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A Review of Tracking and Clustering Multiple Objects by Using Graph Mining Algorithms

Mustafa Asaad Hasan Alkhafaji
University of Babylon, Iraq.
E-mail: Mustafa.alkhafaji@utq.edu.iq

Tawfiq A. Al-Assadi
University of Babylon, Iraq.
E-mail: Tawfiqasadi@itnet.uobabylon.edu.iq

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Abstract

Video tracking is the process of propagating a position of moving object over time by using a camera. The group and extended object tracking become a big problems and challenges in any applications. Groups are structures objects, formations of entities moving in a coordinated fashion, whose number vary in time, it can split, merge, can be near to each other or can spawn new groups. The main purpose of this paper is to present how to identify multiple moving objects in a scene and then apply preprocessing operations to prepare them for tracking. After that we illustrate the ways to find the trajectories of the objects in order to use graph mining algorithms to cluster these trajectories.

Keywords

Object Tracking, Object Detection, Trajectory, Feature Extraction, Graph Mining.

Introduction

Computer devices are used for finding knowledge in different and massive amounts of data that is stored in a diverse form of database or may be represented by data structures that have tremendous information such as image, video, audio and text. However, for the designers of search algorithms, the amount of input data and the size of database are increasing rapidly, but the difficulty of finding interesting data isn't aligned with the size of input that is increasing linearly. Therefore, best algorithms and fast computers are needed.

Video tracking is the process to estimate the position of object that moves over time by using a camera. There are many usages of video tracking, of such as security and surveillance, human-computer interaction, video communication and compression, augmented reality, video editing, medical image, and traffic control (Shaikh et al., 2014).

Detection of object is a computer vision approach that permit us to locate and determine objects in an image and video. With this kind of identification- localization, object detection can be used to count objects in a scene and determine and propagate their exact locations, and all objects will be labelled accurately (Shaikh et al., 2014).

Data mining is defined as a process used to extract meaningful data from a large amount of data. It means using one or more software to analyze data patterns in large batches of data (Bian et al., 2018). Data mining is an interdisciplinary sub-investigation of computing whose general objective is to obtain information from data sets (through intelligent methods) and transform the information into understandable structures for later use (Liu, 2007). Data mining is the process of "knowledge discovery in the database" or analysis step of KDD (Hand, 2007) (Rajaraman and Ullman, 2011).

Grouping is the process of dividing information into connected, homogeneous sets of objects. Some groups can describe the data, but these groups are mostly missing specific restriction details, but they have been improved. This is the way to model data across your clusters. Data modeling is grouped from a historical perspective rooted in numerical analysis, statistics, and mathematics (Bian, 2018). From a machine learning perspective, clusters are related to hidden modes, searching for clusters is unsupervised learning, and the post-framework represents a data concept. From a practical point of view, clustering plays a complex role in data mining applications (Liu, 2007). For example, scientific data exploration, text mining, information retrieval, spatial database applications, CRM, web analytics, computational biology, medical diagnostics, object grouping, etc. (Hand, 2007). In other words, we can see that cluster analysis is a data mining technique that identifies similar data. This technique helps to identify differences and similarities between data. Clustering is very similar to the classification process, but it involves grouping blocks of data based on the similarity of the data (Rajaraman & Ullman, 2011).

The clustering techniques are hierarchical, partitioning, grid based, density based and model-based methods. The complex job to make clustering is given data in n-dimensional space, then split these data into k clusters that have similar properties within the same cluster. Many data mining strategies are used for mining the graph-based data and performing useful analysis on these data. There are many graph mining approaches have been proposed. Each one of these techniques is based on classification; clustering or decision making (Rajaraman and Ullman, 2011).

Graph is a non-linear data form that is same as discrete mathematics concept of graphs. It is a set of nodes (also called as vertices) and edges that link these vertices (Diot et al., 2012) (Han et al., 2006). Graphs are used to represent random relationship between objects. A graph can be directed or undirected (Yan and Han, 2002) (Li et al., 2009) (Gudes et al., 2006).

