Elephant Routes – Alert System for Villagers via Motion Tracking


Abstract—The Human Elephant conflict has become a topic of concern world-wide, including Sri Lanka. Sri Lanka, as a developing country, has a population of 20 million people plus a wild elephant population of approximately 4,500 to 5,000. With its increasing human population, the demand for jungle land for development has increased. This has led to a decrease in the wild elephant population rapidly. The decrease in habitats has resulted in the Human-Elephant conflict, which has led to deaths for both humans and elephants. This conflict has made serious damage to property, crops and harvest as well. There is no action taken yet in Sri Lanka to solve this burning problem. As Sri Lanka is moving forward in the 21st century with ICT, introducing a computer aided automated tracking and warning system would be an ideal solution to stop the human-elephant conflict. Analysing the behavioural patterns of wild elephants using GPS, this research aims to introduce a movement prediction and tracking system. A successful tracking and a prediction will help alert the villagers and the responsible authorities to avoid a disaster coming in their way. To analyse the behavioural patterns of wild elephants it is proposed to use a pattern analysis algorithm, so that the next moving direction of an elephant will be predicted logically.

Keywords—Elephants, GPS tracking, pattern analysing algorithm, prediction algorithm, alert systems.

I. INTRODUCTION

The route system of Elephants, designed to help people who live near national parks in Sri Lanka, make people more vulnerable to elephant attacks. Each year more than 200 Asian wild elephants and 70 humans die because of this conflict. Key problems to be considered in a solution to this problem are: cases of deaths reported, loss in major income for people involved and damages to cultivation and property done by the elephants. The application to track wild elephants and analyse their movement pattern to predict the next movement, could alert villagers and the wildlife conservation department if any harm can be sensed by elephant movement towards villages. GPS technology and prediction algorithm are used to identify the location of elephants and predict their movements.

Most of the current tracking systems and researches are done using Very High Frequency Radio signals (VHF) which are not very efficient [1]. By using these sensors, it is not possible to track or predict the movements of elephants (animals) accurately. This equipment has a limited working range. Therefore, it cannot be used to track long distances. A long distance tracking system is necessary to track elephants in the wild. So there is a clear research gap. Therefore, Elephant Routes research has identified these glitches and plan to give a solution using Global Positioning System (GPS). The team expects to track elephants using GPS and predict their movements using pattern analysing methods.

All existing do not serve the main purpose of tracking elephants successfully. It is necessary to track the movements of elephants (animals) and predict their movements accurately and by doing so identify whether there is a change from their normal lifestyle. If so, alert the wild life department and the nearby villages.

Proceeding with the research the main research questions were identified as follows:

- How to track an elephant or herd of elephants using tracking devices and GPS technology.
  - Elephants in the jungle have to be tracked from this system in order to analyze their moving patterns. So the research question remains, ‘What is the best way to do the tracking efficiently?’

- How to predict that an elephant or herd of elephants is heading towards the village.
  - After tracking the elephant and analyzing the moving patterns the system has to predict whether a particular movement will be a harmful step to the village or not (whether the elephant is coming towards the village or not).

- Who are the people that the system should alert if there is a possibility of an elephant or herd of elephants coming towards the village?
  - The system should automatically send alerts to the people that should have been alerted if there is a possibility of an elephant or herd of elephants coming towards the village. Here the research team has to identify the people and the responsible authorities that should be alerted.

- How to alert the people and the responsible authorities if there is a possibility of an elephant or herd of elephants coming towards the village.
  - The system should have a methodology to alert different people using different and most suitable technologies to suit particular parties that should be alerted.
II. BACKGROUND

To obtain information on denning behaviour and activities of grizzlies fitted with radio transmitters, the position and movements of instrumented bears were plotted from the intersection of bearings (fixes) which were made from a distance. Then, guided by the fixes and using portable directional receivers at close range [1].

By studying animal movements, researchers can gain insight into many of the ecological characteristics and processes important information to understand population-level dynamics. Brownian bridge movement model (BBMM) is used to estimate the expected movement path of an animal, using discrete location data obtained at relatively short time intervals. The BBMM is based on the properties of a conditional random walk between successive pairs of locations, dependent on the time between locations, the distance between locations, and the Brownian motion variance that is related to the animal’s mobility [2].

