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TEMPERATURE CAPTURE AND IMAGE PROCESSING SYSTEM: A CASE STUDY

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Abstract. This paper describes a technical solution to stop the spread of COVID-19 by creating a system consisting of a video camera with a thermal sensor connected to a web-based platform, which would help to manage to restrict access of people who have fever into a building. The main purpose of the project system is to measure body temperature, to detect and to recognize the person that has at the moment or had fever in the past 14 days, the registration in the database of both the fever and the person, and validate the access of the person in the building if it has a temperature below 37 degrees Celsius. The technical details as analysis and determination of the domain of interest, development of the new system design, functional and non-functional requirements, interface, project planning, technical specification and quality of the proposed solution are discussed. The proposed system aims to reduce the number of employees responsible for collecting the temperature, thus no longer exposing them to the risk of infection.

Keywords: *covid-19, thermal camera, body temperature, OpenCV library, activity diagram, user interface.*

Rezumat. Prezenta lucrare descrie o soluție tehnică de stopare a răspândirii COVID-19 prin crearea unui sistem ce constă dintr-o cameră video cu un senzor termic conectat la o platformă web, care ar ajuta la gestionarea și restricționarea accesului persoanelor cu febră într-o clădire. Scopul principal al sistemului propus este măsurarea temperaturii corpului, recunoașterea persoanei care a avut febră în ultimele 14 zile, înregistrarea în baza de date atât a febrei, cât și a persoanei și validarea accesului persoanei în clădire dacă are o temperatură sub 37 de grade Celsius. În lucrare se discută detaliile tehnice precum analiza și determinarea domeniului de interes, dezvoltarea noului proiect de sistem, cerințe funcționale și nefuncționale, cerințe față de interfață, planificarea proiectului, specificația tehnică și calitatea soluției propuse. Sistemul propus urmărește reducerea numărului de angajați responsabili cu colectarea temperaturii, astfel nu îi mai expune riscului de infecție.

Cuvinte cheie: *covid-19, camera termica, temperatura corpului, biblioteca OpenCV, diagrama de activitate, interfața utilizator.*

Introduction

On December 31, 2019, people with unknown form of pneumonia have been diagnosed in Wuhan, China. The World Health Organization announced a virus outbreak which led to a global pandemic [1]. The infection caused by the SARS-CoV-2 virus, called COVID-19 [2] is still contagious with a high spread rate from person to person, with a predominance of asymptomatic forms [3]. Fever has proved to be the main symptom of this infectious disease, causing outbreaks such as severe acute respiratory syndrome SARS, coronavirus (COVID-19) previously tracked in influenza A H1N1 and Ebola virus disease (EVD). Fever screening is a medical countermeasure used at international borders, public transport hubs and hospitals to lessen the spread of these diseases [4].

Globally, there has been launched a huge number of projects aiming to identify and provide solutions, tools and methods to stop the spreading of the pandemic [5, 6, 7].

A large variety of digital solutions were proposed worldwide, from communication within the community to supervision of population for new cases identification [8]. A diversity of mobile contact tracing apps in the EU Member States have been created. Most of these applications (Coronalert in Belgium, CovTracer-EN in Cyprus, Smittestop in Denmark, etc.) are based on Bluetooth technology, available on GooglePlay and Appstore, based on anonymity, provide information to users of the applications about those tested positive and their location for period of 14 days [9]. However, users are asked to inform their relatives and family about a possible infection.

The EU 30+ satellites system is involved in monitoring the impact of the outbreak during the COVID-19 pandemic, within the EU Space Programme [10].

Supercomputer platforms from 4 countries (Spain, Italy and Germany), along with pharmaceutical companies and top research centers within an EU-funded project named EXSCALATE4CoV are searching the best treatments for the disease [11].

In this context, the Technical University of Moldova applying for several projects, was selected as the first beneficiary for *"Scanner thermique intelligent – IntelST"* project launched by AUF (Agence Universitaire de la Francophonie) in May 2020 as part of its special COVID-19 action plan [12].

