SMART LIFT – Intelligent lift service system

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Abstract.— **The paper presents the results of the development of an intelligent lift service software system that allows the detection of people and their numbers on each floor, the recognition of persons by assigning a conventional identity, the prediction of the destination floor for each user using facial detection applications and data forecasting based on the history of lift usage statistics.**

Keywords: software, intelligent systems, facial detection, data forecasting.

I. INTRODUCTION

Today's SMART systems and equipment enable the facilitation and automation of services in various industrial and public domains. The automation of public services contributes to more efficient equipment operation and optimized service costs. The development of a smart lift service system can help optimize service expenditure by minimizing electricity consumption. This aspect would facilitate the experience of lift users in offices or residential blocks.

To this end, the possibility of using existing facial detection and data forecasting applications to develop an intelligent lift service system was explored, which would allow the detection of persons on each floor of the elevator, their identification by assigning a conventional identity, the determination of the number of persons on each floor, and the forecasting of the destination floor for each user using data forecasting applications based on the history of lift usage statistics. The software system allows rapid processing of images received from the video cameras installed on each floor of the lift, the identification and registration in the database of the users of the system, determination of the number of users for each floor and the forecast of the destination floor for each user.

For system implementation purposes, it was developed a user interface to control, guide and monitor the intelligent software system. The system ensures the connection of the whole equipment to the Internet network for assuring e-mail and SMS alert messaging.

The 3 floor study block 1 of the Technical University of Moldova and the staff working at the Faculty of Electronics and Telecommunications, TUM were identified as a case study, in order to achieve these objectives.

II. DESIGN OF FACIAL DETECTION AND RECOGNITION ALGORITHM

Facial detection and recognition involves the usage of the most obvious facial features. Attempts have been made to measure the importance of certain intuitive features [1] (mouth, eyes, cheeks) and geometric measures (distance between eyes [2], width-to-length ratio). There are still some relevant human features that are taken into account such as skin color, location of human mouth and eyes, etc.

Facial recognition includes several subproblems. The input of a facial recognition system is always an image or a video stream. The result is an identification or verification of the subjects appearing in the image or video.

Facial detection is defined as the process of extracting faces from images. This procedure involves face tracking, position estimation, etc. Feature extraction involves obtaining relevant facial features from data such as certain facial regions, variations, angles or dimensions, which may or may not be relevant to the human (e.g. distance between eyes).

Facial detection faces several challenges such as:

• Position variation. The performance of face detection algorithms essentially decreases when there are large variations in face position. Position variation can happen due to subject movements or camera angle.

• Feature occlusion. The presence of features such as beards, glasses or hats introduces a complex component as faces may be partially covered by objects or other faces.

• Facial expression. Facial features vary due to different facial gestures.

• Image conditions. Camera and environmental conditions affect image quality, i.e. the appearance of the face.

Some face detection systems detect and locate faces at the same time, others perform a detection first and then, try to locate the face. Then, several tracking algorithms may be needed (Fig. 1).
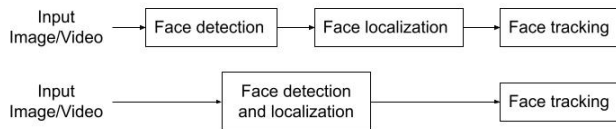

Figure 1. Facial detection process

Facial detection methods can be divided into four categories:
• Knowledge-based methods. Rule-based methods that encode knowledge about human faces.
• Methods based on invariant features. Algorithms that attempt to determine invariant features of the face, independent of its angle or position.
• Template matching methods. These algorithms compare input images with stored face templates or features.
• Appearance-based methods. A template matching method whose database of patterns is learned from a set of training images.

III. EQUIPMENT NEEDED TO IMPLEMENT THE SMARTLIFT SOFTWARE SYSTEM

To develop the software system, it is necessary to install a wireless IP camera, with a coverage angle of 110⁰ - 120⁰ , on each floor of the lift for capturing. To ensure connection and transmission of digital data over the Internet network, it is necessary to use a 5G Wi-Fi router and a medium-speed Internet connection with unlimited traffic. The processing and storage of information data is provided by a web server (VPS) with medium processing characteristics. The use of a VPS can ensure the operation of the system for one or more office or residential blocks. The small number of devices reduces the cost of the whole SmartLift system, which makes it easier to implement the smart system in practice.

