SPATIOTEMPORAL SEMANTICS AND MOVING OBJECTS RESEARCH

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WHO I AM…

- GIScience faculty in Department of Geography, The University of Iowa
- Interested in spatiotemporal modeling, moving objects research, geospatial semantics, ontologies for GIS
THE REAL WORLD...

- Interconnected...
- Continuous
- Dynamic
CONTINUANTS VS OCCURRENTS

- **Continuant** entities endure through some extended interval of time

  Houses, roads, cities
**CONTINUANTS VS OCCURRENENTS**

- **Occurrent** entities happen and then are gone
  - Traffic jams
  - Volcanic eruptions
  - Landslides, avalanches
NOW FOR OUR PURPOSES...

- **Continuants** map to **objects**
- **Occurrents** map to **events**
- **Both** are needed to model fully a dynamic system
A geospatial domain (e.g., a harbor) is partitioned into zones.
A zone may be a departure or destination zone.

If a vessel heads for the sea from the harbor, the departure zone is the ferry landing and the destination zone is the offshore zone.
The movement of an object across a zone boundary is modeled as a ChangeZoneEvent.
SUCCESSIONS OF MOVEMENTS ARE MODELED AS SEQUENCES

- An event sequence, $E$, is defined as a set of events $e$ that capture movements of an object,

$$\{ id_{e_{t_1}}^{zone}, id_{e_{t_2}}^{zone}, ..., id_{e_{t_n}}^{zone} \}$$

where,

$$id_{e_{t_1}}^{zone} < id_{e_{t_2}}^{zone} < ... < id_{e_{t_n}}^{zone}$$

For any two events, one precedes the other.
An event sequence that models an object's movement through a geospatial domain is referred to as a **transit**

\[ \mu T = \{ e \in E \mid e. id = ID \} \]

\[ F_{\text{FRY}} c_{\text{zE}}^{\text{inlad_SE_TSS}} < F_{\text{FRY}} c_{\text{zE}}^{\text{precautionary}} < F_{\text{FRY}} c_{\text{zE}}^{\text{approach}} < F_{\text{FRY}} c_{\text{zE}}^{\text{anchor}} < \]
TRANSITS CAPTURE SPECIAL KINDS OF MOVEMENTS

oldZone: offshore  WFG dep i
inhd SE TSS

WFG CZE precautionary

WFG CZE approach

WFG CZE arr

expectedDest: anchorage

anchorage
- The transit is not ended with an **arr** event, but with an **ude** event
NOTEWORTHY EVENTS

- This type of event is distinguished by comparing the movements associated with an object with the movements associated with which that object is expected to be associated...

- E.g., an UnexpectedZoneEvent where, 
  \[ \text{cze.zone} \neq \text{cze'} \text{expectedNext} \]

- And \text{cze} is the previous \text{changeZoneEvent}

- UnexpectedDestinationEvent where an \text{arr} is expected at a certain destination zone but instead occurs at a different destination
**ADDITIONAL SEMANTICS**

- **Aborted Transit**

A vessel enters the harbor waters and then leaves again without ever reaching its intended destination.
Event sequences, therefore, can represent a mixture of movement semantics in a domain, modeling both routine and noteworthy (possibly unexpected) movements.
So far we have discussed individual events within a transit in order to model the semantics associated with particular movements of objects.

In addition, the pattern of movements themselves can also be meaningful.
An unexpected reversal of a moving object reflected by events in the same zone

\[ G([e_1, e_2]) \text{where} (id_1 = id_2), (name_1 = name_2), (zone_1 = zone_2) \]

\[ G \left\{ \left\{ \text{CDE approach, approach method, SW, approach} \right\} \right\} \]
The same event is experienced twice in the same zone
The same event is experienced twice in the same zone.
CLASSIFICATION OF MOVEMENTS
RELATIVE MOTION PATTERNS


WHAT’S NEXT?

- So far we have been modeling total orders of events
- Focus on *before* and *after* relation
- Creates temporal and spatial patterns of event common for simulations
Extend this research to capture **multiple possibilities**

For example, what might happen in the **future** or what might have happened in the **past**

Useful for emergency response, public safety, spatial decision support
BRANCHING: DIVERGENCE

- **Divergence**
- A key element of branching
- **After an initial event**, two more are possible
- recursive
- **Convergence**

- Where *prior to an event*, two or more events are possible
COMBINING ALL ELEMENTS

- Both converging and diverging can be combined
Have been considering spatiotemporal semantics associated with moving objects

Different kinds of events
  - routine, noteworthy, unexpected...

Different classes of paths of moving objects

Extend underlying temporal model to support branching events
QUESTIONS?