# CRACK DETECTION ON CONCRETE SURFACES USING IMAGE PROCESSING

***A Project report submitted in partial fulfilment of the requirements for***

***the award of the degree of***

**BACHELOR OF ENGINEERING**

**IN**

**COMPUTER SCIENCE & ENGINEERING**

***Submitted by***


**K. SRI VARSHA (316126510022)** **P. SURYA TEJA (316126510041)**

**T. AKHIL (316126510055)** **U. BHAVANA (316126510056)**


**Under the guidance of**

**G. JAGADISH M. Tech (Ph.D.)**

**ASSISTANT PROFESSOR**



**DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING**

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY AND SCIENCES

(*Permanently Affiliated to AU, Approved by AICTE and Accredited by NBA & NAAC with 'A' Grade*)

Sangivalasa, Bheemili mandal, Visakhapatnam dist. (A.P)


2019-2020

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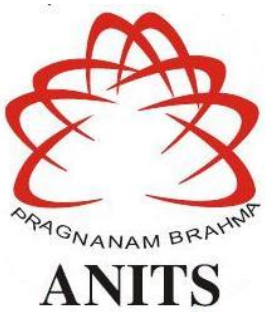


# CERTIFICATE

*This is to certify that the project report entitled* "**CRACK DETECTION ON CONCRETE SURFACES USING IMAGE PROCESSING"** submitted by **K.SRI VARSHA (316126510022), P.SURYA TEJA (316126510041), T.AKHIL (316126510055), U.BHAVANA (316126510056)** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science & Engineering** of Anil Neerukonda Institute of Technology and Sciences, Visakhapatnam is a record of bona fide work carried out under my guidance and supervision.

**Project Guide**

**G. Jagadish**
Asst. Professor
Department of C.S.E
ANITS

**Head of the Department**

**Dr. R. Sivaranjani**
Department of C.S.E
ANITS

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**PROJECT STUDENTS**

**K. SRI VARSHA (316126510022)**
**P. SURYA TEJA (316126510041)**
**T. AKHIL (316126510055)**
**U. BHAVANA (316126510056)**

# ABSTRACT

Due to environmental changes and poor quality of construction materials, cracks may develop in the walls of the building which is critical for maintenance as well as the continuous exposure will cause the severe damage to the environment. One of the initial signs of the degradation of a concrete surface or a material is cracks. Manual inspection has many drawbacks like invisibility of the crack, time consuming and it completely depends upon specialist's knowledge and experience. So automatic image-based crack detection is used as replacement for manual inspection which reduces the cost when compared to the manual approach. The proposed algorithm has been tested against various concrete crack images to study how effectively the algorithm is working, and how effectively it is overcoming the drawbacks of the present manual approach. The algorithm is projected to serve the purpose of various people by estimating the parameters of the crack so the bricklayer can take the necessary actions from the degradation of concrete structures.



**Keywords** - Construction Materials, Degradation, Crack, Manual Inspection, Image-Based detection

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# 1. INTRODUCTION

## 1.1 INTRODUCTION

Image processing is any form of processing for which the input is an image, such as a photograph or video frame. The output of Image Processing can be either an image or a set of characteristics or parameters related to an image. The fundamental principle of Image processing operations carried out will assist us its greater perception and vision but doesn't add any information content the recent availability of sophisticated semi-conductor digital devices and compact powerful computers coupled with advances in Image processing algorithms has brought Digital Image processing to the fore front. Digital Image processing has a broad spectrum. It has varied applications such as remote sensing via satellites and other space craft image transmission and automates inspection of industrial paths storage for business applications, medical processing, radars and acoustic image processing robotics. Image processing is necessary because human beings are adept at interpreting images of certain threshold beyond which we cannot detect just noticeable differences in the imagery. Human beings can detect only 8 to 16 shades of grey, even when data is recorded with 256 shades of grey. Therefore, one may not be able to interpret data in the remaining shades of grey. Also, it is necessary to continuously track large amounts of data and its storage is a problem. To avoid all these difficulties, one shall prefer processing of images by digital computers which processes at a much faster rate than human beings do.

Major requirement of image enhancement is to restore a captured image from degradations arising from imperfect acquisition conditions. For example, to remove the noise imposed, to correct the colour cast and to sharpen the objects that appear in the image. To restore an image to improve

its contrast so that it is pleasant to a human viewer is one of the most demanding features. Image processing is a method to convert an image into digital form and accomplish some operations on it, in order to get and enhanced image or to extract some useful information's from it. It is a type of signal dispensation in which input is image like video frame or photograph and output may be an image or characteristics associated with that image. Usually image processing system includes treating images as two-dimensional signals while applying already set signalling processing to them.

Image processing is among rapidly technologies today, with its applications in various aspects of business. Image processing forms core research area within engineering and computer science disciplines too.

Image processing basically includes the following three steps.

- Importing the image with optical sensor or by digital photography.
- Analyzing and manipulating the image which includes data compression and image enhancement.
- Output is the last stage in which result can be altered image or report that is based on image analysis.

### 1.1.1 Image Processing steps

1. Importing the image via image acquisition tools.

2. Analysing and manipulating the image.

3. Output in which result can be altered image or a report which is based on analysing that image.

### 1.1.2 What is an Image?

An image is defined as a two-dimensional function, F (x, y), where x and y are spatial coordinates, and the amplitude of 'F' at any pair of coordinates (x, y) is called the intensity of that image at that point. When x, y, and amplitude values of 'F' are finite, we call it a digital image.

In other words, an image can be defined by a two-dimensional array specifically arranged in rows and columns.

Digital Image is composed of a finite number of elements, each of which elements have a particular value at a particular location. These elements are referred to as picture elements, image elements, and pixels. A Pixel is most widely used to denote the elements of a Digital Image.

### 1.1.3 Representation of an Image

As we know, images are represented in rows and columns we have the following syntax in which images are represented:

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & f(0,2) & \dots & f(0,N-1) \\ f(1,0) & f(1,1) & f(1,2) & \dots & f(1,N-1) \\ \vdots & \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & f(M-1,2) & \dots & f(M-1,N-1) \end{bmatrix}$$

The right side of this equation is digital image by definition. Every element of this matrix is called image element, picture element, or pixel.

### 1.1.4 Types of Images

1. BINARY IMAGE– The binary image as its name suggests, contain only two-pixel elements i.e. 0 & 1, where 0 refers to black and 1 refers to white. This image is also known as Monochrome.

2. BLACK AND WHITE IMAGE– The image which consist of only black and white colour is called BLACK AND WHITE IMAGE.

3. 8-bit COLOUR FORMAT– It is the most famous image format. It has 256 different shades of colours in it and commonly known as Grayscale Image. In this format, 0 stands for Black, and 255 stands for white, and 127 stands for grey.

4. 16-bit COLOUR FORMAT– It is a colour image format. It has 65,536 different colours in it. It is also known as High Colour Format. In this format the distribution of colour is not as same as Grayscale image. A 16-bit format is actually divided into three further formats which are Red, Green and Blue which is the famous RGB format.

### 1.1.5 WHY CONCRETE CRACKS?

Cracks are of major concern for ensuring the safety, durability, and serviceability of structures. The reason is that when cracks are developed and propagate, they tend to cause the reduction in the effective loading area which brings about the increase of stress and subsequently failure of the concrete or other structures. Since there always exist constraints in ferro concrete structures and buildings deteriorate overtime, cracking seems unavoidable and appears altogether sorts of structures, for instance, concrete wall, beam, slab, and brick walls. Particularly for concrete elements, cracks create access to harmful and corrosive chemicals to penetrate the structure, which consequently damage their integrity as well as aesthetics. Primarily the basic question is Why Concrete Cracks?

Concrete does not require much water to achieve maximum strength, however, a much of concrete used in residential pours tends to possess an excessive amount of water added to the concrete on the job site. This excess water will, however, greatly reduce the strength of the concrete. Water-Cement ratio must be in between 0.45 to 0.60 for the better concrete material, if any changes in the water to cement ratio then there will be a chance of degradation of concrete surfaces.

