Trajectory Clustering and Mobility Pattern Identification of Missing Vessels in Deep Sea

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Abstract— Mobility management is one of the significant research areas in wireless network communication. Tracking the position of fishing vessels in deep sea is a challenging task as it involves the influence of mobility parameters such as the vessel speed and its direction, and their dynamics over time and also several environmental parameters as well. The main focus of the paper is to propose an algorithm for mobility pattern identification of missing vessels in sea. Density based clustering and dynamic time warping algorithms are implemented for tracking and identifying the objects.

Index Terms—Density based clustering, Dynamic Time Warping algorithm, Mobility management, prediction

I. INTRODUCTION

The cognizance of phenomena related to movement of objects has always been a key issue in many areas of scientific investigations. The mobile communication technologies are pervading the wireless networks and our society by tracing their mobility and henceforth producing large volumes of mobility data. The increasingly semantic richness and positioning accuracy of mobile phones with the integration of GSM, GPS technologies enables an increasingly better estimation of the user locations, thereby facilitating the observation of the movement patterns and behavioral models in real time.

Data mining techniques have been widely used in variety of applications to discover hidden pattern and knowledge extraction, classification and clustering, dissemination, management and prediction effectively [9]. No existing approaches discuss the problem to analyze marine data to track and manage missing fishing vessels. The proposed work is an attempt to excel the problem by proposing algorithms for identifying the missing vessel location thereby providing quick and efficient mobility-based communication services.

Collecting the mobility data from marine sector is extremely complex. Transforming the data into mobility knowledge patterns that formulate a collective movement behavior, pertaining to groups of individuals is worth putting into evidence. The work aims at understanding the general movement or behavioral patterns, which is the frequently followed trajectories of the individual fishing boats in the deep sea. This mobility pattern serves as the knowledge base of the fishing vessels, which is being exploited for the mobility pattern identification process.

The central issue in any mobility scenario is that the moving object’s position continuously changes with time. Hence a thorough attention must be paid to the heterogeneous aspects of movement which includes the trajectory in
space, motion characteristics of the object such as its speed and direction, and their dynamics over time. It must also focus on to properties of their surroundings and various phenomena and events.

II. BACKGROUND

A. Trajectory Clustering

Trajectory, the fundamental aspect of mobility data, is a grouping of time-stamped locations, sampled from the channel of a moving object [4, 5]. To record the movement of an object, its position has to know at all times, i.e., on a continuous basis. The trajectory based mobility modeling helps in representing the past, current as well as the predicting the expected future positions of moving vessels. The trajectory of a moving object describes the positioning data as a two dimensional route on the sea surface as an ordered series of locations of a given moving object with format(longitude, latitude, time) at time \( t \) indicating the timestamp of the location (longitude, latitude). It is represented as a sequence of points: Trajectory \( (Vessel\_id):=(x_1,y_1,t_1), (x_2,y_2,t_2),\ldots, (x_n,y_n,t_n)\); \( t_1 < t_2 < \ldots < t_n \). It actually specifies the entire route that particular objects moves in a specific period of time, say a day [6, 2].

The object at position \( (x_i,y_i) \) at time \( t_i \) and during each period \( [t_i,t_{i+1}] \), is assumed to move along a shortest straight line from \( (x_i,y_i) \) to \( (x_{i+1},y_{i+1}) \) at a constant speed and that point is obtained by linear interpolation. Clustering techniques facilitates extracting knowledge from these huge data repositories in an efficient manner.

The paper proposes an approach for discovering the missing boats location in a fair accurate manner from the trajectories of vessels involved in deep sea fishing at that instance of time.

III. THE PROPOSED SYSTEM

A density based mobility pattern identification algorithm is proposed for finding the trajectory of the missing vessels in deep sea. The proposed scheme categorizes the previous trajectory patterns of the missing vessel for determining the appropriate zones in which the vessel is expected to be present.

The paper focuses on to reason about mobility and its sustainability and to support decision support systems with sensible knowledge in discovering user context, real-time mobility pattern prediction of mobile nodes, especially during emergencies like disaster alerts, missing boat identification etc. It has been found that, in case of emergency situation, mere prediction techniques are not always accurate to localize the missing vessels, especially when the moving pattern is not predictive in the case of heavy rain, storm or tsunami. The system tracks the exact or appropriate location of fishing vessels by identifying the trajectories and the path will be set by using dynamic time warping algorithm. Then cluster the trajectories by applying Density-Based Spatial Clustering Application with Noise (DBSCAN) algorithm [1].

DBSCAN algorithm clusters the vessel nodes in the current scenario, thereby paving way for the further processing steps [1, 3]. The velocity of the missing boat is also considered as a major factor while determining the expected trajectory of the vessels. The
environmental parameters of the sea bed are also considered in determining the expected output. This would enable to predict the trajectory of missing vessels. The proposed technique also uses the Vessel Pattern Identification algorithm to categorize the existing trajectory of the missing vessel with its previous trajectory patterns in order to determine the appropriate zones in which the vessel is expected to be present.

