Chapter 14
Early Warning from Car Warranty Data using a Fuzzy Logic Technique

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ABSTRACT

Car manufacturers are interested to detect evolving problems in a car fleet as early as possible so they can take preventive actions and deal with the problems before they become widespread. The vast amount of warranty claims recorded by the car dealers makes the manual process of analyzing this data hardly feasible. This chapter describes a fuzzy-based methodology for automated detection of evolving maintenance problems in massive streams of car warranty data. The empirical distributions of time-to-failure and mileage-to-failure are monitored over time using the advanced, fuzzy approach to comparison of frequency distributions. The authors’ fuzzy-based early warning tool builds upon an automated interpretation of the differences between consecutive histogram plots using a cognitive model of human perception rather than “crisp” statistical models. They demonstrate the effectiveness and the efficiency of the proposed tool on warranty data that is very similar to the actual data gathered from a database within General Motors.

INTRODUCTION

Car manufacturers are responsible for the vehicle maintenance during the entire warranty period. Consequently, the warranty data is being continuously reported by the manufacturer dealers to a central
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database. The warranty database is expected to include the following information for each customer complaint: dealer location, car model, car manufacturing and selling dates, claim date, mileage to date, complaint code, labor code, etc. The taxonomy of labor codes is usually available in a hierarchical form corresponding to car systems and sub-systems.

The central warranty database can be used to continuously monitor the empirical distributions of time and mileage to failure for various problem types in each new car model. In this chapter, the empirical distributions in consecutive time windows are compared to each other using the advanced, fuzzy approach to comparison of frequency distributions (Last & Kandel, 2002a, 2002b) developed within the framework of automated perceptions (Last and Kandel, 1999). This novel monitoring method provides an automated interpretation of the differences between histogram plots using a cognitive model of human perception rather than rigid statistical models. It is able to discover a positive or a negative shift in the histogram of the target distribution, based upon the apparent shift in the central tendency, the sample size, and the available domain knowledge. The proposed fuzzy-based method is implemented by the Early Warning Tool, which issues a warning about a negative shift whenever the values of the new histogram are shifted to the left more than a pre-defined Alarm Threshold and a positive shift whenever the values of the new histogram are shifted to the right more than the same threshold. A car manufacturer would be particularly interested in timely discovery of negative shifts, which indicate an increase in the probability of a certain problem type after a lower mileage or a shorter amount of time elapsed since the car left the factory or since the previous visit to the dealer. Identifying the most common labor codes (“root causes”) associated with negative and positive shifts is another important objective. Fuzzy shifts across multiple consecutive periods can be aggregated to compute a long-term trend of the warranty data. The proposed Early Warning Tool has also to be highly scalable in the size of the warranty database that is updated with thousands of new warranty claims on a daily basis.

This chapter is organized as follows. The next section provides the necessary background on emerging issues analysis in a car fleet. Then we proceed with describing the steps needed for selecting and preparing the warranty data for the early warning purposes. Fuzzy shift and fuzzy trend calculation along with the root cause analysis are presented next. The proposed fuzzy-based methodology is then demonstrated on warranty data that is very similar to the actual data gathered from a database within a major car manufacturer (General Motors). Finally we outline the future research directions and provide some concluding remarks.

BACKGROUND

Tracking of warranty trend of a particular product based on the claim distribution over time is an important problem of any company and industry. Most companies maintain warranty databases for purposes of financial reporting and warranty expense forecasting. Such warranty field data is largely extensive and messy, and hence special tools and algorithms are needed to extract useful information. In some cases, there are attempts to extract engineering information from such databases. Another important application is to use warranty data to detect potentially serious field reliability problems known as emerging issues, as early as possible. With detection of sudden emerging issues it is also important to track the other trends such as “bygone problem” (the failure rate has decreased back to normal), “emerging issue under control” and “emerging issue came gradually over a passage of time”. This is because after some action was taken by the manufacturing process or a precautionary measure taken by dealers through service enhancement it is important to study the behavior of the trends i.e. after process rectification