Android Based Application for Efficient Carpooling with User Tracking Facility

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***Abstract*— Nowadays the number of cars with empty seats travelling a long distance are increasing on the roads. By bringing people, who are travelling to the same destination, in a single car can decrease the number of vehicles on the road and thereby reduce the pollution to a large extent. Web and mobile applications for carpooling are very common now which provide basic features like sharing of journey, user rating etc. However, all these applications could not provide efficient location tracking. In this paper, we propose an efficient mobile application for carpooling with some unique features like user location tracking and traffic anomaly detection. The location tracking is included as a security feature which enables the user to share his or her current location with their near and dear ones. Anomaly detection feature can reduce the unnecessary wastage of time during the journey by analyzing the pre reported traffic anomalies like processions, accidents, road works etc. reported by others and redirecting the vehicle through another best route. But there is a chance for false anomaly reporting possible. In order to make this feature foolproof, we propose a truth estimation technique using recursive EM algorithm in this paper. Recursive EM algorithm is an efficient streaming algorithm generally implemented in social sensing application as it can solve the estimation problem on a real time basis. This android based application consist of a user friendly interface through which user can create and manage trips, track location, report an anomaly, etc. Location tracking is implemented using Google Map API by collecting the GPS data from each client and feeding it into the database in real time.**

Keywords*— *anomaly-detection,recursive-EM,crowd-sourcing, so-cial sensing, foolproof.

I. INTRODUCTION

Carpooling is an environment-friendly method where sharing of rides can reduce the number of vehicles on the road which in turn reduces the problems like environmental pollution, traffic congestion and lack of space for parking area. By having more people in a single vehicle, reduces the various costs of the journey. For example, combining three or more people who set off on the same direction in different vehicles, into one, reduces the costs of fuel needed for separate vehicles. Cost reduction by sharing and company of fellow travelers also reduces the stress of the driver. Most of the existing applications related to carpooling like BlaBlaCar, Pool My Car etc. provides sharing of journey, user rating, feedback, payment, etc. [2]. But these applications are not providing features like user location detection, location sharing, traffic anomaly detection etc.

We intend to integrate anomaly detection into the application which can be used to detect any obstacles in the course of the journey. Anomaly detection is generally used in crowd sourcing application, where users can report an anomaly found in physical world like procession, protest, roadblocks, etc. There may be situations in which false anomaly reporting and manipulation of reported anomalies are created by the user. To remove such inconsistent and manipulated reports, we use Recursive Expectation Maximization algorithm [1] to recognize if these anomalies are true. Recursive EM algorithm is a streaming approach which is able to process streaming data reported continuously to the algorithm. EM algorithm estimate the truth by only processing the newly arriving data and then it combines the result with the previous estimates. By using anomaly detection method passengers can save a lot of time by notifying them to use an alternative route to reach the destination rather than being stuck at the anomaly reported.

Location tracking facility is an added feature to the application in which the driver and passengers can track each other's position. Passengers will be able to locate the current location of the car which will help them to report at the boarding point before the vehicle arrives. Drivers can also track the passenger's location and figure out whether they had reached the boarding point. This method can reduce the wastage of time. Location sharing facility is also implemented where a user can share their location with friends or family. The additional features designed in the application will be much helpful for female passengers for improved security. The major drawback of applications related to carpooling is the user's authenticity and safety. Users authentication is done by various processes like validating mobile number using OTP, e-mail verification etc. User's interaction is made easier through Facebook integration also.

II. LITERATURE REVIEW

Anomaly detection is a general approach that can be applied in any field related to outlier detection. The Recursive EM algorithm is commonly applied to find such outliers from a data set [1]. In this research work, we plan to integrate the anomaly detection for traffic obstructions, truth analysis to make it foolproof and user location tracking facility into the carpooling application. Many researches are made to find the truthiness of these reported anomaly.

Dong Wang, Tarek Abdelzar and Lance Kaplam [1] proposed a method to implement anomaly detection using truth analysis process to find out whether the reported anomaly is true or not. In their paper, they proposed an algorithm based on truth analysis, viz. Recursive Expectation Maximization algorithm, which can process streaming data that is continuously given to the algorithm and conclude the correctness of the statement.

