



## Machine Learning Based Mammogram Classification for Breast Cancer Diagnosis Using Neural Networks

R. Akashraj<sup>1</sup>  
A. Muthukumaravel<sup>2</sup>

EMAIL :

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<sup>1</sup>Master of Science, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, India.

<sup>2</sup>Dean -Arts & Science, Department of Computer Science, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, India. [dean.arts@bharathuniv.ac.in](mailto:dean.arts@bharathuniv.ac.in)

**ABSTRACT:** Among females, breast cancer is high as a major killer. Breast cancer is easily diagnosed when anomalies are spotted in their earliest stages. Accurately diagnosing breast cancer and treating patients as soon as possible will be facilitated by effective diagnostic technologies. Experiments were performed to determine if breast cancers were benign or malignant using data from the Wisconsin Diagnosis Breast Cancer database. To do this, we employ the supervised learning algorithm Support Vector Machine (SVM) with kernels such as Linear and Neural Networks (NN). Comparing the models' results reveals that the Neural Network technique is more "accurate" and "precise" than the Support Vector Machine in the categorization of breast cancer and appears to be a quick and efficient method.

**Keywords:** Machine Learning, Mammogram, Breast Cancer, Diagnosis, Neural Networks, Support Vector Machine

### INTRODUCTION

Breast cancer kills many women. Early breast abnormalities help radiologist diagnose breast cancer. Efficient breast cancer diagnostic techniques enable doctors make accurate diagnoses and treat patients quickly [1]. In this study, breast cancer was classified using the Wisconsin Diagnosis Breast Cancer database. Support Vector Machine (SVM) with Linear and Neural Networks (NN) kernels are utilised for comparison. Neural Networks deliver higher 'accuracy' and 'precision' than SVMs in breast cancer categorization. ANN appears quick and effective. Our project employed these algorithms: Existing SVM and suggested ANN are compared for accuracy [2-5]. Semi-supervised learning has gained popularity because it reduces the need for huge labelled datasets to train deep neural network models. Getting tagged data can be expensive and/or time-consuming [6-12]. Labeling or segmenting massive medical imaging data requires professional radiologists or technologists. Segmenting each Imaging techniques fall into two categories: analogue and

digital. Hard copies, such as printouts and photographs, can benefit from analogue or visual image processing methods [13-19]. When analysing images, analysts rely on a wide range of interpretation principles [20]. The field of image processing encompasses more than just the expertise of analysts, though that is certainly important. Visual association is another powerful technique used in image processing [21-26]. Because of this, analysts use a mix of their own expertise and other data while analysing images. As the raw data from imaging sensors on satellite platforms has flaws, digital processing techniques help modify digital images with the use of computers [27-31]. To overcome these issues and obtain authentic data, it must go through several stages of processing [32-38]. When dealing with digital technology, there are three main steps that must be taken before any type of data can be used: pre-processing, enhancement and presentation, and information extraction [39-45]. Figure 1 shows the image processing hierarchy [46].



Fig.1: Hierarchy of Image Processing [1]

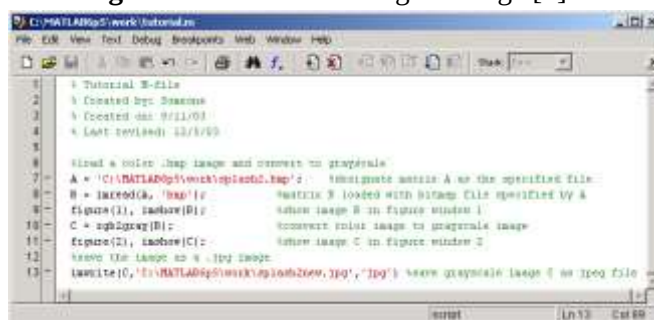
### Images in Matlab

Knowing that a digital image is made up of a two- or three-dimensional matrix of pixels is the first step in processing digital images with MATLAB [47-52]. Each pixel in a picture stores a number or integers that denote its hue, saturation, and lightness. Depending on the colour representation technique, colour images can have up to three times the amount of information of grayscale images [53-61]. As a result, the amount of computing power required to process a colour image is three times that of a monochrome one. In this article, we will show you how to change colour photographs into grayscale so that we can work with them more easily. However, we will start with the analysis of basic two-dimensional 8-bit matrices to learn how image processing works [62-71].