IV. IMPLEMENTATION AND TESTING OF THE BETAFACE FACIAL DETECTION APPLICATION

To achieve facial detection and recognition, there had been identified several face detection and recognition applications (Face++, Luxand, and Betaface), each one with its selected algorithms (not known by us). After testing all these APIs, the BetaFace application (https://www.betafaceapi.com/) was identified and its possibilities were analyzed. It showed that this API provides best facial recognition. BetaFace API offers

many facial recognition possibilities and features, such as face detection, face creation and search in own person databases, determination of age, gender, expression and ethnicity of faces, etc. For populating the person database of the system a user interface was developed (Fig. 2). Communication with the BetaFace application is provided by REST access methods and the transfer data is delivered as XML or JSON.

Figure 2. User data management interface for the BetaFace application

After processing the images with the BetaFace application, data about the user and the processed image, the person's name, the mobile phone number, the floor of the office where they work, the conventional identifier of the image and that of the detected face are recorded in the database.

Figure 3. Facial detection test interface using the BetaFace application

Several cases have been identified for testing, including the identification of a single or multiple individuals (persons). From the test results it was determined that BetaFace provides satisfactory results for the implementation of the system. The API proved to be quite reliable, detecting and identifying one, two and more persons from the captured image (Fig. 3). Additionally, a decrease in the time required for image processing was observed for the same test conditions.

Based on the test results it was decided to use this application for the next steps of the implementation of the SmartLift intelligent lift servicing system.

V. CREATION OF THE DATABASE FOR SYSTEM CONTROL AND MONITORING

The operation of the software system, monitoring, user database registration, facial detection and floor forecasting for each person is provided by the database developed using the MariaDB/MySQL service installed on a medium capacity VPS. The MySQL database consists of tables populated with the data of persons using the lift, statistical data of lift activity for each person and tasks required to be performed at a given time. Accessing the database, insertion and updating the data in the tables is done through the PDO/MySQL (PHP Data Objects) interface, which provides a higher degree of security when accessing the database.

The statistical data table of the lift activity contains information about the day, date and time when a specific person accessed the lift from any floor and left to another floor. Since no real statistical data were available for testing and simulation of the system, simulated statistical data from a graph of the ordinary work of persons according to time and period of the day were used.

VI. PRINCIPLES OF PREDICTIVE ANALYSIS AND DEVELOPMENT OF FLOOR FORECASTING ALGORITHM

Data Mining is an important aspect of predictive analytics and data forecasting, used to extract useful information from current data (usually large data sets) to predict trends. This aspect is the identification of relevant data to be analyzed and used in predictive models.

Machine learning (ML) and predictive analytics are both focused on efficient data processing. Machine learning can be taken as an extension of predictive analytics, which is responsible for self-learning and identification of data patterns, which are regularities, associations or relationships existing in the data).

There are several models of machine learning in time series data analysis. The most widely used are ARIMA, ARCH/GARCH, Vector AutoRegressive (VAR) model, Recurrent Neural Networks (RNN) for reading sequence dependencies, which create predictions based on previous data.

In order to realize the forecasting model, it is necessary to consider the time of access to the lift by the user, and the processed dataset must be consisted of days corresponding to the current day and/or even the current time. For this purpose an open-source API was used "Algorithmia". Figure 4 shows the test results of the "Algorithmia" API. The processed dataset for the forecast (payload) was made up of statistical data selected independently of the time and day of the week they were recorded. Figure 4, A shows the number of statistical cases for changing Value 3 to Values 1, 2 or 3, and in Figure 4, B are shown the forecast result of the change of Value 3 to possible Values 1 or 2 (probability 0.2 and 0.8,

respectively) for a given randomly selected day and time. The result obtained after testing the API "Algorithmia" is not quite satisfactory, as it does not reflect the desired statistical results.
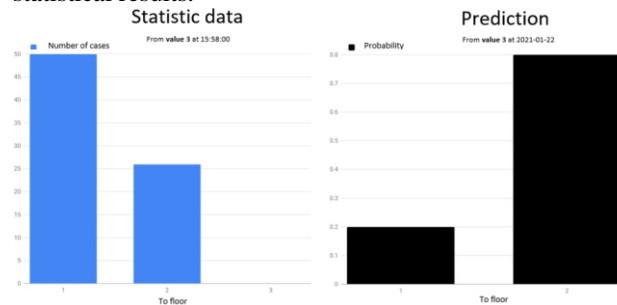

Figure 4. Number of statistical cases processed (A) and forecast result (B) for the "Algorithmia" API.

For our case of services or processes where statistical data are acquired at different points in time, time series forecasting models do not provide satisfactory results, because the statistical data used in this case are distributed with an equal step, and the most suitable are non-temporal forecasting models with linear regression, such as "Naive Forecast" or "Seasonal Naive Forecast". For the "Naive Forecast" model the forecast value is the value of the most recent observation. This method is often used to evaluate the performance of more sophisticated forecasts. The "Seasonal Naive Forecast" model is similar to the "Naive Forecast" model, but the forecast value represents the last observed value of the same season of the time period.