A. Tracing the Mobile Path

The locations which are frequently followed by the mobile nodes are called mobility patterns [8]. The mobility pattern prediction algorithm proposed in this paper helps predicting the current location of the missing vessels. Fig.1 shows the proposed system architecture.

![Fig. 1. Mobility Prediction Architecture](image)

B. Mobility Prediction of Fishing Vessels

The proposed mobility prediction system helps predicting the position of the missing vessels by tracking the previous movement trajectory patterns of the missing vessel. In addition to this prediction we are also taken into consideration several deep sea environmental parameters such as wind speed and direction which in turn can affect the direction of movement of the vessel.

Assume that there are m base stations \{B_1, B_2, ..., B_m\} located at the shore with n number of clusters \{C_1, C_2, ..., C_n\} which comes under its communication range. The data base \{D_1, D_2, ..., D_p\} contains the actual paths of the mobile nodes coming under m base stations, distributed over the network.

Most of the time the mobile nodes exhibit some kind of regularity in their movement trajectories. The proposed mobility pattern algorithm helps to mine the mobility pattern of each of the mobile nodes from the user actual path.

The main steps involved in the mobility prediction algorithm are as follows: The paper proposes a methodology for Vessel Mobility Pattern Identification by discovering the Bounding Trajectory of the trajectory clusters by taking into consideration the local similarity between portions of trajectories. DBSCAN clustering algorithm helps to detect clusters of arbitrary shape and is also insensitive to noise.

The Vessel Mobility Pattern Identification algorithm helps in creating a knowledge base which consists of the mobility patterns for each of the authorized fishing boats based on the \(<src, dest>\) constraint. The src attribute indicates the source from which the journey starts and the dest attributes indicates their terminal point of the journey. The mobility pattern for each vessel per day is considered for the formulation of the trajectory dataset.

Vessel Mobility Pattern Identification Algorithm

```python
vesselMPI()
for each \( V_i \in V \) do
    apply Trajectory Extraction from \( D \) w.r.t. the
```
mobPred ($T_B^x$)

Extract Current Movement Trajectory of the Boat $T_B^x = \{ T_{Bx_1}, T_{Bx_2}, T_{Bx_3}, ..., T_{Bx_n} \}$; $T_{Bx_n}$ is the location where the boat $B_x$ LAST-FOUND;

$T_{C_B^x} = \{ T_{C1}, T_{C2}, T_{C3}, ..., T_{Cn} \}$; existing bounding trajectory patterns of Boat $B_x$

for each $V_i \in V$ do

Apply DTW to identify the similar trajectories

Assign the input trajectory path in to the appropriate cluster $T_{C_B^x}$

If there exists more than one such clusters

Choose the one with minimum distance subject to the constraint

Min (dist) = Lower_bound <= (dist (TBi, C(TBj)) <= Upper_bound

Predicted Trajectory=Movement Trajectory of $C_k$

locateVessel (LAST_LOC (lat, long: time), env_par, boat_speed, boat_dir)
/* Extract the clusters constrained to eps and MinPts w.r.t. [LAST_FOUND location, env_par] ;

Apply SimplekMeans(data_pts, NC);

Calculate Cluster Centroids;

Choose the one with minimum distance from the missing_loc; subject to env_par;

end

The dynamic time warping algorithm helps in comparing the similarities of the trajectory of the fishing boats with their corresponding bounding trajectories [10]. It has been found that, in case of emergency or isolation, mere prediction techniques are not always accurate to localize the missing vessel, especially when moving pattern is not predictive in the case of heavy rain or Tsunami. A more determined method is to integrate the prediction technique with the communication pattern. The localization of fishing vessels can be performed by using the proposed prediction techniques to anticipate the possible region of movement based on the communication pattern model and the history of the movement pattern.

The nearest vessels in the communication pattern in which the affected vessel appears will be taken and analyzed to obtain its mobility pattern in the sea. That estimation would help the SAR teams to localize the missing vessel at any emergency situation without direct contact. The machine learning approaches used in the implementation helps
in the analysis and classification of such communication patterns. This will learn the patterns and infer the anticipated location of the misplaced vessel [7].

Our basic assumption is that the fishing vessels often follow the cluster and also tends to follow similar routes subject to the fishing zones in different time periods. Having enough data to model typical behavior patterns of the fishing vessels, we can fairly predict the future movement pattern of the individual or group vessel pattern.

The data selection is done in such a way that in the spatio-temporal primitives, a spatial area over a specific time period is selected for the prediction. By selecting only a specific region, which is choosed based on the <source, dest> preference of the fishing fleet, and also the time period required for crossing that area is considering in this work.

V CONCLUSION
The technological lag and financial constraints had been the major bottlenecks in the deep-sea fishing industry in India. The information about the current status of the fishing vessels are to be regularly monitored and the need to be passed to the fishermen, which would significantly increase the ease of rescue operations thereby ensuring their lives. The strengthening of the existing communication technologies is a pre-requisite to widen the exploitation of deep-sea fishery. The mobility pattern identification proposed in the paper helps in providing location-based services to fishermen while deep sea fishing.

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REFERENCES


