International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

MATLAB PETITION

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ABSTRACT :

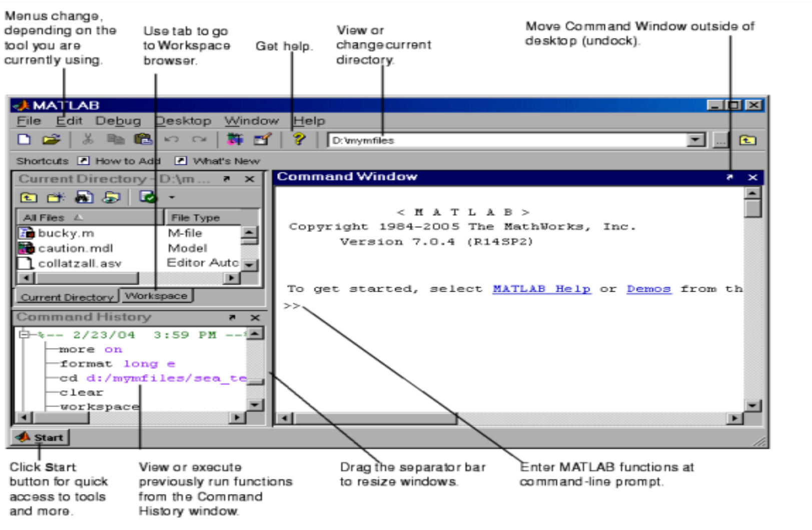
This study presents the development and evaluation of an ear recognition application using a combination of Artificial Neural Networks (ANN), Probabilistic Principal Component Analysis (PPCA), and Coherent Point Detection (CPD) techniques. The primary goal is to enhance human identification based on ear lobes, which requires accurate feature extraction and classification methods for effective performance in real-world environments. The application was tested using two distinct ear image datasets: the AMI Ear Database (210 color images from 30 classes) and the USTB Ear Database (200 grayscale images from 20 classes). For both datasets, the Ear Distance (ED) and Ear Shape Distance (ESD) values were calculated to evaluate the accuracy of the system. The AMI dataset showed an accuracy of 96.1%, while the USTB dataset achieved a higher accuracy of 99%, demonstrating superior performance in matching ear images. The ANN-PPCA-CPD system proved to be more efficient when tested on the USTB dataset, with a 2.9% accuracy deficit compared to the AMI dataset. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN Notably, the proposed algorithm provides significant benefits in ear recognition by offering a shape-based parametric model, extracting ear lobe features directly without extensive processing, and generating pre-established correspondences (landmarks) around the ear. This improves both the computational efficiency and detection accuracy, outperforming many existing methods in terms of both speed and precision. The findings highlight the potential of the proposed ear recognition system for various computer vision and biometric applications. Multimodal biometric systems, combining eyes, hands, and face, still face challenges in delivering reliable results, even with advanced security layers. Adding ear biometrics offers unique advantages, strengthening identification systems for the future.

Keywords: Ear recognition, MATLAB, Artificial Neural Networks (ANN), Feature extraction, Biometric applications, Accuracy.

INTRODUCTION :

The name MATLAB stands for MATrix LABoratory. MATLAB was written originally to provide easy access to matrix software developed by the LINPACK (linear system package) and EISPACK (Eigen system package) projects. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming environment [1]. Furthermore, MATLAB is a modern programming language environment: it has sophisticated data structures, contains built-in editing and debugging tools, and supports object-oriented programming. These factors make MATLAB an excellent tool for teaching and research. MATLAB has many advantages compared to conventional computer languages (e.g., C, FORTRAN) for solving technical problems [2]. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. The software package has been commercially available since 1984 and is now considered as a standard tool at most universities and industries worldwide [3]. After logging into your account, you can enter MATLAB by double-clicking on the MATLAB shortcut icon (MATLAB 7.0.4) on your Windows desktop as shown in Fig. 1.1. When you start MATLAB, a special window called the MATLAB desktop appears. The desktop is a window that contains other windows. The major tools within or accessible from the desktop are: The Command Window, The Command History, The Workspace, The Current Directory, The Help Browser and The Start button [4]

Figure 1.1: The graphical interface to the MATLAB workspace



When MATLAB is started for the first time, the screen looks like the one that shown in the Figure 1.1. This illustration also shows the default configuration of the MATLAB desktop. You can customize the arrangement of tools and documents to suit your needs. Now, we are interested in doing some simple calculations. We will assume that you have sufficient understanding of your computer under which MATLAB is being run [5]. You are now faced with the MATLAB desktop on your computer, which contains the prompt (>>) in the Command Window. Usually, there are 2 types of prompt: >> for full version EDU> for educational version Note: To simplify the notation, we will use this prompt, >>, as a standard prompt sign, though our MATLAB version is for educational purpose.