Swati.R.Tare and Neha B.Khalate [2] proposed a carpooling application with location tracking facility. In their application they used Google map facility for location tracking which can be used to share current location of the car to the passengers. They used comment and rating system to improve security and authenticity of other users. In their paper, they implemented client server architecture where the information is stored in a central database. They also implemented many safety features for women passengers.

Deepak B.Nagare and Kishore L.More [3] proposed an application where they included social networking integration to their application. This provided more security to the application and gave more authenticity to the users. They also used location tracking using Google maps and some measures to ensure the safety of passengers.

Avila Antao and Venisha Correia [4] proposed an android application which has the facility for the users to interact each other. They gave many filtering methods to choose an appropriate driver or ride, from their application database. This application provides only the basic functionalities of carpooling like ride creation, ride sharing, user review, communication and efficient methods to sort all the available rides.

Nikhil Bacchav and Priya Malode [5] proposed an application for carpooling. In their paper, they implemented route matching which can help other user to find the best rides available for their journey. Source and destination will be taken to create a shortest path and the application will match the identified path with already existing trips. And the results will be sorted considering the similarity of path matching. They also implemented location tracking using Google maps and GPS.

Athul Sai and Sini Salim [9] proposed a carpooling application that uses crowd sensing to detect traffic anomalies and social media data to determine traffic anomalies. Their architecture includes an android based application which uses a combination of J2EE application server and Hadoop as the backend server. In their paper, they implemented Recursive Expectation Maximization algorithm to find the authenticity of the reported anomalies.

III. METHODOLOGY

Anomaly detection is the identification of unique observation from a data set that doesnt match with the usual pattern. In our work, we used traffic obstructions like traffic block, accidents, procession, etc as the anomalies. In order to find the correctness of the reported anomaly we used a fact-finding algorithm known as Recursive Expectation Maximization algorithm. Recursive EM is a general algorithm to find the truth from a set of values in social sensing applications. We developed a software implementing Recursive EM algorithm in such a way that it can identify the correctness in the anomalies reported. We finally integrate this work with the carpooling application so that the users can report an anomaly directly from the Google Map API with the current location, where the anomaly is found, along with the type of the anomaly. These anomalies are passed to the server using HTTP connection and the correctness is calculated. The result from the algorithm is notified to all the passengers travelling in that direction and suggests them to reroute from the actual course.

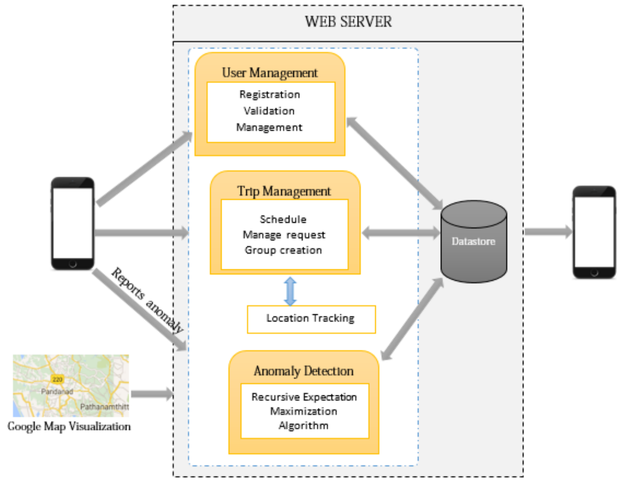

Fig 1 : System Architecture

The android application provides the basic functionalities of a carpooling application available in the market including creation of trip, rating, and Facebook integration. The major innovation we made into the android application is that it provides the facility of tracking the current location of both the car and the passengers each other. It continuously interact with the server using HTTP connection for data management.

Fig 1 shows the system architecture of our application. It depicts the major modules including user management, trip management, anomaly detection and location tracking. The client having the application user interface can interact with the server for each functionalities shown in the architecture. Datas including user details, trip details, location details and anomaly are stored in the datastore which is implemented using Postgres SQL.

