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Extracting Task Designs Using Fuzzy and Neuro-Fuzzy Approaches

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Abstract:
Several applications generate large volumes of data on movements including vehicle navigation, fleet management, wildlife tracking and in the near future cell phone tracking. Such applications require support to manage the growing volumes of movement data.
Understanding how an object moves in space and time is fundamental to the development of an appropriate movement model of the object. Many objects are dynamic and their positions change with time. The ability to reason about the changing positions of moving objects over time thus becomes crucial. Explanations on movements of an object require descriptions of the patterns they exhibit over space and time. Every moving object exhibits a wide range of patterns some of which repeat but not exactly over space and time such as an animal foraging or a delivery truck moving about a city. Even though movement patterns are not exactly the same, they are not completely different. Moving objects may move on the same or nearly similar paths and visit the same locations over time. In this paper we discuss some technique of fuzzy approaches.

Keywords: Fuzzy Set, Spatio-temporal Modeling

I. Introduction:

Most real world phenomena are dynamic and the positions of many objects change with time. The ability to reason about the changing positions of moving objects thus becomes crucial. The phenomenon of movement arises whenever the same object occupies different positions in space at different times (Galton, 1995). Movements are complex types of spatio-temporal change. Although movements occur continuously, people often perceive them discretely. Movement is the key to contemporary life. People, animals, objects and ideas move in space and time, always interacting with each other and with their environment, creating a highly dynamic system.

We define movement **as** comprising a change in the location (i.e., a translation) or in the orientation (i.e., a rotation) of a point object over time. We categorize change to an object's boundary **as** shape change (Agouris et al., 2000a) and distinguish it from movement. This separation distinguishes important behavioral differences between objects, for example lakes and cars. Lakes frequently shrink and expand, but are not subject to rotation or translation and hence do not change position (except in a possible catastrophic event). Cars, on the other hand, frequently change their position, but do not change their boundary configuration or shape. Objects may exhibit both types of change: n~oven~ent (Beard and Palancioglu, 2000) and boundary reconfiguration (Agouris et al., 2000a).

Modeling moving objects has become a topic of recent interest, but it is still in its infancy. Modeling of moving objects has turned out to be a multi-disciplinary research issue involving disciplines like linguistics, cognitive science, physics, robotics, geography, computer science, and mathematics. Research activities during recent years have addressed representation and modeling of moving objects within GIs environments. Most research in this area focuses on tracking the movement of a single object, i.e., the trajectory of an object over a period of time. There is an increasing need to represent the paths of moving objects over extended time periods and the relative spatio-temporal relations among multiple moving objects (Partsinevelos et al., 2000; Stefanidis et al., 2000). Models of moving objects should be capable of expressing a set of spatio-temporal topological and orientation (direction and distance) relations among them. The representation of these relationships may be expressed qualitatively as well as quantitatively (using the coordinates) both to save space and to simplify reasoning

II. Why Use a Fuzzy Set Approach?

A key motivation for the use of fuzzy sets is the ability to handle uncertainty. Traditionally, uncertainty is considered undesirable and one tries to reduce it as much as possible in order to come to precise conclusions. However, all perceptions of the real world are imprecise and uncertain, and our natural language has evolved to represent and communicate this imprecision. Despite the vagueness in linguistic descriptions, valuable information can be conveyed linguistically provided one can deal with the imprecision. The benefits of the fizzy approach stem from the following aspects: Fuzzy systems are able to capture and deal with meanings of linguistic expressions and conceptually such systems are easy to understand. Fuzzy systems are able to blend different types of quantitative and qualitative information.

Because of the ability of fizzy logic to incorporate qualitative information, fuzzy systems are able to adequately model processes where human reasoning and decision-making are involved.

Fuzzy systems can be built on top of the experience of experts. Cognitive science has shown that humans often use fizzy logic methods to reason about events in their daily life. In many real world situations, humans have the ability to reason about movements of objects using vague variables and linking different objectives. In many problems, fuzzy set theory is an approach that is much closer to real human observation, reasoning and decision making than traditional statistical approaches, such as probability theory (Hoogendoorn et al., 1998). For humans, navigation in space can be handled by using approximate values and constraints (i.e., weather and road conditions). People draw on previous experience to decide on the most appropriate path to choose among different options to travel between two locations. For example, a person who travels between home and work can predict certain information related to the path such as how long this path might take according to the time of day and weather Fuzzy logic methodologies (Zadeh, 1979) provide a framework for the modeling and handling of the uncertainties that are related to the positions and paths of moving objects. Instead of numerical descriptions for the representation of positions and paths of moving objects, fuzzy values can be assigned. For example, assume the statement that "the package was picked up from location A and delivered to location B". There is uncertainty in this statement related to the perception of the pickup and delivery locations and the path connecting them. The perceived locations and the path can be represented with fuzzy values based on movement observations.