### Writing an Image

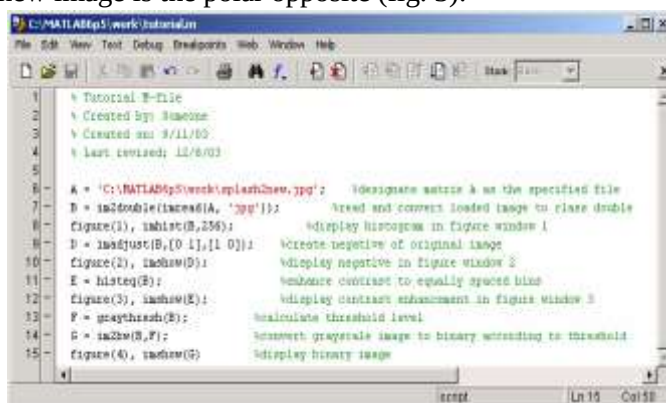
It is often necessary to save a picture so that it can be moved to a disc or opened in a different application [72]. As opposed to reading an image from a file, which is what you would normally do, you would save it to a file. The write command in MATLAB is what you need to get the job done [73-75]. Using this command, you can save a picture in any of the formats recognised by MATLAB, which are identical to those recognised by reading [76]. Figure 2 illustrates the m-file image-saving procedure.

Figure 2: M-file for Saving an Image [2]



### Image Properties

To display the distribution of data, a histogram is used. Histograms are used in image processing to display the frequency distribution of pixel values. Using a histogram, it's possible to zero in on the most significant pixel values in an image [77-82]. You can use this information to customise the animation to your liking. It is possible to improve contrast and set a threshold with the help of histogram data [83]. The `hist` function can be used to produce a histogram from an image. The `histeq` function can be used to increase contrast, while the `greythresh` and `im2bw` functions can be used to set thresholds. Using the `imhist` operation on the image produced by `histeq` will display the resulting histogram of the contrast-enhanced image. To create a picture's negative involves inverting the original image. In an 8-bit image, the pixels that were previously valued at 0 become valued at 255, while the pixels that were previously valued at 255 become valued at 0. Everything in between the two extremes has its pixel value inverted [84-89]. When compared to the original, the new image is the polar opposite (fig. 3).



**Figure 3:** M-file for creating histogram, negative, contrast-enhanced, and binary images. [2]

### Median Filters

When it comes to cleaning up photos, a Median Filter can be a powerful tool. You might think of a median filter as a kind of average filter [90-94]. The pixel in question and its surrounding pixels' values are analysed by the averaging filter, which then calculates and returns an average. Similar pixels are examined by the median filter, but instead of a mean value, the median is provided. The median filter excels at disregarding huge disparities in pixel values, allowing for the removal of noise while preserving sharp edges [95-101]. Here, we see that when applied to the same data, not one but two median filters produce the same result. The median value of the target pixel and its neighbours is used by the first filter, `medfilt2`. The median value of the nine analysed pixels is returned. `ordfilt2` is a second filter that, in this setup, performs the same function. It is also flexible enough to be used for various filtering tasks [102-111]. This method examines all ninety-nine pixels in a 3x3 matrix and returns the fifth-ranked value, the median [112].

### Edge Detectors

When searching for specific objects in an image, edge detectors prove invaluable. We'll focus on two of the many edge detectors available: the Sobel and the Canny. The horizontal, vertical, or both can be searched for with the Sobel edge detector. In addition to picking up on all strong edges, the Canny edge detector can also locate any linked weak ones [113-120]. The binary images provided by these edge detectors have white edges on a black background.