**APPLICATIONS**:

Almost in every field, digital image processing puts a live effect on things and is growing with time to time and with new technologies.

1. Image sharpening and restoration-It is the process in which we can modify the image. We can convert the colour image to grey image, sharpening, enhancement of the image, detecting edges, and recognition of images.

2. Medical Field-Now a days if we have brain tumour through the image processing the tumour is detect that where the tumour is. Also, it is used to detect any kind of cancer. Xray imaging, medical CT Scan, UV imaging depends on the functioning of digital image processing.

3. Robot -Vision-There are several robotic machines which work on this technique. Through this technique robots find their ways. Like they can detect the hurdle and line follower robot.

4. Pattern- recognition-It involves study of image- processing. It is also combined with the artificial intelligence such that computer-aided diagnosis, handwriting- recognition and images- recognition can be easily implemented.

5. Video processing-The collection of frames and pictures are arranged in such a way that movement of pictures become faster. It involves frame rate, motion detection, reduction of noise and colour space conversion etc.

**ADVANTAGES AND DISADVANTAGES**:

Advantages

1. Processing of images are faster. It requires less time to process the image. There is no need of films and other photographic equipment.

2. Interactive method for detecting face, recognizing fingerprints, detecting cancer.

3. It is eco-friendly process since it does not require chemicals while processing images.

4. We can change the quality of image. We can compress, enhance, quality of image produced are good.

5. Image can be made in any required format.

6. Now a days each and every book is available on the digital stage. The demand and needs of people are changing so having optimized digital book is need of today's generation so the digital image processing plays vital role in publishing world.

7. Errors in images can easily be rectified.

8. It analyse blood cells and their composition in our body.

9. Through this technique robots can detect their visions.

10. It also helps in pattern recognition.

Disadvantages

1. It is more time consuming.

2. It is cost effective.

3. More complex program are required for implement digital image processing.

## 1.2 PROBLEM STATEMENT

The objective of the project is to identify the cracks on the concrete surfaces and to estimate the parameters of the crack. Using this calculated information builders can easily estimate the strength of any concrete structure and take immediate necessary action. Concrete is a quasi-brittle material with a low tensile strength. Applied loadings, deleterious chemical reactions and environmental effects can result in the development of tensile stress in concrete. When these tensile stresses exceed the concrete tensile strength, the concrete will crack. The extent and size of cracks influence the performance of the bridges and buildings. Although this cracking can be reduced by proper selection of concrete constituent materials, some cracking is inevitable.

## 1.3 MOTIVATION FOR THE WORK

Image Processing at present is used in various applications. It is fascinating and exciting area to be involved today. Visual Information, transmitted in the form of digital image is becoming a major method of communication in modern age. Image Processing in future can be widely in recognition and aware of cancer tumors and helps in prevention of diseases by making the person aware. Digital Image Processing deals with manipulation of digital images through a digital computer. It is a subfield of signals and systems but focus particularly on images. Digital Image Processing focuses on developing a computer system that is able to perform processing on an image. The input of the system is a digital image and the system process that image using efficient algorithms, and gives us an output.

There are various types of tasks in Image Processing which includes Image Acquisition, Storage, Transmission; Image enhancement and Restoration; Image understanding and Recognition. All of these play an important role in the real world. Out of them, Image enhancement plays a vital role in various fields. Enhancements are used to make it easier for visual interpretation and understanding of imagery. The advantage of digital imagery is that it allows us to manipulate the digital pixel values in an image. An image ‘enhancement’ is basically anything that makes it easier or better to visually interpret an image. Also, an enhancement is performed for a specific application. This enhancement may be inappropriate for another purpose which would demand a different type of enhancement.

# 2. LITERATURE SURVEY

## 2.1 CRACK CLASSIFICATION

Cracks can be broadly classified into two categories namely active and dormant. In active cracks, the change in direction, width or depth occurs over a measured period whereas in dormant cracks it remains unchanged. If left unrectified, both active and dormant cracks provide passage for moisture penetration, which can lead to future damage. Some of the active cracks are longitudinal crack, transverse crack, miscellaneous crack, crocodile crack and reflection crack. Dormant cracks are very fine in nature and auto healing occurs over a time period. The various types of crack based on their structure are micro crack, thin crack, sealed crack, mixed crack, line-like crack, minor crack, tiny crack, medium crack, large crack and complex crack.

Crack classification is an approach to find the specific crack type using machine learning algorithms. Crack detection identifies or recognizes the presence of crack whereas crack classification classifies the crack based on the feature extracted from the crack region. Machine learning is a subfield of Artificial Intelligence (AI), useful to perform classification, prediction and clustering of the dataset depends on the application. Classification/Prediction is carried out using supervised learning algorithms whereas clustering is carried out using unsupervised algorithms. The different types of supervised learning algorithms applied for crack classification are Support Vector Machine (SVM), K Nearest Neighbours algorithm (KNN).

In underwater dam, it is difficult to detect and classify the cracks. Hence, solar images are used to detect and classify crack into tiny, medium and large using tensor voting method. Salari and Ouyang stated that images

not only contains a concrete segment, but also includes other complicated background components. Crack in the pavement images with complicated background components such as trees, houses, etc. are also detected and classified using SVM, fractal thresholding and radon transform. Some of the images require pre-processing techniques for effective results. It includes wiener filter to remove the blurriness and reduction method to reduce the noise. Chen et al. classifies the bridge crack into vertical, longitudinal, reflexive and crocodile cracks using SVM. Fuzzy clustering method, Nouha Ben et al. is useful when the input regions can't be defined clearly and precisely. As a combination of Fuzzy clustering method, k-means thresholding, segmentation, de-nosing, morphological operation and skeletonization gives an accuracy of 82% for pavement crack.

A detailed review based on crack type has been done for crack detection and classification. The first level crack types (minor, moderate and severe) and its appropriate subtypes are shown.

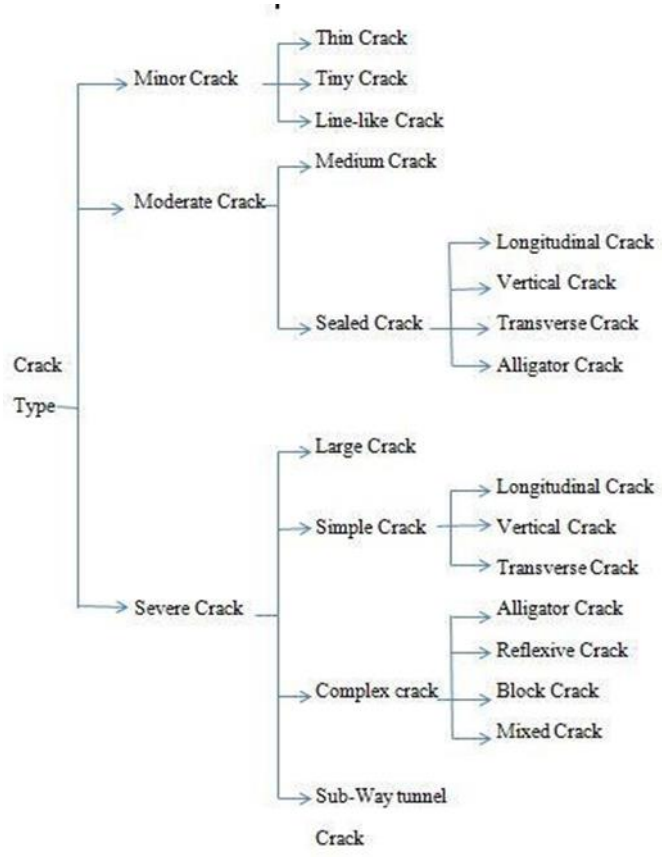



Fig (1) Cracks Classification

### 2.1.1 Minor Cracks

Minor cracks are very small or thin crack with three sub types namely thin, tiny and line-like crack. This crack is common in Concrete bridges, underwater dam, plastic, automobiles and aircraft. Thin cracks are common in Concrete bridges and can be detected using stereo triangulation technique, least square method and optical flow analysis method. These techniques are capable of capturing concrete surface cracks with width of 0.2 pixels using Region of Interest and control point, whereas for better result the images should be captured using single camera without any change in the lighting effect. In underwater dam it is difficult to detect and classify the cracks into tiny, medium and large crack and hence solar image is used. The methods applied in that paper are

adaptive tensor voting, minimum spanning tree and K-means clustering. Line-like cracks are common in plastic surface and it follows sequence of methods to detect the cracks. The methods are: reduction method to remove the noise, image gradient for reconstruction of the crack image, shape based optical model to identify the crack and circularity to find the shape. The proposed approaches are better than Otsu's method and clustering method whereas discontinuities and quantitative analysis are not discussed. From analysis, it is noted that minor crack requires more time for crack detection and classification. Since cracks are small and has discontinuities, accuracy ranges between 80% and 86%.

