An Evaluation of Fractal/Velocity Pattern Extraction

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Abstract

Visual analysis of maritime tracking data has been shown to be a useful complement to automated approaches. However, detecting interesting or anomalous movement patterns can be a challenging task due to the size of spatio-temporal datasets. Datasets can include a large amount of uninteresting data, which hinders the task of pattern extraction. This paper presents a method by which uninteresting patterns can be filtered out, based on their velocity and fractal properties, simplifying the pattern extraction problem considerably. This technique is then compared to an automated statistical pattern extraction technique, called Behavioural Change Point Analysis, by a number of experts in the course of a field trial.

1 Introduction

Visual analysis of maritime tracking data has been shown to be a useful complement to automated approaches [6]. Detecting specific patterns within a data set can be challenging due to the large volume of data to either process or visualize [5]. Vehicle tracking data sets, such as those generated by Vessel Monitoring Systems (VMS) or Automated Identification Systems (AIS), often consist of hundreds of thousands of data points, with most of them not being part of any interesting patterns or behaviours. In these cases, the vast majority of the data is not interesting, so it can be very difficult for users to detect relevant patterns. By taking into account the velocity ranges of particular activities, as well as the fractal nature of the movements, these patterns can be detected and filtered out, if required.

Many approaches have been proposed for pattern extraction, from a multitude of fields, such as signal processing [2], finance [1] and biology [4]. For this study, we chose to compare an approach recently proposed[3] to one from the field of biology, Behavioural Change Point Analysis (BCPA) [4]. This technique is designed for use in animal tracking, statistically analyzing sets of velocities (or velocity components) in order to locate the points in the data where the observed behaviour changes. This is done by treating each candidate change point as the point on which to split the data set in half. These two halves are then tested for statistical difference, with the highest-likelihood point becoming the Most Likely Change Point (MLCP). The entire process is repeated using a moving window, yielding a set of potential change points within the full data set.

The data used in this project come from VMS units installed on-board fishing vessels operating off the East coast of Canada. The use of VMS is a condition for license by Fisheries and Oceans Canada (DFO), the Canadian government's fisheries regulation department. This is done to aid DFO in monitoring when and where captains fish, providing an indication of the distribution of fishing effort. The VMS units record the latitude and longitude of each vessel at a predetermined time-interval, usually one hour, and then transmit these data via a satellite link.

2 Fractal/Velocity Signatures

By taking into account both the velocity and the complexity of movements, it is possible to categorize movements into particular pattern classes. Doing so in an exploratory and interactive fashion is what we term fractal/velocity signature building. It is essentially an iterative process by which users develop a set of filter settings, leaving only the patterns they are interested in. These signatures can then be saved and applied to multiple similar data sets to allow for rapid extraction of the target patterns, and hence allow more efficient data analysis processes.

Signatures are made up of velocity and fractal dimension ranges. Velocity is estimated using linear distance between data points, divided by the time between data points. The fractal dimension, a parameter which estimates the complexity of a path, is estimated using a moving window. By varying the width of the moving window, the temporal range of the behaviour under investigation can be adjusted.

3 Evaluation

In order to validate the fractal/velocity signature approach, we compare our proposed technique with BCPA. While the main goal of both techniques is to aid in the detection of specific patterns, BCPA is an automated approach, whereas our work is interactive. Both approaches were shown to fisheries enforcement officers working for DFO. The primary task in their work is to detect irregular or illegal fishing activities, often using VMS datasets to identify such patterns. As such, they were very familiar with the pattern extraction activities both system support, and could therefore gauge the usefulness of one technique versus the other.

The evaluation proceeded by presenting the experts with the interactive interface first, on an individual basis, wherein they were able to develop signatures to match the various patterns they would be interested in within a pre-determined data set. They were then shown the output from the BCPA method, which they could visually explore. Finally, they were asked to rate each method in terms of usability and usefulness, as well as giving specific comments as to strength and weaknesses of each method. An overview of the approach, along with the results of this field trial will be discussed in this presentation.

References

[1] M. Dong and Z. Xu-Shen. Analyzing dividend events with neural network rule extraction. In *Proceedings of the International Joint Conference on Neural Networks*, pages 2854–2859, Portland, OR, USA, 2003. IEEE.

[2] B. Eisenstein and J. Fehlauer. Signal processing for feature extraction and pattern recognition. In *Proceedings of the International Conference on Acoustics, Speech, and Signal Processing*, pages 749–752, Philadelphia, PA, USA, 1976. IEEE.

[3] R. Enguehard, R. Devillers, and O. Hoeber. Geovisualization of fishing vessel movement patterns using hybrid fractal/velocity signatures. In *Proceedings of GeoViz Hamburg*, 2011.

[4] E. Gurarie, R. D. Andrews, and K. L. Laidre. A novel method for identifying behavioural changes in animal movement data. *Ecology Letters*, 12:395–408, 2009.

[5] P. Lundblad, M. Jern, and C. Forsell. Voyage analysis applied to geovisual analytics. In *Proceedings of the 12th International Conference on Information Visualization*, pages 381–388, London, UK, 2008. IEEE.

[6] M. Riveiro and G. Falkman. Evaluating the usability of visualizations of normal behavioral models for analytical reasoning. In *Proceedings of the 7th International Conference on Computer Graphics, Imaging and Visualization*, pages 179–185, Sydney, Australia, 2010. IEEE Computer Society.

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