The first technique involves use MATLAB special to generate the filter and `imfilter` to apply it to the image. The alternative approach involves calling the edge MATLAB function and passing it the appropriate edge detection method. First, the Sobel approach was utilised, and then the Canny method was used for edge detection. The top image shows the raw data, while the bottom image, labelled "Horizontal Sobel," was created by applying an `imfilter`. When applying the edge filter, the image with the label "Sobel" is the result of utilising the Sobel setting, whereas the image with the label "Canny" uses the Canny setting. The photographs' finer points were brought out with the `Zoom In` function [121-125]. The filter used to generate the Horizontal Sobel image, as can be seen, picks up horizontal edges far more easily than vertical ones. Edges in both the horizontal and vertical planes were picked up by the filter used to

generate the Sobel picture. Due to MATLAB's independent searches for horizontal and vertical edges and subsequent summation, this was the outcome [126]. The Canny picture is proof that the Canny technique can pick up on every edge. Unlike the Sobel approach, which only displays strongly connected edges, the Canny method displays all edges, regardless of their strength [127-131].

### **Project Introduction**

Cancer occurs when a clump of cells in one place of the body begins to grow and divide uncontrollably. Tumors are groups of rapidly dividing cells that can manifest as a variety of abnormalities, including a mass, calcifications, or alterations to the structure of the body. Breast cancer refers to a group of diseases characterised by the development of malignant tumours from breast cells [132-139]. Breast cancer ranks among the deadliest forms of the disease. More than 400,000 women worldwide lose their lives to breast cancer every year, according to the World Health Organization's International Agency for Research on Cancer (IARC). Breast cancer prevention is now very important, and this is mostly possible through awareness of the various risk factors. Second, identifying the various signs of this condition is crucial for early detection, which is when it is most amenable to treatment. There are two main subtypes of breast cancer: invasive and non-invasive [140-146]. Invasive breast cancer occurs when malignant cells invade surrounding healthy tissue and spread to other organs. When breast cancer is classified as non-invasive, malignant cells are contained to a single breast tissue area rather than spreading to neighbouring ducts or lobules [147]. In the last decade, advances in breast analysis techniques have allowed for more accurate diagnoses. Recently, we've seen the introduction of some automatic classification methods [148-151].

The outcomes of various methods vary. However, there are still problems that need to be addressed, such as the creation of more effective methods. When we compare systems, we learn which one is the most effective, which in turn helps radiologists make more precise diagnoses [152-157]. However, there is still some error introduced by radiologists while interpreting images. Therefore, the classifier is necessary for the goal of automatically interpreting images or for an automated categorization system. Neural Networks (NN) and Support Vector Machines (SVM) are two of the numerous methods currently in use for classification, although they often produce the best results. This paper contrasts NN with support vector machines [158].

When it comes to female cancers, breast cancer is by far the most prevalent and second-leading killer. Mammograms often show cancers and masses in the breast as dense areas. Unlike malignant tumours, which typically have a jagged, rough, and hazy perimeter, benign masses are typically round, smooth, and well-circumscribed. Screening mammography CAD systems provide radiologists with a second view by highlighting areas where a high malignancy risk is present. CAD's end goal is to provide pinpoint indication of these spots. Studies conducted on the topic so far tend to agree that CAD technology aids in the diagnosis of breast cancer at an early stage [159]. The creation and assessment of mammography CAD systems have been the subject of a lot of published work. The majority of the suggested system is structured in a hierarchical fashion. To begin, a mammography is prescreened by the CAD system to look for potentially problematic areas in the breast parenchyma. This initial step utilises a Gaussian smoothing filter, top hat operation for image improvement, and the original grey tone image, allowing for more sensitive lesion site selection using the improved images. The second step is to create a thresholding technique for tumour area segmentation. SVM is a learning machine that has been successful in many applications thanks to its generalisation ability, such as data classification, function approximation, etc. By increasing the distance between the hyperplane and the dataset, SVM is able to minimise the generalisation error and place a lower constraint on the error. The appropriate number of basis functions and their positions are automatically computed during training, giving SVM the added benefit of automatic model selection. SVM's efficiency is heavily reliant on the hardware's kernel.

