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Application of Computer Systems in Facial Recognition Efficiency

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ABSTRACT

This paper focuses on the application of computer systems in facial recognition efficiency for smartphones. The process of facial recognition is broken down into different stages and a simple system for each step is overviewed. These systems make use of various techniques such as spatial imaging, artificial neural networks, rough set theory, etc. However, as the systems created for this paper are simply overviewed, each stage is not tackled as in-depth. The shortcomings and difficulties encountered in facial recognition are also discussed. The systems created may still be effectively used as a basis for the improvement of existing and the creation of new facial recognition systems, especially if the given systems were to be made more concrete and each stage of image processing were to be tackled and dissected one by one. This paper also briefly discusses other applications of facial recognition outside of smartphones, such as in surveillance.

Key words: Facial Recognition, Spatial Imaging, Artificial Neural Networks, Computer Systems, Smartphones.

1. INTRODUCTION

If one ought to draw a comparison between today and decades ago in terms of technology, the evolution and growth have been nothing but exponential. Along with the rapid advancement of technology, different concepts, theories, ideas, and innovations have stemmed out of it. Focusing on computers and computer systems, these different ideas have changed the face of how these devices have been built, operated, and utilized in this day and age. Some concepts and innovations such as spatial imaging, rough set theory, database monitoring, and electronic sensors, just to name a few have arisen from the continuing growth of technology.

The connection that these various methods have with technology and computer systems is that with the onslaught of different ideas, people have come up with numerous programs and applications applying the previously stated concepts using technology. “All technologies are born out of purpose”, as stated by Lamey [1] is concrete validation of the significance of each invention and innovation people have done in order to use different computer systems to integrate the mentioned concepts. In addition, the onset and use of more modern computers, along with its programs and applications, have not just eased the creation of different systems but has simplified research and communication as well [2].

As previously stated, the continuing evolution of technology has brought in an influx of varying concepts and theories that have reached out to different fields, which in effect has led to the creation of different systems applying those ideas. Just to present a few scenarios, digital imaging has greatly improved due to studies regarding spatial resolution and imaging have been undertaken to review how images are constructed using pixels, frequency [3]. In the field of electronics, specifically signals, the behaviour of these different waveforms are researched on which have led to the invention of different kinds of electronic sensors. These sensors, according to Teel [4], “measure real-world quantities...then converted into an electrical signal”. These are just some of many examples of how engineering and scientific concepts have led to the creation of various systems.

2. BACKGROUND OF THE STUDY

The main driving force of these different ideas and concepts, along with the computer systems integrating these theories is the vast improvement of communication technology as well as computers and operating systems. Digging further into computers, various innovations and upgrades have been done as each generation passed by. In general, all advancements that the computer has experienced a common denominator which was not just to keep up with the demands of the current generation but also to ease one’s usage of the device. Oak [5] has stated that in different aspects, computers have indeed improved and developed over the course of time. In terms of size, computers went from the bulky, room-sized devices to a portable gadget one can easily bring with him/her to any destination they wish. Computer performance is another significant aspect that was enhanced during the evolution of

these devices. Before, computers could only comprehend and process one task at a time and relied on machine language for computation. Today, modern computers can support multiple tasks while at the same time is able to understand natural language for processing.

Operating systems (OS) are also a crucial element in the ingress of different computer systems integrating various scientific and engineering concepts. Modern OS offer different features, programs, applications, and functions that can enable any user to fully utilize his/her personal computer. Since operating systems are considered the "core set of software...that keeps everything together" according to Hoffman [6], most, if not all, computer facial recognition systems created would not have been possible if it were not for these said OS.

In connection with the advancement of technology and communication, facial recognition is indeed widely used from the simplest of households up to the biggest of establishments for security purposes. "Advancements in artificial intelligence and biometric technology have led to the widespread use of computerized facial recognition" as stated by van Schelle [7] is a testament on how much facial recognition has grown over time. Different advancements and enhancements in various aspects of facial recognition have led to better performance and "increased accuracy, accessibility…. of facial recognition" [7]. Currently, devices that support facial recognition are used in a different field for various purposes due to its plethora of features people can utilize.