### 2.1.2 Moderate Cracks

Moderate cracks are not much severe crack and hence remedial measures are required. In common, this crack occurs in underwater dam and concrete structures with types such as medium, sealed and severe crack. Pengfeishi stated that it is quite difficult to detect and classify the crack into tiny, medium and large crack and hence solar image is used. The methods applied in that paper are adaptive tensor voting, minimum spanning tree and K-means clustering. Sealed cracks are common in concrete surfaces with types such as longitudinal, vertical, transverse and alligator crack. It can be detected by using thresholding method, segmentation and morphological operation with high level of accuracy and consistency. The observed metric values of recall, precision, and accuracy are 87%, 98% and 93% respectively. From the analysis, it is inferred that the moderate crack sizes are larger than minor crack and hence discontinuities can be easily handled. The accuracy of moderate cracks classification ranges in between 93% and 93.3%.

### 2.1.3 Severe Cracks

Severe cracks are very large and dangerous crack and hence immediate remedial measures are required. This crack is very common in underwater dam, sub-way tunnel, bridges, pavements, concrete and civil structure. Severe cracks include large, simple and complex cracks.

The large cracks can be easily identified, but underwater dam cracks are difficult to detect and classify and hence solar image is used. The methods applied in this paper are adaptive tensor voting, minimum spanning tree and K-means clustering. This method is efficient than wasp colony algorithm and maintains an accuracy of 93.3% for large crack. Wenyu Zhang detect and classify sub-way tunnel crack using morphological operation, thresholding operation, radial basis function neural network, Support Vector Machine, and KNN. For that, the accuracy rate is 90%. From analysis, it is observed that severe cracks can be classified even in the presence of complicated backgrounds like tree, houses, etc., and resulted with an accuracy of 90%. Accuracy level for severe cracks is around 95%. The summary of severe cracks is given in Table 1 for better readability.

**Table 1:** Severe Cracks

| Crack type | Crack surface | Crack detection techniques | Crack Classification techniques |
|---|---|---|---|
| Large crack | Underwater dam | Particle filter method | K-means clustering and minimum spanning tree |
| Sub- way tunnel crack | Sub-way tunnel | Morphological operation, thresholding operation | SVM, and KNN |

#### 2.1.3.1 Simple Cracks

Simple cracks are less complex and it includes longitudinal, vertical and transverse crack. Longitudinal crack is common in bridges, pavements, concrete road and civil structure. It can be detected using wavelet transform, morphological operation, KD-tree, binarization, region growing method and fractal thresholding and classified using SVM, random forest. Vertical crack is common in bridges, concrete road and civil structure and can be detected using particle filtering, sobel edge detection method, least square method, wavelet transform, morphological operation, KD- tree and classified using SVM, random forest. Transverse crack is common in concrete road, concrete pavement and civil structure and can be detected using thresholding method, segmentation, morphological operation, color feature extraction method, particle filtering, sobel edge detection method, least square method, fractal thresholding, radon transform and classified using SVM, random forest. Simple cracks from low resolution images and discontinuities in the image can also be identified using wavelet transform and KD – tree. The summary of simple cracks is given in Table 2 for better readability.

**Table 2:** Simple Cracks

| Crack type | Surface | Crack detection techniques | Crack Classification techniques |
|---|---|---|---|
| Longitudinal crack | Bridges, pavements, concrete road and civil structure | Wavelet transform, morphological operation, KD-tree, binarization, region growing method and fractal thresholding | SVM, random forest |
| Vertical crack | Bridges, concrete road and civil structure | Particle filtering, sobel edge detection method, least square method, wavelet transform, morphological operation, KD-tree | SVM, random forest |
| Diagonal crack | Concrete road, concrete pavement and civil structure | morphological operation, color feature extraction method, particle filtering, sobel edge detection method, least square method, fractal thresholding, radon transform | SVM, random forest |

### 2.1.3.2 Complex Cracks

Complex cracks are complex in shape and direction and hence more details are required for classification. Complex cracks are common in bridges, pavements, concrete road and civil structure. Complex cracks include alligator, reflexive, block and mixed crack. Alligator crack are common in bridges, concrete pavement and can be detected using thresholding method, segmentation, morphological operation, binarization, radon transform, region growing method, least square method and classified by SVM, random forest. Reflexive crack is common in bridges and can be detected using wavelet transform, morphological operation, KD- tree and SVM. Block crack are common in

concrete pavement and can be detected using fractal thresholding, radon transform classified using SVM, random forest. Mixed crack is common in asphalt pavement and can be detected using Gabor filter method. The summary of complex cracks is given in Table 3.

From analysis, some conclusions are derived. (i) particle filter algorithm is best suitable for underwater crack detection, (ii). In classification, random forest algorithm resulted better accuracy than K-nearest neighbor, (iii) Otsu's method is widely used for crack detection. Otsu's based thresholding approach has been implemented to find the limitations of existing system for various image acquisition conditions.

**Table 3:** Complex Cracks

| **Crack type** | **Surface** | **Crack detection techniques** | **Crack Classification techniques** |
|---|---|---|---|
| Alligator crack | Bridges, concrete pavement | Thresholding method, segmentation, morphological operation, binarization, radon transform, region growing method, Least square method | SVM, random forest |
| Reflexive crack | Bridges | wavelet transform, morphological operation, KD- tree | SVM |
| Block crack | Concrete pavement | Fractal thresholding, radon transform | SVM, random forest |

## 2.2 TYPES OF DIGITAL IMAGES

The images types we will consider are:

1. Binary
2. Grey- Scale
3. Colour

### 1. **Binary Images**

Binary Images are the simplest type of images and can take on two values, typically black and white, or 0 and 1. A binary image is referred to as a 1-bit image because it takes only 1 binary digit to represent each pixel. These types of images are frequently used in applications where the only information required is general shape or outline.

Binary images are often created from the grey-scale images via a threshold operation, where every pixel above the threshold value is turned white (‘1’), and those below it is turned black (‘0’).

### 2. **Grey-scale images**

Grey-scale images are referred to as monochrome (one-color) images. They contain grey-level information, no colour information. The number of bits used for each pixel determines the number of different grey levels available. The typical grey-scale image contains 8bits/pixel data, which allows us to have 256 different grey levels. In applications like medical imaging and astronomy, 12 or 16 bits/pixel images are used. These extra grey levels become useful when a small section of the image is made much larger to discern details.

## 3. **Colour images**

Colour images can be modelled as three-band monochrome image data, where each band of data corresponds to a different colour. The actual information stored in the digital image data is the grey-level information in each spectral band. Typical colour images are represented as red, green, and blue (RGB images). Using the 8-bit monochrome standard as a model, the corresponding colour image would have 24-bits/pixel (8-bits for each of the three colour bands red, green, and blue).