A. Anomaly Detection

Anomalies are outliers, which means, observations which are not expected in a general pattern. Anomaly detection is the identification of such outliers from a dataset. Here we implemented an anomaly detection feature to find anomalies related to traffic.

1) Recursive Expectation Maximization Algorithm: In this application we implemented anomaly detection using Recursive Expectation Maximization algorithm[1]. Users can report an anomaly from their application through the Map activity. Each anomaly reported by end users are taken as observations. These Different observations are taken into consideration and is solved to determine the correctness of the anomalies reported. This algorithm is more suitable for real time applications with location tracking as this algorithm is a streaming fact finder which updates the previous estimate with the updated data arrived. Thus we can overcome the difficulty of re executing the algorithm again whenever a new anomaly is reported.

Recursive EM algorithm is a general approach to solve truth estimation problem in social sensing applications. Users can report anomalies related to our application like road blocks where these reports are taken as input to this algorithm. Each reports will be taken with its corresponding location and a Boolean value which represents if an anomaly is detected there. Algorithm 1 shows the pseudo code of Recursive EM where it takes new input as Xk+1 with its corresponding location and is processed to find its final output. In our application there will be M users (S1, S2 .. SM), who may collectively report observations of N Boolean variables, C1, C2 CN.

```
initialization : Cj = false;
Input : Xk+1;
while new anomaly Xk+1 reported do
    for i = 1 to M do
        calculate ai^(k+1),bi^(k+1) using equation (1)
        update ai^k,bi^k with ai^(k+1),bi^(k+1)
    end
    for j = 1 to N do
        calculate Zj^(k+1) using equation (2)
    end
    capture "ripple effect" by executing an EM iteration
    Z^r j = Zj^(k+1) after the iteration
    a^r j = ai^(k+1) after the iteration
    b^r j = bi^(k+1) after the iteration
    for j = 1 to N do
        if Z^r j ≥ 0.5 then
            Cj is true
        else
            Cj is false
        end
    end
    for i = 1 to M do
        compute b^r i from a^r i, b^r i using equation (3)
    end
    k = k + 1 end
```

Algorithm 1: Recursive Expectation Maximization

$$a_i^{k+1} = a_i^k + \frac{1}{Nd(k+1)} \times \sum_{j\in SJ_i^{k+1}} g\left(a_i^k, b_i^k, X_k, X_{k+1}\right)\left(1-a_i^k\right) - \sum_{j\in SJ_i^{k+1}} g\left(a_i^k, b_i^k, X_k, X_{k+1}\right)\left(a_i^k\right)$$

$$b_i^{k+1} = b_i^k + \frac{1}{Nd(k+1)} \times \sum_{j\in SJ_i^{k+1}} \left(1-g\left(a_i^k, b_i^k, X_k, X_{k+1}\right)\right)\left(1-b_i^k\right) - \sum_{j\in SJ_i^{k+1}} \left(1-g\left(a_i^k, b_i^k, X_k, X_{k+1}\right)\right)\left(b_i^k\right)$$

$$\mathit{Equation}\ 1$$

The base state of each Boolean variable will be set to negative. When a user report an anomaly which represent a particular location, the Boolean variable corresponding to the location will be set to positive value. Anomalies are reported at different times rather than all at once. Recursive EM algorithm can process the streaming observation which is continuously reported by different users.

Whenever a new update X^{k+1} arrives recursive update on the estimation parameters a^{k+1} and b^{k+1} is calculated using Equation 1. It gives the recursive computation of estimation parameters a^{k+1} and b^{k+1}. The calculated values for each estimation parameter a^i and bi is updated with a^{k+1} and b^{k+1}.

$$Z_j^{k+1} = f\left(a_i^{k+1}, b_i^{k+1}, X_{k+1}\right) = \frac{A_j^{k+1}\times d}{A_j^{k+1}\times d + B_j^{k+1}\times(1-d)}$$

$$\mathit{Equation}\ 2$$

The correctness of the variable is calculated from the estimation parameters using the Equation 2. The change in estimation parameter of the sources will affect the credibility of other reported sources which is known as the "Ripple effect". To find this effect, we need to run one EM iteration again from the beginning.

$$a_i = \frac{t_i \times s_i}{d} \qquad b_i = \frac{(1 - t_i \times s_i)}{1-d}$$

$$\mathit{Equation}\ 3$$

Correctness of each measured variable C_j is decided from the updated value of Z^r_j. If Z^r_j is greater than 0.5, C_j is considered to be true.