Graph Mining is the set of methods and tools used to (a) the analysis of real-world graphs, (b) predict how the pattern and characteristics of a given graph might affect some application, and (c) evolve models that can generate realistic graphs that match the structures (pattern) found in real-world graphs (Han, Kamber, & Pei, 2006).

Multimedia data mining is the detection of interesting patterns (structures) that extracted from multimedia data to store and manage tremendous collections of multi-media objects, including image data, video, audio, as well as sequence data and hypertext data containing text, text labels, and linkages. Multimedia data mining is an interdisciplinary branch that integrates image processing and understanding, computer vision, data mining, and pattern recognition. Problems with multimedia data mining including content-based retrieval and similarity search, as well as generalization and multidimensional analysis (Kotsiantis et al., 2004).

Literature Review

Object tracking is very important research area in computer vision due to the large applications like video-surveillance, pedestrian protection systems, tracking complicated surfaces, medical image applications etc. Clustering is one that plays an important function in moving object trajectory mining. It is not a rigid research in data mining and an unsupervised learning process because there is unknown class to assist. It is a collection of data objects that are like one another within the same cluster. Clustering in object tracking can be applied on topological relationships such as trajectory orientation, area, rich points in trajectories etc. or clustering based on topological clusters and all trajectories by using graph mining algorithms. Many researches have been presented:

1. (Diot, Fromont, Jeudy, Marilly, & Martinot, 2012) have been proposed a concentrate example of using graph mining for tracking objects in video with moving camera and without any organized information on the objects to track. They got benefits from video representation relied on dynamic planer graphs and then they defined

several numbers of restrictions to efficiently find spatio-temporal graph patterns. Those patterns are linked with an occurrences graph to permit us to solve occlusion or graph properties issues in video.

2. (Bian, Tian, Tang, & Tao, 2018) introduced survey on trajectory clustering analysis. There are many limitations that face trajectory clustering by complex criterions such as data dimensions and application scenarios. The research paper supplies a holistic understanding and deep insight trajectory clustering and proposes a comprehensive analysis of representative techniques and good future works. They divided trajectory clustering models into three categories: unsupervised, supervised, and semi-supervised algorithms.
3. (Dai, Zhang, and Li, 2006) discussed video mining concept, approaches and applications. Video mining copes with the figured out of semantic features, knowledge, patterns implicit from video data to improve the clever level of video applications. They proposed that feature-based video mining can be classify into four classes: mining of video clustering, classification mining of video, association video mining, and video trend mining. For the clustering mining of video approaches use many clustering algorithms such as K-means to put similar objects in video data by their features into clusters. video classification mining used motion properties of moving objects, histogram of shot, or any other semantic information to categorize objects in video into groups. For the association mining, the features that extracted from video objects can be built as organized data stored in permanent storage; therefore, conventional association rule mining algorithms can be utilized to fetch association structures (patterns). For example, detecting two objects in video always occurring concurrently. Finally, time series analysis and sequence analysis technology can be used to extract the time pattern from the time characteristics of the video trending method.
4. (Israa Hadi and Saad Taleb, 2013) have been used graph mining algorithms to discover patterns containing of relationships between objects in video. They were designed an algorithm that operates over graph data. Their approach involves a technique for many steps. First step is to convert the video into number of sequence frames. Second step is to apply segmentation techniques to determine the objects in each frame (still image) and then extract features for each object. Third step is to build data-based contain row for each feature. In the fourth step, researchers construct a graph structure that represents each frame. Finally, they apply graph mining algorithm (gSpan) to cluster the objects and specify the behavior of these objects.