The Satellite Tracking and Analysis Tool (STAT) is a freely available system designed for biologists who work on animal tracking; it includes a set of standardized tools and techniques for data management, analysis, and integration with environmental data [3].

Habitat isolation can affect the distribution and abundance of wildlife, but it is an ambiguous attribute to measure. Presumably, isolation is a characteristic of a habitat patch that reflects how spatially inaccessible it is to dispersing organisms. Patch isolation is a key component of patch-based approaches that seek to predict the distribution of organisms in spatially-subdivided populations [4].

GPS technology enables collection of moving object’s positions remotely. Recent research on moving objects concerns analysis of their movement to increase the knowledge about their movement patterns. Discovery of biogeographically significant locations such as a den, rendezvous sites or kill-sites is very important in order to gain insight into animals’ behaviour, habitat selection and predator–prey interactions. This Expert system discovers significant locations which enable inclusion of knowledge about both intrinsic and extrinsic properties of animals. Our expert rules are adaptable to different application domains, based on characteristics of animal and algorithm parameters. The results of this study will be useful to community members engaged in studies of wildlife [5].

The moving object or vehicle location prediction based on their spatial and temporal information is an important task in many applications. Different methods were utilized to perform the vehicle movement detection and prediction process. The implementation result shows the effectiveness of the proposed heuristic algorithm in predicting the future location of vehicles from the current location [6].

It is about new methods for animal tracking in environments where the use of batteries has to be minimized and replaced by energy harvesting procedures. The baseline was proposed where basically two kinds of nodes are defined: primary nodes which integrate a GPS module for their own positioning and secondary nodes with a kinetic generator that just broadcasts their identification according to the animal movement. Upon such a broadcast from a secondary, a primary node in the secondary transmission range may receive the beacon and store its payload (secondary ID) along with the time stamp and the last positioning provided by the GPS. Therefore, a heterogeneous asynchronous dynamic network is meant to be the network paradigm [7].

We consider the following two problems: Map Matching: Given a sequence of (imprecise) location measurements from a mobile user moving on a road network, determine the most likely path in the network this user has travelled along. Prediction of Trajectories: Given the path of where a mobile user has moved along in a road network up to now, predict where he will travel along in the near future [8].

Periodicity is one of the most frequently occurring phenomena for moving objects. Animals usually have periodic movement behaviours, such as daily foraging behaviours or yearly migration behaviours. Such periodic behaviours are the keys to understand animal movement and they also reflect the seasonal, climate, or environmental changes of the ecosystem. However, periodic behaviours could be complicated; involving multiple interleaving periods, partial time span, and spatiotemporal noises and outliers. A period is usually a single value, such as 24h. And a periodic behaviour is a statistical description of the periodic movement for a specific period [9].

Fundamental to models of animal movements are statistical distributions of move distance and direction. Using GPS-based locations, the distance moved, or step length (SL), requires two consecutive fixes, whereas the direction moved, or turn angle (TA), requires three consecutive fixes. Statistical detection of whether animals select or avoid certain conditions, the apparent magnitude of selection or avoidance and the predictive ability of statistical models are sensitive to both spatial imprecision and habitat biases in GPS location data. The magnitude of observed effects depends on the magnitude of imprecision and bias, GPS sampling interval, landscape grain [10].

III. METHODOLOGY

Elephant Routes is more a practical world system rather than a system that solves theories, so it needs an Object Oriented design to take the system further and make the modification and adjustments when required. Using prototyping methodology is the ideal solution to fulfill this requirement. Prototyping will test the system time to time and will provide the feedback of the accuracy of the system.

A. Planning

Under the planning phase the team had some brainstorming sessions to build up a detailed work plan for the project and then identified the priorities and the milestones of the project. The gathered data was differentiated according to the requirement of the project. The team was expected to perform each stage of project according the information taken.
by analysing all gathered data. The team will continue gathering relevant data and identify correct project requirement.

B. Information Gathering

To gather primary data, the team met with wildlife conservation department officers and Grama Niladhari officers in the affected areas, and took interviews as a qualitative method of data gathering. The team did formal interviews with wild life officers and Grama Niladhari officers and informal interviews with villagers. Interviews with wild life officers were done to gather information regarding complaints made by villagers due to elephant attacks and immediate reactions taken by officers. Main task of interviewing is to specify the problem.