## 2.3 ARCHITECTURE

Cracks on the concrete surfaces are captured by using high resolution cameras, those images are analysed which is a field of Image Processing. There are several steps involved in the image processing which is shown in Fig (2); (1) Image Acquisition (2) Pre-Processing (3) Image Processing (4) Crack Detection (5) Parameter Estimation

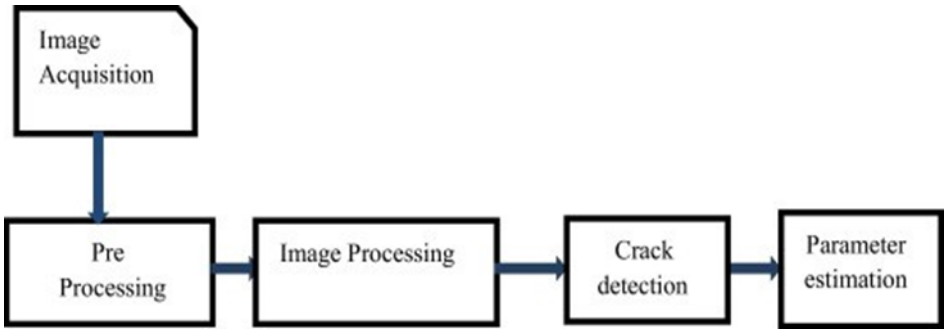



Fig (2) System Architecture

1. **IMAGE ACQUISITION**– It could be as simple as being given an image which is in digital form. The main work involves

a. Scaling
b. Color conversion (RGB to Gray or vice-versa)

2. **IMAGE ENHANCEMENT**– It is amongst the simplest and most appealing in areas of Image Processing it is also used to extract some hidden details from an image and is subjective.

3. **IMAGE RESTORATION**– It also deals with appealing of an image, but it is objective (Restoration is based on mathematical or probabilistic model or image degradation).

4. **COLOR IMAGE PROCESSING**– It deals with pseudo colour and full colour image processing colour models are applicable to digital image processing.

5. **WAVELETS AND MULTI-RESOLUTION PROCESSING**– It is foundation of representing images in various degrees.

6. **IMAGE COMPRESSION**-It involves in developing some functions to perform this operation. It mainly deals with image size or resolution.

7. **MORPHOLOGICAL PROCESSING**-It deals with tools for extracting image components that are useful in the representation & description of shape.

8. **SEGMENTATION PROCEDURE**-It includes partitioning an image into its constituent parts or objects. Autonomous segmentation is the most difficult task in Image Processing.

9. **REPRESENTATION & DESCRIPTION**-It follows output of segmentation stage, choosing a representation is only the part of solution for transforming raw data into processed data.

10. **OBJECT DETECTION AND RECOGNITION**-It is a process that assigns a label to an object based on its descriptor.

## 2.4 EDGE DETECTION TECHNIQUES

For any edge detection algorithm, the primary process is to remove blurriness of the image or removing noise from an image which can be done by filtering algorithms. There are several filtering algorithms, but the best for any kind of the image is Gaussian Filtering. The second step after filtering algorithm is the edge detection around the image which can be done by using various algorithms such as Roberts Edge Detection, Sobel Edge Detection, Prewitt Edge Detection, Canny Edge Detection. An adaptive edge detection algorithm must provide a rough and tough solution that is adaptable to the varying noise levels. Some of the other edge detection techniques are:

(1) **Roberts Edge Detection**:

It performs 2-D spatial gradient measurement on an image which is very quick and easy to compute. This method insistence regions of high spatial frequency which often correspond to edges. The input to the operator is same as the output which is a grayscale image. The Roberts edge detection is introduced by Lawrence Roberts (1965). The input to the operator is a grayscale image the same as to the output is the most common usage for this technique. Pixel values in every point in the output represent the estimated complete magnitude of the spatial gradient of the input image at that point.

(2) **Sobel Edge Detection**:

The Sobel edge detector computes the gradient by using the discrete differences between rows and columns of a 3*3 convolution matrix. The Sobel operator is predicted on convolving the image with a small, separable, and integer valued filter. The Sobel edge detection method is introduced by Sobel in 1970. The Sobel method of edge

detection for image segmentation finds edges using the Sobel approximation to the derivative. It precedes the edges at those points where the gradient is highest. The Sobel technique performs a 2-D spatial gradient quantity on an image and so highlights regions of high spatial frequency that correspond to edges. In general, it is used to find the estimated absolute gradient magnitude at each point in n input grayscale image. In conjecture at least the operator consists of a pair of 3x3 complication kernels as given away in under table. One kernel is simply the other rotated by $90^0$.

**ADVANTAGES:**

- It is less susceptible to noise.

**DISADVANTAGES:**

- It produces thicker edges. So, edge localization is poor in case of images having fine details.

(3) **Prewitt Edge Detection**:

A discrete differential operator is Prewitt operator which computes the approximation of the gradients. It uses 3x3 convolution mask to detect horizontal and vertical edge of an image. It combines Gx (gradient along X-axis) and Gy (gradient along Y-axis) to estimate absolute orientation and magnitude of the gradient at each pixel. The Prewitt edge detection is proposed by Prewitt in 1970. Even though different gradient edge detection wants a quite time-consuming calculation to estimate the direction from the magnitudes in the x and y-directions, the compass edge detection obtains the direction directly from the kernel with the highest response. It is limited to 8 possible directions; however, knowledge shows that most direct direction estimates are not much more perfect. This gradient based edge detector is estimated in the

3x3 neighbourhood for eight directions. All the eight convolution masks are calculated. One complication mask is then selected, namely with the purpose of the largest module.

(4) **Canny Edge Detection**:

Canny edge detection is a multistage algorithm to detect a wide range of edges in images. This detector finds edges by looking for local maxima of the gradient of f (x, y). The gradient is calculated using the derivative of a Gaussian filter. If the pixel has value greater than high thresholding, then it set as edge pixel and a pixel value has a value below than low threshold value, then it does not set as edge pixel. By analysing all these algorithms for several input data Canny Edge detection algorithm provides better results for any kind of input data. In industry, the Canny edge detection technique is one of the standard edge detection techniques. It was first created by John Canny for his Master's thesis at MIT in 1983, and still outperforms many of the newer algorithms that have been developed. To find edges by separating noise from the image before find edges of image the Canny is a very important method. Canny method is a better method without disturbing the features of the edges in the image afterwards it applying the tendency to find the edges and the serious value for threshold. The algorithmic steps are as follows:

- Convolve image with a Gaussian function to get smooth image.
- Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtained as before.
- Apply non-maximal or critical suppression to the gradient magnitude.
- Apply threshold to the non-maximal suppression image.

(5) **Laplacian of Gaussian**:

The Laplacian method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp If we take the gradient of this signal (which, in one dimension, is just the first derivative with respect to t) we get the following: Clearly, the derivative shows a maximum located at the centre of the edge in the original signal. This method of locating an edge is characteristic of the "gradient filter" family of edge detection filters and includes the Sobel method. A pixel location is declared an edge location if the value of the gradient exceeds some threshold. As mentioned before, edges will have higher pixel intensity values than those surrounding it. So once a threshold is set, you can compare the gradient value to the threshold value and detect an edge whenever the threshold is exceeded. Furthermore, when the first derivative is at a maximum, the second derivative is zero.

**Table 4:** Comparison of various edge detection techniques

| S.No | Methods | Operation | Advantage | Disadvantage |
|---|---|---|---|---|
| 1 | Sobel Operator | Maximum of edges are identified with respect to perpendicular angle | Simplicity Finding of smooth edges | In accurate Average results with respire to complex images. |
| 2 | Prewitt Operator | Provide a better performance on horizontal and vertical edges in the images | Detection of edges and their orientations are high | Inaccurate. Size of the coefficient and kernel filter is fixed and cannot be changed to a given image. |
| 3 | LoG | Considers the double edge images. Continuous edges can be detected using raw images | Finding the exact edges. Checks the pixels in wider area. | Few edges cannot be detected. |
| 4 | Canny operator | Used to eliminate the noise and to find the effective edges | Finding the error rate is high. Better detection Remove streaking problem. Adaptive in nature. Good localization | False Zero crossing. |

## 2.5 IMAGE PROCESSING TECHNIQUES

The main steps included in the detection of cracks are mentioned in Fig (3). They are pre-processing, detection and classification. From the literature it is clear that during the pre-processing phase the smoothing and filtering methods were used and detection phase have been carried out by many methods like Otsu method, statistical approach, threshold method and classification can be done using deep learning algorithms like convolutional neural network, fuzzy logic controlled etc.