LITERATURE REVIEW :

Driver Identification using Ear Biometrics

Jana Kalikova, Jan Krcal

Authors deal with the biometric identification of drivers, using an ear thermogram. Samples are acquired using an IR camera and then further evaluated by an artificial neural network. Input image data is acquired from a standardized distance at 5 different angles and the effect of the settings of the artificial neural network on the result of successful driver identification is studied [6]

ScoreNet: Deep Cascade Score Level Fusion for Unconstrained Ear Recognition

Umit Kacar, Murvet Kirci

Authors evaluated ScoreNet using the Unconstrained Ear Recognition Challenge Database, which is widely considered to be the most difficult database for evaluating ear recognition developed to date, and found that ScoreNet outperformed all other previously reported methods and achieved state-of-the-art accuracy. Although biometric ear recognition has recently gained a considerable degree of attention, it remains difficult to use currently available ear databases because most of them are constrained. Here, the authors introduce a novel architecture called ScoreNet for unconstrained ear recognition. The ScoreNet architecture combines a modality pool with a fusion learning approach based on deep cascade score-level fusion. Hand-crafted and deep learning methods can be used together under the ScoreNet architecture. The proposed method represents the first automated fusion learning approach and is also compatible with parallel processing [7]

Fusion of Geometric and Texture Features for Ear Recognition

Salman Mohammed Jiddah, Kamil Yurtkan

Authors publish that the field of ear recognition has been getting a lot of attention in recent years in biometric recognition systems field, which have seen a rise in interest in the present day, not only because it provides a better substitute for conventional identification and authentication systems, but also because of the high rise in global insecurities which makes the biometric research field a very active research field. The aim of this study is to contribute to the field of ear recognition by applying both texture and geometric features. This research in respect to its aims and objectives carried out experiments on AMI ear database by extracting the Local Binary Patterns features, and also applying Laplacian filter on the raw images separately to extract the geometric features. The ear database was processed by dividing ear images into four quarters and experimented on them individually in a pursuit of identifying the region of high interest in human ear images. Texture and geometric features are then fused and experiments were carried out on verifying the contribution of the fused features [8]

A Data-Augmented 3D Morphable Model of the Ear

Hang Dai, Nick Pears, William Smith

Authors propose that Morphable models are useful shape priors for biometric recognition tasks. Here authors present an iterative process of refinement for 3D Morphable Model (3DMM) of the human ear that employs data augmentation. The process employs the following stages 1) landmark-based 3DMM fitting; 2) 3D template deformation to overcome noisy over-fitting; 3) 3D mesh editing, to improve the fit to manual 2D landmarks. These processes are wrapped in an iterative procedure that is able to bootstrap a weak, approximate model into a significantly better model. Evaluations using several performance metrics verify the improvement of our model using the proposed algorithm. Authors use this new 3DMM model-booting algorithm to generate a refined 3D morphable model of the human ear, and authors make this new model and our Augmented Training Dataset Public [9]

Ear Recognition in 3D using 2D Curvilinear Features

Iyyakutti Iyappan Ganapathi, Surya Prakash, Ishan Rajendra Dave, Piyush Joshi, Syed Sadaf Ali1, Akhilesh Mohan Shrivastava

Authors present a novel approach for human recognition using co-registered three-dimensional (3D) and 2D ear images. The proposed technique is based on local feature detection and description. The authors detect feature key-points in 2D ear images utilizing curvilinear structure and map them to the 3D ear images. Considering a neighborhood around each mapped key-point in 3D, a feature descriptor vector is computed. To match a probe 3D ear image with a gallery 3D ear image for recognition, first highly similar feature key-points of these images are used as correspondence points for an initial alignment. Afterwards, a fine iterative closest point matching is performed on entire data of the 3D ear images being matched. An extensive experimental analysis is performed to demonstrate the recognition performance of the proposed approach in the presence of noise and occlusions, and compared with the available state-of-the- art 3D ear recognition techniques [10]

Towards Accessories-Aware Ear Recognition

Ziga Emer, Nil Oleart Play, Vitomir Struc, Peter Peer

Authors try to close this gap and study the impact of ear accessories on the recognition performance of several state-of-the-art ear recognition techniques. Authors consider ear accessories as a tool for spoofing attacks and show that CNN-based recognition approaches are more susceptible to spoofing attacks than traditional descriptor-based approaches. Furthermore, authors demonstrate that using imprinting techniques or average coloring can mitigate the problems caused by ear accessories and slightly outperforms (standard) black color to mask ear accessories. Automatic ear recognition is gaining popularity within the research community due to numerous desirable properties, such as high recognition performance, the possibility of capturing ear images at a distance and in a covert manner, etc. Despite this popularity and the corresponding research effort that is being directed towards ear recognition technology, open problems still remain. One of the most important issues stopping ear recognition systems from being widely available are ear occlusions and accessories. Ear accessories not only mask biometric features and by this reduce the overall recognition performance, but also introduce new non-biometric features that can be exploited for spoofing purposes. Ignoring ear accessories during recognition can, therefore, present a security threat to ear recognition and also adversely affect performance. Despite the importance of this topic there have been, to the best of our knowledge, no ear recognition studies that would address these problems [11].

Ear Detection in the Wild using Faster R-CNN Deep Learning

Susan El-Naggar, Ayman Abaza, Thirimachos Bourlai

Authors propose an ear detection system that uses Faster R-CNN. The training of the system is performed on two stages: First, an AlexNet model is trained for classifying ear vs. non-ear segments. Second, the unified Region Proposal Network (RPN) with the AlexNet, that shares the convolutional features, are trained for ear detection. The proposed system operates in real-time and accomplishes 98% detection rate on a test set, composed of data coming from different ear datasets. In addition, the system's ear detection performance is high even when the test images are coming from un-controlled settings with a wide variety of images in terms of image quality, illumination and ear occlusion. Authors publish that ear recognition has its advantages in identifying non-cooperative individuals in unconstrained environments. Ear detection is a major step within the ear recognition algorithmic process. While conventional approaches for ear detection have been used in the past, Faster Region-based Convolutional Neural Network (Faster R-CNN) based detection methods have recently achieved superior detection performance in various benchmark studies, including those on face detection [12].

