

On Complex Event Processing for Real-Time Situational Awareness

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Real-Time Situational Awareness

Real-time situational awareness:

- ▶ the ability to recognise in **real-time, or even ahead of time**, situations of special significance given large data streams.

Aim:

- ▶ enable organisations to react to occurring situations **as soon as possible**.

Social Media Observation

- ▶ Real-time situational awareness given large data streams from social media channels.
 - ▶ Eg, public opinion monitoring to immediately (re-)define marketing strategies.
- ▶ Future-situation awareness.
 - ▶ Eg, context-based predictions that point to new business threats or opportunities.
- ▶ Situational awareness in the presence of uncertainty.
 - ▶ Eg, noisy content analysis on blogs, Facebook, Twitter, etc.
- ▶ Continuous change of the structure of an 'interesting' situation.

Activity Recognition from Video Content

SURVEILLANCE
CAMERAS



SHORT-TERM
ACTIVITY
RECOGNITION

LONG-TERM
ACTIVITY
RECOGNITION

HUMAN
OPERATOR



Activity Recognition from Video Content

- ▶ Real-time long-term activity recognition given a large number of short-term activities per video frame.
- ▶ Predictive long-term activity recognition.
 - ▶ Eg, a person **is about to** leave an object unattended.
- ▶ Long-term activity recognition in the presence of uncertainty.
 - ▶ Limited dictionary of short-term activities and context variables.
 - ▶ Incomplete short-term activity stream.
 - ▶ Erroneous short-term activity detection.
 - ▶ Inconsistent short-term activity annotation.
 - ▶ Inconsistent long-term activity annotation.
- ▶ Continuous change of the structure of a long-term activity.

Other Examples

- ▶ Computer network monitoring.
- ▶ Financial market monitoring.
- ▶ Item tracking in RFID-supported logistics.
- ▶ Public transport management.
- ▶ Emergency rescue operations.

Challenges

A process for real-time situational awareness should:

- ▶ be very efficient in order to deal with huge amounts of events;
- ▶ predict the occurrence of 'interesting' situations;
- ▶ be tolerant to various types of noise;
- ▶ deal with dynamically changing situations.

Addressing the Challenges

Various approaches have been proposed from various fields:

- ▶ Distributed Systems.
- ▶ Database Systems.
- ▶ Software Engineering.
- ▶ Artificial Intelligence (AI).

AI Approaches: Efficient Situation Recognition

Event Calculus:

- ▶ Logic programming language for representing and reasoning about events and their effects.
- ▶ Formal & declarative semantics, very expressive language.
- ▶ Caching techniques allow for very efficient reasoning.

Real-time situational awareness for city transport management:

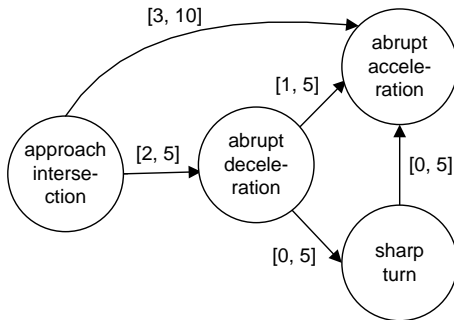
- ▶ Input: sensor (GPS, accelerometers, microphones, thermometers, RPM) data from each bus & tram.
- ▶ Output: evaluation of passenger satisfaction & safety, driver performance, etc.
- ▶ Recognition of 12000 interesting situations/activities at rush-hour in Helsinki (over 1000 operating vehicles) in **50ms** on a desktop PC.

AI Approaches: Predictive Situation Recognition

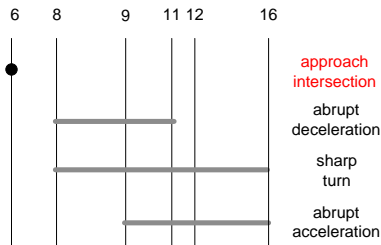
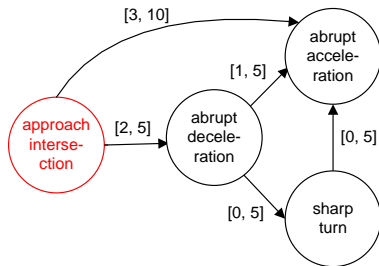
Chronicle Recognition System:

- ▶ Purely temporal reasoning system for situation/chronicle recognition.
- ▶ A situation is expressed as a Temporal Constraint Network (TCN).
- ▶ Incremental instantiation of a TCN allows for predictive recognition.

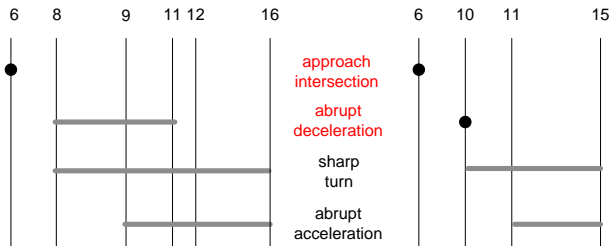
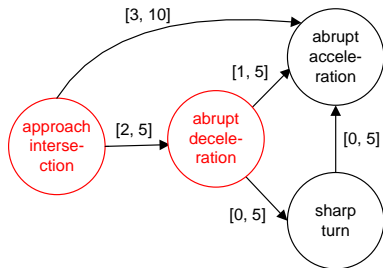
AI Approaches: Predictive Situation Recognition



AI Approaches: Predictive Situation Recognition



AI Approaches: Predictive Situation Recognition



AI Approaches: Probabilistic Situation Recognition

Markov Logic Networks:

- ▶ Combination of first-order logic and probabilistic graphical models.
- ▶ Rules expressing a situation are associated with weights (confidence values).
- ▶ Incoming events are associated with weights.

Probabilistic Situation Recognition:

- ▶ Situation/activity recognition from video content.

AI Approaches: Dynamic Situation Recognition

Structure learning:

- ▶ Inductive logic programming.
- ▶ Abductive & inductive logic programming.

Weight learning:

- ▶ Generative estimation.
- ▶ Discriminative estimation.

Open issues in AI research:

- ▶ Further improvement of situation recognition efficiency.
- ▶ Learning situation structures given very large, partially supervised datasets.
- ▶ Simultaneous learning of the weights and logical structure of a situation.

There is a lot to be gained by bringing the AI and event processing communities closer.