Fig (3) Steps for Crack Detection

Shivaprakash et al. has introduced a method to detect cracks in the noisy environment using mathematical morphology technique and curvature evaluation. Their objective was to find the surface of the crack. In their study filtering and segmentation was performed. The sequential irregularities were identified in this paper using geometry-based features of cracks. They have used real dataset and the accuracy was less than 70 percent. The major drawback of their research was the poor implementation of the algorithm which in turn resulted in less accuracy.

Ahmed et al. has adopted a three steps methodology. Their objective was to find the surface of the crack. First step was the conversion of the image to gray scale image and then they have used sobel's filter for the detection of cracks. The next step was to categorize the images in to

foreground and background images. After categorizing the noise removal was done by using sobel's filtering. After that Otsu method has been used for the detection of cracks. They have used real dataset and accuracy was above 85percent.

A method was introduced by Baohua et al. for the detection of width of the cracks. Their objective was to find the surface of the crack. They have used stereo vision cameras to recover the co-ordinates of the edges of the crack. In order to obtain the image coordinates they have used the Canny-Zernike algorithm. The width of the crack was assessed using a technique called minimal crack edge detection. They have used real dataset and the accuracy was 90-95 percent. The limitation of their work was regarding the effect of lighting conditions that has to be deeply investigated.

A picture analysis methodology was planned by Yuan-Sen et al. in order to capture the cracks. They have minimized the requirement for pen marking in reinforced concrete structural tests. Their objective was to find the surface of the crack. They have used the studies like crack depth prediction, crack pattern recognition based on artificial neural networks, applications to micro-cracks of rocks and efficient sub-pixel width measurement. They adopted stereo triangulation method based on cylinder formula approximation and image rectification. Their observation was that once the rectified output was obtained, surface of the observed regions could be unfolded and presented in a plane image for displacement and through deformation analysis, the crack was analyzed. They have used real dataset and the accuracy was less than 90 percent. The limitation of their work was that the adopted methods were not applicable for thin cracks, which do not present clear dark lines in images.

A novel method based on sparse representation was developed by Xiaoming et al. that could detect pavement cracks and reconstruct the main pavement profile. Their objective was to find the surface of the crack. The key for cracks separation from main profile was based on the features of the mixed over- complete dictionary, which consisted of two kinds of atoms, one for crack representation and another for main profile representation. In their study, atoms of trapezoidal membership function were adopted to represent crack, and exponential function for main pavement profile. They have stated that the novel method would match with the steps of the crack very well when compared with wavelet and median filter without damaging the information of the main profile signal. Experiments were conducted by them proved that that the method was able to detect the position of pavement crack efficiently as well as reconstruct the main profile.

They had also stated that in future they will be able to achieve improved computational efficiency by using computer grid technology. The datasets used was locally available images. The accuracy achieved by them was more than 90 percent. The limitation of their work was that the main profile was very time consuming.

A new method for accurately detecting crack edges on a concrete surface was proposed by Hoang-Nam et al. Their objective was to find the surface of the crack. In their method, a novel phase symmetry-based crack enhancement filter was developed for detecting crack edges. Geometric properties of cracks including line-like and local symmetry across the center-lines were considered carefully to detect the true crack-edges from 2D image. Specially, edges of cracks were specified from analyzing the cross-section of cracks. It was stated that, the time taken to identify crack edge was very less. The results of

application of the method to images of concrete surfaces showed that their method can accurately detect weak crack edges and considerably reduce the noise caused by unintended objects. Furthermore, their proposed techniques could be extended to compute crack width from the edge points in the cross-section profiles. Their proposed image processing technique was expected to make the crack inspection process more efficient and cost effective. They have used locally available images and the accuracy was 80-85 percent. The limitation was that crack width alone was computed.

J. Zakrzewski et al. used nonlinear imaging of a crack. Their objective was to find the surface of the crack. Acoustic signals at two different fundamental frequencies were launched in their sample, one photo acoustically through heating by the intensity-modulated scanning laser and another by a piezo electrical transducer. The acoustic signal at mixed frequencies generated due to system nonlinearity has been detected by an accelerometer. The contrast of the images obtained at a mixed frequency was compared with the obtained linear photo acoustic images. They have used dataset and the accuracy was 85 -90 percent. The limitation of their work was that only physical mechanisms of the nonlinearity contributing to the contrast in linear and nonlinear photo acoustic imaging of the crack were discussed.

Sunil et al. has investigated the cracks by using the two- step approach. Their objective was to find the surface of the crack. They have developed a statistical filter design for the crack detection. After filtering, the two-step approach at which the crack feature extraction was carried out at the first step of the pre-processing and then they have

fused the images. The second step was to define the crack among the image segment by the process of cleaning and linking. They have used real dataset and the accuracy was less than 90 percent. The limitation was that although joints and laterals have a predictable appearance, the presence of randomness and irregularity of cracks made modeling a difficult task.

Yusuke et al. has proposed a system for automatic crack detection on the noisy concrete surface mages. Their objective was to find the length of the crack. Their system includes two pre-processing steps and two detection steps. The original image was used for the pre-processing. They have removed the shadings using the median filtering. A multi scale linear filter with the Hessian matrix was used to emphasize the cracks. After pre-processing, they have detected the crack coarsely without noise by a probabilistic method. They detected the crack more finely using an adaptive threshold algorithm. They have used real dataset. The accuracy was 90-95 percent. Limitation was that they have evaluated robustness and accuracy of their proposed method quantitatively by using 60 actual noisy concrete surface images. Leo et al. has proved that as the number of layers are increased the accuracy and recall of the network increases. This is mainly because as the networks get deeper it learns more and more discriminative features from the images that helps the networks to differentiate the pavement cracks from non-crack images. The network trained on images taken from a particular location does not perform well when tested on images taken from another location. Therefore, location variance is a very important hurdle that has to be tackled for implementing a universal automatic crack detection system using computer vision techniques. They have used real dataset and accuracy was more. The major limitation was the training with limited data.

B. Hari Prasanth, S. Karthikeyan, et al. in their paper introduces an automated technique which detects cracks in concrete surfaces with the help of digital image processing. Some parameters like bad illumination, non-uniform background and complex texture may affect the accuracy of an automatic system. In their novel methodology, they firstly processed the images with the help of gray scale morphological processes. Then they obtained the results by filtering images and after those applying edge detection operations. They use the MATLAB tool for conducting their research. Their System Performance=89% and Recall= 94.5%. Anan Banharnsakun in his paper uses hybrid between an artificial bee colony and artificial neural networks for pavement surface distress detection and classification. In his system, he firstly captured pavement images and then segmented it into distress and non-distress region by using the thresholding method. Then the optimal thresholding value is obtained by using an artificial bee colony algorithm. For classification of cracks, he uses an artificial neural network method. Accuracy of this method is 20% increased when it is compared with other methods.

Henrique Oliveira and Paulo Lobato Correia in their paper presents a novel method for automatic detection and classification of the cracks by using survey images which are acquired by the high-speed vehicle. For enhancement of an image, they used morphological filters which reduce pixel intensity variance. After that a dynamic thresholding technique is applied, which identify dark pixels as compared with potential crack pixels. In achieving entropy block matrix, a second dynamic thresholding is applied, which identify image blocks containing crack pixels. Then the classification system classifies the type of cracks. Henrique Oliveira and Paulo Lobato Correia in their paper proposed a

novel technique to detect cracks automatically in concrete surfaces pavement, acquiring an image with the help of the laser imaging system. They use posteriori classifier procedure to link different segments of crack region. In the first step, they use an anisotropic diffusion filtering technique which smooths the image texture. Then uses Gaussian function to model histogram for calculating intensities of pixels below some certain value for image segmentation. After that, binary region, which is less relevant are kept only if they linked to the relevant region of cracks. Aiguo Ouyang, Chagen Luo et al. analyzed key problems of pavement crack detection like image enhancement, edge detection and image segmentation. For enhancement, they used median filters for removing the noise in images of pavement cracks. For edge detection, they use canny edge detection operator.

