RESEARCH PAPER- MOVING OBJECT QUERY

With recent advances in positioning, telemetry and telecommunication technologies, and with wide availability of devices that produce information about the position of an object in some time, enormous amounts of data about moving objects are being collected and employed by many applications. Examples of such devices include mobile phones and devices with embedded GPS or sensor networks.(A spatial-temporal trajectory is defined as the recording of the position and timestamp of an object at specific times).

Moving objects are objects (points) that change their locations (geometric attributes) over time , which requires a higher update frequency. For instance, taxis traveling around the cities are considered as moving objects because they frequently change their locations over time, which requires a high level of updating in the taxi centers’ databases. Other examples are cars, aircraft, ships, mobile phone users, armies, individuals and many more. Moreover, tracking these moving objects is essential for big data applications. Therefore, the indexing of moving objects plays a critical role in query processing.

With the development of tracking and positioning systems, such as GPS and WI-FI, the correct recording of locations has become available which allows the querying of the moving objects.There are different types of queries in moving objects like  the moving objects change their locations with time; therefore, tracking moving objects at certain times (temporal queries) is essential in security applications. Moreover, tracking moving objects that entered or left a certain area (topological queries), is another unique perspective of moving objects querying. These queries illustrate the different vectors of the moving objects which do not exist in static object applications.

ENVIRONMENTS

The queries of moving objects are performed in different environments of moving objects. Therefore,understanding the underlying structures (the moving object envi-

ronments) is essential.The environments of the moving objects include the Euclidean

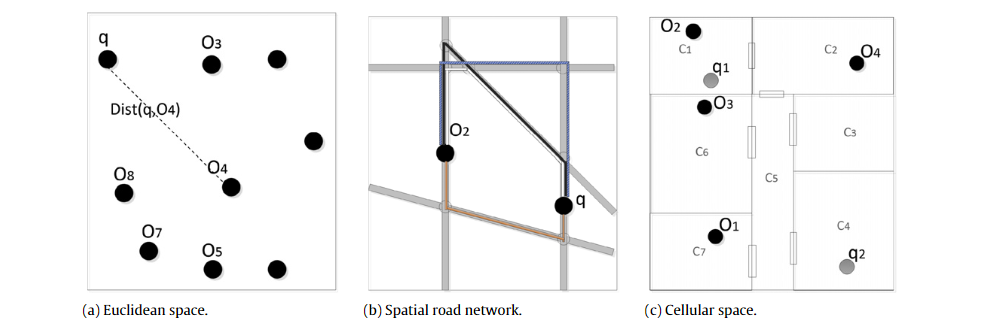
space, spatial road network and cellular space.

1. In Euclidean space, the distance between object Oi and Oj is the straight

and direct distance between them.n this space, the queries will be considered from the Euclidean space measurement point of view. For example, a range query performed in Euclidean space could return the moving objects in a 2 km radius. In this example,

the Euclidean space’s measurement will be used to measure thedistance from the query point to the points of interest up to the 2 km radius.

1. The spatial road network is the other space that can be considered for moving objects. In a geospatial database setting, moving objects can be located in the road network where the distance between Oi and Oj is a network distance (or shortest road) between them . Note that a spatial road network has topological restrictions and the distance between two objects is the actual road distance (avoiding the obstacles).
2. Cellular space is a representation of location by sets of cells that include moving objects.the queries in cellular space are usually based on cellular notations such as: ‘‘What are the moving objects in cell 48?’’ In this example, the cell number represents a cell identifier.



MOVING OBJECT DATABASES

Moving objects are those whose position changes frequently over a period of time. Conventional databases don't know how to handle this scenario, as they assume the data objects are stationary. In this case, we use moving object databases. These databases can store information about moving objects and allow querying on them.

For example- The location of nearest taxis for a particular customer can be found using querying on moving object databases.

Different approaches used for handling moving objects are:

1.Location Management :The current locations of the objects are saved in the database and estimations are made on their near future positions.An example of location management is a database storing locations of taxis in a particular locality.In this case, if the taxis frequently send data to the database, then their position in the database will be accurate but there will be too much data to handle. Conversely, if they don't send their location parameters too often, then database may contain outdated data.

The only solution to this problem is to store the speed and direction of the moving objects in addition to their location. The near future locations can be calculated using the speed and direction and the data flow is also reduced.

1. Spatio-Temporal Database :The spatio temporal database stores not only the present data but also data that was collected well into the past. All of this data is used to observe patterns in a particular situation and analyze it.Example is migratory patterns of bird are changing, Antartica iceberg are decreasing etc.

The spatio temporal data is stored in the form of points, lines, regions etc.

* Point is used to show a location of a particular object (like-school, building).
* Lines show linear features, such as streets, rivers, and roads etc.
* Polygon composed of bounding arcs and label points shows the boundary of a city, forest, lake.

The spatio temporal data can be in 2 forms −

* ****Moving point****- Only the location of the data point matters and not its size or extent.Example - The location of an airplane at any given moment
* ****Moving region**** - The location of the region as well as its size and extent matters as the region may reduce or increase with time. Example - The location and size of a hurricane as it travels across the country.

MOVING OBJECT QUERY

There are variety of possible queries about moving objects in spatio-temporal databases.The moving objects query taxonomy from various perspectives are:

1. First is the Location perspective, It considers the location as the key element in the moving object queries. Therefore, the results will be retrieved based on the location requirements in the queries. For example, range queries use the location as the main element to return the points of interests in a certain location with a certain range distance to the query point. Location perspective includes many query types such as spatial, navigational,topological, N-body constraints and aggregate queries.
2. Second is the Motion perspective, Motion can be observed by linking a reference to a moving object and measuring its location change relative to another reference frame. It covers direction, velocity, distance and displacement queries.There are many

motion vectors of the moving objects which can be classified as motion vectors related to non geo-referenced moving objects (such as wind) and geo-referenced moving objects (such as vehicles).

