Vladlena Markvirer
Svetlana Ulitina

Perm National Research Polytechnic University

Владлена Марквирер
Светлана Улитина

Пермский Национальный Исследовательский Политехнический Университет

Video Stream Object Recognition Module for Intelligence Buildings

Модуль распознавания объектов в видеопотоке для интеллектуальных зданий

Abstract: The article presents analytical review of existed solutions and technologies applied in computer vision control access systems, video monitoring and analysis areas. Such technologies are parts of the smart city concept and commonly used for recognition of faces in modern office buildings and business centers. Face recognition is used to distinct employees and guests, separated rooms and to evaluate the position of people, to expose atypical behavior. Commercial centers use such technologies for storing marketing information and estimating more popular route of buyers' movements. The article discusses the process of construction and realization of object recognition in video stream prototype system. This prototype uses single-board computer Raspberry Pi 3 model B+ and RPi-camera (Raspberry Pi Camera Board v2.1). Prototype can be used as the video recording module of "Smart office" or "Smart home" system.

Аннотация: В работе представлен аналитический обзор существующих решений и технологий, применяемых в области компьютерного зрения систем контроля доступа, видеомониторинга и видеоаналитики. Данные технологии являются составными частями концепции умного города и широко используются в современных офисных зданиях и бизнес-центрах для распознавания лиц, разделения сотрудников и гостей (посетителей) отдельных помещений, оценки положения людей, выявления нетипичного поведения. В торговых центрах такие решения используются для сбора маркетинговой информации и оценки наиболее популярных маршрутов движения покупателей. Рассматривается процесс проектирования и реализации прототипа системы распознавания объектов в видеопотоке с использованием одноплатного компьютера Raspberry Pi 3 model B+ и RPi камеры (Raspberry Pi Camera Board v2.1). Разработанный прототип может использоваться в качестве видеорегистрирующего модуля систем «Умного офиса» или «Умного дома».

Keywords: face recognition, video stream, smart home, smart office, singe-board computer

Ключевые слова: распознавание лиц, видеопоток, умный дом, умный офис, одноплатный компьютер

Introduction

Nowadays lots of research and development works show that computer vision and object recognition technologies have become more demanded in the information technologies market and are commonly used in practice. Computer vision is used to solve different tasks from domestic up to industrial scale.

In casual life people use smartphones to communicate through social media services, to share their thoughts and stories with friends and relatives. The embedded camera and mobile

applications are used in these processes. Users are excited of such features of photos as masks, transformations of face from an actual state to a childly or elderly, or even swapping of faces.

It is worth noting that technologies of augmented and virtual reality (AR and VR) are rapidly developing now. These technologies are used for adding objects and fixing them at some point of the real picture (AR) or ultimately change it (VR) in real time. However, it is not the subject of the article and it requires more detailed consideration.

The main idea of this article is video surveillance systems for recognition faces. Such systems are used for securing and observing surrounding territory and inside of houses or offices. Security surveillance systems assume the presence of the number of IP-cameras and controller in terms of user interface application that may send notifications to users to alert about dangerous situation or to inform about events. Often ready-made systems give us limited scope of functions and ability to extension. Sometimes security systems have functionality of recognition, but such systems are more expensive than surveillance systems itself [1].

In industrial sphere organizations use systems to ensure security by using turnstiles and passes to get into offices, workshops, and warehouses. Passes can be lost or stolen, that may lead to illegal access to private or government property. Passes also require physical contact with equipment that provide spreading bacteria.

That is why the problem of lack of opportunity and inconvenience of using ready-made photo and video recognition systems is discovered in this article. The aim of the work is to develop the prototype of intelligent object recognition system. To achieve the aim, it needs to analyze technologies for object recognition, and then design and develop prototype which can be further used as module of security system in smart house or office.

1 Technologies used in object recognition

There are four technologies of recognition: two-dimension, three-dimension, thermal image, and skin texture recognition. There are some pros and cons for every technology.

Two-dimension recognition technology uses usual images (photos), the vast majority of cameras works with such type of image, also there are a lot of samples to analyze photo and objects on it and that technology is more explored and cheaper than the other ones [1, 2].