5. (Khaing and Thein, 2014) developed an efficient clustering algorithm for moving object trajectories. They address the issue of clustering of spatial domain of applications with noise (DBSCAN) where it cannot cluster data sets well with huge gaps in densities. They propose clustering algorithm that improved the DBSCAN by solving time consuming. This a new technique consists of three phases: partitioning, clustering, and grouping. To solve the time-consuming problem, they drove the dividing the dataset first and then cluster the trajectories by performing DBSCAN algorithm in each barnch, and then they applied the grouping stage to incorporate the diffusion clusters.
6. (Yan and Han, 2002) They proposed a novel approach for frequent graph-based pattern mining in graph datasets which discover frequent patterns without candidate generation. gSpan algorithm constructs a new lexicographic order between graphs, and then maps each graph to a unique minimum DFS code. Moreover, gSpan adopts the depth-first search strategy to mine frequent connected subgraph based on lexicographic order.
7. (Han and Whang, 2007) suggested a new trajectory grouping framework to group sub-trajectories. Discover common sub-paths that have areas of particular interest for analysis. The proposed method is called segmentation and grouping framework, which is used to group trajectories and then group similar trajectory line segments into a group. The main advantage of this method is to find popular sub-paths from the trajectory database. The technique has two stages: partitioning and grouping. For the first stage, they used the concept of minimum description length (MDL) to propose a formal path partitioning algorithm. The second stage includes the proposal of a density-based line segment grouping algorithm.
8. (Li, Lin, Zhong, Duan, Jin, & Bi, 2009) A new algorithm called mSpan is proposed to extract frequent patterns in directed labeled plots. According to FP-Growth, the algorithm obtains the smallest edge code and abstract node code sequence to determine the directed graph pattern with the smallest expansion. It can solve the problem of isomorphism and repeatable expansion of graphic mode. The results show that the mSpan algorithm can extract all frequent directed tagged chart patterns.
9. (Gudes, Shimony, & Vanetik, 2006) they used disjoint paths to find frequent graphic patterns. Since data mining in structured data emphases on frequent data values, semi-structured data, and graphs, the problem is frequent labels and some popular topological structures; therefore, the data structure here is as important as its content. In this article, they proposed a new priori-based graphics data mining algorithm, whereby the basic building blocks are relatively large disjoint paths.

10. (Bian, 2019) proposed that trajectory analysis including trajectory clustering in computer vision is a great use for a lot of works. A lot of characterizations are contained in trajectory data that can be powerful and useful in trajectory clustering such speed, distance, orientation, relative displacement and some other features. This paper suggested a new method to reference point are detected and used the Scale-Invariant Feature Transform (SIFT) descriptor to represent the image patches around the points. Moreover, SIFT descriptor is robust and fast to match in order to unify the length of trajectories. Discrete Fourier Transform (DFT) transforms trajectories into frequency domain with fixed length; therefore, that pattern information is retained. In addition, one more feature type is proposed to describe object motion that presents the motion of object relative to the camera, and the difference between the static objects and moving objects can be figure out.

Research Objectives

The objectives of research are proposed as:

1. Construct a model to deal with induvial objects and group of objects that share similar properties.
2. The model should control unlimited moving objects and any type of video data.
3. Apply an adaptive hybrid or improve one of the graph mining algorithms to clustering the moving objects.

Contribution

The contribution of research is illustrated as:

1. Construct the trajectories for each object.
2. Find distinct features for each trajectory.
3. Construct a graph for each trajectory and graph for all objects.
4. Extract topological relationship between elements that form the trajectories (not among vertices).
5. Propose algorithm to cluster trajectories based on distinct geometrical features for each trajectory.
6. Suggest a method of graph mining algorithm (hybrid or enhance one of graph mining algorithms) that clustering moving objects.

Research Challenges

There are many struggles that face the moving objects to cluster them. Let us address them in brief:

1. Noise that result due to moving object with speed and change in appearance (illumination change effect on correspondence between multi views).
2. Changing pose: moving object changes its appearance when the projected of moving object onto the image plane, for example, when rotating, translation.
3. Occlusions: an object cannot be noticed when total or partially occluded by other objects. Occlusions are usually happened because:

    a) A target object moving behind a static object like clouds, a wall etc.
    b) The view of a target object is occluded by other moving objects.

For partial occlusions that effect on just a small gap of the target area could be coped with by the target detection algorithm or by the target appearance model, while the totally occlusions that represent the high challenging task, we can cope with this problem via higher-level reasoning or through multi-hypothesis methods.

4. Build hybrid graph mining algorithm by using two or more classic graph mining algorithms that used to find frequent patterns or by develop any one to get a good performance.
5. Find an appropriate dataset where we can apply our ideas such as viruses under microscope, collection of bacteria, fish swimming in tank.

Additionally, there are many challenges that could appear when we start to implement this type of environment.

