Modeling Historical and Future Spatio-Temporal Relationships of Moving Objects in Databases

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Overview

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Balloon Predicates

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Introduction

Moving Objects Models

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- Existing moving objects models focuses exclusively on either the past or future movements.
  e.g., The traditional moving object model has been defined for the past movements whereas the MOST model for near future movements.
- Recently, we have proposed a new moving object model called *Balloon Model*.
- Balloon model supports both the past and future movements of moving objects.
- New moving objects data types, operations, and queries are introduced.
- Need to define spatio-temporal predicates between balloon objects (*balloon predicates*) so that they can be used in queries.

The Need for Balloon Predicates

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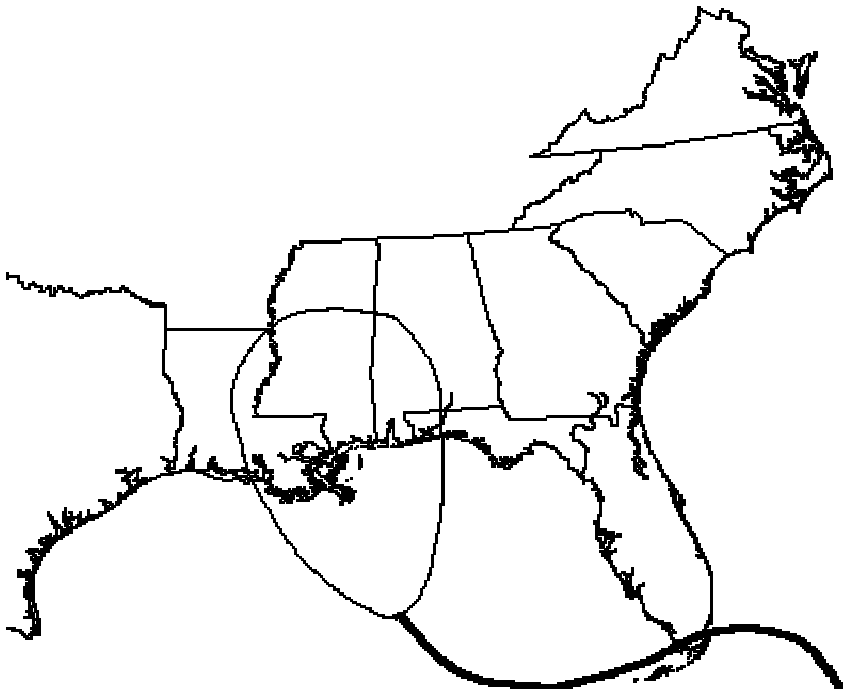
- Assuming that Hurricane Katrina is making its way across the Gulf of Mexico.
- Query: ”List all airplanes that will potentially cross the projected path of Hurricane Katrina.”
- Require the use of a spatio-temporal predicate *potentially_cross* between balloon objects.
- Goal: Model how *balloon predicates* can be defined.



An Overview of the Balloon Model

The Balloon Model

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- A balloon object is composed of the past movement and future prediction connected at the *current state* of the object.
- An object's current time may be the same as or older than the *absolute present* (clock).
- Balloon type constructor:
  $\Omega(\alpha, \beta) = \tau(\alpha) \times \tau(\beta)$ such that $dim(\beta) \geq dim(\alpha)$ where α and β are spatial types corresponding to the past and future movements respectively.
- Balloon Data types:

$$balloon\_pp = \Omega(point, point) = mpoint \times mpoint$$
$$balloon\_pl = \Omega(point, line) = mpoint \times mline$$
$$balloon\_pr = \Omega(point, region) = mpoint \times mregion$$
$$balloon\_ll = \Omega(line, line) = mline \times mline$$
$$balloon\_lr = \Omega(line, region) = mline \times mregion$$
$$balloon\_rr = \Omega(region, region) = mregion \times mregion$$

