SIDAC
AN INTEGRATED SYSTEM TO DETECT ANOMALIES IN CONSUMPTION PATTERNS OF UTILITY CUSTOMERS

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SUMMARY

SIDAC (Integrated System to Detect Anomalies in Consumption Patterns) is a personal computer tool for detecting patterns of meter malfunction and potential Theft of Service (TOS) in customer billing record information. So, it can be considered as an auditing system for utility billing records.
This paper presents the detection approach used in SIDAC based on Artificial Neural Network, one of the technologies which offers best results for pattern recognition.

INTRODUCTION

Loss of revenue due to meter malfunction and theft of service (fraud) can be significant for electric utilities.
In general, every company that supplies a product to a big number of clients and use meters to quantify the amount of product supplied, should have to face this problem. In the Spanish electric sector these losses could be around 0,3-3%.

Traditional detection processes are mainly based on vigilant meter readers and statistical detection algorithms. Hence, although the problem of fraud and meter malfunction is significant, the tools available for identification of these clients are limited.

When the detection methodology applied is not very effective, it could generate high false alarms rates and increase the inspection cost: verifications of meter malfunction requires an inspection by a utility employee. Reducing the number of suspect clients to be inspection will produce important savings in both cost inspection and loss of revenue.

SYSTEM DESCRIPTION

SIDAC is a decision support system to detect customers with anomalous consumption behaviors. It is based on the technology of Artificial Neural Network (ANN). Pattern recognition is certainly one of the most relevant areas of applications of ANN.
Neural networks are mathematical models inspired by the functioning of biological neurons (Figure 1). They consists of a number of highly interconnected but simple processing elements (neurons). Each one communicates its results to its neighbours. The path between neurons consist of weighted links over which signals can pass (the connections weights are adjusted during training)

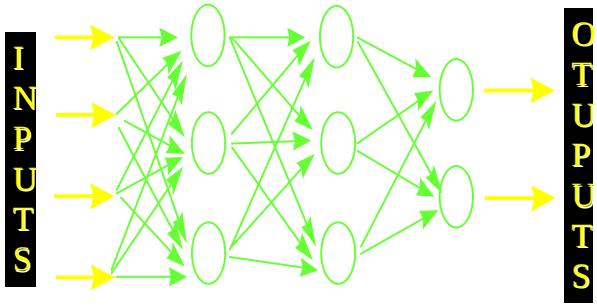

Figure 1. Basic ANN Architecture

An ANN have to be trained for its correct operation. Training of an ANN consists of repeatedly exposing the network to sets of examples for which the model entries are associated to the right corresponding answer. The connections weights between neurons are systematically modified until the output error is within limits.

The classifications module implemented in SIDAC consists of: a) an "ANN Forecasting Model" which forecasts customer consumption patterns in "normal" situations (not fraud and not meter malfunction); b) a "Decision Model" which compares the real customer consumption behavior data with the forecasting pattern, and classifies the customer as "normal" o "anomalous" depending on the differences found (Figure 2).

In this case, the ANN model has to be trained with examples of "normal customers", customers confirmed as not having a problem.

Every customer information in the billing system that aids in explaining his consumption behavior (explanatory variables) must be used as input to the ANN model. They will be parameters that group customer behaviors in homogeneous typologies by size, business type, etc. An example of these parameters can be: geographic location, economic activity, rate type, contract capacity (kW), energy and capacity billing option, business area (m^2), etc.

As customer consumption data we use both energy and demand information: yearly and monthly energy (kW), hourly period energy (peak, off peak, partial), power factor, monthly highest registered capacity (kV), etc.

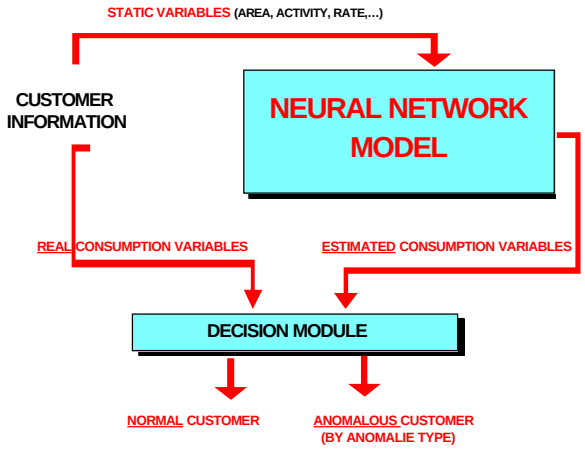

Figure 2: SIDAC Customer Classification Model

The figure 3 shows for one customer his contract data and his real and forecast consumption data. The differences between these values (error column) are the data used by the decision model to classify the customer.