The particular objective of this project was to provide a technical solution to stop the COVID-19 pandemic by creating a system that would help both the medical system and the entire population of the Republic of Moldova. The main purpose of the project system is to measure body temperature, to recognize the person that have had a fever in the past 14 days, the registration in the database of both the fever and the person, and validate the access of the person in the building if it has a temperature below 37 degrees Celsius. All of this will help implement public health measures to prevent the rapid spread of infection and increase the readiness of the health system and replace the person measuring the fever at the entrance to the building. As a result of the system, students will be able to slowly return to offline classes. The system requires security measures other than those recommended for the operating system.

The team of students of Technical University of Moldova and mentors of the project's partners came with a solution that could allow students to return to classes. One of the solutions to achieve this goal is a temperature capture and image processing system, allowing students to return to courses openly and quietly [13].

Thus, the system provides for prevention, preparedness and intervention measures for public health emergencies, risk assessment, declaration / cancellation of public health

emergency, special powers of attorney for rooms and property, including containment measures and / or quarantine, the establishment of entry / exit rules for the area subject to isolation or quarantine, by informing the population of the public health emergency, the mechanisms for coordination and mobilization of emergency funds.

It is important to mention that the processing of registered data occurs in accordance with the legislation of the Republic of Moldova and Technical University of Moldova, being registered as an operator that meets the requirements of personal data protection legislation, respects the rigors of the normative framework related to the protection of personal data.

Infrared thermo-scanners are widely used in airports, public facilities and hospitals because their non-invasive nature allows massive screening. In the created situation, we would need a modern and comfortable tool to use to detect potentially sick people and monitor the number and frequency of illnesses in each closed building or public place separately.

The body temperature is imperative to be checked in countering transmission of the COVID-19 virus. The main effective weapon applied in combating infection, as professionals require, is restraining of contact with infected people [14].

1. Analysis and determination of the domain of interest

The application is an innovation for people who would visit any public space, and it will replace the person who identifies the temperature of the people entering the building.

This project is split into three modules:

1. The part of facial recognition and fever measurement thanks to the thermo-camera using the OpenCV library and the transmission of people detected in the database for 14 days.
2. The front-end part that will allow to set the camera, the interface parameters, to view statistics and identified cases, to allow entry for people identified with negligible fever, to view covid information, etc.
3. The backend part which will create the database with the detected people who will be in quarantine and the creation of functionalities such as the statistics of the detected people with fever, the creation of notifications, the possibility of defining the days and the temperature in the interface, etc.

General objective: development of a solution with immediate technological and social impact for:

- help the health system not to reach a critical level of saturation. The proposed solution aims to identify the sick or infected people and prohibit their access to common areas, thus reducing their contact with many people.
- help the population cope with the difficulties caused by the COVID-19 pandemic, in particular the fear of going to common access areas, by setting up a system that reduces the risk of infection.
- replacing the person taking temperature measurements and is exposed themselves to the risk of being infected with the temperature collection device.

The direct beneficiaries of the project are economic actors (shops, pharmacies, companies), employers, hospitals, universities (including the Technical University of Moldova) – all of which aim to ensure a safe environment for customers / employees / students and

reduce the possibility of infection in their spaces. In such way the population that will be exposed to less risk of being infected.

The indirect beneficiaries of the project are the health system because the solution aims to reduce the possibility of spreading the virus, thus avoiding the saturation of the medical system.

2. Development of the new system design

In terms of design, this system is developed using technologies such as:

- Vue.js on the front end that the general user will interact with, i.e., the institution administrator who will allow access to people;
- Symphony for the functional backend where data will be stored;
- OpenCV for facial recognition and fever measurement of people entering the building [15].

The proposed solution highlights the knowledge of the students but also come with the possibility of hosting new experiences such as:

- innovation: the implementation of a solution that is less expensive compared to existing solutions - therefore accessible for universities, theaters, shops;
- engineering: the construction of the temperature collection device;
- algorithmic: the definition of the decision-making algorithm based on the data collected.