Examples of Balloon Objects

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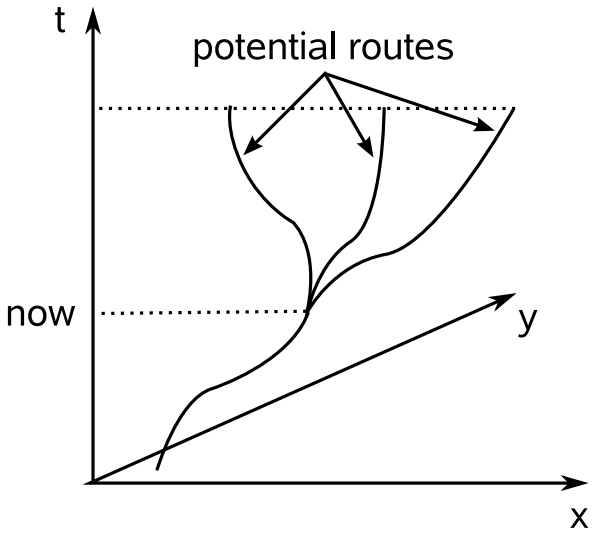
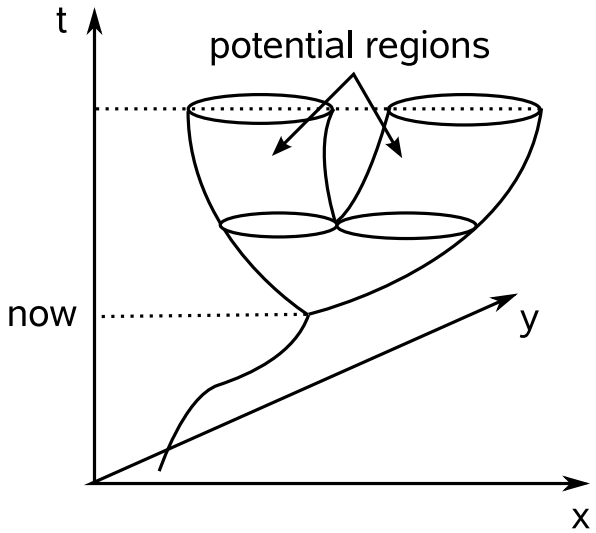


A balloon_pp object



A balloon_pr object

Balloon Predicates

Predicates on Balloon Objects

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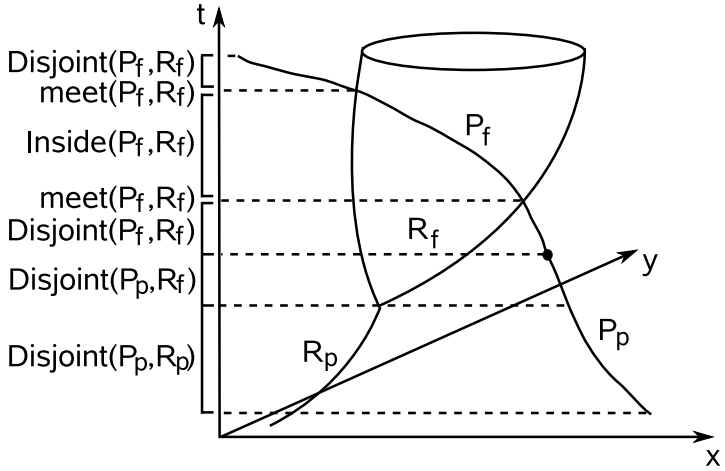
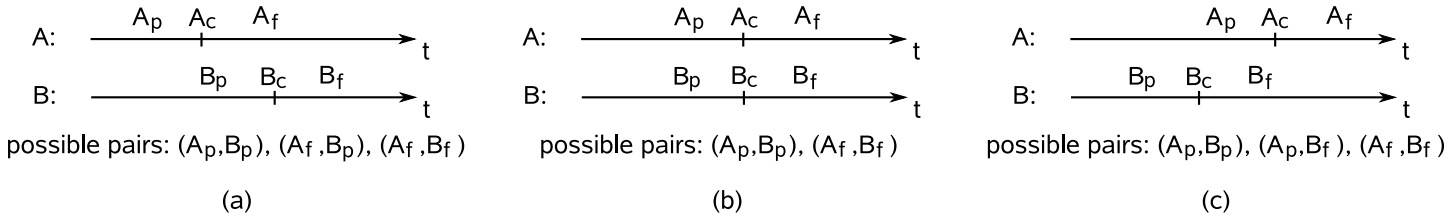
- A $probably\_will\_cross$ situation:



- A Balloon predicate is a function of the form $\Omega(\alpha_1, \beta_1) \times \Omega(\alpha_2, \beta_2) \rightarrow bool$

- Possible interactions between the past movements and future predictions:



Predicates on Balloon Objects (cont.)