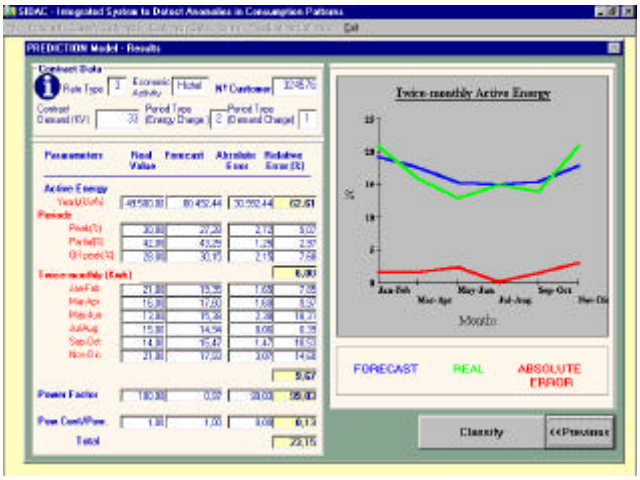

Figure 3: SIDAC. Display with the results of the AAN forecasting model applied to one customer.

When a customer is classified as anomalous by the system it means that his consumption behavior not follow the patterns of his customer typology. The reason for this could be: meter malfunction, fraud, error in the billing data base, or it could be a normal situation. SIDAC Data Base has additional customer information about meters (meter type, installation date), inspection dates, number of meter readings in the year, reading type (real, estimated) and any useful parameter that is accessible in the billing system. This additional information allows the user to look for explanations based on the available data before ordering a site inspection.

Framework

SIDAC is a modular system with the following most important functionalities:

- Preprocessing and Data Management. SIDAC reads, processes and down loads customers information from the utility data bases.
- Customer Classification. A pattern recognition based module is implemented in SIDAC to recognize and classify customers with patterns of TOS and meter malfunction. Previously, the classification module must be adjusted during a learning process.
- Automatic classification model adjustment. SIDAC offers the possibility to adjust the pattern recognition model automatically without algorithm reformulating, but only via an auto-learning mechanism activated by the user when he considers it appropriate.
- Error Analysis. SIDAC can estimate a classification error parameter and give to the user a set point to decide when the model adjustment to the new consumption patterns could be appropriate.
- Inquiry module. SIDAC provides additional analytic tools such as customer selection analysis and access to the SIDAC data base for further analysis and reporting.

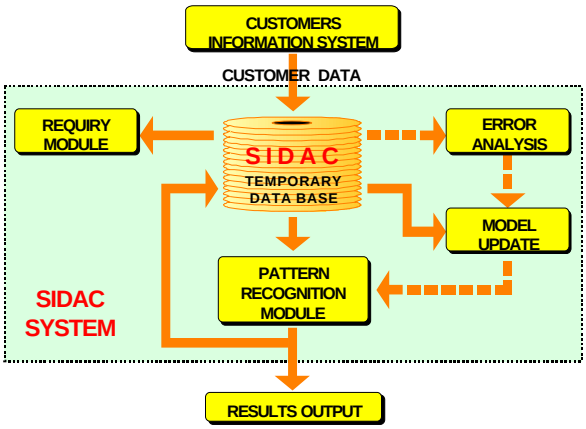

Figure 4: SIDAC functionalities

Benefits

- Reducing Loss of Revenue and inspections costs due to billing meter malfunction and TOS.
- Automatic model update by the user without specific knowledge about the technology that is used by the system.
- Very small processing time.

MODEL UPDATE

The ANN offers the possibility to update the initially designed model very easily without users specific knowledge on the technology.
The application is equipped with an option which permits self-update the model to the new customer consumption behaviors.

SYSTEM CHARACTERISTICS

SIDAC has been implemented in a PC 486 under Windows environment and uses the following tools :

- Visual Basic for the user's interface
- C for the model implementation

The specific neural network libraries for hourly electric demand forecasting and for model updating are property of IBERDROLA Ingeniería y Consultoría.

CONCLUSIONS

This paper has presented SIDAC, a Integrated System to Detect Anomalies in Consumption Patterns based on Artificial Neural Networks.
These are the most remarkable aspects of SIDAC :

- PC platform system
- Customer consumption patterns forecasting depending on customer contract information.
- Detection of anomalous customers with consumption behavior different from normal behavior patterns.
- SIDAC uses Artificial Neural Network (ANN) technology, one of which today offers the best results for error minimization in pattern recognition.
- Non-dependent on the user's specific knowledge of the technology.
- Model self-update as new data are introduced in the system.
- Error analysis to determine the need of the model update.
- SIDAC have been developed to be applied in the electric and the gas sectors. However, it can be easily adapted to the industrial sectors that share the following characteristics: supply company with a high number of customers, possibility of product billing meter manipulation and high possibility of billing losses due to TOS and meters malfunction.

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