Three-dimension recognition technology represents transformation two-dimension image into three. This technology uses stereo and structural highlighting and requires additional devices to do it. The technology is perspective but much expensive than two-dimension [1, 3, 4].

Thermal image recognition can solve the problem of twins recognition because every person has their own heat transfer. The thermogram of the person is created by using special and expensive equipment. The database of thermograms should be initialized and filled from zero. This technology uses deep neural networks and two-dimensional benchmark images [1, 5].

The skin texture recognition can be used for analyzing special features on the face of the person, such as moles, dimples, scars and so on. It is assumed that the technology is used in combination with other technologies, but it requires revision of the algorithms used [1].

To choose the appropriate technology it is needed to decide what is more valuable false reject rate (FRR) or false acceptance rate (FAR). Table 1 presents values of rates for known technologies. And figure 1 shows the dependencies of making decisions according FRR and FAR.

Table 1. FAR and FRR comparison of recognition technology

Technology of identification	FAR, %	FRR, %
Two-dimension recognition	0,10000	2,500
Three-dimension recognition	0,00050	0,100
Fingerprint	0,00100	0,600
The iris of the eye	0,00001	0,016
Retina of the eye	0,00010	0,400
Vein pattern	0,00080	0,010

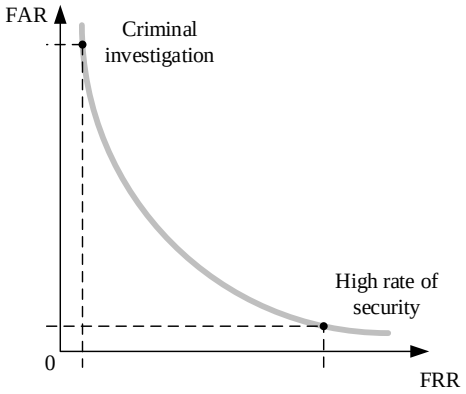

Figure 1. Dependencies between FRR and FAR

2 Constructing the prototype of employee recognition module

To construct prototype, the idea of security system via video stream recognition should be projected to a small area. Let the area be an educational institution, where there are students and instructors who continuously enter the academic buildings, show passes, want to get keys from offices and auditorium. This process is too complex and there are some rules to regulate it [6]. In figure 2 formalized process of entry to the office of the academic building according to rules in IDEF3 notation is presented. In this picture the employee (instructor or other employee) in building that was accessed to enter to the building bypass is the input of the process. The subprocess A2 is assumed at checking the employee for getting the access to demanded key. Condition J4 is for the decision after checking the employee. If the answer is “yes” then the process goes to A3, vice versa it goes to A5. Condition J5 is for the question “Is there the key?”. The answer “yes” leads to A4, and another answer to A5.