3. STATEMENT OF THE PROBLEM

In today's generation, technology and computers have not been able to just create different systems that apply various theories and concepts but also use those programs in order to ease and enhance one's way of living. Along with the brisk and ongoing pace of how researches are being conducted on those scientific and engineering concepts, the main dilemma is how to fully utilize computers and different systems in order to not just come up with more innovations but also improve the quality of facial recognition systems. During the earlier generations of technology, the number of resources was very limited as compared to today wherein enormous numbers of extensive research and analysis can be accessed anywhere. With this, searching and creating computer systems that can satisfy and meet not just the needs of a certain field but also be able to utilize these for the benefit of the population. These systems may also be fused with other existing programs which can further ease and meet the expectations of modern technology.

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

4. SIGNIFICANCE OF THE STUDY

With technology, specifically computers, at its highest in terms of evolution and innovation today, this paper aims to present how these devices can be fully utilized in creating these different facial recognition systems. In this age of modern technology, it is important that these different devices must be used in order to not just provide services for different fields of learning and basic needs but also mitigate the struggles of working with different technology. Another association it has with facial recognition is that since it is mainly used for security and privacy reasons, this paper aims to dig deeper into the various methods it undertakes for the system as a whole to operate. In addition, this also focuses on how facial recognition can be further improved to mitigate errors in the system.

In connection with computers, this paper also pursues and advertises the significance of computer literacy in the present time. Richards [8] addresses that these devices have now become part of one's way of living and that learning skills in operating computers along with sufficient knowledge is a must-have in today's setting. To support this, most communication and methods of research are now conducted through online means. Sending information and other data are mostly done online as compared to before. Different activities and transactions are also done using computers with the help of the internet and other software. In addition, most information can now be accessible with just the click of a button and will result in multiple kinds of literature on just one topic. This paper can serve as a path for one to equip themselves with enough knowledge to also join the chain of advancements in creating systems integrating facial recognition.

5. DESCRIPTION OF THE SYSTEM

The several stages of image processing are a capture, extraction, comparison, and matching. A facial recognition system comprises different elements. The first are sensors, which serve to "capture" or collect images of the person or subject to be scanned. Next are computers, which serve to "extract" or encode the visual images, detect facial features, and basically process the images into information that may easily be compared with that of other images. Lastly, a database which serves to "compare" or store the new data from the newly processed image, compare this data with others already stored in the database and "match" or identify whether the two images match or were taken from the same subject.

6. METHODOLOGY

This paper will create a simple system encompassing all stages of facial recognition and image processing for smartphones. This system will make use of electronic sensors, which are the smartphone's cameras, for capturing images; spatial imaging and rough set theory for extracting only the

relevant portions of the images and processing them; database monitoring and data/information transfer for comparing the images with the templates or other images already stored in the database; and logic scoring of preference and artificial neural networks for checking whether or not the new image matches any in the database. As this system is intended for smartphone use, only one person or subject will be stored in the database at a time. Despite this, the system will not only use one image for reference but, as will be discussed later, the artificial neural network will be used, as demonstrated by Sekhon and Agarwal [9], in order for the system to learn after each scan and better optimize the data for the next time.

7. REVIEW OF RELATED LITERATURE

Facial recognition may seem so appealing to many users in today's world with so many improved devices, but there are still drawbacks to it that may prevent others from using it. First, storing videos in CCTVs takes up a lot of storage when the useful portion of the video is only around 10-25% according to TecSynt [10]. Second, templates used for facial recognition may be of poor quality. For example, a scanned picture of an employee may have high quality while the CCTV looking at his face may have a very low-quality capture because of current technology. This results in the CCTV unable to verify the face because of the possible huge difference in image quality. Third, camera angles are also important because current face recognition only relies on frontal views. However, surveillance cameras don't have a frontal view of the subject being scanned.