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- A Balloon predicate is defined as a *temporal composition* of traditional spatio-temporal predicates(stp):
  $stp(\tau(\alpha_1), \tau(\alpha_2)) \triangleright (stp(\tau(\alpha_1), \tau(\beta_2)) | stp(\tau(\beta_1), \tau(\alpha_2))) \triangleright stp(\tau(\beta_1), \tau(\beta_2))$

- Some examples of Balloon predicates:

$$
\begin{aligned}
did\_cross &:= Cross(\tau(\alpha_1), \tau(\alpha_2)) \\
probably\_will\_cross &:= Cross_u(\tau(\beta_1), \tau(\beta_2)) \\
may\_have\_been\_disjoint &:= Disjoint_u(\tau(\alpha_1), \tau(\beta_2)) \triangleright Disjoint_u(\tau(\beta_1), \tau(\beta_2)) \\
probably\_always\_inside &:= Inside(\tau(\alpha_1), \tau(\alpha_2)) \triangleright Inside_u(\tau(\beta_1), \tau(\beta_2))
\end{aligned}
$$

- Canonical collection of Balloon predicates:

	balloon_pp	*balloon_pr*	*balloon_rr*
balloon_pp	4,394	14,924	43,904
balloon_pr	14,924	1,600,144	136,996,944
balloon_rr	43,904	136,996,944	21,237,972,784

Querying Using the Balloon Predicates

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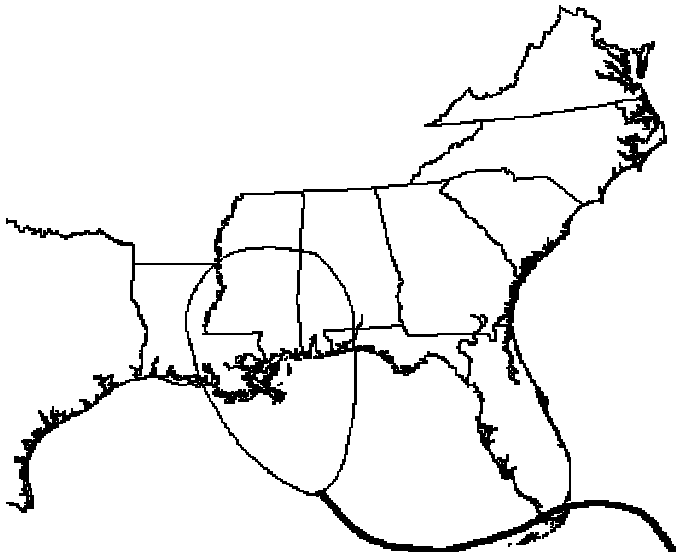
- Using Spatio-Temporal Query Language (STQL):

```
hurricanes(name:string, eye:balloon_pr,
extent:balloon_rr)
cities(name:string, position:point)
airplanes(flightNo:string, flight:balloon_pp)
```



```
DEFINE probably_will_cross AS
<Cross(future/future)>
SELECT flightNo FROM airplanes, hurricanes
WHERE hurricanes.name="Katrina" AND
probably_will_cross(flight, extent)
```

- Can also use Visual Query Language (VQL).

Conclusions

Conclusions and Future Work

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- Defined spatio-temporal relationships between Balloon objects (past movements and future predictions).
- Showed that Balloon predicates are temporal compositions of traditional STPs between their past and future parts.
- Enables the use of Balloon predicates in query language.
- Future work includes the investigation of how relationships between future predictions imply future relationships of the objects.

Thanks!