Kernel Discriminant Correlation Analysis: Feature Level Fusion for Nonlinear Biometric Recognition

Yang Bai, Mohammad Haghighat, Mohamed Abdel-Mottaleb

Authors propose Kernel-DCA which generalizes DCA in order to handle nonlinear problems. Similar to Kernel-SVM, Kernel-DCA utilizes a kernel method to map feature sets to a high-dimensional space in which features are linearly separable. Experimental results, for the fusion of ear and face feature, using the WVU database with large variations in pose, show that Kernel-DCA achieves better results on nonlinearly distributed data than DCA and other feature fusion methods. In biometric recognition, feature fusion is an important area of research due to the fact that multiple types of features contain richer and complementary information. Discriminative Correlation Analysis (DCA) is a recently proposed feature fusion method, which incorporates the class association into correlation analysis so that the features not only have the maximum intrinsic correlation between feature sets but also have class structure information. However, DCA is a linear technique that finds a linear transformation of the original space. For highly nonlinearly distributed data, classification with nonlinear techniques works better than the linear ones [13].

METHODOLOGY :

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

Typical uses include:

1. Math and Computation
2. Algorithm Development
3. Modeling, Simulation and Prototyping
4. Data Analysis, Exploration and Visualization
5. Scientific and Engineering Graphics
6. Application Development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN. The name MATLAB stands for matrix laboratory. Today, MATLAB is the state-of-the-art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments; it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB: Features

Matlab is an interactive system for doing numerical computation. A numerical analyst called Cleve Moler wrote the first version of Matlab in the 1970s. It has since evolved into a successful commercial software package. Matlab relieves you of a lot of the mundane tasks associated with solving problems numerically. This allows you to spend more time thinking, and encourages you to experiment. Matlab makes use of highly respected algorithms and hence you can be confident about your results. Powerful operations can be performed using just one or two commands. You can build up your own set of functions for a particular application.

MATLAB: Toolboxes

MATLAB features a family of application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, image acquisition, image processing and many others.

MATLAB: System

The MATLAB system consists of five main parts:

1. Development Environment: This is the set of tools and facilities that help you use MATLAB functions and files. Many of these tools are graphical user interfaces. It includes the MATLAB desktop and Command Window, a command history, and browsers for viewing help, the workspace, files, and the search path.
2. The MATLAB Mathematical Function Library: This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigen-values, Bessel functions, and fast Fourier transforms.
3. The MATLAB language: This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both “programming in the small” to rapidly create quick and dirty throw-away programs, and “programming in the large” to create complete large and complex application programs.
4. Handle Graphics®: This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow you to fully customize the appearance of graphics as well as to build complete graphical user interfaces on your MATLAB applications.
5. The MATLAB Application Program Interface (API): This is a library that allows you to write C and FORTRAN programs that interact with MATLAB. It include facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

MATLAB: Starting and Quitting

(a) Starting MATLAB

On a Microsoft Windows platform, to start MATLAB, double-click the MATLAB shortcut icon on your Windows desktop.

(b) Quitting MATLAB

To end your MATLAB session, select Exit MATLAB from the File menu in the desktop, or type quit in the Command Window. To execute specified functions each time MATLAB quits, such as saving the workspace, you can create and run a finish.m script.

MATLAB: The Desktop

When you start MATLAB, the MATLAB desktop appears, containing tools (graphical user interfaces) for managing files, variables, and applications associated with MATLAB (Fig 1.2).