Suwarna Gothane, Dr. M. V. Sarode proposed that concrete networks are preserved if sufficient maintenance can be done at the proper time. Some types of distress on the concrete surface are potholes, cracks, patches, etc. In their paper, data assessment regarding crack distress is reported with the help of data collection regarding distress and the processing of raw data. They analyzed different types of solution using the concept of neural network, fuzzy logic, artificial intelligence, computer vision etc. for automation of process. For monitoring cracks and concrete conditions GPS and sensor-based techniques are used. Tien Sy Nguyen, Manuel Avila et al. introduce a method which can not only detect crack size as small or large, but also detects other types of defect like joints and bridged. For capturing crack images, the image acquisition system is used. In the first step, the pre-processing step is done to remove the unwanted marking.

After that crack defects are detected by calculating an anisotropy measure. Finally, for classifying an image, they use back propagation neural network, which classifies an image into four classes like: defect-free, joint, crack and bridged.

Qin Zou, Song Wang et al. in their paper, develop a fully-automatic technique which detects cracks from a crack pavement images. Firstly, they develop geodesic shadow-removal technique for enhancement, which remove the pavement shadows but preserving the cracks. Secondly, they build a crack probability map using tensor voting to enhance the connection of the crack fragments. Finally, they sample a crack seeds from crack probability map, which represent these seeds by a graph model, derive minimum spanning trees from this graph, and conduct recursive tree-edge pruning to identify desirable cracks. They evaluate the proposed method on a collection of 206 real pavement images. Akhila Daniel, Preeja. V in their paper includes that there are several techniques for detection of cracks. But all these techniques access the condition of the concrete based on the type of cracks. Because of different climate conditions, concrete surfaces suffer from various types of distress like potholes etc. The main goal of their paper is to introduce a technique which determines the concrete surface condition. The steps which they follow are Collection of the images, Detection of distress, and Classification of the distress and assignment of the crack's severity which analyze the concrete performance.

Shi Guiming, Suo Jidong, et al. states that pavement cracks are a very common damage to. Underdevelopment software for image acquisition and hardware technology sometimes achieved pavement images having high noise, which makes difficult to detect low cracks. Their paper focuses on processing of vehicle-mounted crack detection

system, which deals with high noisy image. In their novel methodology, they firstly acquire an image, then apply pre-processing, then apply morphological operations and at last determine the optimal threshold. They also use MATLAB tool for conducting their research. B. Santhi, G. Krishnamurthy et al. in their paper presented an automated technique which detects cracks in pavement with the help of digital image processing. Their technique can detect the vertical, horizontal and diagonal cracks. Some problems, like bad illumination, complex texture, and non-uniform background of the images may affect the accuracy of an automatic system. So, to overcome from these problems a well organize technique for crack detection was introduced by them. Firstly, they processed the images by using gray scale morphological processing. After that, they obtained final result by applying the Butterworth filtering technique to the images and at last they applied the canny edge detection technique.

Peggy Subirats, Jean Dumoulin et al. in their paper presented a new technique for developing an automated system for crack detection conducted on the pavement surface images. In their first step, they use a two-dimensional continuous wavelet transform for performing at several scales. From this they built the complex coefficient. After that, they searched the maximum value of wavelet coefficients and analyzed their propagation with the help of scales. Finally, a binary image obtained after post-processing indicates that whether the cracks are present or not on the surface of pavement image.

Ghada Moussa, Khaled Hussain in their paper presented a novel technique for an automated pavement assessment which is based on machine learning methods and an image processing technique. The system has an ability to identify cracks, extract the parameters of crack, and report

the extent, type and severity of that crack. They use actual pavement images for verifying the performance of their proposed system and the results clearly states that the proposed system was performing its functions very effectively and efficiently. They use mainly four stages for crack detection. Firstly, they perform segmentation of images by using a watershed algorithm. Secondly, they extracted the features in images. Thirdly, they classified the types of cracks using Support Vector Machine. At last, they quantify the cracks parameters.

Ouyang Aiguo, Wang Yaping in their paper proposed a novel method which is based on Beamlet for extraction of pavement crack images. Firstly, they used Otsu's thresholding segmentation algorithm for transferring the collected images into the binary images. After that, they used Beamlet Transform on the binary images to extract some linear features of the cracks with different kinds of scales and thresholds. Their experiments show that their proposed algorithm could achieve satisfactory performance also in cases of some of low signal to the noise ratios.

Liang Ying in his paper, proposed method which used a pavement distress method for image enhancement algorithm so that a non-uniform background illumination is corrected by calculating multiplicative factors which eliminates a background lighting variation. He uses Beamlet Transform algorithm for extracting the linear features from a pavement image and the image is divided into small windows. After that the crack segments are linked together then classified cracks into four types: horizontal, vertical, block types and transversal. His results show that the method is an effective and robust for the extraction of the cracks on various pavement images.

## 2.6 FILTERING TECHNIQUES:

Filtering is a technique for modifying or enhancing an image. For example, you can filter an image to emphasize certain features or remove other features. Image processing operations implemented with filtering include smoothing, sharpening, and edge enhancement.

Filtering is a neighbourhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighbourhood of the corresponding input pixel. A pixel's neighbourhood is some set of pixels, defined by their locations relative to that pixel. Linear filtering is filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighbourhood.

Most images are affected to some extent by noise, that is unexplained variation in data: disturbances in image intensity which are either uninterpretable or not of interest. Image analysis is often simplified if this noise can be filtered out. In an analogous way filters are used in chemistry to free liquids from suspended impurities by passing them through a layer of sand or charcoal. Engineers working in signal processing have extended the meaning of the term filter to include operations which accentuate features of interest in data. Employing this broader definition, image filters may be used to emphasise edges that is, boundaries between objects or parts of objects in images. Filters provide an aid to visual interpretation of images, and can also be used as a precursor to further digital processing, such as segmentation. Most of the methods considered are operated on each pixel separately. Filters change a pixel’s value taking into account the values of neighbouring pixels too. They may either be applied directly to recorded images, or after transformation of pixel values.

**NON-LINEAR FILTERS**:

All filters which are not linear are more diverse and difficult to categorize, and are still an active area of research. They are potentially more powerful than linear filters because they are able to reduce noise levels without simultaneously blurring edges. However, their theoretical foundations are far less secure and they can produce features which are entirely spurious. Therefore, care must be taken in using them.

**GABOR FILTER:**

Gabor filter is a linear filter used in image processing for edge detection. Its frequency and orientation representations are similar to the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination.

## 3. EXISTING ALGORITHM

This section briefs about processing techniques based on the camera image for the detection of the cracks with in the engineering structures. A work done by Yiyang et al. [1] have proposed a crack detection algorithm which is based on digital image processing. By performing the image pre-processing, image segmentation and feature extraction they derived the information the crack image. An experimental work done by Iyer et al. [2] have proposed a method for the crack detection from the high contrast images. The method detects the crack patterns in the noisy environment using curvature evaluation and mathematical morphological methodology. In the Image processing scheme different filtering techniques are adopted which alter the overall efficiency of the process; Salman et al. [3] proposed an approach that automatically distinguish cracks in digital images based on Gabor filtering. The Gabor filter is a highly potential technique for multidirectional crack detection. The images obtained from the Gabor filter function was directly related to the manual visual perception. Once filtering was completed, the cracks obtained from different directions are detected. Talab et al. [4] have presented a new approach in image processing for detecting cracks in images of concrete structures, the methodology involves three steps: (1) Change the image to a grey image using the edge of the image. (2) Use Sobel's method to develop an image using Sobel's filter for detecting cracks. (3) Using suitable threshold binary image of the pixel they are categorized into the foreground and the background image. Once again Sobel's filtering was used for the elimination of residual noise. Lee et al. [5] have proposed a system for particle detection using nearest neighbour algorithm. Based on the probability function of their corresponding location the crack features were acknowledged. Wang et

al. [6] have proposed system for the image-based crack detection and to characterize the image based upon their effectiveness. According to their proposed system they have categorized the present image-based crack detection into four categories [8]. They are an integrated algorithm, morphological approach, percolation approach and practical technique. A shading correction was done using integrated algorithm [8]. The unclear crack prediction was detected using percolation method. The crack detection was done using morphological approach for the micro crack detection with the sensible method providing high- performance feature extraction. Fujita et al. [7] have proposed system for automatic crack detection on noisy concrete surface images. Their system includes two detection steps and two pre-processing steps. In pre-processing only original image is used. Using image filtering they have removed shadings. After pre-processing, they have detected the crack coarsely without noise by a probabilistic method [8]. They detected the crack more finely using an adaptive threshold algorithm.