As stated by both Wiskott, et. al [11] and Vasilescu & Terzopoulos [12], even with facial images where the subject is looking directly at the camera, the task of facial recognition is still not so simple because of the many possible variations in expressions, facial and head position, lighting conditions, etc. Variations in these things can often cause the accuracy of systems that perform facial recognition to drop. There are, however, methods already developed to work around this, such as the use of different mathematical procedures like bunch graphs and wavelet components [11], tensors [12], and eigenvectors [13]. The extraction of facial features (such as eyes, nose, lips) to be fed to an artificial neural network for recognition and training is another method that may be used [14,15]. With methods like these, necessary information is extracted from the raw images, simplifying the recognition process and making it more accurate.

In addition to the common facial features to be analyzed, facial marks, gender, and ethnicity are also factors in accurate recognition. Facial marks such as moles, freckles, and warts, prove to be useful as it contains three uses: to complement the result obtained by a conventional identification accuracy, to reduce the search time and enable fast face image retrieval in case of large databases, and to recover partial face images [16]. By combining the idea of facial masks with conventional techniques, low error rates in facial recognition were attained.

8. THEORETICAL CONSIDERATIONS

For our experimental setups, we used a phone camera from the Samsung Galaxy J7 Pro. It has a 13-megapixel front camera. The main camera of the phone was not used as traditionally facial recognition is used with the frontal cameras of a phone. With the rapid development of smartphone technology, this phone is also better equipped to handle the different processes undergone in the facial recognition systems.

9. DATA AND RESULTS

As there are several different stages in the facial recognition process, each stage will be covered separately in this section. Figure 1 shows capturing the block diagram.

Figure 1: Capturing the Block Diagram.

The first stage in facial recognition is the "capture" phase. In this stage, electronic sensors are used in order to capture the image in front of the camera. It begins with the user placing his/her face in front of the smartphone's front camera. When this is done, the image goes through the camera lens and to the sensor, which is either a charge-coupled device (CCD) or complementary metal-oxide semiconductor, which both play the same role of converting the photons, or light, into electrons for processing the image digitally [17]. In addition to this sensor, light and motion sensors will also be used in order to detect light and motion that may cause issues in the accuracy of the scan [18]. After detecting any of these deterrents, the smartphone will then conduct any necessary adjustments so that the captured image may be made clearer before moving on to the following step. Once all of the photons are converted into electrons, they move on to the image signal processor. This image signal processor, or ISP, is used to process the electrons from the sensor and determine the color of each pixel, reduce noise, etc. Afterward, the image from the user's face in front of the smartphone has already been converted into digital information ready for the next step, which is extraction. Figure 2 shows extraction block diagram.

Figure 2: Extraction Block Diagram

Extraction begins with line edge mapping, which makes use of spatial imaging in order to map out the different curves and lines present on the image. This first step is important in order to create a rough outline of the image for the computer to be able to more easily be able to distinguish, in the following

steps, which parts of the image are the face and which are the background, the different facial features, etc. This line edge mapping is also very helpful because up until a certain point, changes in illumination do not have much of an effect on it [19]. Next after line edge mapping is region selection. In this step, the region in the image with the face is selected based on approximation of face shapes and the help of rough set theory to optimize the process and make the boundaries between the face and background clearer. After this, the background is omitted as it is not needed in the process. Once the facial region is selected, still with the help of the edges mapped out, the different facial features are extracted. The facial structure and such are analyzed and the different features, which are the eyes, nose, and mouth, are separated again into regions and analyzed individually, which will increase the accuracy as compared to only analyzing the face as a whole [20]. With this segmentation of the face from the scene and the facial features from the facial region, the most necessary information is taken with each part of the face dissected to get a more accurate scan [21]. The shapes of the edges, the distance between features/regions, relative sizes, all of these factors are analyzed and converted by the system into data for comparison. After this is done, the data is then compared to others in the database (figure 3).