Methodology

The proposed system of this research is illustrated as:

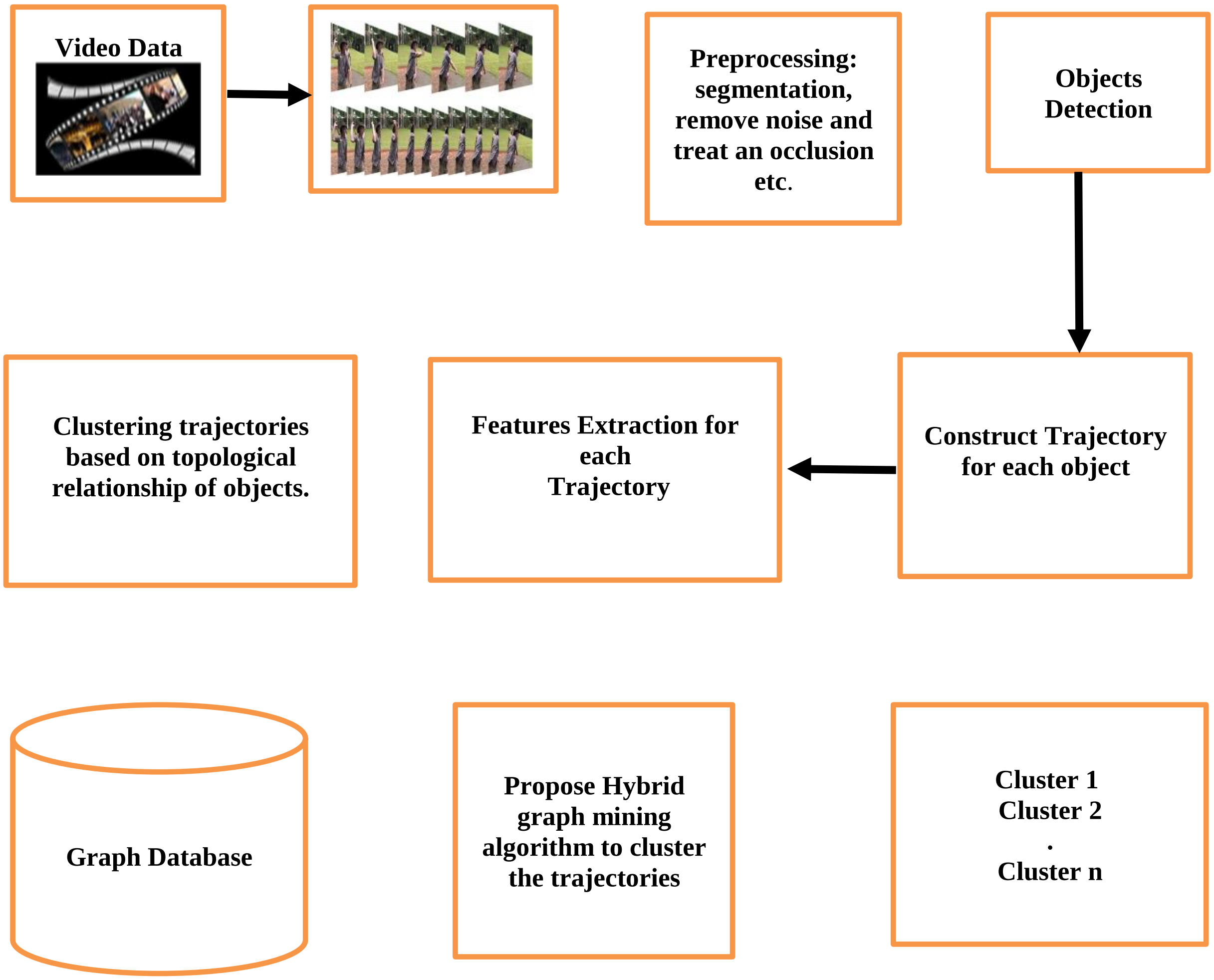

Figure 1 Proposed System of clustering object tracking using hybrid graph mining algorithm

The following consecutive steps will apply in operating and implementing the proposed system:

First, given a movie film to read as a raw data that consider clustering the objects inside it. The video will be in between 1-2 minutes and should have unlimited moving objects. Also, the content of video should be biological experiments, chemistry analysis, scientific intelligent, swarm of fish, or swarm of birds.

