# Ear Recognition Strategies

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## ABSTRACT

*Biometrics is currently a heavily researched area in identifying persons based on characteristics that they possess. Biometric systems are commonly used for identity access management and access control. Biometrics is defined as the science and technology of measuring biological data by means of statistical analysis. Human body characteristics of different traits are measured and analyzed for authentication (or identity confirmation). These characteristics or traits can be physical or behavioral and each trait has its own strengths and weaknesses when being used for a Biometric system so it is of great importance that the modality that works best for a particular application is found.*

*The human ear has become a topic of great interest in the biometric community in recent years because it has many advantages over other biometrics. It has potential to be successfully used in both the low and high security applications as well as in combination with other biometrics such as face. Many different methods and techniques have been proposed. This paper will include information about some of the past research that has been done in this area as well as the future research that the lab I worked in this summer is preparing to do.*

## INTRODUCTION

My summer was spent in the Biometrics and Pattern Recognition Laboratory in the School of Computing at Clemson University, researching under Dr. Damon L. Woodard as my mentor. The ultimate goal for this research experience was to learn more about the science and technology of Biometrics, with a concentration on ear as a biometric, learning about the ear recognition process and the advantages and disadvantages of previously proposed techniques.

## BACKGROUND

Biometrics is a method of direct human identification chosen over other methods of determining identity because it truly identifies a person instead of being dependent upon keys and cards they possess which can be stolen or lost or passwords that can be forgotten or shared easily. Biometrics allows human identification to be more secure as a whole and it is based on the physical and behavioral characteristics that humans possess. Behavioral Characteristics include keystroke, which is the rhythm in which you type, voice patterns, gait, which is human motion or how you walk, or signature while characteristics such as DNA, Fingerprints, facial patterns, ear geometry, etc. are classified as physical. Physical characteristics tend to be more stable and consistent that behavioral characteristics.

There are four main modules that make up the design of a Biometrics System as shown in Figure 1.. The sensor, which is used for detection of the characteristic, whether it is a camera, microphone, etc., is used to capture the biometric data of the individual. The next component is the feature extraction where the acquired biometric data is then processed to extract a set of significant features. The matcher module is where the extracted features are compared against the stored templates (which are features already stored in the system after a person was enrolled or entered into the system) and a match score is generated. A match score is a determination of the similarities between the extracted features and the template features. The last component, the system database, is used to store the biometric templates of the enrolled users.

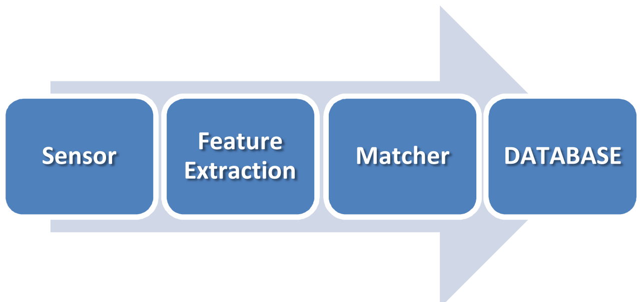


**Figure 1.** Biometric System Components flow chart..

When selecting a good biometric trait to research or use in a system, things you must consider to determine whether it will be a good form of Biometrics to use include the permanence (does not change over time), performance (low error rates and processing time), acceptability (is it acceptable to users) distinctiveness (unique and varies across users), circumvention (can it easily be spoofed/fooled), collectability (can be measured quantitatively), and universality (possessed by all users). When considering these things, compared to face, Ear is more consistent as far as variability due to expression, orientation of the face and effect of aging. The ear's location on the side of the head makes detection easier.

The ear is broken down into the parts shown in Figure 2. Several approaches to carrying out ear biometrics have been proposed and researched by different researchers and scientists. The approaches include the geometric approach, global approach, and local approach, which all possess different feature extraction methods.