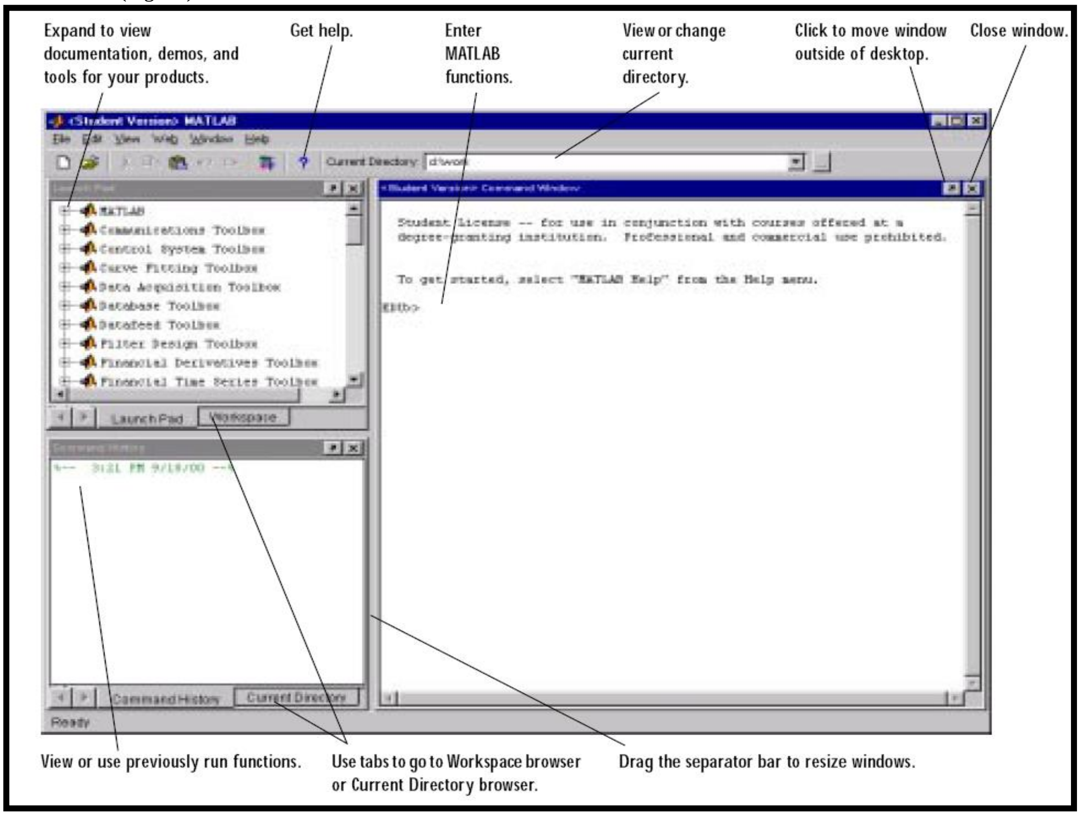


Fig.1.2 MATLAB Desktop View

The desktop includes these panels:

1. Current Folder — Access your files.
2. Command Window — Enter commands at the command line, indicated by the prompt (>>).
3. Workspace — Explore data that you create or import from files.
4. Command History — View or rerun commands that you entered at the command line.

As you work in MATLAB, you issue commands that create variables and call functions. For example, create a variable named a by typing this statement at the command line [5].

MATLAB Image Processing Toolbox

Image Processing Toolbox provides a comprehensive set of reference-standard algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. You can perform image enhancement, image de-blurring, feature detection, noise reduction, image segmentation, geometric transformations, and image registration. Many toolbox functions are multithreaded to take advantage of multicore and multiprocessor computers.

Image Processing Toolbox supports a diverse set of image types, including high dynamic range, gig pixel resolution, embedded ICC profile, and homographic. Graphical tools let you explore an image, examine a region of pixels, adjust the contrast, create contours or histograms, and manipulate regions of interest (ROIs). With toolbox algorithms you can restore degraded images, detect and measure features, analyze shapes and textures, and adjust colour balance.

Key Features

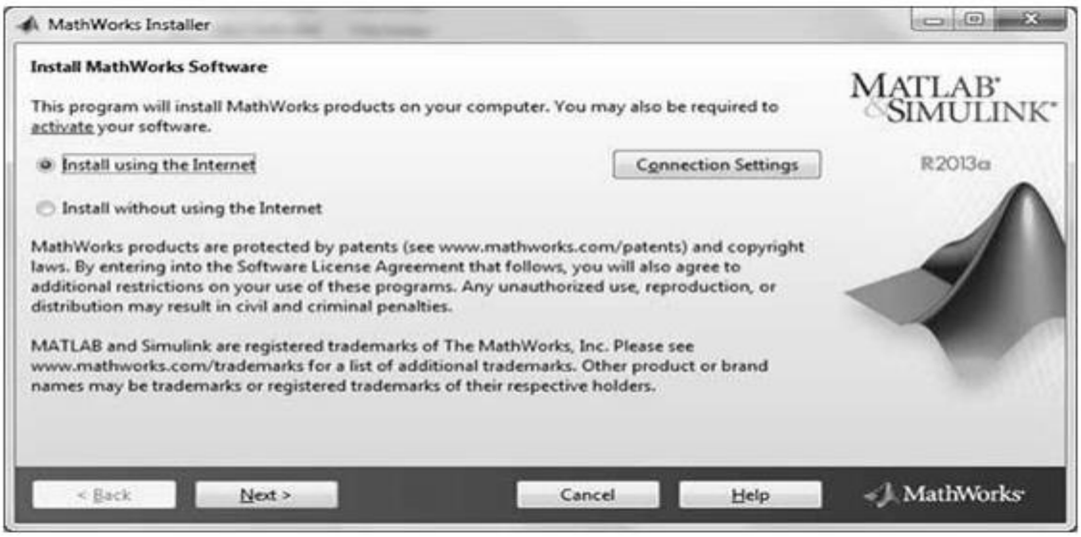
- Image enhancement, filtering, and de-blurring.
- Image analysis, including segmentation, morphology, feature extraction, and measurement.
- Spatial transformations and image registration.
- Image transforms, including FFT, DCT, Radon, and fan-beam projection.
- Workflows for processing, displaying, and navigating arbitrarily large images.
- Modular interactive tools, including ROI selections, histograms, and distance measurements.
- ICC colour management.
- Multidimensional image processing.
- Image-sequence and video display.
- DICOM import and export [14].

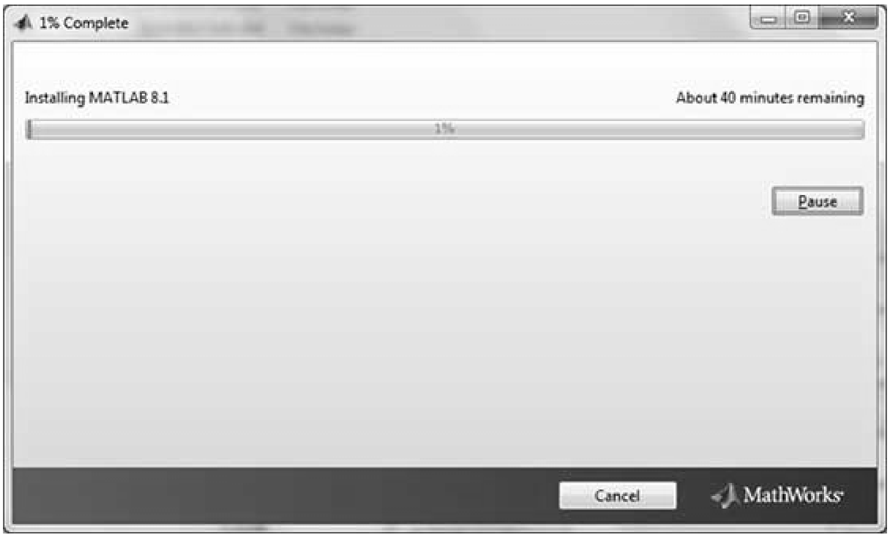
RESULTS AND DISCUSSION :