### **System Study Feasibility Study**

In this stage, the project's viability is assessed, and a business proposal outlining the project's broad strokes and some preliminary cost estimates is presented. A feasibility assessment of the proposed system is to be conducted during system analysis. This makes sure the suggested solution won't cost the business too much. Feasibility analysis relies heavily on a thorough familiarity with the system's most pressing needs. A feasibility analysis delves into the nature



of the issue and the information requirements of the many parties involved. Its goal is to calculate how much time and money will be needed to implement an information systems solution, how much good it will do, and whether or not it's even possible. The purpose of the feasibility study is to examine potential solutions to the organization's information systems issues, assess their viability, and then recommend the most promising one. A solution's viability is determined by analysing each of its constituent parts.

#### **Economic Feasibility**

The purpose of the analysis is to determine how much money the system will cost the company. The corporation can only devote so many resources to the system's development at this time. All costs must be adequately explained. Because so many of the underlying technologies are open source, the designed system may be implemented without breaking the bank. The only things that were required to be bought were the personalised ones.

#### **Technical Feasibility**

The purpose of this research is to determine whether or not the technical specifications of the system are actually achievable. For technical feasibility, any new system can't place an excessive load on existing infrastructure. That will put a strain on our technological infrastructure. As a result, the client will have to meet stringent requirements. The developed system should have low requirements, as implementing it should involve few or no changes.

#### **Social Feasibility**

Examining how well received the system is by its end users is a key part of the research. Part of this is teaching the user how to get the most of the technology. Instead of feeling frightened by the system, the user should view it as something they need in order to function. User adoption is directly proportional to the effort put into familiarising and training each individual user. His self-assurance needs to be bolstered so that, as the system's end user, he can provide some constructive feedback, which is always appreciated.

#### **Operational Feasibility**

Willingness, ability, and interest of stakeholders to utilise, support, and run the proposed computer information system. Management, staff, customers, and vendors are all considered stakeholders. Stakeholders care about whether or whether a system is intuitive to use, prone to minimal mistakes, reliably generates the expected results, and consistent with the organization's goals.

#### **Existing System Support Vector Machine (SVM):**

The main process of the SVM is to identify an optimal hyperplane for many diverse cases in a high-dimensional space. More than one hyperplane exists so that this model holds true. The bolster vector is the data that is closest to the closed surface and aligns with the optimal choice surface, making it crucial to this procedure. It classifies data by plotting input vectors in a high-dimensional space and building the hyperplane to partition the information. Specifically, this method is employed to resolve a non-convex, unconstrained minimization problem and a quadratic programming problem. When it comes to classifier processes, SVM is superior.

#### **Proposed System Artificial Neural Network (ANN):**

Artificial neural networks (ANNs) are a specific type of neural network characterised by a temporal sequence graph formed by the links between nodes. In this way, it is able to display temporal dynamics in its behaviour. Adapted from feed-forward neural networks, these networks can interpret input sequences of varying lengths by drawing on their own internal state. Because of this, they can be used for things like speech recognition or the recognition of handwriting that is not segmented. In common parlance, the phrase "recurrent neural network" is used interchangeably for both finite- and infinite-impulse networks, both of which share some structural similarities. Time-varying behaviours are seen in both types of networks. An unrolled finite impulse recurrent network can be used in place of a conventional feed-forward neural network. As opposed to finite impulse recurrent networks, infinite impulse recurrent networks are unrollable directed cyclic graphs. Additional stored states are possible in both finite- and infinite-impulse recurrent networks, with storage managed entirely inside the neural network itself. You can also use a different network or graph in place of storage if it has time delays or feedback loops built in. Memory networks (LSTMs) and gated recurrent

units include such controlled states, which are referred to as gated or gated memory. Another name for this is a "Feedback Neural Network" (FNN).

