lor \text{mean}_t \mu(p_3, t'))
\]

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

\[
\begin{align*}
\text{IsMoving}(e, t) & \land \bigwedge_{t' \in I_2} \text{disjoint}(e, o, t') \\
& \land \bigwedge_{t' \in I_2} \mu(p_6, t')
\end{align*}
\]
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…