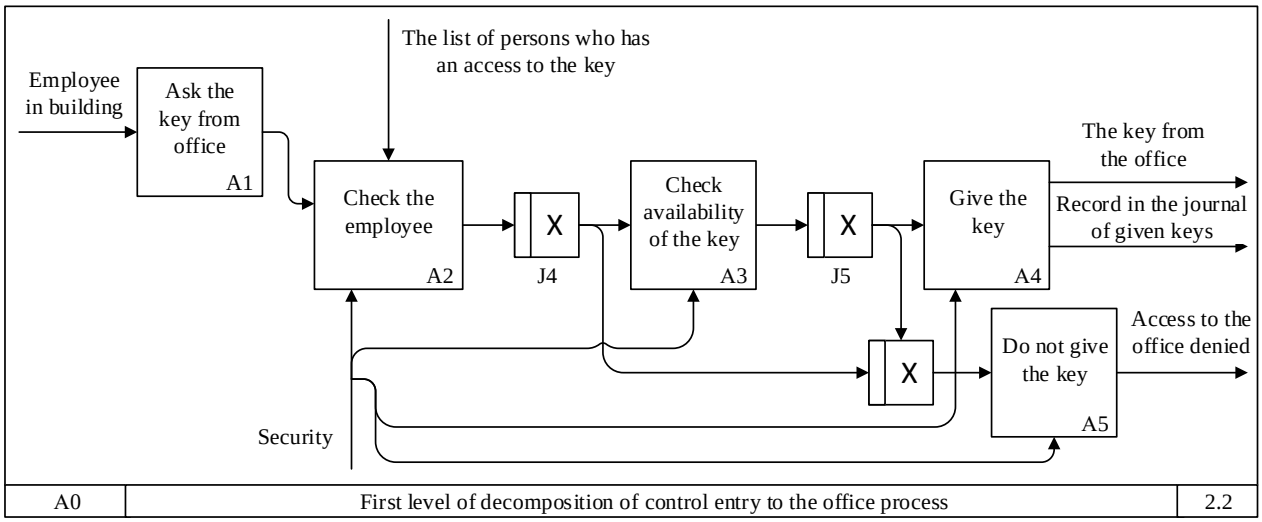

Figure 2. First level of decomposition of control entry to the office process

Besides there is not only the process of entry to the building or office, but also the process of exit. The person who exits from the office must check if windows are closed, turn off the light, electrical appliances, and close the door, give back the key to the security. This is not a secret that sometimes employees are tired, in a hurry or just forget to check everything. Such situations violate security rules and may lead to damages and even accidents. To avoid this it may be the best way to integrate the contactless intelligent recognition system, which will automatically control security and give an access to any building and office for those who have permission.

Though the prototype of the intelligent recognition system in video stream should be the part of complex system, the architecture of the system is presented in figure 3. This architecture is service-oriented where common bus NODE-TS/BUS relates to services by REST API.

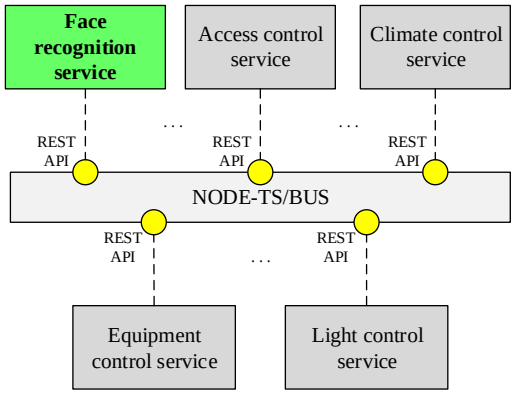

Figure 3. Service-oriented architecture of "Smart office"

The architecture of the recognition service should be multi-level. This architecture is shown in figure 4 where data level includes camera as input device and forming json package from data of employee database in DBMS. The logic level contains software of data processing in server and client parts in single-board computer Raspberry. And presentation level includes web-page with user interface.