3. Functional Requirements/ Non-Functional Requirements

The software solution meets the following functional and organizational requirements:

a. The application has to contain a system configuration allowing users shared access to system resources.
b. The security of the application has to be ensured by the rights offered by the application's administrator, which gives access to the registration for users and user groups.
c. The application will guarantee the ability to work in an open multi-level structure, using database management systems.
d. The application must have an ergonomic interface in which the user can view all the information relating to the identified persons.
e. The application will provide viewing permissions of people with a fever above 37 degrees Celsius and prohibit entry into the building.

4. Project planning requirements:

User requirements must be clear, verifiable, complete, precise, achievable. Requirements' analysis is the first step in the product development cycle in which the requirements of the application are established, from the requirements of the end user, the functions of the future software product are identified as well as the data involved. This step answers the question of what will be achieved by developing the software product [16].

5. Interface requirements:

The system should have a graphical interface through which it will be convenient and easy to perform operations for the building administration [17]. Thus, the application must

have an ergonomic interface in which the user can view all information related to case statistics:

1. the list of identified persons
2. notices
3. application settings
4. covid information
5. access to live view of camera data.

6. Quality requirements:

- The system must have high stability, security and safety, as it is to store a person's data.
- The application must contain a configuration system that allows internal access only for institution-specific administration to SL resources. To be comfortable to be used by an administrator.
- The security of the application concerning the inaccessibility to other pages of the site by the manual change of the link as well as the impossibility of following from the browser the data entry for the connection / registration.

Elaboration of the Technical Specifications necessary for the realization of the information system.

General objectives;

1. the destination and objectives of the creation / modernization of the information system;
2. description of the object of automation;
3. system requirements;
4. the composition and content of the work to create the system;
5. how to test/check and hand over/receive the system;
6. requirements for the composition and content of work for the preparation of the object of automation for the launch of the information system

In the diagram represented on the Figure 1, it can be visualized the appearance and physical component of the elements in the IntelST system. There can be observed the bearings and the data transmission wire for processing and its return.

At the entrance of the building the kit of the system has to be installed: the Hikvision camera the TV, a Raspberry Pi and a computer. The camera here has the role of measuring the temperature of the people who enters the building. The thermal camera sends data which are automatically added to the database and deleted after a certain period of time.

The temperature measurement process: the person who measures the temperature is replaced by the camera, which facilitates data processing and saving. The system will display a list of people who do not have access to the building. After that, a person can be allowed to enter. After giving permission, it can be seen if the given person is in the building or not.

The transmission of processed data: this is the component of the system. The processed data (temperature and person identifier) are transmitted to the display screen, then to the administrators.

An administrator being a part of the company has the right to modify certain configurations. So, the administrator can change the temperature limit and restriction for entering to the building.