The findings from the interviews were that there are about 300+ families in a village and paddy and chena cultivation is there main source of living. About 20 elephant attacks per month have become normal and about 3-4 people are dying annually from attacks by elephants. About 25-30 houses are being destroyed annually by elephants with their visits to the village. More often elephants come to the villages at night time. But normally they come when they have a shortage of food in the forest. Mobile phones are used at least by a single person in a family. Currently the methods in use to prevent elephants from entering the village are electric fences, digging up gutters around the village and placing watchmen from time to time. These were not successful because a constant supply of electricity is not given and elephants are able to find alternative paths to enter villages. Villagers are informed about these attacks so they stay vigilant all the time. Their English literacy is very poor. So the team decided to send a specific symbol if an attack takes place.

About 45-50 elephants roam the villages frequently. Currently the methods in use to prevent elephants from entering the village are electric fences, digging up gutters around the village and placing watchmen from time to time. These are not successful because there is no constant supply of electricity and elephants are able to find alternative paths to enter villages. But normally they come when they have a shortage of food in the forest. More often elephants come to the villages in the night time. Villagers’ reaction for this issue is shooting down elephants using guns. Because of that fact 5-6 elephants die annually and about 20 get injured. Elephants are intelligent and, therefore, they can get used to the physical intrusions and avoid them. Therefore, the solution that the team provided can be successful because elephants will not be able to identify the methodology used.

For secondary data gathering, the team studied the unique behaviour of elephants and their routes. They studied currently available animal tracking systems, motion identifying methods and tools which can be used in the project and the language to implement the system by going through a number of research papers for the technology aspect of secondary data gathering.

C. Analysing

The primary objective of the analysis phase was to understand and document the business needs and the processing requirements of the new system. In the analysis phase the project team continued gathering requirements about the research and prioritizing the requirements in order to tracking as the main requirement and alert system and prediction algorithms as sub requirements.

D. Implementation

According to the information gathered a prototype of the system was developed and shown to the responsible persons. The team will be using GPS technology to track the elephants and pattern analysing methods to identify the deviations of their movements. Fig.1 shows the system diagram. Table1 summarizes the functionalities of the main modules of the system.

<table>
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<tr>
<th>Module</th>
<th>Functionalities</th>
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<tbody>
<tr>
<td>1. Track Elephants</td>
<td>Identify the locations of elephants using GPS transceivers; system is able to track the elephants’ exact current location from latitude and longitude.</td>
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<tr>
<td>2. Add Path</td>
<td>Using tracking data of elephants, the system can identify the areas that they have passed through and analyse elephant routes / path accordingly.</td>
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<td>3. View Path</td>
<td>‘View Path’ section displays the current path of the elephant.</td>
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<td>4. Predict Next Moment</td>
<td>Analysing elephants past data about their routes such as most standing areas, most visited areas and natural factors such as weather, seasons and food, the system predicts elephants’ next movement whether it is towards the village or towards the jungle in critical areas near the village.</td>
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<tr>
<td>5. Alert</td>
<td>The System generates messages and sends alarms to villagers and the wildlife conservation department if it reads more than 70% of probability of elephants coming towards the village.</td>
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Based on that data the elephants’ next movement will be predicted using a probability algorithm which has been developed based on the Weighted Markov Model. Since it is the best solution available the team decided to continue with the above mentioned technologies. All other technologies have difficulties in getting accurate data. After receiving their feedback further adjustments and extensions will be done accordingly and the final product will be developed.

Elephant Routes system has been developed using PHP as the main language. Integration of Google maps has been done using Google API coding. Adobe Dream Viewer CS5 has used as the IDE for PHP code handling and Google API code handling. The system database has been developed in MySQL environment using HeidiSQL and MySQL control center as the IDEs. Use of these languages and database environment is based on cost effectiveness as all of them are open source resources.

The ultimate system output of sending the alert to the villagers had to be done using java because it is a more reliable and available technology than message functions in other open source languages. Implementation of java programming has been done using NetBeans IDE 7.2.1. Running the Elephant Routes system will require MySQL Server, JDK 6 (minimum) and Wamp server 2.1 (minimum) installed platforms. Integration with a SMS server will be required in order to send SMS alerts.