B. Location Tracking

Location tracking facility is implemented using Global Positioning System (GPS) with the help of Google map. When the driver accepts the ride request of a user, location tracking is started one hour prior to the journey. This module continuously track the current location using GPS and is updated to the database which will be available to both the driver and other passengers. Google map is used to provide the layout of the map.

Whenever a trip is scheduled, a shortest path from the source and destination is suggested to the driver. The passengers can review the route which the driver has opted to travel and may suggest for any changes. For the safety of women passengers, there will be an option to share the current location to selected friends or family so that they can also track their current location.

IV. Result and Analysis

In this research, we developed an efficient carpooling android application with anomaly detection implemented using Recursive Expectation Maximization algorithm. Application user interface provides users to manage several activities like user management, trip management, location tracking, anomaly detection and user rating feature. The Recursive EM algorithm [1] [9] gives a foolproof result from different anomalies reported by users.

Table 1 shows the input data structure of anomaly reported from the application including the latitude and longitude, anomaly type and the status. In our test case, we reported an anomaly for the location having latitude 8.717 and longitude 76.81 with a positive value. The algorithm returned that the reported anomaly is true and suggested an alternative path to the destination. The red marker in the Figure 2 shows the current location of the user. The blue marker shows the anomaly location. The blue path is the current route for the user and the grey path is the alternative path to reach the destination.

Latitude	Longitude	Type	Status	Time	User
8.717° N	76.81° E	Block	1	9:14	user787

Table 1: Input data structure

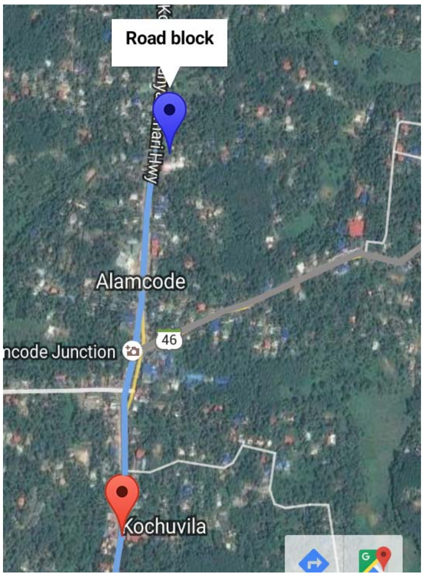

Fig 2: Anomaly report status

By implementing Recursive EM algorithm we can determine the correctness of the anomalies that are being reported continuously from the application. And thereby, users can save a lot of their time rather than being stuck at those obstructions. But in some cases like, if for a certain location in a time slot different users report false report, Recursive EM algorithm may not be able to find the truth efficiently. For such cases, we need to optimize the current algorithm to make it more efficient in the worst case scenarios.

V. Conclusion

In this work, we proposed an efficient carpooling application with user location tracking and anomaly detection. Carpooling is much efficient in current society as it can reduce traffic, environmental problems, etc. Applications related to carpooling provides basic carpooling functionalities. Some of the applications provides location tracking where the passengers can only track the current location of the car. Whereas, we have provided an efficient application where the users including both driver and passengers can track each other. In most of the navigation applications, time wastage is a major problem as they get delayed by obstacles like road accidents, traffic, etc. We have provided an efficient anomaly detection method integrated to this carpooling application to find foolproof anomalies from all the reported anomalies. By this feature we can assure the credibility of the application and makes it more efficient than other carpooling applications available in market.

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