CHAPTER 192

Wireless biometric information exchange system

Crossref doi https://doi.org/10.56238/alookdevelopv1-192

Rafael R. Casaque
Graduating in Systems Analysis and Development Technology, PIVICT, IFSP, Câmpus São Carlos
E-mail: casaque.rafael@ifsp.edu.br

Joao Luiz de Castro
Post-Graduation in Specialization in Information Systems Management, IFSP, Campus Guarulhos
E-mail: castro.joao@aluno.ifsp.edu.br

Fabriciu A. V. Benini
Teacher of Basic, Technical, and Technological Education, IFSP, São Carlos Campus
E-mail: benini@ifsp.edu.br

ABSTRACT
This work is part of the seventh scientific initiation of the project called SEAID (Embedded System for Fingerprint Acquisition). This edition resulted in the physical and practical implementation of the knowledge generated in previous works. Initially, wireless communication was implemented between two Raspberry Pi devices using socket architecture, with one device acting as a client and the other as a server, to establish a connection and enable the exchange of images captured by the biometric modules. Additionally, the Fast Fourier Transform (FFT) algorithm was integrated into both devices. This algorithm was used to measure the frequency similarity between two different images, aiming to achieve greater accuracy in evaluating them as belonging to the same individual's fingerprint. With these modifications, the main objective is to use one device as a fingerprint collector, creating a repository for storage, and another device as a validator, making requests to the images stored in the first device to test the developed algorithm. It compares the current fingerprint with each previously saved image, verifying if there is a match.

Keywords: Robotics, Fingerprint, Raspberry, Computer Vision, Sockets Communication, Image Processing.

1 INTRODUCTION

In the current times, society is immersed in an era of continuous technological advances, which bring with them greater practicality and comfort. In the realm of technological security, this trend is no different, and a new era of identity validation has set in. Ordinary individuals are already familiar with the daily use of highly specialized information systems, the fingerprint being the most notable of them. It is important to emphasize the relevance that this method of identification has already achieved. According to a field survey conducted by Panorama Mobile Time, about 43% of respondents consider fingerprinting as their favorite identification method (MOBILE TIME, 2019).

In parallel, embedded circuits and computing systems have evolved significantly in terms of processing capacity, storage, and information transfer speed (LEVEZ; BENINI; GOMES, 2018). In this context, a promising opportunity arises to integrate these two technologies, thus developing an embedded system capable of acquiring and validating biometric fingerprints.

Throughout the previous editions of the scientific initiations, the SEAID project has accumulated vast knowledge, incorporating improvements to each iteration. In this particular edition, the communication technique Python sockets (ROCHA; BENINI, 2021) was employed to enable the interconnection between the two systems, along with the use of the cross-correlation algorithm between two images, based on the fast Fourier transform (OLIVEIRA; BENINI, 2021), known as FTT. In this way, the algorithm converts each image captured by the biometric sensor into a numerical vector that represents the black and white color values (0 to 255) and then compares the similarity between the sequences of these two images. Through this comparison, it is possible to obtain a similarity coefficient. If this coefficient exceeds an established limit value, it is indicated that both images correspond to the same biometric printout.

2 MATERIAL AND METHODS

In the context of the physical components, two Raspberry Pi microcontrollers were employed, one belonging to the second generation and the other to the third generation of these devices. In addition, FPM10A modules were used for the acquisition and validation of fingerprints. A wireless connection module was employed to establish a direct link between the two Raspberry Pis. In addition, power cables were employed to provide power and connect the circuits, network cables to connect the devices to the local network, and a personal notebook to perform the operations and provide them with power.

Regarding the software used, initially, we opted for the use of the Python language due to its wide range of directories and ready-to-use libraries, in addition to being the main language for development with the Raspberry Pis, also considering the predominance of this language in previous works.

To design the graphical interface of the Raspberry Pi in the notebook, the VNC Viewer software was used, and to enable access to this feature, the PuTTY software was used, which allows the connection to the terminal of the equipment through SSH and grants access to the VNC connection. Finally, to make this connection, the devices were connected to a hub through a network cable, establishing a local network that allowed the connection of the notebook to the equipment through the respective IP addresses.

The Python libraries used in the development of the work were researched and implemented based on the needs of the system. Initially, the py-fingerprint library (Raschke, 2020) was used for the implementation of the FPM10A module, enabling the acquisition, download, and search of biometric images. In parallel, the socket library, available in the standard Python installation package (pip), was used to establish the connection between the two devices, which required the development of two algorithms: a server, responsible for keeping the connection open, and a client, used to establish the connection, allowing the sending and receiving of information. Finally, for the implementation of the cross-correlation algorithm, we used the libraries Numpy, which specialized in operations with multidimensional matrices and with a wide range of advanced mathematical functions; Tkinter, responsible for the creation of graphical interfaces, Pyllow (Python Imaging Library), used to facilitate the opening and manipulation of images, and also the native OS library, to allow manipulation of the operating system through terminal commands.