MATLAB (matrix laboratory) is a fourth-generation high-level programming language and interactive environment for numerical computation, visualization and programming. MATLAB is developed by MathWorks. It allows matrix manipulations; plotting of functions and data; implementation of algorithms; creation of user interfaces; interfacing with programs written in other languages, including C, C++, Java, and FORTRAN; analyze data; develop algorithms; and create models and applications. It has numerous built-in commands and math functions that help you in mathematical calculations, generating plots, and performing numerical methods [15].

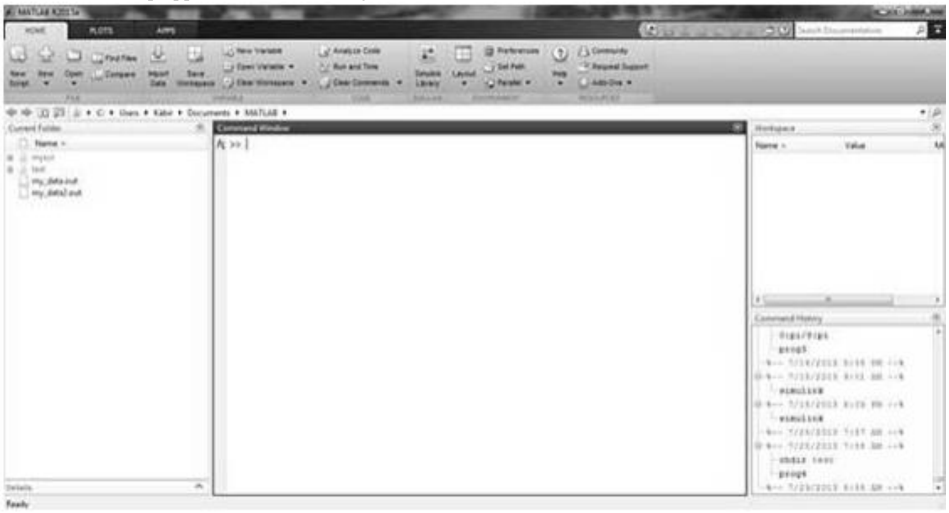
MATLAB's Power of Computational Mathematics MATLAB is used in every facet of computational mathematics. Following are some commonly used mathematical calculations where it is used most commonly: Dealing with Matrices and Arrays• 2-D and 3-D Plotting and graphics• Linear Algebra• Algebraic Equations• Non-linear Functions• Statistics• Data Analysis• Calculus and Differential Equations• Numerical Calculations• Integration• Transforms• Curve Fitting• Various other special functions. MATLAB is widely used as a computational tool in science and engineering encompassing the fields of physics, chemistry, math and all engineering streams. It is used in a range of applications including: signal processing and Communications• image and video Processing• control systems• test and measurement• computational finance• computational biology [16]

Setting up MATLAB environment is a matter of few clicks. The installer can be downloaded from http://in.mathworks.com/downloads/web_downloads: MathWorks provides the licensed product, a trial version and a student version as well. You need to log into the site and wait a little for their approval. After downloading the installer the software can be installed through few clicks.





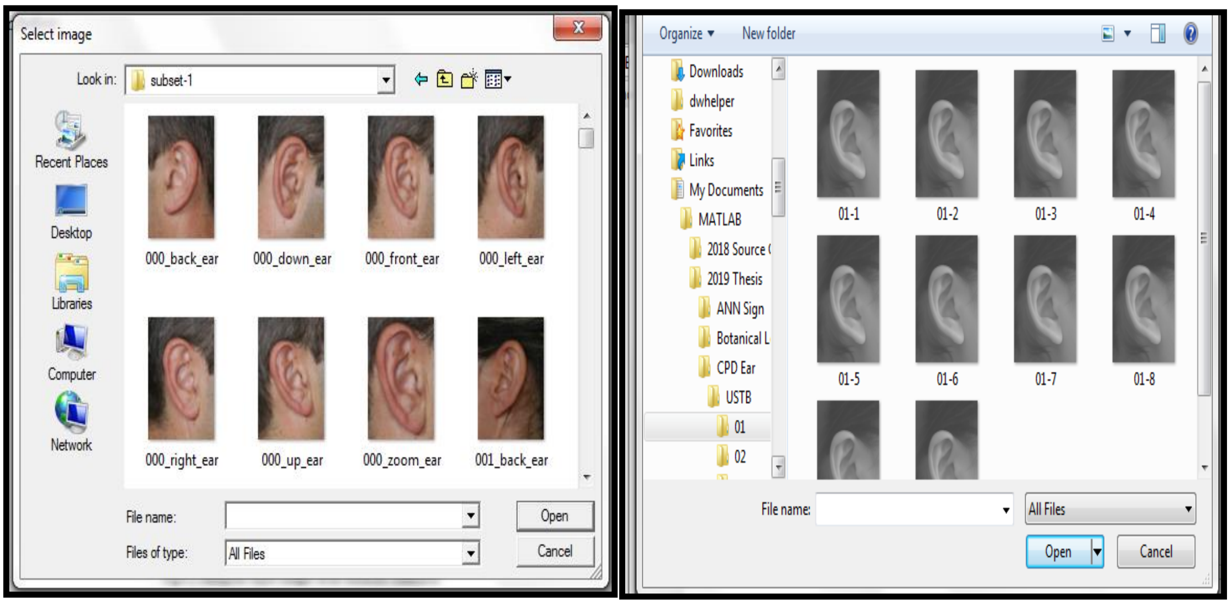
MATLAB development IDE can be launched from the icon created on the desktop. The main working window in MATLAB is called the desktop. When MATLAB is started, the desktop appears in its default layout:



ANN-STATISTICAL EAR RECOGNITION: DATABASE IMAGES

The ear database snapshot from which the input image has to be selected is shown in Fig 1.3

Fig. 1.3 Ear Database Images: AMI Database (left) and USTB Database (right)



The AMI Ear Database consists of color ear images in .jpg/.jpeg file format and USTB Ear Database consists of grayscale ear images in .bmp i.e. Bitmap file format. The color input image from database is converted to grayscale and opened in MATLAB for AMI Ear Dataset. The snapshot of the image is shown in Fig. 1.4

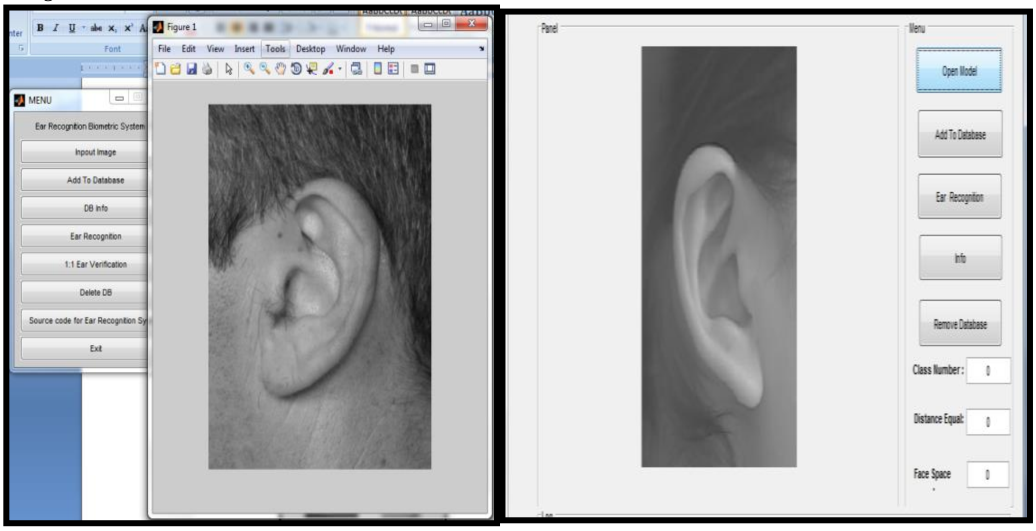


Fig.1.4 Ear Input Image after grayscale conversion operation in MATLAB: AMI Database (left) and USTB (right)

ANN-STATISTICAL EAR RECOGNITION: ONE TO MANY MATCHING

The MATLAB Command window showing ear recognition results with Nearest Class, Euclidean Distance, Distance from ear space values for 1:N Matching. Fig. 1.5 and Fig. 1.6 shown MATLAB command window

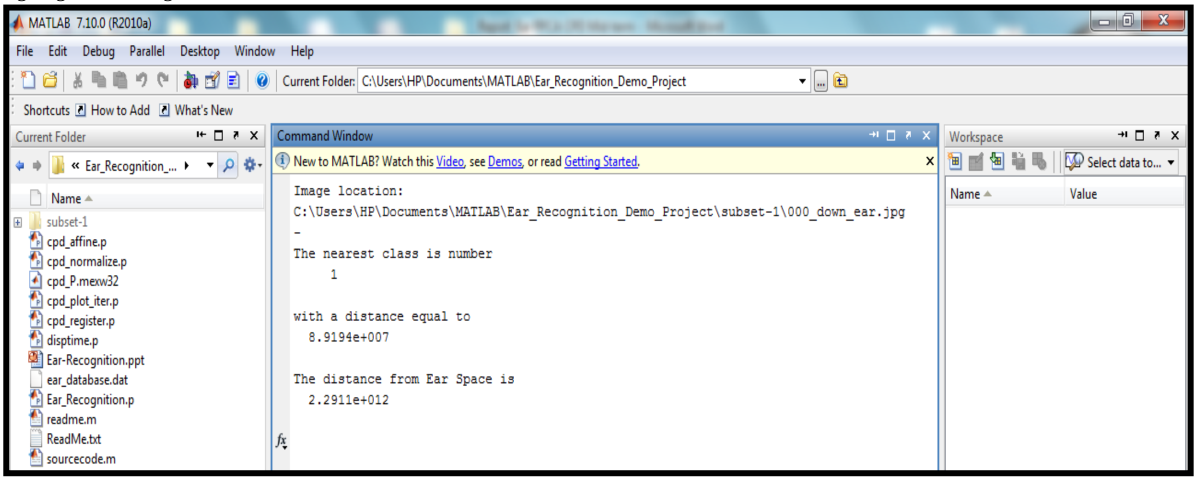


Fig. 1.5 MATLAB Command Window: Hybrid ANN-Statistical Ear Recognition (1: N) Result in MATLAB Command Window

Fig. 1.6 MATLAB Command Window: Hybrid ANN-Statistical Ear Recognition (1: N) Result in MATLAB GUIDE GUI

ANN-STATISTICAL EAR VERIFICATION: ONE TO ONE MATCHING

The MATLAB Command window showing CPD based Ear Verification results for 1:1 matching. Diagram shown in Fig. 1.7, 1.8 and 1.9 showed MATLAB command Window .