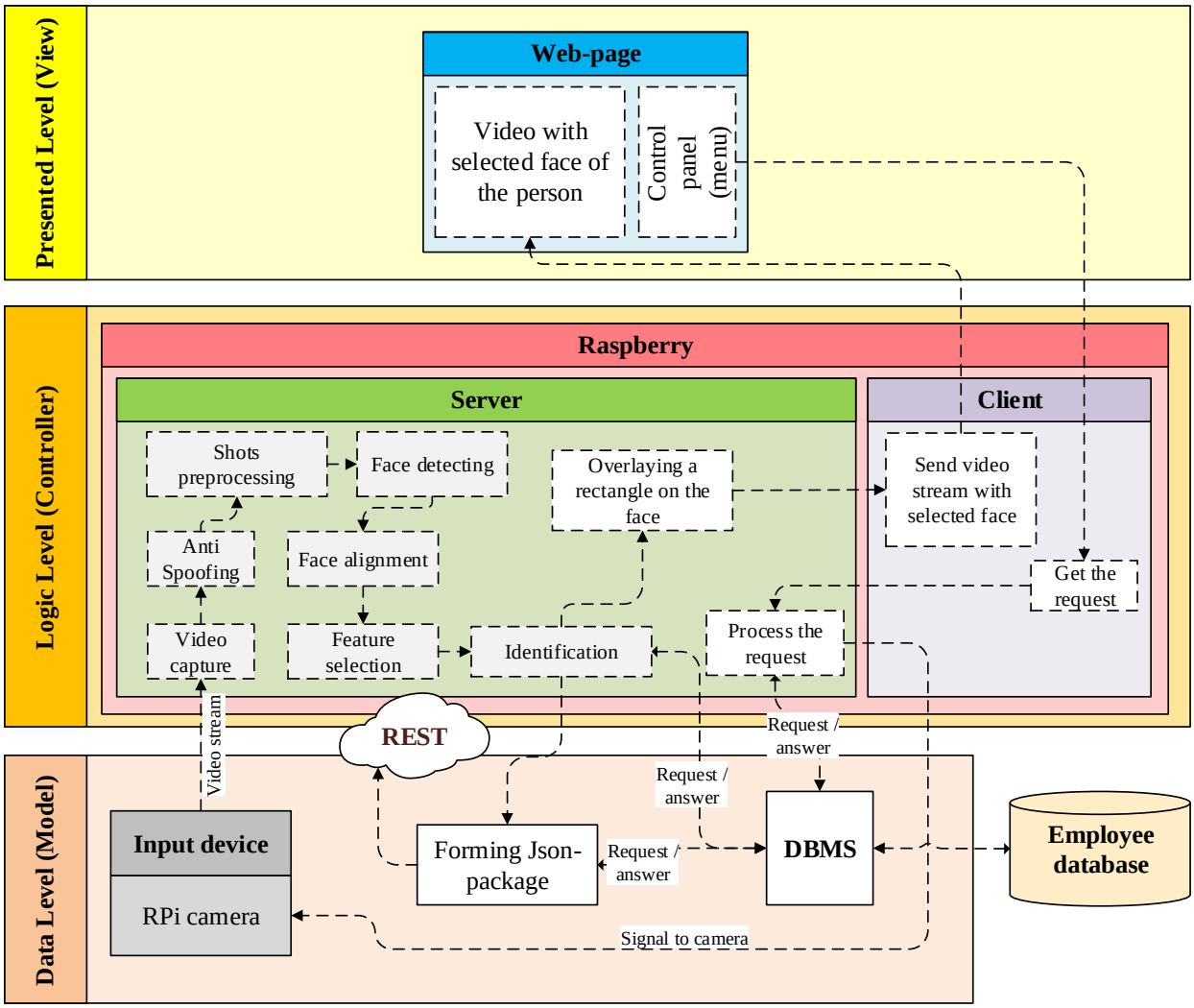

Figure 4. Multi-level architecture of recognition service

3 Results

According to designed architecture and assembled physical device scheme (conceptual scheme of the assembly can be seen in figure 5) the prototype was developed. The version of developed prototype with Russian language interface is displayed in figure 6.