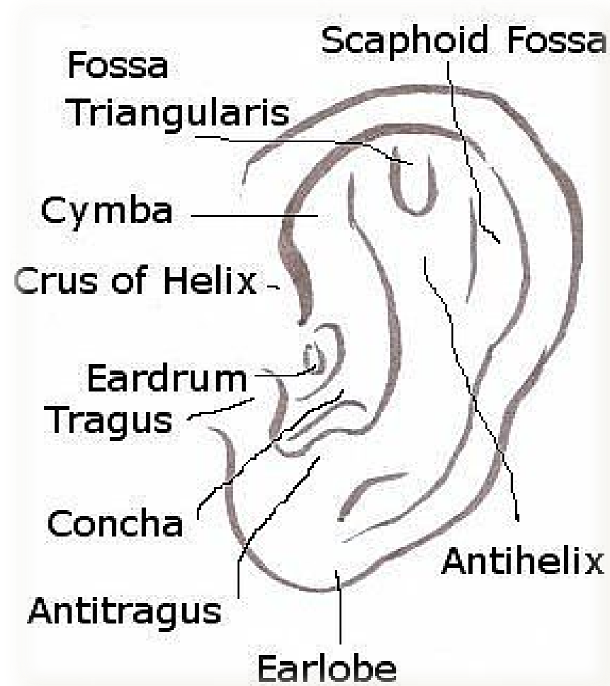


**Figure 2.** Outer human ear physical anatomy. The complete outer ear is called the pinna and the top outer rim is the helix.

An ear recognition biometric system works by first enrolling identifying features of an individual into the system database. A person cannot be identified if they are not enrolled into the system. Specific points of data are identified and compared, and determined to be match points. The system will succeed in identifying the comparison of the biometric sample to a template in the database (also known as the match score) falls within the previously set threshold value, which is the point where it becomes reasonably certain that a match has been found.

It has been suggested that in most cases, the performance of ear recognition using a 3d image (as shown) will be slighter higher than if a 2d image were used, due to the fact that variation in pose and imaging conditions greatly affect how a person's ear may appear in a 2d image. 2d images contain much less information than 3d images, which contain surface shape information related to anatomical structure and are relatively insensitive to illumination.

**Figure 3.** 2D Ear Image.

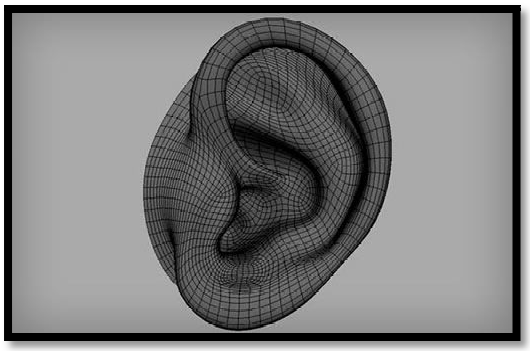

**Figure 4.** 3D Ear Image.

## PROJECT

My summer project began with the goal of being an evaluation of the performance of ear recognition algorithms, determining how improvements can be made in recognition performance. I was assigned to obtain two publicly available ear recognition implementations, test them using multiple 2D ear image databases, and perform a detailed analysis of the results using biometric system performance metrics. As time went along and I worked toward the goal of this project, my advisor and I both realized that this project required a bit more than we bargained for within a 10 week period. My project then became more geared toward an educational research project in which I would learn about Biometrics and ear recognition and give a presentation to Human-Centered Computing students and faculty to enlighten them on the subject area.

My research initiated reading many papers about Biometrics, which provided me with a foundation of what work has been done in the past, what researchers are currently studying in this area, as well as what visions have been seen for the future of biometrics. The first paper I read was "An Introduction to Biometric Recognition" by Anil Jain, Arun Ross, and Salil Prabhakar from *IEE Transactions on Circuits and Systems for Video Technology, Vol. 14*. It was one of the most informative papers anyone looking to learn about Biometrics could read. Reading this paper and a few others helped me decide after a couple of introductory weeks what specific area of Biometrics that I would like to research for the summer. Once I chose to focus on ear biometrics, I decided that by the end of the summer I wanted to have a clear understanding of how ear recognition works through hands on experience and wanted to be clear on the limitations of current approaches to ear recognition. This would help me to know where I stand and what future contributions I could make if I were to become a part of this laboratory after graduation.