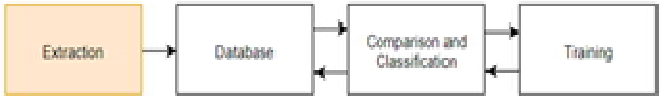

Figure 3: Comparison and Matching Block Diagram.

In comparison and matching, the given data on the image is cross-checked with other data found in the database through database monitoring to check for matches. For this system, however, there will only be one person in the database as it is intended for smartphone use, wherein only the owner of the phone is granted access through facial recognition. The data in the smartphone's memory is then used to determine whether the same face is attempting to access the phone through similarities. The two images, however, will definitely not be exactly the same due to different factors [22] such as lighting and camera position, as discussed earlier. To counter these difficulties, logical scoring of preference is used with fuzzy numbers [23]. These are used to be able to classify whether the images are matches or not despite the inexactness of the comparison [24]. Afterward, with an artificial neural network, relevant information from the new scan is stored in the database in order to have more reference for a more accurate reading in future scans.

10. ANALYSIS OF DATA

According to our retrieved data, facial recognition can be an effective medium in certain conditions. Instances such as phone cameras and surveillance cameras having the same resolution for similar image quality. Viewing angles from the surveillance camera may result in the inability to recognize the face because of the usual tradition of only having a frontal scan from the cellphone [25]. Storage for the footage of surveillance cameras has been lacking as well [26]. The previous recording had to be deleted in order to continue recording. Lighting conditions may play a factor in face recognition [27]. This results in some faces not matching because of the lighting present when surveillance cameras are checking faces. Some surveillance cameras naturally do not have great lighting, especially in their placed locations. Some surveillance cameras do not focus on the face which would have a large difference compared to an image template from a phone that has focus. Facial expressions may also result in unsuccessful scans. Most cameras today would have a difficult time recognizing faces when there are different facial expressions with multipath geometry tracking [28]. The only way to combat this is to have the person send multiple facial expressions to be scanned. Using surveillance cameras that have a different resolution from used cellphones for templates will result in inconsistent facial recognition.

11. CONCLUSION

Ever since the digital revolution, there have been constant advancements in the technology that is present everywhere. Parallel to the increase of problems all around the world, society is experiencing huge breakthroughs in technology, whose purpose is to solve all these problems. Recent technologies can easily be replaced by other technologies in just a short amount of time. Technology that is known today may be unrecognizable tomorrow. An example is the camera. When the camera was created, its purpose is to capture still or moving images. Now, it can be used for a lot of things like forensics. Cameras, specifically CCTVs, serve as evidence whenever a crime is investigated, and through further advancements, these CCTVs can accurately identify the people in the crime scene. In the middle of the said technological breakthrough, the computer plays the most important role since it is flexible to all kinds of data or information that goes through it. The continuous upgrade of computers has made other fields faster and easier. It allows for the study of concepts such as spatial imaging and resolution which allowed facial recognition to have a lot of applications such as security, criminology, and even payments [29]. When it comes to technological advancements, there is no "ceiling" when talking about how much further technology can improve.

12. RECOMMENDATIONS

The use of smartphones in facial recognition is a small step for the adaptation of facial recognition in more complex devices. Instead of applying facial recognition one person at a time, it would be ideal to apply it to analyzing multiple people simultaneously. In order to improve the accuracy of facial recognition, adapting better algorithms with more variables to complement the result would be recommended. Better software in analyzing the images would also be advisable. In

addition to that, cameras with high resolution would complement facial recognition a lot, reducing the percentage of errors. Storage for modern surveillance cameras also need an upgrade because of the usage of stored footage is too big. A possible application of multiple facial recognition can be in the manufacturing industry [30]. The manufacturing plant will be able to keep track of its workers and their safety. Their databse system will be considered [31,32,33]. Applying this idea can also reduce the risk of security breaches in the plant compared to the conventional way of key cards. This can ensure that only people that have granted access can enter the plant.

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