III. BACKGROUND

Is should be able to represent and reason about dynamic geographic phenomena in both space and time. Integration of space and time for spatio-temporal analysis and reasoning has gained significant attention (Langran, 1992b; Peuquet, 1999; Worboys, 1998). There has been considerable research in modeling, representing, and reasoning about space and time resulting in different forms of temporal (Allen, 1984) and spatial logic (Egenhofer and Franzosa, 1991; Randell et al., 1992). An integrated logic of space, time, and motion was presented by (Galton, 1993).

As space and time dimensions interact with each other, changes occur on geographic phenomena. Explanations of geographic phenomena often require the description of these changes. Without including changes, especially movements of geographic phenomena, it is impossible to model and reason about the dynamics of the real world. Understanding how geographic objects change over time is fimdamental to the development of appropriate models of the real world (Homsby, 1999). We identify spatio-temporal changes as the differences between the states of dynamic geographic phenomena over time. Examples of spatio-temporal changes include changes in the boundary of a country, in the position of a car, and in the path of a wild fire. People are good at detecting changes through visual observations from such sources as satellite images, photographs, and videos. Collectively, these heterogeneous observations form a rich source for identifying changes. People observe various types of changes in their daily lives such as movements and they have no difficulty in understanding and reasoning about them. However, the implementation of models of spatio-temporal change within information systems has yet to be realized. Currently, data stored in a GIs can be updated, but records of changes are not explicitly maintained. Spatio-temporal systems must be designed to deal with changes of spatial and temporal properties. Beard and Palancioglu (2000) identified three components of change: boundary redefinition (Agouris et al., 2000a), thematic state change, and movement. The main focus of this research is on the third component: movement and uncertainties related to it. We seek to improve the understanding of the concept of movement for geographic phenomena and its representation in information systems. As one of the crucial components of dynamic geographic phenomena and change, the concept of movement has been studied under various names, such as migration, motion, and transportation in different scientific fields. In this thesis, we use the term movement.

IV. Spatio-Temporal Modeling

An object that occupies a position in a space is referred to as a 'spatial object'. An object whose position may change over time is called a 'spatio-temporal object'. In addition, an object that is able to move over time and change its position is referred to as a moving object.

A data model has been defined as the structure that describes types of data objects and a framework for organizing and managing them. It has three major components: a set of object types, a set of operations, and a set of integrity rules. A spatio-temporal data model can be defined as a data model that is designed for modeling the real world where objects change their positions and shapes over time (Susumu and Makinouchi, 1999). Currently, spatio-temporal models assume that objects have crisp boundaries, precisely defined relationships with other objects, and accurately measured positions in space with error-free representation. However, in the real world, objects have vague boundaries, relationships, and positions. In addition, moving objects have changing relationships and positions that might not be exactly known at all times (i.e., due to lack of observations and knowledge). In other words moving objects have uncertainties and Modeling, indexing, and query languages for spatio-temporal data have all received attention. Langran (1992b) addressed a set of practical issues concerned with data representation, incremental updates, and system longevity. Langran (1988) examined the concept of combined spatial and temporal dimensions and suggested that dimensional dominance must be determined for the optimization of data and the algorithm described the need to consider the evolution of spatial objects in addition to retroactive or post active changes.

Temporal indexing often includes two aspects of time, valid time and transaction time. When both times are included this is referred to as a bitemporal database (Jensen and Snodgrass, 1999). Full spatio-temporal support is assumed to include these two temporal aspects as well as two or three spatial dimensions. Spatio-temporal indexing raises significant challenges. Spatio-temporal indexing has typically used one of two approaches (Saltenis and Jensen, 1999): 1) overlapping index structures that index spatial objects at different times or 2) the addition of time as another dimension to an existing spatial index.