# 4. PROPOSED ALGORITHM

There are four phases in our proposed algorithm:

1. Gaussian filtering
2. Canny edge detection
3. Morphological approach
4. Parameter estimation

## 4.1 Gaussian filtering

Gaussian filter is a linear filter which is used to blur the image or to reduce noise. If we apply Gaussian filtering and Median filtering to an image and subtract their outputs, final output can be used for unsharp masking (edge detection). The Gaussian filter alone will blur edges and reduce contrast. From the image perspective, during Gaussian filtering each individual pixel is modified with a Gaussian shaped blob with the same total weight as the original intensity value. This Gaussian is also referred as convolution kernel.

## 4.2 Canny Edge Detection

Canny edge detection [8] is a technique to extract useful structural information from different vision objects and dramatically reduce the quantity of data to be processed. It has been widely applied in various computer vision systems. Canny has found that the requirements for the application of edge detection on diverse vision systems are relatively similar. Thus, an edge detection solution to address these requirements can be implemented in a wide range of situations. Detection of edge with lower rate, which means that the detection should accurately catch as many edges. The Canny algorithm contains a many adjustable parameter,

which can affect the computation time and effectiveness of the algorithm. Primarily the smoothing filter used in the first stage of Gaussian filter directly affects the results of the canny edge detection algorithm. To reduce blurring effect and to detect small, sharp lines we can use small filters. But there is are some disadvantages of using large filters. They increase the amount of blurring effect in the image and value of particular pixel slights out over large area of image [9]. Larger blurring radii are more useful for detecting larger and smoother edges.

### 4.3 Morphological approach:

Morphological Image Processing is a collection of non-linear operation associated to the shape or morphology of features in an image. Morphological processing is capable of removing noise and has the ability to edit an image based on the size and shape of objects of interest. It is used in place of Linear Image Processing, because it sometimes distorts the geometric form of an image but in the case of Morphological approach the information of an image is not lost. In the Morphological Image Processing the original image can be reconstructed by using Dilation, Erosion, Opening and Closing operations for a finite number of times. There are basically four Morphological transformations:

(1) **Dilation**:

Dilation causes objects to dilate or grow in size. Dilation makes an object larger by adding pixels around its edges. Dilation is one of the operators in the area of mathematical morphology, the other being erosion. It is typically applied to binary images, but there are versions that work on grayscale images. The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of

foreground pixels .

Thus, areas of foreground pixels grow in size while holes within those regions become smaller.

(2) **Erosion**:

Erosion makes an object smaller by removing or eroding away the pixels on its edges and causes objects to shrink. Erosion is one of the basic operators in the area of mathematical morphology, the other being dilation. It is typically applied to binary images, but there are versions that work on grayscale images. The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels .Thus areas of foreground pixels shrink in size, and holes within those areas become larger. In this process we increase the black pixel in the image making, it looks thinner. Every object pixel that is touching an background pixel is changed into background pixel. In dilation we increase the white pixel in the image making, it looks broader. Every background pixel that is touching an object pixel is changed into an object pixel.

(3) **Opening**:

Opening generally smoothness the outline of an image and eliminates thin inflammations. It is structured removal of image region boundary pixels. Together with closing, the opening serves in computer vision and image processing as a basic workhorse of morphological noise removal. Opening removes small objects from the foreground (usually taken as the dark pixels) of an image, placing them in the background, while closing removes small holes in the foreground, changing small islands of background into foreground. These techniques can also be used to find specific shapes in an image. Opening can be used to find things

into which a specific structuring element can fit. In this process we firstly do Erosion and then Dilation. This method is used to remove the extra white pixels from the images.

(4) **Closing**:

Closing fuses narrow breaks, eliminates small holes and fills gaps in the contour. It is structured filling of image region boundary pixels. It is a powerful operator, obtained by combining Erosion and Dilation. In image processing, closing is, together with opening, basic workhorse of morphological noise removal. Opening removes small objects, while closing removes small holes. In this process we firstly do Dilation and then Erosion. This method is used to remove the extra black pixels from the images.

### 4.4 Parameter estimation:

Implementing the above proposed algorithm, we will calculate the height, depth, width, direction of propagation and severity of the crack.

Steps involved in proposed algorithm are stated in the below Fig (4).

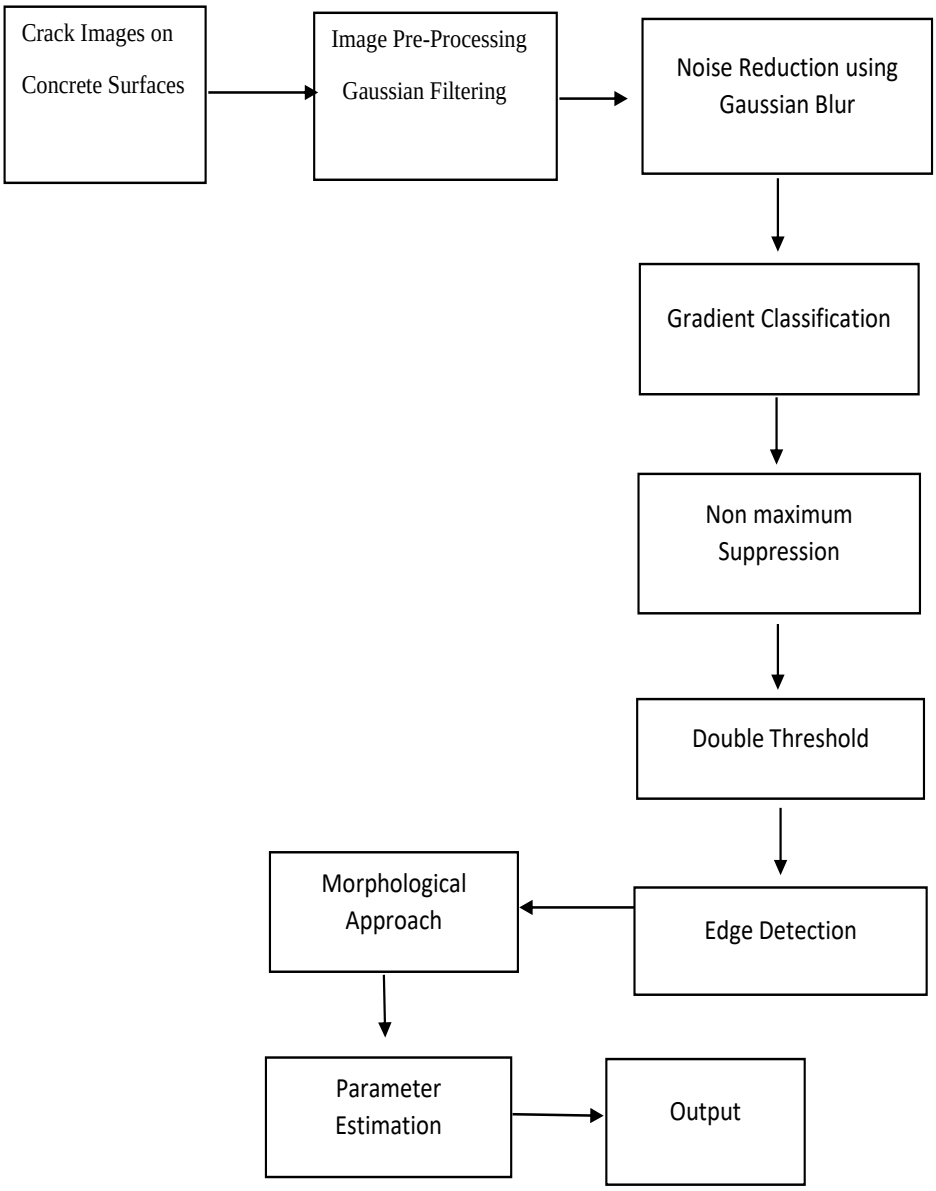



Fig (4) Steps for Proposed Algorithm

# 5. SYSTEM CONFIGURATIONS

## 5.1 HARDWARE CONFIGURATIONS

These are the Hardware interfaces used

Processor: Intel Pentium 5 or equivalent

RAM: Minimum of 512 MB or higher

HDD: 10 GB or higher

Monitor: 15'' or 17'' color monitor

Mouse: Scroll or optical mouse

Keyboard: Standard 110 keys keyboard

## 5.2 DISCRIPTION ABOUT SOFTWARE "MATLAB"

For implementing digital image processing, we can write code in any language like python, java and any other language. We can also use the software 'MATLAB' which offers lots of feature to programmers for exploring their imagination and can make any projects related to digital image processing by using their coding skills.

