FINITE-STATE MARKOV MODEL BASED KNOWLEDGE DISCOVERY

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ABSTRACT
In this paper we describe a method based on finite-state Markov machine for knowledge discovery i.e., predicting the trend of a time-series data. In this paper, it has been applied for the prediction of frequency of occurrence, downtime, and mean-time to repair (MTTR) of faults in manufacturing cells. A fully connected first-order finite-state Markov model has been trained for each event type using real time-series data. It has been tested by predicting common fault data parameters as frequency of occurrence, downtime and MTTR for a given starting day and time period (e.g., a week). Our results indicate that the predicted most likely path of the fault parameters matches the real data fairly accurately. For example, for 27 different manufacturing operations in a 12 months data set with a total number of fault occurrences of 24988 and with a total downtime of 7744 hours this algorithm is able to predict 18496 (75%) fault occurrences, 2316 (83%) hours of downtime and 3221 (91%) hours of MTTR with 90-100% prediction accuracy.

INTRODUCTION

The problem of accurately discovering knowledge for predicting the trend of time-series processes or events based on the knowledge of past data samples is very valuable in many applications such as the prediction of faults in manufacturing cells, health monitoring of machines and vehicles, predicting stock market trends, etc. In particular, such a prediction will prove highly valuable to the manufacturing industry because it can save millions of dollars by predicting which faults may occur, how long it takes to fix them, and by fixing the faults before they cause the shutting down of a manufacturing cell, line or plant.

Current techniques [1-6] either a priori choose a model such as Auto Regressive (AR), Auto Regressive Moving Average (ARMA) and then fit the time-series data to this model or use Neural Networks, and/or rule based approaches with the assumption that the time-series data exhibit repeatability or autocorrelation. These techniques then use the trained model to predict the future trend of the time-series data. Such techniques provide accurate trend prediction if the chosen model fit the data well, the data is not too noisy, and the data exhibits repeatability. However, in practice the data is subject to high levels of noise and often do not exhibit clear patterns.

The technique described in this paper, can handle these two situations since we learn the overall trend of events in terms of probabilities from the past data and train a finite state Markov (FSM) model using the computed probabilities.