For improving the results an API in 2 versions (NA Predict v3 and NA Predict v3.1) has been developed and implemented, with some modifications and adjustments to increase the veracity of the forecast. The results obtained demonstrated the need to use a "Seasonal Naive Forecast" model in the API. The statistical data processed in this API (NA Predict v3.1) correspond to the randomly selected hour and day of the week and adjacent hours within a ±2 hour interval (Fig. 5).
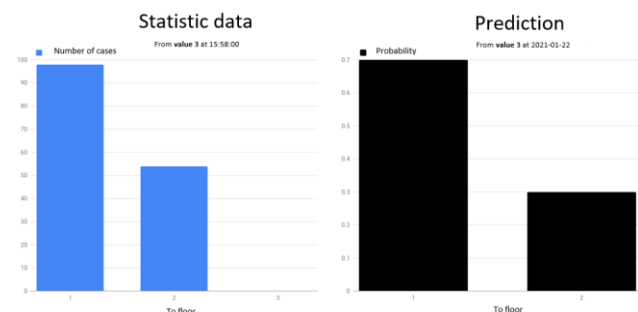

Figure 5. Number of statistical cases processed and forecast result for NA Predict API v.3.1

The obtained results match satisfactorily the processed statistical data with a probability of 0.7 and 0.3 for floors 1 and 2, respectively. For this API, a much more varied and extensive processed dataset (payload) was obtained, but also a much more essential difference between probabilities. The results of testing the NA Predict v3.1 application showed promise for use in automating the operation of the SmartLift system [3].

VII. SMARTLIFT SOFTWARE SYSTEM USER INTERFACE

For the convenience of testing the system and service functionalities, a simplistic user interface was developed using PHP/MySQL and HTML/CSS languages, with graphical representation of the office block floors (Fig. 6).
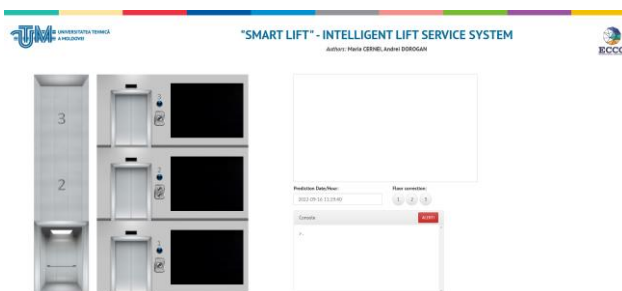

Figure 6. SmartLift user interface (https://smartlift.one/)

The interface shows the system console for monitoring lift tasks. Taking into account that the forecasting of destination floors is a probabilistic process, it is necessary to take into account the cases when the destination floor of the lift user is different from the forecast one. For these purposes, the floor correction option has been reserved in the interface.

VIII. INTEGRATION OF SMS ALERT SYSTEM FOR LIFT LOCKOUTS

The automation of the SmartLift operating process can additionally be supplemented with an alert module for lift service companies. Alert signals can be transmitted using the possibilities of the Internet and GSM network in tandem. Alert signals can be transmitted in cases of lift lockout or shutdown due to loss of mains connection.

For these purposes an alert system has been implemented that autonomously transmits short SMS messages over the GSM network using an already available application SmsGateway24, which can be installed on an Android or iOS mobile phone. The transmission of messages can be controlled automatically via a REST API.

Based on the capabilities of the developed software system, the identities of the persons in the blocked lift car can be recognized and transmitted at will, including the age of the persons (in case a child or adult is blocked).

IX. CONCLUSIONS

The implementation of the intelligent lift service software in offices and residential blocks can make a vital contribution to improving the quality of service provided to consumers by ensuring lower power consumption and subsequently lower servicing costs. At the same time, the implementation of the autonomous alert system increases the serviceability of the lifts by the responsible companies.

Automated operation of lifts is an important aspect in the case of servicing people with physiological and motor disabilities by minimizing the actions required when using the lift.

The statistical data accumulated in the system allows an analyzing the operating efficiency of the lifts and how the lift performs the tasks of raising and lowering the cabin according to the number of people inside.

The use of the implemented API "NA Predict v3.1" can provide forecasting, automation and optimization of the processes and activities of lift in offices and residential blocks by excluding the human component from the process.

The use of IP cameras within the system can serve as an additional utility in ensuring the security of office and apartment blocks. Considering all these aspects and the new possibilities offered, the SmartLift software system can be used as an additional option within existing SmartHouse systems.

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