V. Modeling Moving Objects

Management of information about moving objects requires database support and there has been substantial research activity in this area recently. Relevant research covers spatio-temporal databases, moving object databases (Erwig et al., 1997; Wolfson et al., 1999; Wolfson et al., 1998), spatio-temporal indexing (Saltenis and Jensen, 1999), indexes for moving objects (Kollios et al., 1999; Saltenis et al., 2000), representations of the uncertainty of moving objects (Moreira et al., 1999; Pfoser and Jensen, 1999), and ontological considerations for movement and moving objects (Galton, 1995). Existing databases are incapable of handling continuously changing data, such as the position of moving objects. Sistla et al. (1997) proposed a model to solve this problem by representing the position of moving objects as a function of time. In this model, a higher level of data abstraction that treats an object's motion vector as an attribute of the object is considered. Moving objects fall directly within the purview of spatio-temporal databases. Moving object databases are a specialization of spatiotemporal databases for discrete and continuously varying spatial and temporal information. **A** continuous model for continuous movement may be desirable but not practical in the near term. Data observation streams are not fully continuous and there are difficulties in storing and indexing continuous movements.

VI. Analyzing and Summarizing Movements

Hagerstrand (1970) introduced the concept of a "space-time path" to illustrate how a person navigates his or her way through the spatial-temporal environment. Later, Miller (Miller, 1991) discussed using the concept of a space-time path for modeling accessibility within a GIs framework. In addition, recently the notion of "geospatial lifeline" as a special class of spatiotemporal data has been introduced in (Mark and Egenhofer, 1998). The notion of geospatial lifelines can be seen as a natural operational extension from the concept of space-time path. **A** geospatial lifeline is a continuous set of positions occupied by an object in geographic space over some time period (Mark and Egenhofer, 1998). Geospatial lifelines that capture an individual's movement over space and time is a powerful concept in dealing with a wide range of practical problems across in many disciplines. The geospatial lifelines were used to model movements of objects (Ramaswamy, 2000). "Lifeline beads", which are a particular form of a geospatial lifeline that model the set of all possible locations an object could visit while moving between locations is developed in (Ramaswamy, 2001). Intersections of lifeline beads reveal more detailed information about the properties of objects' movements and provide more powerful support for query processing. These intersections can be used in analyzing movement patterns of multiple objects.

VII. The Iterative Self-organizing Data Analysis Technique

The iterative self-organizing data analysis technique (Isodata) is a widely used technique in unsupervised data clustering (Bezdek, 1980; Dunn, 1973; Takahashi et al., 1995). The Isodata clustering method (Tou and Gonzalez, 1974) iteratively classifies data, redefines the criteria for each class, and classifies again, so that the Euclidian distance patterns in the data gradually emerge. Isodata provides a means to automatically determine the optimal number of clusters by splitting and merging clusters. The way in which it locates clusters with minimum user input is referred to as self-organizing. In order to carry out Isodata clustering, one needs to determine: The maximum number of clusters, ***N*,** to be considered. This number is the maximum number of classes to be formed The convergence threshold *T*, which is the maximum percentage of data whose cluster assignments are unchanged between iterations. This prevents the Isodata algorithm from running indefinitely.

The maximum number of iterations Mto be carried out. The means of ***N*** clusters can be arbitrarily identified on the first iteration of the Isodata algorithm. As a result of each iteration, a new mean for each cluster is computed based on the actual Euclidian locations of the data in the cluster. Then, these new means are used for defining clusters in the next iteration. The process continues until there is little change between iterations (Swain, 1973). Isodata method is composed of the following procedures: All members are relocated into the closest clusters by computing the distance between the member and the cluster center. The center of all clusters is recomputed and the above procedure is repeated until convergence. It is possible for the percentage of unchanged data to never converge or reach T. Therefore, it may be beneficial to monitor the percentage, or specify a reasonable maximum number of iterations, M.