Predicting the next movement of elephants was done based on the Weighted Markov Model algorithm. Page Rank calculation is one of the key calculations in Weighted Markov Model. It calculates the weight of a point according to the number of paths towards the point and number of paths from the point (In links and out links). The following section shows the key points used to generate an accurate prediction.

(1) Calculating Page Rank

\[ PR_u = (1 - d) + d \sum_{v \in B(u)} PR(v)N_v \]

where “u” represents an area or node. B(u) is the set of nodes that point to u. PR(u) and PR(v) are rank scores of node u and v, respectively. N_v denotes the number of outgoing links of node v. d is a dampening factor that is usually set to 0.85.

(2) Calculating the Weights

\[ Win(v,u) = \frac{I_u}{p R(v)} \]  
\[ Wout(v,u) = \frac{O_u}{p R(v)} \]

Where I_u/O_u and I_p/O_p is the number of in links/out links of node u and p. R(v) denotes all nodes that are pointed from v. Then the weighted PageRank is defined in formula.

(3) \[ PR(u) = (1 - d) + d \sum_{v \in B(u)} PR(v)Win(v,u)Wout(v,u). \]

(4) Weighted Markov Model Formula

\[ \hat{P}[c_l|c_0, c_{-1}, \cdots, c_{-n+1}] = \frac{\sum f(ck cke)\Sigma f(cl cle)}{\Sigma f(cl cle)} \]

Fig.2 illustrates how the system works step by step.
IV. RESULTS

The system was tested more than 100 times under the most needed circumstances such as changing of weather, seasons which cause lack of water and food for the animals, day/night times and for the herd of elephants to maximize the accuracy of the system. The following explains the test cases as evidence.

V. DISCUSSION

Since Elephant Routes system is going to be the key information providing source to villagers to be pre-informed about the danger, it should touch the highest level of accuracy since accuracy is the most important factor of the system. But the system got 60 out of 100 times accuracy at testing time under various circumstances. It is partially a good value because the system runs with insufficient data. But, when it runs in the real world, the system will auto learn itself and accuracy level will be increased because the system will fine tune with more data.

Using different kinds of testing methods the development team ensures the reliability of the system. Due to hardware failures and technical failure such as power cut, Internet problems the system stops. Other than that software wise it showed no signs of crashing. Elephants’ movements towards the village could happen any time of the day, Therefore, the system availability will be 24 hours to alert the villagers. After the software is up and running, it often requires continuous maintenance. In general, software remains operational for an extended period of time after initial implementation and requires regular maintenance to ensure that the software operates continually at peak performance levels. Software patches are given to correct issues relating to bugs in the software or to resolve potential security issues.

In addition to main objectives that are expected to be achieved, crowd protection over elephants can be determined in a situation such as elephants passing through or gathering on road sides. Then the road can be closed or relevant authorities can be summoned to take action against elephants. The same technology also can be used to understand the living patterns of animal beings such as: most popular areas, most disliked areas and etc. As a result bio-scientists can plot graphs easily to establish contentions. The same method can be used to track rare wild animals such as leopards and then inform wild life guides their locations to get more attraction from foreigners to wild life experiences in areas such as Yala and Wilpattu.

VI. CONCLUSION

The population of Sri Lanka which is currently over 21 million increases rapidly each year. As a result the demand for land has increased and it has caused a threat to the habitat of wild animals. The conflict between human and wild elephants has been a burning issue for decades but there has been no proper solution for this conflict. When carrying out the research the team found some limitations of the system. Accuracy of the functions of the application will depend on the accuracy of GPS location information. A system such as Elephant Routes needs real time tracking. Since the team cannot implement own tracking system, the System functionalities depend on what it retrieves from GPS transceiver. In future, if there are more accurate animal tracking systems such as image processing, it can easily be integrated to the system and avoid difficulties when placing GPS transmitters. Elephant Routes System is being developed not only to predict elephants’ next movement, but also to predict certain other animals’ behaviours as well. As the
System uses prediction algorithm it can benefit the tourism industry as well. When rare animals are considered, the System can predict their location and tourists will be able to see them alive in their natural habitats.

REFERENCES