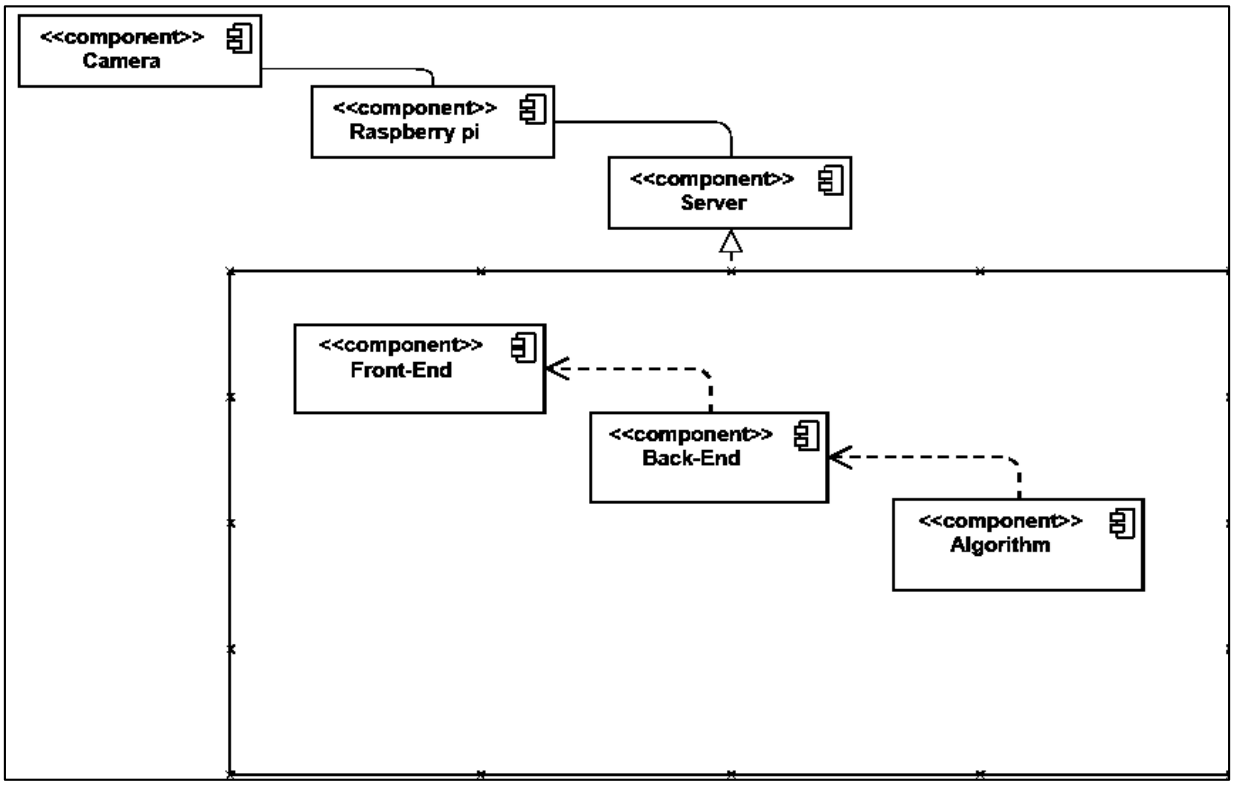

Figure 1. IntelST System Components Diagram.

The system allows the administrator to change the settings of a company as well. To edit a company, he must fill in a form with the data of the company he will edit.