When it came to my specific, solo project, I was assigned the task of locating (internet searches), obtaining, and preparing ear recognition source implementations for conducting ear recognition experiments in order to produce a performance analysis using retained or acquired 2d ear database images. After a few weeks of searching, I realized that the simple-seeming assignment of finding two ear recognition implementations would be more difficult than previously imagined. I was able to found one seemingly good example, however, to obtain the source code there was an unreasonable price to pay. Nonetheless, I was still able to utilize this program for my summer exploration of the ear recognition process.

In order to perform ear recognition, the database has to include at least one image so before I could actually discover how this code worked, I had to obtain a database of ear images. It was brought to my attention that the lab had access to a couple of ear databases all along. The galleries included multiple photos of side profiles of different subjects' ears and the area around their ears. However, for the experiments that I am trying to run, I need the photos to be of the ear only and they must all be the same size. My advisor supplied me with a MatLab User's Guide specifically for Image Processing which will help me learn the different tools for analyzing and measuring features in an image and resizing them. I still spent time trying to figure out a way to crop them after I selected the smaller sample of images that I would be working with. Since a lot of time was spent trying to figure out how to process the images, I was instructed to spend a good amount of time searching for a pre-processed ear image database instead. After a couple days of searching, I was able to find one that could be used; it had 102 total images of 17 different subjects', or individuals', ears with all images already cropped to show only the ear, including the images from Figure 5.

**Figure 5.** Images from pre-processed ear database

This implementation was coded in Matlab, "a high-level technical computing language and interactive environment for algorithm development." Prior to working with the implementation, it was necessary for me to go through tutorials in order to become familiar with this language that was completely new to me. The tutorials were very helpful in allowing me to become comfortable with Matlab and learn about the features that it possessed. Once I obtained a working knowledge of Matlab, I was able to learn more about how the ear recognition program worked. Before using the program, I needed to resize the images, which I had already found the command to do so with Matlab inside of a Matlab Image Processing book that I was previously reading. I began trying to test the program by adding a few images from the gallery to the program database. I then attempted to perform ear recognition between two of the images that I added. The program was based on the Principal Component Analysis (PCA) approach which is a global feature extraction method that uses an orthogonal transformation. To test the implementation, I had to enroll the images into the database, using different classes to separate each individual. The code allowed for you to perform ear recognition or 1:1 ear verification as shown in Figure 6. When performing ear recognition, the dimensionality of the images is reduced to produce a feature vector of manageable size for comparison. After a significant amount of experiments, performance metrics are used to determine how well a biometric system performs.

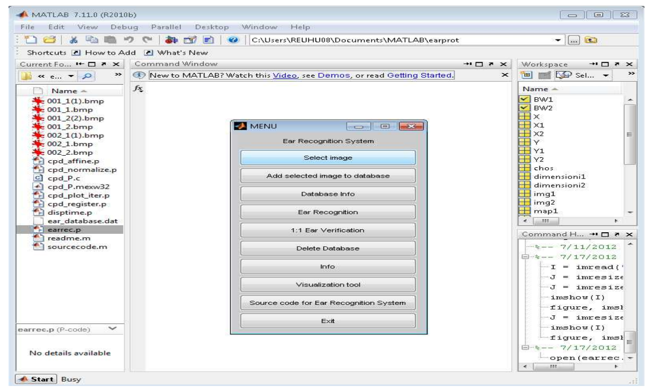


**Figure 6.** Screen shot of the GUI with the options to choose from once the program runs.

## CONCLUSION

Overall, my summer was an enjoyable one. I learned a lot of useful information and got an accurate view of the research process and being in a research group setting. If my initial project had worked as planned then I would have had the opportunity to analyze the system that I obtained using the performance metrics. Despite the fact that I encountered issues with the code, it was still a big help to my Biometrics learning experience. My summer research experience really helped give me a better outlook on graduate school and has improved my interest in and consideration of the Human-Centered Computing PhD program at Clemson University.

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