Identification of Unexpected Behavior of an Automatic Teller Machine Using Principal Component Analysis Models

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Abstract. Early detection of the unexpected behavior of the automatic teller machine (ATM) is crucial for efficient functioning of ATM networks. Because of the high service costs it is very expensive to employ human operators to supervise all ATMs in an ATM network. This paper proposes an automatic identification procedure based on PCA models to supervise continually the ATM networks. This automatic procedure allows detecting the unexpected behavior of the specific automatic teller machine in an ATM network. The proposed procedure has been tested using simulations studies and real experimental data. The simulation results and the first real tests show the efficiency of the proposed procedure. Currently the proposed identification procedure is being implemented in professional software for supervision and control of ATM networks.

Keywords: Automatic teller machine, principal component analysis, ATM network supervision, unexpected behavior.

1 Introduction

Automatic teller machines (ATMs) are computerized telecommunication devices which provide a financial institution's customers a method of financial transactions in a public space without the need for a human clerk. According the estimates developed by ATMIA (ATM Industry Association) the number of ATMs worldwide in 2007 was over 1.6 million. As the ATM networks expand it is very important the proper monitoring, supervision and cash management of the ATM networks [1, 2].

The crucial elements in development of efficient ATM network supervision and management system are creation of the cash demand forecasting models for every ATM and identification of unexpected behaviour of the ATMs in ATM network. The forecasting models have to be created based on historical cash demand data. The historical cash demand for every ATM varies with time and is often overlaid with non stationary behaviour of users and with additional factors, such as paydays, holidays, and seasonal demand of cash in a specific area. Cash drawings are subject to trends and generally follow weekly, monthly and annual cycles. The development of
efficient cash demand forecasting models for ATMs we have introduced in earlier papers [3, 4]. Although these models generally can be used for detection of the outliers in ATMs’ cash demand behaviour, they can’t state the reason of these outliers. E.g., the wetter conditions can influence the cash demand of a specific ATM significantly, but this behaviour isn’t anyhow connected with malfunctions of ATM or clients’ illegal actions.

In this paper we propose a new computational procedure for identification of unexpected behaviour of an ATM in ATM network. The procedure is based on application of principal component analysis methods. The unexpected behaviour of an ATM can emerge from different reasons, e.g., it can be bundled with some rising obstacles in the ATM environment, with the operational problems of the ATM, or with clients’ illegal actions. It is important to note, that for the identification of the unexpected behaviour of a specific ATM it is necessary to compare the ATM’s behaviour with the behaviour of similar ATMs in the neighbourhood. If for some reasons (whether conditions, events in the region, etc.) disturbances are common for all ATMs in neighbourhood, then the changed behaviour of the specific ATM hasn’t to be interpreted as unexpected. For the banking institutions it is crucial to identify the unexpected behaviour of an ATM as quick as possible and then act adequately to solve these problems timely. Because of the size of the ATM networks (some service institutions maintain ATM networks with over 1000 ATMs in network) human operators can’t supervise efficiently the functioning of all ATMs. Therefore automatic procedures for detection of the unexpected behaviour of the ATMs have to be employed. This paper proposes a new solution for this task.

The paper is structured as follows. After short introduction of the problem in this section, the proposed identification procedure is introduced in section 2. In section 3, simulation studies using the proposed identification procedure are depicted and in section 4 practical tests are presented. Finally, the main results of this work are discussed in section 5.

2 Identification Procedure

To identify whether an ATM in ATM network shows an unexpected behaviour it is important to evaluate carefully the transactions prosecuted on the specific ATM together with the transactions prosecuted on the other ATMs with similar transactions’ patterns. Based on this information the conclusions about the disturbances in behaviour of partial ATMs can be made. The proposed identification procedure consists of following steps:

a) Historical data of transactions (cash withdrawal) in ATM network have to be analyzed and clusters of the ATMs which similar behaviour must be formed. Each cluster includes specific number of ATMs. This number \( j \) can be defined by the user and in this applications was \( j = 45 \); b) For every ATM cluster a group of principal component analysis (PCA) models must be build. By development of the PCA models the historical data of ATM transactions are used. Inputs for PCA models are transactions data collected from ATMs cluster. Number of inputs for every model is \( j-l \) and the