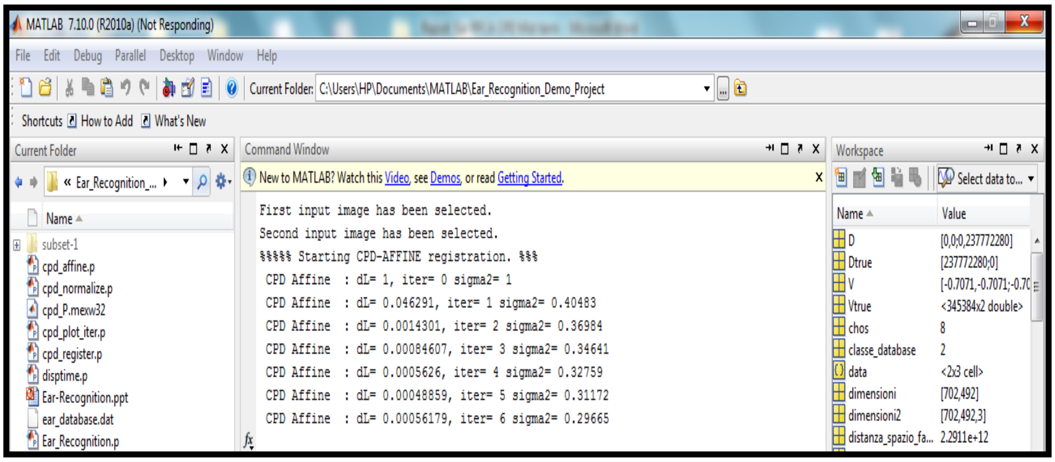


Fig. 1.6 MATLAB Command Window: Hybrid ANN-Statistical Ear Recognition (1:1) CPD Result Iterations under process

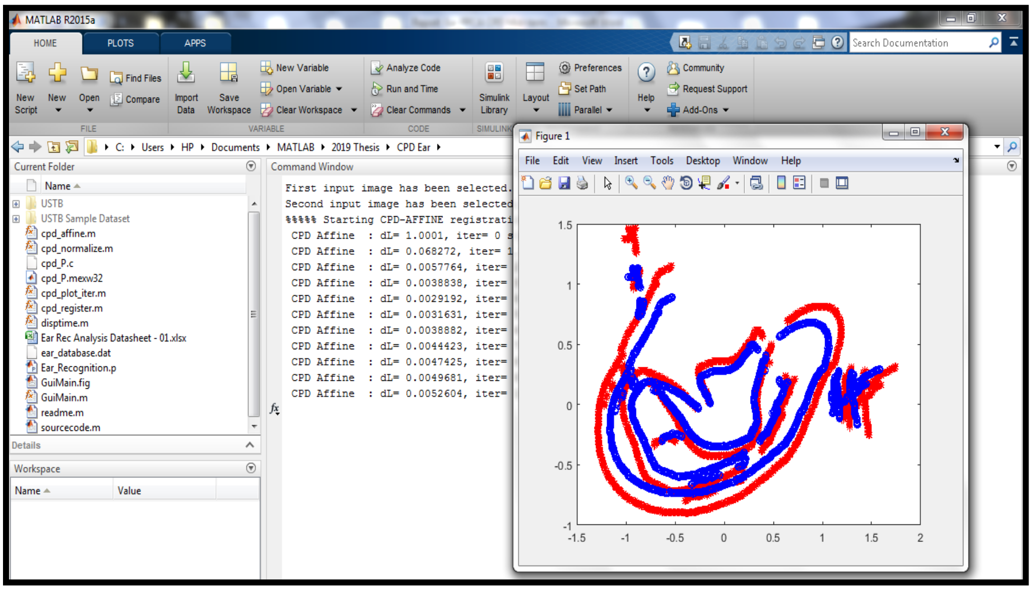


Fig. 1.8 MATLAB Command Window: Hybrid ANN-Statistical Ear Recognition (1:1) CPD under process