The second stage in this proposed system is to split the video file into sequences frames (still images) to cope with each frame individual.

Third stage: preprocessing operations must be done. Preprocessing will play important functions in preparing and arranging the data for the next step. This stage includes:

1-Removing noise and logo (label) to diminish the unwanted effects in each frame. This process can be used to make enhancement for each frame by removing boarders, noise, logo, and labels of the frame. Indeed, the proposed model regard any things in the image (frame) that considers to be noise. The object is set of connected pixels in the image, where system identify the object depend on features like color, texture, and size of the object.

2-Apply the segmentation and tracking methods to figure out the objects in each frame and find the features for each object such as area, direction, texture. The results of the segmentation and tracking approaches are to track and identify the objects in the scene as fast as possible. Also, it can cope with overlapping. Segment the individual objects based on strongly on the ability to identify the object region and classify all pixels in a given image to be object or pixels that aren't representing objects.

3-Occlusion detection: occlusion appears due to objects processing disparate motions and covering/uncovering one another. It can be solving this issue of occlusion by applying morphology opening filter to separating an occlusion objects.

Fourth stage: object detection is the process of finding instances of objects in images. Object detection process is necessary to start tracking. It is always applied on each frame.

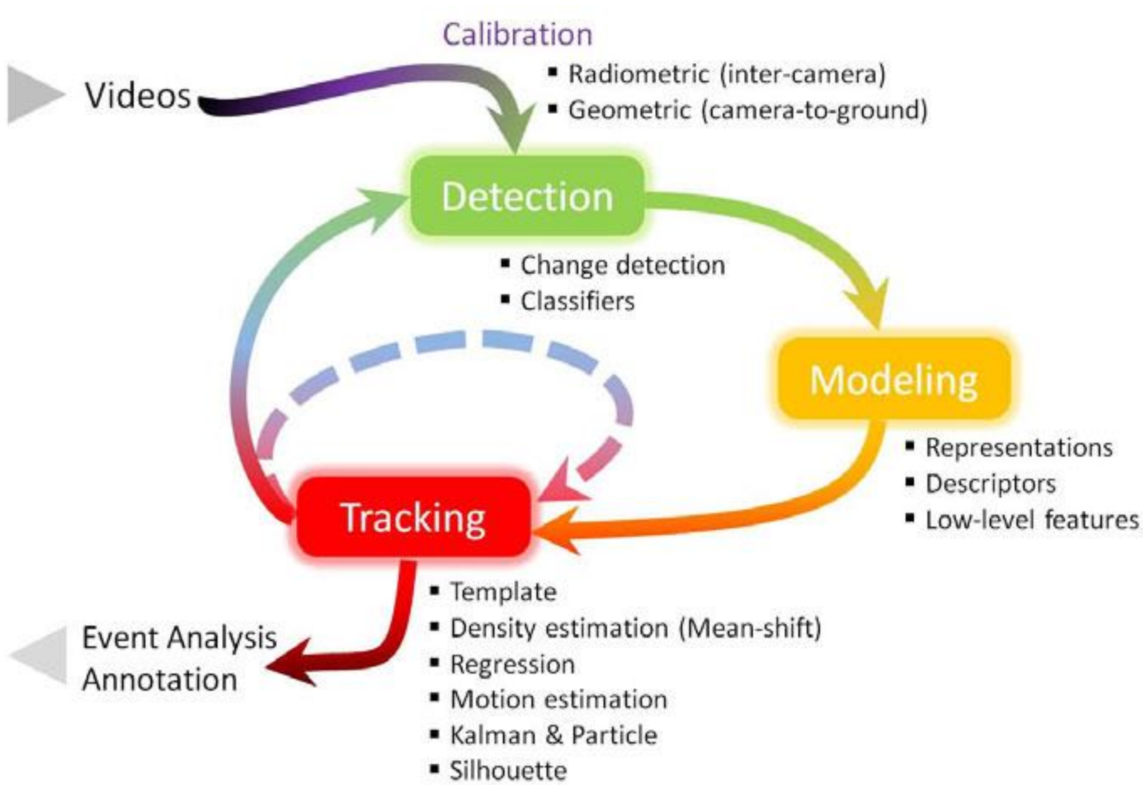

Figure 2 Basics tasks for detection and tracking objects

A popular method to detect moving object is to use time information fetched from a consecutive frame, for example by supervised learning a static background model and comparing it with the current scene, figure out high motion areas, and by computing inter-frame difference.