#### **Data Dictionary**

Included in the database itself is a data dictionary. It saves metadata, or details about the database and the data it stores. You may find the adbmS-required database descriptions in the data dictionary. The data dictionary is typically an operational part of the DBMS. Each time a database is visited, the DBMS compares the query to the data dictionary. Due to the collaborative nature of database creation and maintenance, it can be difficult to communicate precisely what information can be entered into which fields. Therefore, a data dictionary is a useful adjunct for ensuring data uniformity. The creation of a data dictionary follows no universally accepted format. Each table has its own unique metadata. All that's required of a data dictionary is that it be searchable.

#### **System Implementation**

The building blocks of a system are created during the implementation phase (system breakdown structure). If the process to be implemented is one of production, it may be necessary to employ a manufacturing system that makes use of conventional techniques and administration methods. The purpose of the implementation process is to produce a system component that meets the specifications specified for that component during the design phase. The component is built using standard commercial methods. This phase connects the steps of defining the system to the phase of integrating it. System The implementation phase of a project is when the plan drawn out in the planning phase is put into action. Achieving a successful system and inspiring user faith that the new system will perform as intended is the most important step. Time was a major issue with the previous system. Matlab was used in the creation of the suggested system. Due to the current setup, transmission times were rather lengthy. Even so, the newly implemented system features a great user-friendly tool: a graphical user interface with a menu system. Project installation on the required system follows coding and testing. It is required to build the executable and run it. The code is retested in the production environment. The created code is implemented in the system as an executable file is installed.

#### **Module Description**

During the process of Image Acquisition, live breast images are taken. The size of the collected photos is controlled via cropping. During this phase of picture processing, the RGB images that were previously cropped are changed to grayscale. The third part is image segmentation. K-means filtering is used to divide the grayscale images into distinct regions. This aids in getting rid of issues like backdrops, lighting, etc. To facilitate categorization, images are segmented, and then features are extracted (either extracted or shown) from the segmented images. Classification, utilising both Tensor Flow and ANN, is included in the final module.

#### **Classification**

In this case, we employ an ANN-based categorization strategy. In this final section, we'll go into classification using methods from Tensor Flow and machine learning. The open-source tool for numerical computation Tensor Flow is compatible with MatLab and speeds up and simplifies machine learning. Dataflow graphs are structures that depict the flow of data across a graph or a set of processing nodes, and they may be created by developers using Tensor Flow. Each "node" in the graph stands for a different mathematical process, and each "edge" between "nodes" is a tensor or multidimensional data array.

#### **System Testing**

Testing's ultimate goal is to unearth flaws. When testing, we look for any and all issues that could compromise the quality of the final product. It's useful for verifying the operation of individual parts, whole assemblies, and even finished goods. Software testing is the practise of putting a programme through its paces to see that it doesn't break in unacceptable ways, as defined by the software's specifications and the needs of its intended users. There are many distinct kinds of examinations. Different kinds of tests are available to fulfil various needs.

#### **Types of Tests**

Unit testing

The goal of unit testing is to ensure that the internal logic of a programme is working as intended and that legitimate inputs will result in expected outputs. It's crucial to check the logic of all possible paths a programme could take. To put it simply, it's the process of verifying the functionality of the application's constituent parts. Before integrating, it is done after each individual unit is finished. Such intrusive structural testing requires specific information about the structure being tested. The purpose of a unit test is to validate a single business function, application, or system setup at the component level. Each branch of a business process should have its own set of unit tests to guarantee that it conforms to the stated standards and works as intended.

#### **Integration testing**

The goal of an integration test is to verify that all of a program's parts work together seamlessly. In testing, the focus is on the most fundamental results of screens and fields rather than on how they look. Even though each part was tested separately and found to be satisfactory, integration tests prove that the whole is reliable and consistent. The goal of integration testing is to reveal any issues that manifest due to the interaction of many parts.