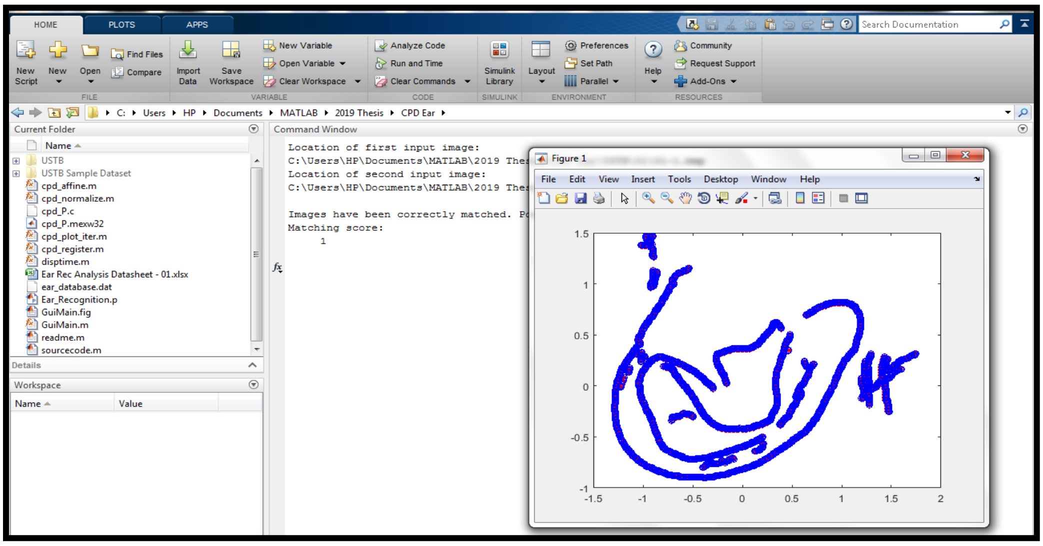


Fig. 1.9 MATLAB Command Window: Hybrid ANN-Statistical Ear Recognition (1:1) CPD Process Completed

ANN-STATISTICAL EAR RECOGNITION: PERFORMANCE ANALYSIS

The Performance Analysis is done by statistical and graphical comparison and evaluation of parameters like Euclidean Distance, Ear Space Distance, and Matching outputs for class, Average Euclidean Distance and Average Ear Space Distance per class, % Accuracy for matching. These parameters belong to the PPCA technique for one-to-many (1: N) matching criteria for a total of 410 input ear images including 210 images from AMI Ear Database and 200 images from USTB Ear Database. The CPD technique involves parameter like Delay time, no. of iterations, sigma and duration for coherent point detection for one-to-one (1: 1) matching criteria.

Training of Neural Network using MATLAB (nntraintool) for 30000 iterations is shown in figure 1.10 and 1.11

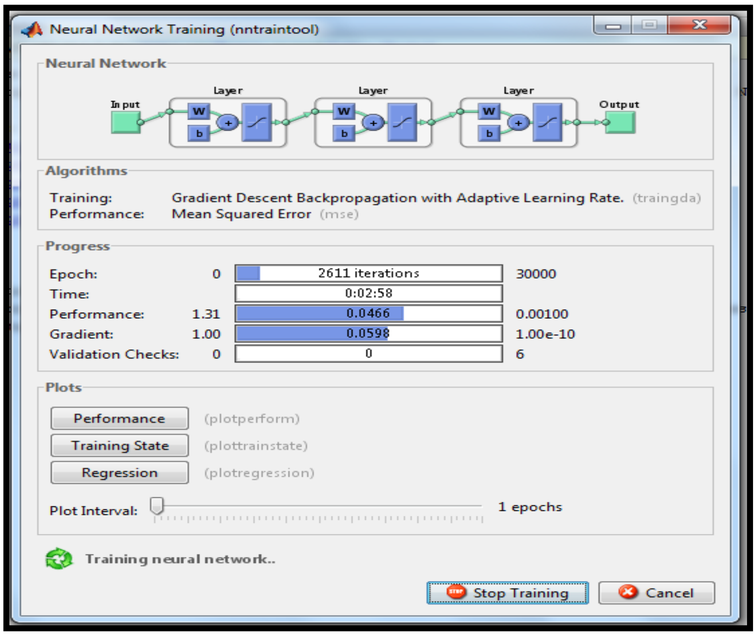


Fig.1.10 Hybrid ANN-Statistical Ear Recognition: ANN Training using MATLAB

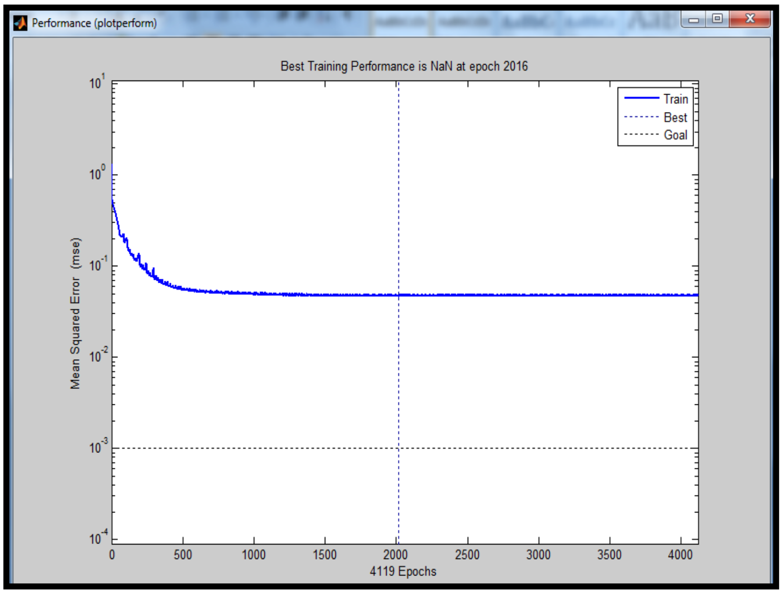


Fig.1.11 Hybrid ANN-Statistical Ear Recognition: ANN Training using MATLAB (MSE)

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