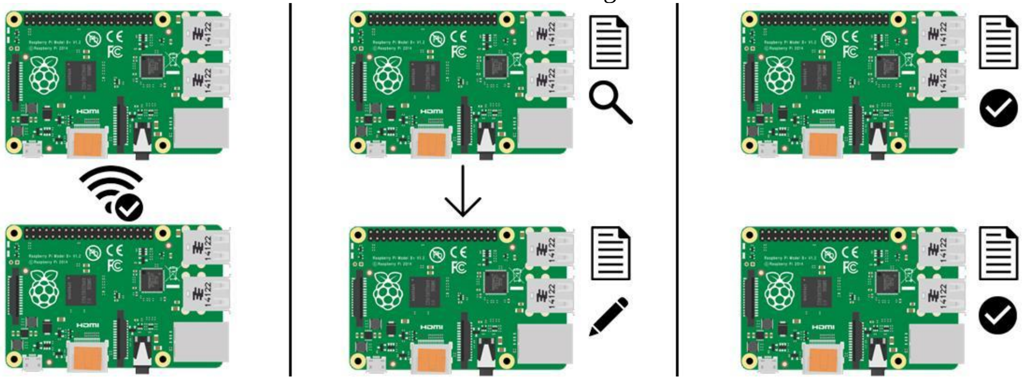
3 RESULTS AND DISCUSSION

Based on the components and libraries used, it was feasible to perform the testing and complete the implementation of the circuit of the two embedded systems. Both Raspberry Pis demonstrated autonomy in all biometric operations, using the FPM10A module and the Pyfingerprint library. In addition, both devices have been successful in wireless communication, employing the wireless communication module and the algorithms developed with the Socket library.

FIGURE 1. Circuit assembled and energized with biometric and wireless modules.

With the use of the Socket library, it was possible to develop algorithms for the exchange of images captured by the biometric module. The server establishes the session and waits for the client to connect. After the connection is established, a device opens the biometric print file in read mode and sends the file line by line in a repeating structure. On the other hand, after the connection is established, the device opens a file in write mode (assuming it is a new file, Python interprets it as a creation). With the file open, the lines are written with the responses obtained from the sending of the other device. After all, lines have been sent by the sender and written by the recipient; the file is closed and available on both devices.

FIGURE 2.Illustration of file sharing between devices.



Thus, taking advantage of the knowledge acquired in previous work and combining it with the research carried out in the current project, it was possible to implement the biometric validation algorithm directly in the Raspberry Pi. This algorithm performs the operations on the very fingerprints captured by the FPM10A module and also allows validation with images shared between the devices. The development of this algorithm took place during scientific initiation in 2021, using the Fast Fourier Transform (FFT) technique as a basis. To do this, with the help of the imported libraries, the algorithm opens the image and converts it into a numpy-array, an n-dimensional data structure provided by the numpy library. This process is repeated for the second image. Next, the Fourier transform formula is applied using ready-made methods from the Numpy library. At the end of these operations, the resulting arrays are compared element by element. After this comparison, the correlation value between the impressions is calculated, representing the similarity rate. Finally, it is verified whether this percentage value is higher than a pre-defined limit, established at 0.7% based on precision and accuracy tests (OLIVEIRA; BENINI, 2021). If higher, the algorithm returns true, indicating that both impressions belong to the same person. Otherwise, it is returned false, suggesting that the verified biometrics are not included in the database of biometric prints accessed.

4 CONCLUSIONS

With the practical implementations resulting from the study carried out in the last two scientific initiations, it was possible to take another step in the construction of the project initially conceived. At this current stage, it is feasible to establish the connection and communication between the two devices, exchange biometric impressions captured by the FPM10A modules, and validate the similarity through the cross-correlation algorithm. Importantly, as in the previous implementation, the validation algorithm requires quality and properly positioned biometric images. This means that even when two prints belong to the same person, it is essential that they are positioned similarly, both in terms of angle and central distance from the finger. Failure to comply with this requirement can result in false negatives, where the algorithm concludes that the impressions do not correspond to the same individual, compromising the effectiveness of the verification system.

ACKNOWLEDGMENT

I would like to thank immensely Professor Fabriciu Alarcão Veiga Benini for the opportunity to participate in this incredible project and for the guidance throughout the journey and also to the collaborator João Luiz de Castro for the help and willingness in the development of the reports and academic texts. I also thank the Federal Institute of Education, Science, and Technology (IFSP) for the materials and structure provided for the feasibility of the project. Finally, I also thank the professors who are members of the research committee (COMPESQ), for their attention and willingness to review and validate the partial report.

REFERENCES

LEVEZ, F. B.; BENINI, F. A. V.; GOMES, G. H. F. Aplicando opencv no raspberry pi. In: WORKSHOP DE INOVAÇÃO, PESQUISA, ENSINO E EXTENSÃO, 3., 2018, São Carlos, SP. Anais... São Carlos, SP: IFSP, 2018. p. 17-20. ISSN 2525-9377.

OLIVEIRA, P. A. B. & BENINI, F. A. V. SEAID - Sistema Embarcado para Aquisição de Impressão Digital: captura e reconhecimento de impressão digital. In: CONGRESSO DE INICIAÇÃO CIENTÍFICA E TECNOLÓGICA DO IFSP (CONICT) , 2021, São Carlos, SP.

PAIVA, Fernando. A nova era da da comunicação mobile. Mobile Time. Disponível em: https://static.poder360.com.br/2021/04/panorama-mensageria-fe2021.pdf Acesso em: 09 set 2022.

ROCHA, R. D. & BENINI, F. A. V. SEAID - SISTEMA EMBARCADO PARA AQUISIÇÃO DE IMPRESSÃO DIGITAL: REPRODUÇÃO DO EQUIPAMENTO COMPLETO. In: CONGRESSO DE INICIAÇÃO CIENTÍFICA E TECNOLÓGICA DO IFSP (CONICT) , 2021, São Carlos, SP.