#### **System Test**

When a software system is fully integrated, system testing is performed to ensure that the system as a whole is up to snuff. It puts a setup through its paces to make sure it always produces the same, reliable results. The configuration-oriented system integration test is a type of system test. The foundation of system testing is the documentation and modelling of processes, with an emphasis on the predetermined connections and interfaces between individual processes.

#### **White Box Testing**

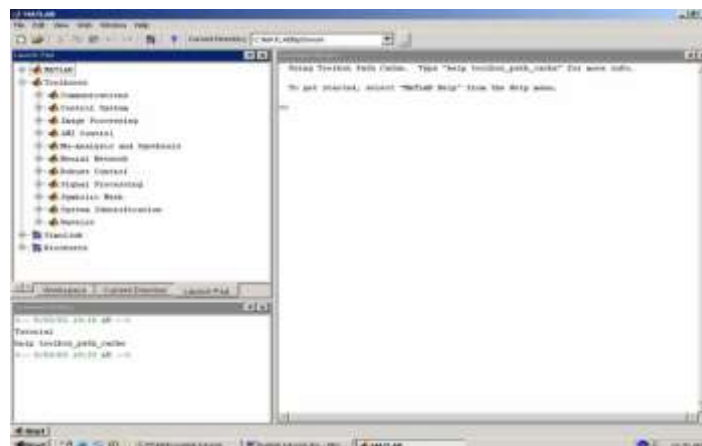
To perform White Box Testing, the software tester must be familiar with the program's design, implementation, and language, or at least its intended function. In other words, it's about having a reason for living. In other words, it probes inaccessible depths at the black box level.

#### **Black Box Testing**

Without knowing the specifics of the module being tested, or even the language it was written in, testers perform "black box" testing. Similarly to other types of testing, black box tests require a definite source document, such as a specification or requirements document, from which to derive their own implementation. Testing in which the target programme is ignored entirely. You simply can't "see" into it. Without taking into account how the software actually operates, the test simply offers inputs and reacts to outputs.

#### **Unit Testing:**

The software development life cycle often incorporates a code and unit test phase where unit testing is performed. However, it is usual practise to separate the coding stage from the testing stage. This course will introduce you to the MATLAB Image Processing Toolbox. All of MATLAB's capabilities are outside the scope of this guide. If you have any questions not covered in this guide, you can get answers by selecting HelpMATLAB Help from the MATLAB window's menu bar. This course heavily borrows from MATLAB's online documentation by presenting updated versions of the example found there (figure 4).



**Figure 4:** MATLAB window [2]

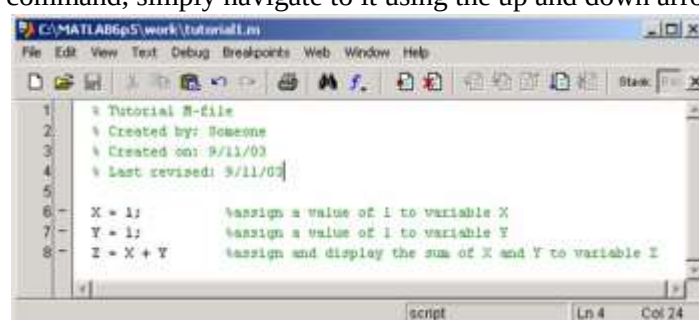
The right-hand window on the screen is the Command Window. This window is where you'll type commands for MATLAB to run, and it's also where you'll see the output of those commands. Recent commands typed into the Command Window are listed in the Command History window, located in the screen's bottom-left corner. There is a tabbed window in the top left corner of the screen that can hold up to three more windows. The first window is the Current Directory, which tells the user which M-files are currently in use. The second pane, labelled "Workspace," shows the size and scope of the currently active variables. The Launch Pad window, the third, is crucial since it provides quick access to the numerous toolboxes, including the Image Processing toolbox. If only two of the three windows are shown as tabs below the window space, click View and then choose the missing window. After the >> prompt, enter some code and hit return to move to the next prompt. A semicolon must be placed after a line of code if you do not want it to reappear in the MATLAB Command Window. If you don't end your code with a semicolon, it will appear in the command window directly beneath your typing.