VIII. Model Framework for Movement Behaviors

Rarely are movements completely random and rarely are they completely unconstrained. They are organized by spatial and temporal structures and the physical properties of an object itself. To characterize the spatial aspect of a moving object, the position of the object should be captured. To characterize the spatio-temporal aspect of a moving object, which gives us its path, the orientation, direction, distance, travel time, and speed of the object should be captured. Complete knowledge of any particular movement is impossible, but movements can be detected, modeled and predicted with some degree of accuracy and reliability. A model for moving objects should be able to support several types of questions about moving objects. Some questions may deal strictly with spatial patterns, others may deal with only temporal aspects while others address combined spatial-temporal patterns. Useful spatio-temporal information on a single moving object at time t may be addressed with the following questions:

What is the position of a moving object at time t?
What is the orientation of a moving object at time t?
What is the direction of the movement of a moving object at time t?
What is the distance of a moving object at time t from certain locations?
What is the speed of a moving object at time t?
What is the path of a moving object during time interval I (ti-],ti)?

In order to effectively model moving objects we need a representational framework for movement behaviors. Most previous approaches to estimating moving object positions rely on a time ordered sequence of observations. Observations refer to any measurements that capture the location of one or more real world objects at specific times. Several approaches have indicated the need to amend recorded positions with additional information at higher levels of abstraction. Wolfson et al. (1999) add a motion plan which is a sequence of way-time points (pi,ti) indicating where **(pi)** a moving object will be at time ti. **A** motion plan is deterministic information on an individual object. This approach assumes that the system has prior information about how an object is going to move over time, which may not often be the case.

