LODZ UNIVERSITY OF TECHNOLOGY
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PHD THESIS (SYNOPSIS)

Biometric Recognition in Less-Cooperative Environments

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Overview

This thesis is devoted to the subject of biometric recognition in less-cooperative environments. The author describes the multitude of issues that must be considered to perform positive recognition in such conditions. At the beginning, the usability of face area for biometric recognition in unconstrained scenarios is analyzed. Then, the application of head pose estimation to decrease the processing time for large scale biometric systems is introduced. Finally, the periocular recognition is deeply studied, as this modality is believed to be useful when the face is covered during sickness or demonstration. As a result, several scientific contributions are proposed. Below, one can find a brief summary of the thesis motivation, scope and main contributions.

Motivation

Over the last few years, the number of terrorist attacks and other illegal acts have drastically increased. Public institutions and private entities are investing large amounts of money in technologies that can replace traditional security systems and increase the overall sense of security, especially in crowded environments. Global security, police and spy organizations try to use these solutions to identify dangerous individuals who attempt to evade authorities. The time differences between traditional security notifications and a system that can nearly instantaneously locate somebody with minimizing human error can change the way law enforcement does their job globally. As a consequence, it can be noticed that during the last few years, the use of surveillance cameras increased drastically, with more than 5.9 million devices installed in the United Kingdom alone. However, despite the widespread belief, current solutions do not provide an automatic approach to people identification. In most cases, the automated understanding of data is limited to action recognition only (e.g. detect fights, suspicious behavior or unattended luggage). For this reason, most of the identification attempts require some kind of human intervention in the process. As a result, such systems are not fully useful in certain situations, such as people entering stadiums or airports.

Simultaneously, biometrics is considered as a successful case in the domain of pattern recognition. With a growing population, the need for faster automated systems for identification purposes are becoming a requirement. A market that is a billion dollar industry is also rapidly changing for institutions that want to change the way you access your information. For instance, financial organizations are slowly changing the methods of how you connect to financial accounts, from using a pin, to fingerprint recognition, facial recognition or voice activation, thus reducing fraud and ensuring a deeper secure connection between your sensitive information. Similar solutions are also widely used in automotive industry or checkin points at airports. However, in most cases, recognition performance strongly depends on the level of cooperation from the subject. For instance, current iris recognition systems require that subjects are close to the imaging camera and look at the same point for a few seconds until the data is acquired. As a consequence, these solutions are still not ready to be used in more challenging environments, where the subject's cooperation is not assumed.

Hence, it can be observed that there is a high need to realize the biometric recognition in less-cooperative environments. On one hand, visual surveillance solutions operate well in uncontrolled scenarios,

however, they are not capable of performing human recognition. On the contrary, biometric authentication systems allow successful identification, but requires stable acquisition conditions. Therefore, the ultimate goal for both industry and a large number of researchers is to develop a less-cooperative recognition system, where subjects do not need to actively participate in the identification process. At the same time, this is the main motivation for this thesis. However, as the research behind moving biometric recognition to such conditions extends to a wide array of studies, the author's main focus is face and periocular recognition in less-cooperative, indoor environments.

Thesis Focus and Scope

This thesis addresses the problems of biometric recognition in less-cooperative, indoor environments. The presented work summarizes the most important author's achievements during his PhD studies. The conducted research was funded by Polish National Centre for Research and Development in the frame of the project LIDER/027/591/L-4/12/NCBR/2013, entitled: "Non-Cooperative bioMetric system for Positive AuthentiCaTion" (COMPACT). This project was realized under the supervision of Kamil Grabowski, PhD. Apart from the author, the research team consisted of Wojciech Sankowski, PhD, and Damian Kacperski, MSc. The ultimate goal was to design and develop a biometric system that does not require a significant cooperation from the authenticated subjects. The main goals of the COMPACT system can be summarized as follows:

- Develop an image acquisition platform that is able to capture high quality images on-the-move and at-the-distance. Image acquisition is considered as a key problem that needs to be solved to perform a successful identification under uncontrolled conditions;
- Develop or adapt subjects detection and tracking algorithms suited for less-cooperative environments. Precise scene understanding is crucial for further processing steps. It allows to compensate the subject's motion and properly target the camera to capture high quality features;
- Develop or adapt biometric recognition algorithms suited for less-cooperative environments. In uncontrolled scenarios, the employed methods should be resistant to various degradation factors, like distance, expressions, motion blur, occlusions or pose variations.

The author's main focus was associated with biometric recognition algorithms. At the same time, Damian Kacperski, MSc, was devoted to detection and tracking techniques. The entire research team was involved in developing the image acquisition platform.

Main Contributions

The main contributions of the presented research can be summarized as follows:

- A comparative overview of the biometric recognition systems that works in less-cooperative scenarios is presented. Additionally, the most common biometric traits used in such conditions are described. As a result, current trends and limitations are analyzed and discussed;

- A design overview of the software architecture for a medium scale biometric recognition system is proposed. The introduced approach is based on a set of independent micro services, which provides a high level of generality, scalability, and fault isolation. The computing performance of the obtained solution is evaluated using the example hardware;
- A dataset for studying biometric recognition in less-cooperative, indoor environments is constructed. The dataset contains images acquired automatically as people go through the recognition gate. The obtained data is available for various distances (1 - 4 meters) and on-the-move. The images are taken in the near infrared light spectrum and include many biometric traits (e.g. face and periocular area);
- A comparative overview of the most relevant research work in the scope of face recognition suited for less-cooperative scenarios is presented. Based on the literature review, the performance of the following algorithms is evaluated and compared: ThreePatchLBP, HighDimLBP and ResNet;
- A strategy to filter the registration set in biometric systems and reduce the number of comparisons by applying head pose estimation is presented. To illustrate the usefulness of the proposed algorithm, a face recognition performance is evaluated and compared to the results obtained for the brute force strategy, where all registration images are used;
- A strategy for periocular recognition using CNNs is proposed. To obtain large data representation for training, several datasets are aligned and combined together. The obtained model efficiency is compared with the performance of state-of-the-art algorithms;
- A performance of periocular recognition under less-cooperative scenarios is evaluated. The obtained results are compared with the performance of state-of-the-art face recognition algorithms to quantitatively determine the gap between periocular and face modalities;
- A strategy for left and right eye fusion in less-cooperative scenarios is proposed. As a result, the individual matching scores of each eye are combined to generate a single score. The performance of two different fusion approaches is evaluated and compared: classification and combination;

Doctoral Theses

First thesis:

Application of the head pose estimation in biometric authentication systems allows to limit the number of gallery templates used in the identification process of a specific subject without a significant loss in biometric authentication system accuracy.

Second thesis:

For biometric authentication systems, which strive to minimize false rejection rate (maximize convenience), periocular recognition algorithm based on deep convolution neural network allows to achieve better recognition performance when compared to the state-of-the-art methods.