Example 1:

`X = 1; %press enter to go to next line`  
`Y = 1; %press enter to go to next line`

`Z = X + Y %press enter to receive result`

`Z = 2`, as you may have seen, was MATLAB's response to your last line of input. If there had been a semicolon following the final statement, the answer would not have been shown. Additionally, the instructions you entered are displayed in the Command History window, and the variables you used are displayed in the Workspace Window. To reenter a previously entered command, simply navigate to it using the up and down arrows ( and ). (figure 5).



**Figure 5:** Example of M-file [2]

A pixelated image may be a value matrix. If you're developing a filter, for instance, you'll need a test subject, but a genuine image isn't required just yet. As a result, it's easy to generate a matrix with the specified qualities, such as high- and low-frequency regions. At other times, processing an image requires importing it into MATLAB from some other location. Assuming it is not crucial, you can use `rgb2gray` to convert a colour image to a black-and-white one (figure 6).



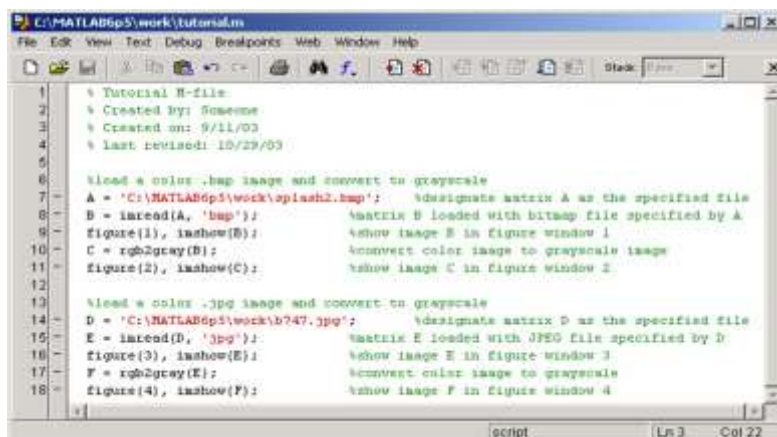


Figure 6: M-file for Loading Images [2]

### Frequency Domain

To understand how image processing filters function, you must first grasp how frequency impacts images. Images are two-dimensional discrete signals. Signals have frequencies. If grayscale values fluctuate little when you scan an image, it contains low-frequency material. If an image's grayscale values vary widely, it has greater frequency content. Let's put things in plain English. Any signal can be represented by sine waves of different frequencies, magnitudes, and phases, according to signal processing. Fourier transforms a signal into sinusoids. This collection of sine waves can be limitless if the signal is difficult to represent, but is often trimmed when adding more signals does not greatly increase signal resolution. In digital systems, we apply a Fourier Transform with discrete inputs, sampling rates, and discrete outputs. Discrete Fourier Transform (DFT) Fast Fourier Transform (FFT) is MATLAB's command for conducting a DFT. MATLAB's `fft2` does a 2-D FFT. In image processing, we may then determine a picture's frequency content. Uncertain? Image as a two-dimensional signal matrix. If you plotted just one row to illustrate each pixel's grayscale value, you'd get a bar graph with fluctuating values. This signal's pixels may not correlate. Fourier Transform determines signal frequencies. To see the frequency content of a Fourier Transform, view its absolute magnitude.

### Conclusion

In this study, we present a classification task model for breast cancer. There is discussion of using a Neural Network (NN) and Support Vector Machine (SVM) to determine if a breast tumour is benign or malignant. The accuracy and precision of NN and SVM were compared. In terms of accuracy and precision, the Neural Network approach used for classification in this research was found to be superior to that of SVM. According to the findings, the NN method outperforms the SVM method when it comes to identifying breast cancer. More sophisticated methods in Convolution Neural Networks will allow for more precise systems in the future.

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