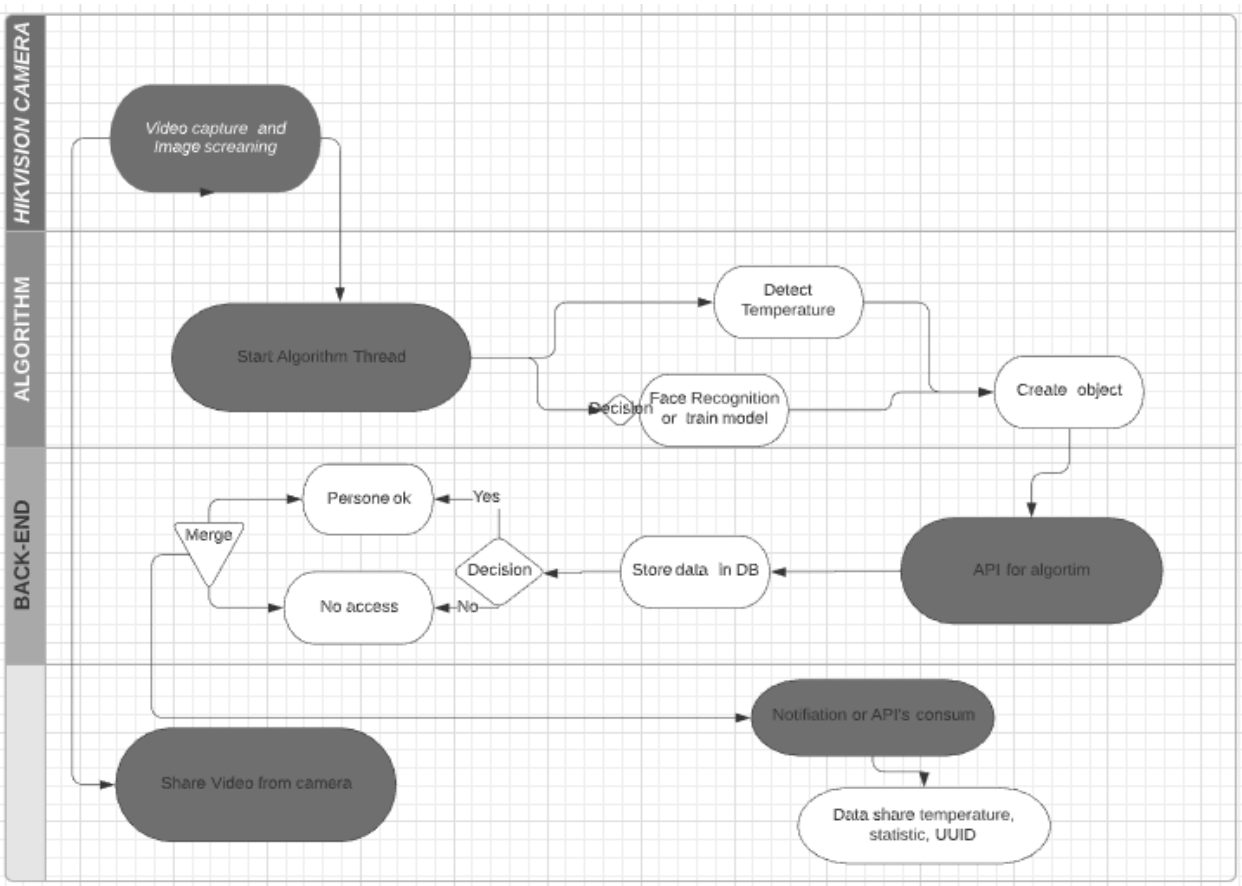

Figure 2. The activity diagram of the system.

In the activity diagram presented in Figure 2 it can be seen the followed steps by the system's data, i.e., it can be seen how the algorithm processes the obtained data and then sent to the back-end and then to the front-end to be monitored and perceived by users of the new system. *The algorithm that processes and saves data:* If a person has a temperature above 37 degrees Celsius, its access is prohibited in the building for a period of 14 calendar days [18]. The access is allowed in the building only if people show normal body temperature, below 37 degrees ºC and are without fever. Depending on the restrictions imposed, these data can be changed in the system, according to the rules of the moment.

The system allows sensors to add a newly identified case. To add a new case, it is necessary for the thermal camera to receive an image of a person and record his/her temperature. Once the two steps are completed and everything goes well, the system automatically saves the request in the database. If the person is already in the database, the data will still be added again.

To add an identified case of a person that has a temperature above 37 degrees Celsius, it is mandatory to detect the person and determine his temperature. This is the moment where it is assigned an ID, images, date, time and input temperature. Depending on the temperature, it will be specified whether or not the person has access to the building. The personal identifier will be assigned depending on whether the person is for the first time or has been identified before. The case is first registered in the database and then it is decided whether the person has access to it or not based on the rest of the cases. The automatic system deletes older cases based on the date they were identified. An important role in this system is played by the statistical part. In order to keep the situation under control it is necessary on daily and weekly bases to present graphs which will show the number the number of registered cases of people who have been detected with fever compared to the total number of people who have entered into the building. The administrator can thus compare and make a decision based on the result of the statistics. The total number of people whose access was restricted due they were detected with fever can be indicated separately. The *IntelST* system is a more complex system, but being a free resource, it can be viewed and installed by anyone, if he has a personal server with the physical capacities necessary for the work and the processing of data for the algorithm, the only difficulty is the server and resources for data processing.

Conclusions

This work presents the proposed solution for the protection against the COVID-19 pandemic spread, for people who want quickly to enter into the stores, hospitals, schools or other institutions. The system purpose is to ensure a safe environment for customers / employees / students and reduce the possibility of infection in their spaces and for the population who will have a lower risk of being infected overall. The system aims to reduce the possibility of the virus spreading, thus avoiding the saturation of the medical system. It offers a much cheaper solution compared to existing solutions, thus offering the possibility to a greater number of actors to benefit from it, to identify patients, but also, to replace the person carrying out temperature measurements and risk to infect himself from the temperature collection device.

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