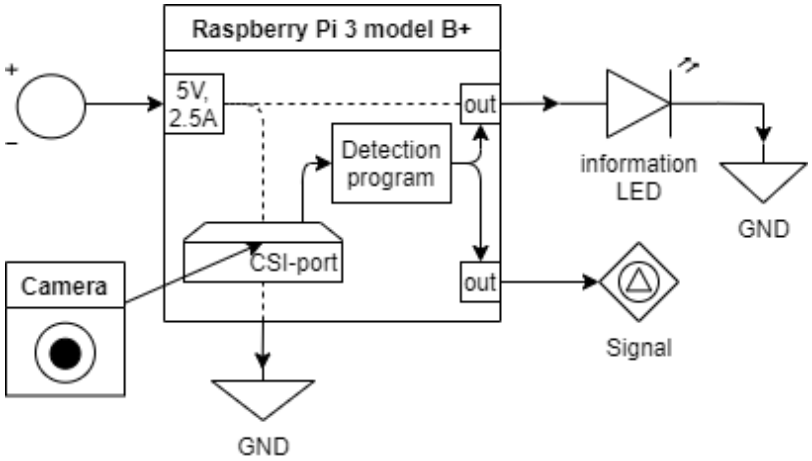

Figure 5. Conceptual scheme of the assembly

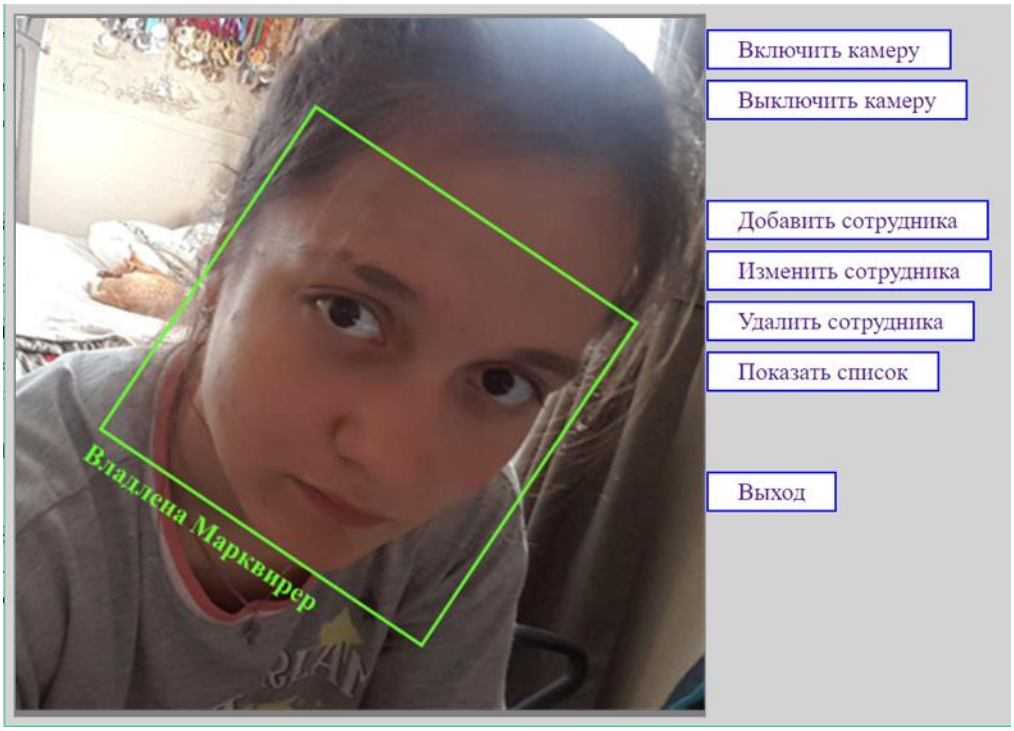

Figure 6. Webpage of developed prototype of recognition system

Conclusion

Analysis, designing architecture and results of prototype realization of intelligent recognition service were considered in this research paper. More detailed process of this research can be discussed with the author. In the text given, summarizing information about recognition technologies, architecture styles that applied for such development can be seen.

The developed prototype contains physical part of device with software realization for processing data from the camera to recognize people (employees). This prototype can be updated for integration into real security control environment. Moreover, the chosen architecture allows to do it without any problem.

Reference list

1. Titov A.N. Face recognition technology from “A” to “Z”. *Blog INTEMS* [The blog INTEMS]. Available at: https://securityrussia.com/blog/face-recognition.html (Accessed 21 April 2021).
2. Jackson A.S., Bulat A., Argyriou V., Tzimiropoulos G. Large Pose 3D Face Reconstruction from a Single Image via Direct Volumetric CNN Regression. *International Conference on Computer Vision*. 2017, 9 p. DOI: 10.1109/ICCV.2017.117.
3. Ivanov. Three-dimensional face recognition technology. *Blog SecGroup* [The blog SecGroup]. Available at: https://sec-group.ru/blog/tryohmernye-tehnologii-v-raspoznovanii-lic/ (Accessed 21 April 2021).

4. Advanced recognition technologies. Development of 3D face identification and scanning. *Aktiv. Gipermarket system bezopasnosti* [Active. Hypermarket of security systems]. Available at: https://www.aktivsb.ru/statii/prodvinutye_tekhnologii_raspoznavaniya_razvitie_3d-identifikatsii.html (Accessed 21 April 2021).
5. Sarfraz M.S., Stiefelhagen R. Deep Perceptual Mapping for Thermal to Visible Face Recognition. *British Machine Vision Conference (BMVC).* 2015, 11 p. DOI: 10.5244/C.29.9.
6. About the pass-through and in-object mode: The position of the State University of the Higher School of Economics of the Perm branch №12-06: Approved by the Academic Council PB SU-HSE. Protocol №02 of 21 October 2004. Perm, 2004. Available at: https://perm.hse.ru/data/2017/03/30/1168527766/Положение%20о%20пропускном%20и%20внутриобъектовом%20режиме.doc (Accessed 21 April 2021).