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COMP 445

AFIS Report

AFIS- Automation of Fingerprint Search, a database that started in the early 60’s with the FBI/ National Bureau of Standards. The purpose for AFIS is to help federal and state investigators solve crimes with prints they can collect at a crime scene or close cold cases. Since a fingerprint is a unique property for each person, and does not change for one’s lifetime, it has been a great way to identify a person for over a century. This system reduced cost, saved a lot of man hours, help solve crimes, and most importantly keep a database of “some 56 million criminal prints (plus nearly 250 million civil prints) submitted by more than 86,000 criminal justice agencies. Included in our criminal database are fingerprints from 73,000 known and suspected terrorists processed by the U.S. or by foreign law enforcement agencies who work with us.” (FBI, 2008). These classifiers that AFIS looks for are called Islands, Dot, Bifurcation, and Ending Ridge.

With the AFIS program we have to consider the pros, cons, and why this system was created to begin with. As I stated in the previous paragraph, I have listed the pros with the AFIS system, it can reduce cost, help cold cases, and apprehend the wanted criminal. What about the cons of this system? Since your fingerprint is unique that makes it your DNA and if that fingerprint is at a crime scene, you can be a potential suspect and possibly get convicted of the wrong crime. Boston University professor Trina Arpin states “Everyone on the planet may have a unique set of prints, as examiners claim, but the real question is whether experts can accurately link the prints collected by crime scene investigators to the right person. Crime scene prints usually consist of only about 20% of the fingertip and they are often smudged.” (Arpin, n.d.). Another flaw about these tests is how the examiner can be taint the identification process from peer pressure or bias “panel of outside print examiners convened by the FBI to review the Mayfield case found that a supervisor made the initial identification and lower-ranking examiners, when asked to confirm or reject their boss’ work, felt pressured to confirm” (Arpin, n.d.). Before investigators present evidence in the court of law they have to first exclude suspects since “it is easier to exclude a suspect than to convict someone based on a DNA match.” (Educational Resources Development Council, n.d.).

The main objective of this research project is to create a program that will be able to extract these minutiae and segregate them according to an ending ridge or bifurcation. This will involve pattern recognition, minutiae detection, statistical calculations, and performing algorithms in order to detect them. All of these can be applied to other types of applications such as segregating apples from oranges or text from pictures. Other aspects of mathematics can be applied after this is completed- such as a database implementation where we can store the minutiae, a GUI application written in any language to better interact with the system and have it be more user-friendly, and more mathematical algorithms in order to match a fingerprint with one we have in the database. Since we are not part of any federal level agency, we will deal with the three-piece extraction.

There are three steps that the prints go through. The first one is Pre-Processing: each individual has these ridge patterns on each finger that makes them unique. These fingerprints have the approximation of 75 to 175 points of identification, these points are extracted by the system via fingerprinting, a process that has the detained place their fingers in ink or the individual has left it at a scene at which it is extracted by tape. The second process is the minutiae extraction: The evidence or fingerprints are scanned into the database in a high quality, since the lower the resolution the noisier the photo becomes and it minimizes error. The third and final is the Post-Processing: which goes though the photo and deletes false minutiae and obtains the required minutiae.

In the first step we need to perform an image enhancement to any fingerprint the system will receive. Information is best gathered at a pixel-by-pixel level so we need to ‘skeletonize’ the image in order to reduce the ‘noise’ of the image and fill in any holes which may lead to false identification of an island or bifurcation. Some images gathered in the field will probably not go by the same standard a print that’s been processed in a lab or police station so we must be able to crop and enhance the image. We can enhance the image by first applying a filter which will blend some areas together. Applying a filter such as a Gaussian blur will help us reduce the noise and fill in the unwanted holes. With all of this image preprocessing, we can now have an image ready for minutiae extraction.

In the second process, minutiae points are collected and ran through the system. Each point classified will result in either a bifurcation or ending ridge. The two can be seen as an opposite of one another as an inverted image of an ending ridge will result in a bifurcation which is where a fingerprint ridge will separate into two; sort of like a fork in a road. The point we look for in an ending ridge will be where a line ends, so we want to capture the x and y coordinates at that location. For a bifurcation, we would want to capture the coordinate points of the exact point the line splits. With this knowledge, we can now create an algorithm that will be able to go through the image and detect these minutiae.

Our third process involves identifying the two minutiae we are looking for. A great way to classify each point is by checking its nearest neighbors. By this time the image should be enhanced and skeletonized and placed in a binary matrix where a 0 represents there is no information there and a 1 represents a fingerprint ridge. If examine the image in a loop, in a sort of scanning motion from left to right and then jumping to the next line, we can examine its eight nearest neighbors as we go. As we scan each central pixel with a value of 1, if it has EXACTLY one neighbor with a value of 1, then it is considered a ridge ending. To detect a ridge ending, if our central pixel has a value of 1 and it has EXACTLY three non-adjacent neighbors with values of 1 we have successfully found a bifurcation minutia.

For our MATLAB code we have the advantage of having most of these preprocessing algorithms at our convenience. MATLAB is easily able to detect our image with an input function that asks the system user for the image name. We then inversed the image after a Gaussian blur is applied to reduce noise though it’s not really needed since our database is set to a certain standard. The image is then converted to a black and white image resulting in a logical matrix of only 1’s and 0’s. Then a thinning algorithm is applied which will give us a skeletonized image. We then create two duplicate matrices with the same data as the skeletonized image which will each detect whether a ridge ending or a bifurcation in the same scanning loop. While the program is in our loop we are gathering x and y coordinates in two different matrices for x and y. Now, all that is left is to mark the specific coordinates in one final image on either the original supplied image, or the skeletonized image and displayed to the user.

In conclusion, this project has shown how to use MATLAB to go through a series of steps to fully extract fingerprints from images to receive some sort of identification and how efficient it is. The program is even able to get some points from photos with a clear fingerprint to those who seem to have a partial match. Though our system can be further improved we believe this displayed the core concepts we learned in our Image Analysis and Pattern Recognition class. We also think that we have met our goals on learning what AFIS is and how it can be applied to MATLAB by detecting and classifying points on a fingerprint and to determine a bifurcation minutia or ridge.

# Works Cited

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