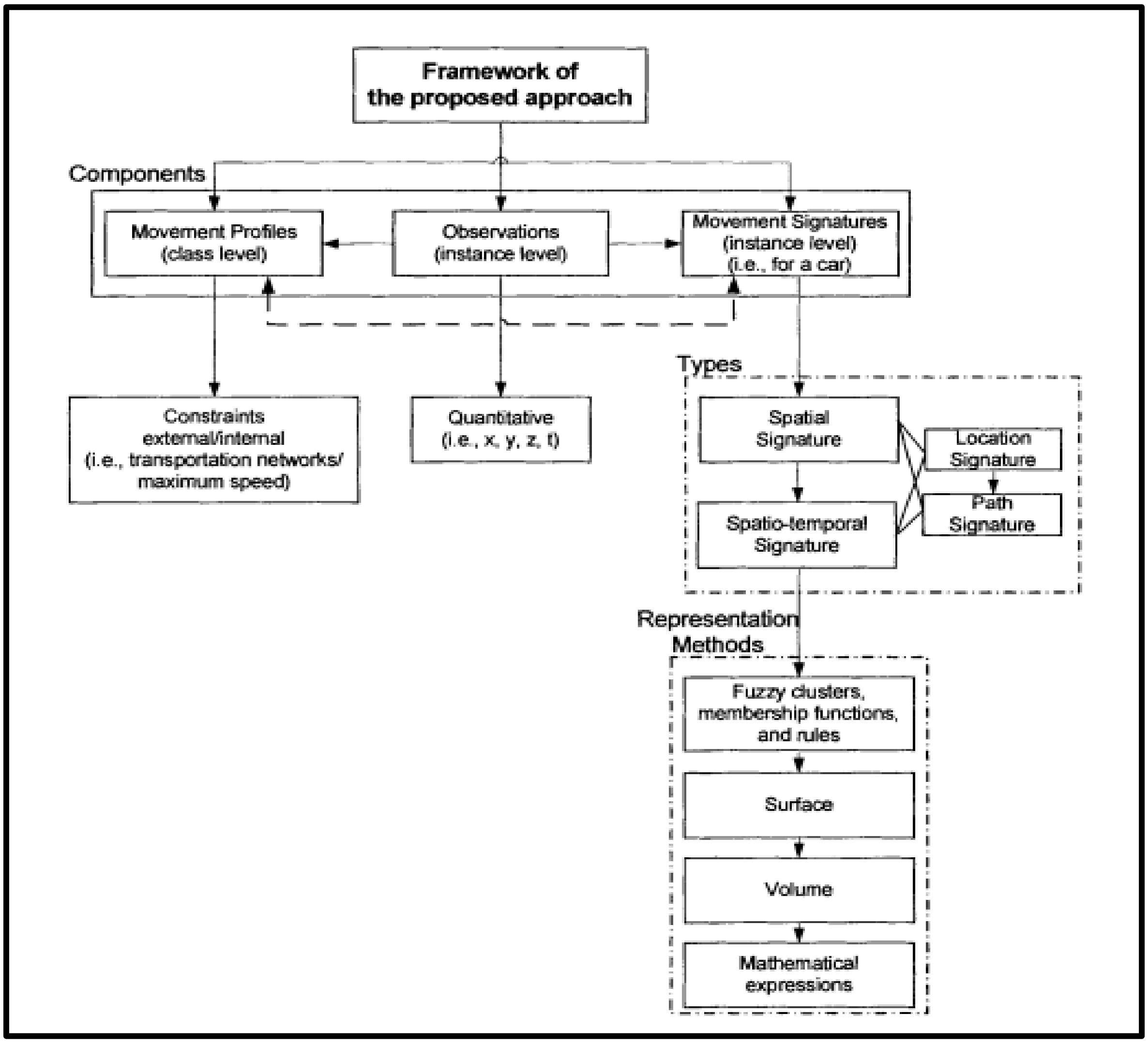

Figure 1:The framework of the proposed approach.

IX. Movement Profiles

Profile information describes general knowledge on the movement behaviors of classes of objects such as cars, planes, boats, and various types of animals. We know that moving objects have general constraints on their movements (i.e., boats are constrained to water). We refer to the general class level behaviors and constraints as movement profiles. The range of movement behaviors belonging to a set of objects such as a car, a truck, and a bus forms the general movement behaviors of a class of object such as the class "vehicle". Most objects move within constrained environments such as roads and many classes of objects is subject to similar sets of constraints. Thus profile level information can be specified in the form of constraints applied to a class. Movements of objects are subject to various spatial and temporal constraints and movement profiles identify these constraints. We identify two types of physical constraints on movements of objects: Internal Constraints: These are related to the physical characteristics of a class of moving objects that define the objects' ability to move. Such constraints bound speed, agility, and ability to move in different media or along different axes. External Constraints: These are constraints that exist in the environment external to an object. A class of moving objects usually shares sets of external constraints including spatial and temporal constraints such as moving on the same type of media.

A movement profile for a class of objects identifies directional axis constraints on movement, medium constraints on movement, general size, shape and weight characteristics that constrain movement, as well as prototypical average or maximum speed for a class of object. These sets of constraints can be associated with class hierarchies. As an example, classes of vehicles, classes of animals or classes of storms can be globally assigned average or maximum speeds. Subsets of classes with different behaviors can be assigned to subclasses distinguished by different directional movement constraints or different media constraints. Directional axis movement constraints describe the ability of an object to move in the X, Y or Z-axis where these are aligned with respect to the object itself as shown in Figure 1.2.

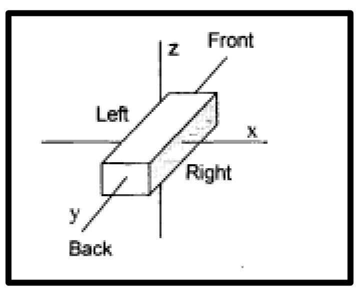

Figure 1.2: Axes used to describe the directional axis movement constraints of objects

Figure 1.2: Axes used to describe the directional axis movement constraints of objects. We assume an object has a fixed orientation: a front and back aligned with the Y-axis and a left and right aligned with the X-axis. Z is the vertical axis aligned with the gravitational field. Some objects are capable of movement along all three axes, but to different degrees. For example, humans' primary axes of movement is Y. However, they can engage in X movements by

sidestepping, but are significantly constrained in Z. In addition, helicopters are capable of Y movement, Z movement, and X movement, a submarine has Z and Y movement, an elevator only Z movement, and a car just Y movement. Media constraints are external constraints referring to the surface or volumetric media on or within which an object is capable of moving. Very few objects are unconstrained with respect to media. Obvious examples of media constraints include roads for automobiles, tracks for trains, and water for ships. Animals, people, and all-terrain vehicles are examples of less media constrained moving objects.

Conclusion

This paper concentrated on modeling movements of objects in spatial and spatiotemporal extents through movement signatures. Spatial signatures, which include dominant or frequently visited locations and paths, and spatio temporal signatures, which associate a temporal pattern with the spatial signatures, of a moving object were identified and extracted from large volumes of data. In this paper, fuzzy and neuro methodologies were implemented in the extraction of movement signatures. The proposed methodologies are a step to incorporate the similar modeling methodologies that are used by humans into information systems. Identification of movement signatures and definition of their attributes provides summary

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