Another common method for detecting moving objects is to slide the widow on the image (possibly on multiple scales) and classify each partial window as containing the background or target (foreground). Or, extract local points of interest from the image, and then classify each area around these points instead of looking at all possible sub-windows.

Fifth stage of our proposed model is how to construct trajectory for each object. It is very important and complex step in our works because it needs to identify the same object in each frame by propagating an object over time frame by frame. After the last frame whole trajectory of object will constructed. In case of that object at i frame will be death (disappeared) the entire trajectory for it will built after i death frame.

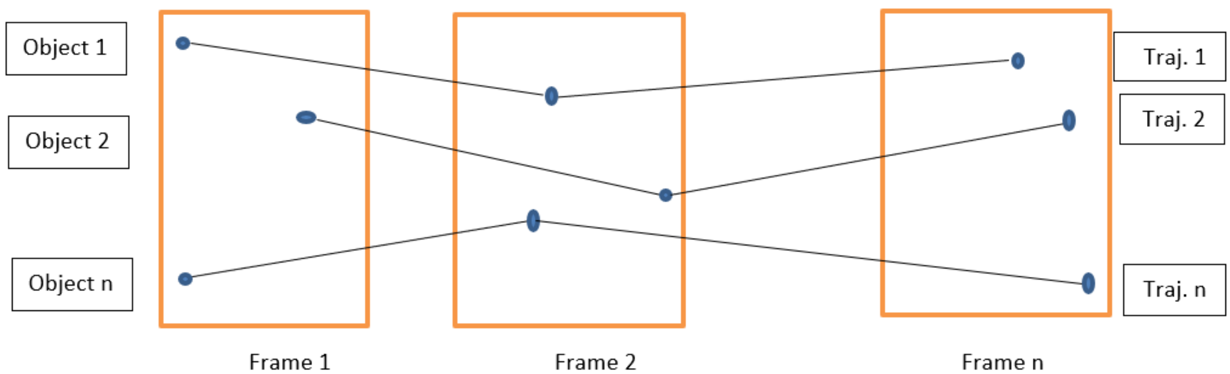

Figure 3 Trajectories construction representation

In Fig.3 each trajectory built by propagating the same object at each frame where in each frame the object represents centroid points of that object at this frame. Therefore, the trajectory is a collection of consecutive points that group together to imply like a path that represents the entire moving object (positions).

Sixth stage: features extraction is the most important step. In this phase, the features of each trajectory will be extracted. Features should be distinct points and the relationship among them (angles, orientations, and distances etc.) that construct that the shape.

Next stage: clustering the trajectories based on topological relationships that extracted from the previous step.

A trajectory T_A, contains a series of m timestamp n dimensional points $a_i=(a_{i,1},\dots,a_{i,m})$:

$$T_A = ((t_1,a_1),\dots,(t_m,a_m)) \qquad (1)$$

Where t, are discrete timestamps and ti < ti+1. Path length is the number of separate (discrete) timestamps (repairs). The complexity of determining the measure of path similarity is the type of random discretization. For example, a simple similarity id Euclidean distance is calculated as the sum of the distances between pairs of ordered points on two trajectories. But such a simple measurement challenge has different sample rates, outliers, and trajectories that require different lengths to cut on average. Therefore, more advanced similarity measures have been proposed and implemented earlier.

Graph database Stage: Graph is a reliable tool to analyze and present knowledge or data. To model frames, graph must be constructed. Nodes represent individual points that construct each trajectory and edges link the same objects in different frames of that trajectory (displacement).

This step is proposed to extract the relationship between the trajectories at end. It could be organizing as table of many attributes (trajectory features) and records (trajectories).