3.Third is the Object perspective, The object perspective considers the object characteristics as the key element in the query. Therefore, the results will be retrieved based on the object characteristics (type or form) that are indicated in the query. Object perspective can be classified as follows: object-type queries which include single-type and multi-types and object-form queries which include point, line and region objects.

4.Fourth is the Temporal perspective which includes queries about the moving

objects which concern to the temporal aspects and characteristics of the moving objects.It deals with trajectory, timestamped, inside, disjoint, meet, equal, contain, overlap and period queries.

5.Fifth is the Patterns perspective, the query depends entirely on the objects’ predefined movement patterns. Patterns perspective queries are classified as: spatial patterns, spatio-temporal movement and temporal patterns.

Spatial patterns are concerned with the spatial aspects of the moving objects. Therefore, these patterns address as the spatial features of the moving objects and the impact on the existence of unique queries.

Spatio temporal patterns address the spatial and temporal features together of the moving objects and the impact on the existence of unique queries.

Temporal pattern of movement is interested in the temporal aspects of the movement. There are a variety of movement patterns in the temporal category. It includes temporal patterns such as temporal relations, and synchronization in time.

AGGREGATE QUERIES

Spatio-temporal databases are becoming increasingly more common. Typically, applications modeling spatio-temporal objects need to process vast amounts of data. In such cases, generating aggregate information from the data set is more useful than individually analyzing every entry. Aggregate queries are used to perform calculations on data stored in a database, such as counting, summing, averaging, and finding the minimum or maximum value. These types of queries can be useful when working with moving objects data, as they can help you to analyze and understand the movement patterns of the objects over time.

The different types of spatio-temporal aggregate queries can be performed on data with both spatial and temporal dimensions.These types of queries are used to perform calculations on the data, such as counting, summing, averaging, and finding the minimum or maximum value.

Few spatio temporal queries that are commonly used :

1. Counting the number of objects within a specific spatial region at a given point of time.
2. Summing the total distance covered by all objects within a specific spatial region over a given period of time.
3. Averaging the speed of all objects within a specific spatial region over a given period of time.

To improve the performance of aggregate queries we can perform indexing techniques.These indexes can be used to speed up the query process by narrowing down the data that needs to be searched to a smaller subset that meets the query's conditions. Different indexing techniques include:

1. Spatial indexes: These indexes are used to organize and retrieve data based on their spatial locations.Examples include R-trees, which are used to index multidimensional data, and Quad trees, which are used to index two-dimensional data.
2. Temporal indexes: These indexes are used to organize and retrieve data based on their temporal attributes, such as time stamp or duration.Examples include Time-stamp-based indexes and Interval-based indexes.
3. Hybrid indexes: These indexes combine both spatial and temporal attributes to organize and retrieve data.Examples include R\*-trees and STR-trees.

A moving object query, also known as a spatiotemporal query, is a query used in geographic information systems (GIS) or location-based services (LBS) to retrieve information about objects that have a specific location and are moving over time. These queries can be used to track the movement of vehicles, people, or other objects that are equipped with GPS or other location-tracking devices. The query typically includes parameters such as the object's current location, its past locations, and its predicted future locations, as well as information about the object's speed and direction of movement. The result of the query may include information such as the object's current location, its past locations, and its predicted future locations, as well as information about the object's speed and direction of movement.

MOVING OBJECT DATABASE

A Spatial Database Management System (SDBMS) is a type of database that is specifically designed to store and manage spatial data, which is data that has a geographic or location-based aspect to it. This type of data is often used to represent moving objects, such as vehicles, ships, or wildlife, and their locations over time.

An SDBMS provides specialized data types, such as points, lines, and polygons, to represent geographic objects, as well as functions to perform spatial queries and analysis, such as finding the closest object to a given location, or determining if two objects intersect. This allows for efficient storage and retrieval of moving object data, as well as the ability to perform complex spatial analysis on that data.

Some popular SDBMS include PostGIS, which is an extension for the open-source PostgreSQL database, Oracle Spatial, which is part of the Oracle Database, and Microsoft SQL Server with the SQL Server Spatial extension. These databases have been widely adopted by organizations in industries such as transportation, environmental monitoring, and logistics, to manage and analyze large amounts of moving object data.

PostGIS is a popular open-source spatial database management system that is built on top of the PostgreSQL database. It provides support for geographic data types and functions, allowing for efficient storage, indexing, and querying of geographic information.

With PostGIS, you can store and manage geographic data such as points, lines, and polygons, and perform spatial operations such as finding the distance between two points, determining if two objects intersect, or finding the nearest neighbors to a given location. PostGIS also provides support for storing and querying data over time, making it a suitable tool for managing moving object data.

In addition to its basic spatial functionality, PostGIS also provides advanced features such as raster data support, network analysis, and 3D analysis, making it a versatile tool for a wide range of spatial data management tasks. With its open-source license and active community of developers and users, PostGIS is a cost-effective and flexible solution for managing and analyzing spatial data.

Microsoft SQL Server with the SQL Server Spatial extension is a database management system that provides support for storing, querying, and manipulating geospatial data. The SQL Server Spatial extension provides a set of geospatial data types and functions that can be used to store and process location-based data from moving objects.

With SQL Server Spatial, you can store information about the location and movement of objects, such as vehicles or people, and perform geospatial queries to retrieve and analyze the data. For example, you can retrieve the current location of all objects within a certain radius of a specific point, or calculate the distance between two moving objects.

SQL Server Spatial also provides support for managing and visualizing geospatial data, making it a good choice for applications that require both spatial data storage and analysis capabilities.