Graph Mining is the collection of approaches and functions used to (a) properties analysis of real-world graphs, (b) guess how the properties and structure of a given graph might influence some application, and (c) evolve models that can create realistic graphs that match the patterns found in real-world graphs.

There are two main types for graph mining algorithms are the following:

a. **Apriori-based approach:** The priority-based chart mining (AGM) algorithm can effectively obtain all the frequently occurring sub-graph patterns in the chart data structure. This method is based on the breadth first search (BFS) concept, which is an algorithm for searching graph data structures. It starts from the root of the tree (or some random node on the graph) and explores all adjacent vertices of the current level before moving to the next level. For example, suppose we have two sets of frequent elements of size-3 (abc) and (bcd). The frequent element set candidates of size generated by them are simple (abcd) and are derived from the combination, and the candidate size-4 generation problem in frequent substructure mining is more complicated than the candidate generation problem in frequent element set mining, because the two substructures are connected There are many ways to do it.

Priority-based algorithms, such as AGM, FSG, and path binding methods, are recently used to frequently extract substructures.

b. **Pattern-Growth Approach:** The priority-based method must use the strategy (BFS) because it is a step-by-step candidate build. To identify whether the (k + 1) size chart is frequent, you need to check all its corresponding k-size subgraphs to get the upper limit of its frequency. Therefore, before extracting subgraphs of any size (k + 1), the Apriori-based method must generally complete the extraction of subgraphs of size k. On the other hand, the pattern growth method uses deep search (DFS) and its search technology is more flexible. The DFS search algorithm starts from the root node or any randomly selected node, and scans as much as possible along each branch before entering other levels of depth. The frequent pattern growth method is a method of discovering frequent patterns and does not generate new candidate patterns. Build a FP tree instead of using Apriori's build and test strategy. The focus of the FP growth algorithm is to separate the paths of elements and extract frequent patterns. Examples of pattern growth methods are gSpan, ADIMine, and DPMin.

Indeed, we should use one of graph mining algorithms to clustering the trajectories by developing it to enhance the performance or using two or more algorithms to improve the efficiency of clustering process.

Results Evaluation

After a collection of clusters is founded, we need to evaluate the quality of the clusters. For clustering no one knows what the right clusters are given a data set. Thus, the quality of a clustering is much harder to evaluate. There are some commonly used evaluation methods:

a. The Accuracy measures the closeness of the estimates to the real trajectory of the target.
b. The goal of achieving high similarity between groups (similar objects in the group) and low similarity between groups is formalized by the standard objective function in the grouping (objects in different groups are different). For grouping consistency, this is an internal standard.

Purity is a simple and transparent evaluation index. In order to calculate the purity, assign each group to the class, the group that appears more frequently in the group, and then formally measure the accuracy of the assignment by calculating the number of correctly assigned objects and dividing by N:

Purity (Ω, C) = ⍁{1}{N}∑_{k}j max |wk ∩ cj| (2)

Where Ω={w1, w2,…,wk} is the set of clusters,
and C={c1, c2,…,cj} is the set of classes.

We want to put two objects in the same group if and only if they are similar. The true decision (TP) assigns two similar objects to the same group, and the true negative decision (TN) assigns two different objects to different groups. We can submit two types of errors. (FP) The decision to assign two different objects to the same group. (FN) The decision to assign two similar objects to different clusters precision and recall are most suitable for this type of application because they measure the accuracy and completeness of the grouping in the positive category.

$$Recall = TP/(TP + FN) \quad (3)$$
$$Precision = TP/(TP + FP) \quad (4)$$

There are other measures we can use to evaluate clustering performance like F-score, Entropy, and random index.

Conclusion

A group of different data objects is called group related objects. A community means a set of data. In cluster analysis, data sets are divided into different classes, which is based on the similarity of data. In this research work, we suggest a model to detect, and track moving objects and then construct trajectory for each object. After that we extract the most significant features for each trajectory based on topological relationships. Also, build graph data base to store these features of trajectories as table of some attributes and records. Then propose an adaptive hybrid graph mining algorithm to cluster these trajectories (objects).

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