Some features of MATLAB are:

1. It has several in built commands and math functions that help in performing mathematical calculations.
2. It also provides an interactive environment for design and problem solving.
3. MATLAB features a family of add on application specific solutions called toolboxes. Toolboxes allow us to learn and apply special technology.

4. We can add toolboxes for signal -processing, control -systems, neural- networks, and many other areas.
5. It has facilities for displaying vectors as graphs, and printing these graphs.
6. It includes high level function for two dimensional and three-dimensional data visualization, image processing, and presentation graphics.
7. It provides many functions and algorithms with external applications and languages such as C, Java.

## 5.3 SOFTWARE CONFIGURATIONS

These are the software configurations used

Operating system: windows 10, mac os, Linux.

IDE: PyCharm, MATLAB.

# 6. SAMPLE CODE

## MATLAB CODE

```
%%load image

clc
clear all
close all

I=imread('C:\Users\Hp\Desktop\Final Year project\crack\im21g (2).jpg');

% I=rgb2gray(I)

figure,imshow(I)
title('Original image')

%%Image adjust

Istrech = imadjust(I,stretchlim(I));
figure,imshow(Istrech)
title('Contrast stretched image')

%%Convert RGB image to gray

Igray_s = rgb2gray(Istrech);
figure,imshow(Igray_s,[])
title('RGB to gray (contrast stretched) ')

%%Image segmentation by thresholding
%%use incremental value to run this selection till required threshold
'level' is achieved

Ithres = imbinarize(Igray_s,'global');
figure,imshow(Ithres)
title('Segmented cracks')

%%Image morphological operation

BW = bwmorph(Ithres,'clean',10);
figure,imshow(BW,[])
title('Cleaned image')
```

```
BW=not(BW);
figure,imshow(BW,[])
BW = bwmorph(BW,'open',10);
figure,imshow(BW,[])
E=edge(BW,'canny');
figure,imshow(E,[])
f=find(E==1);
L=length(f)/2

[rx,cx]=size(BW);

S=[];

for i=1:rx
    A=BW(i,:);
    f=find(A==1);
    if numel(f)>0
     S=[S numel(f)];
    end
end

Wmx=max(S)

Wmn=min(S)

Wavg=mean(S)

Wmid=round((Wmx+Wmn)/2)
```

## 7. SAMPLE OUTPUT

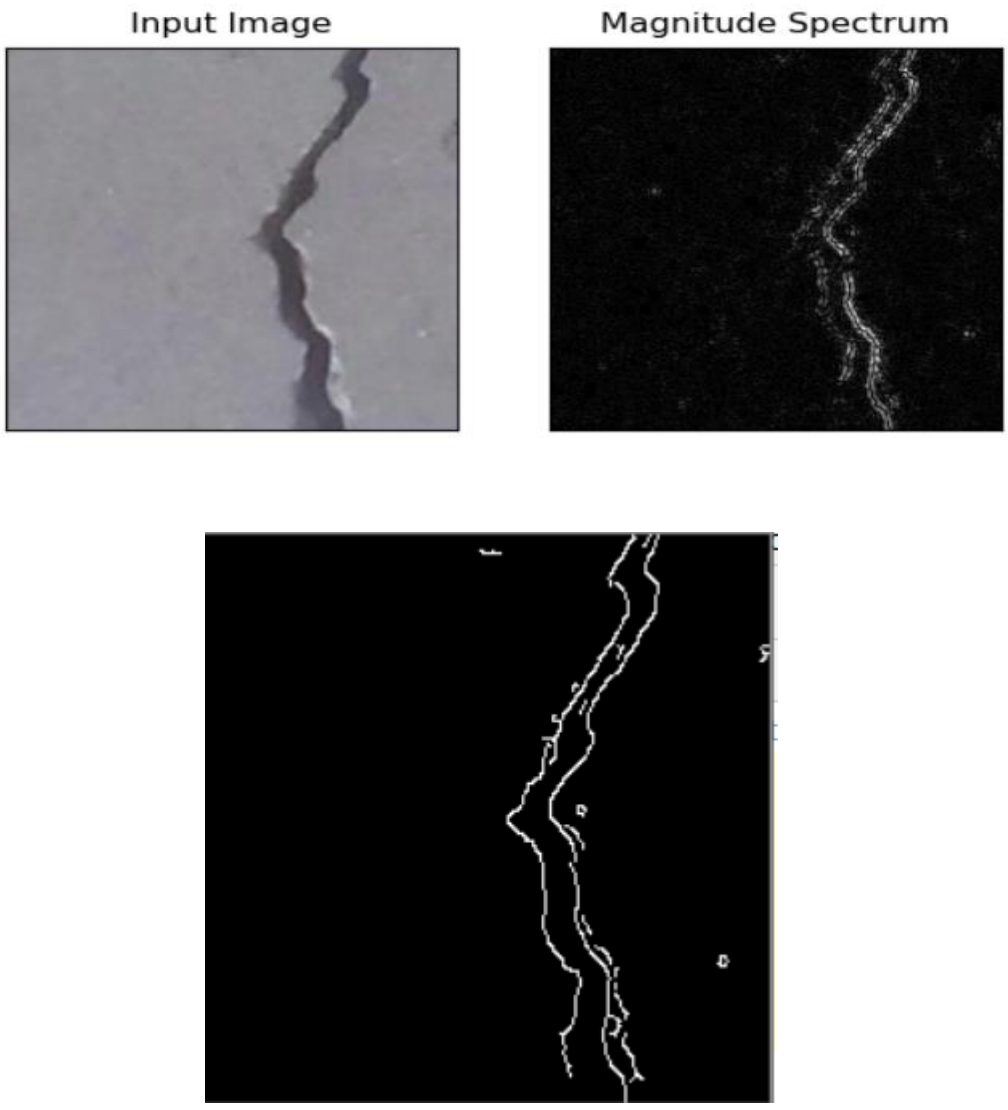



Fig (5) Sample Output

L = 158

Wmx = 48

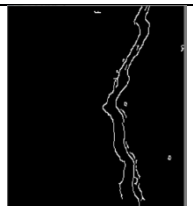
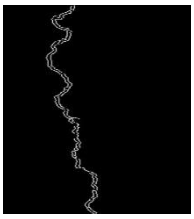
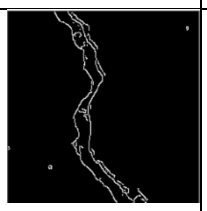
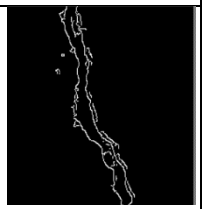
Wmn =6

Wavg =14.9079

Wmid =27

# 8. EXPERIMENTAL RESULTS

**Table 5**: Experimental Results

| S. No | Original Image | Crack Image | Length (in pixels) | Width (in pixels) |
|---|---|---|---|---|
| **1.** |  |  | 158 | 86 |
| **2.** |  |  | 218 | 97 |
| **3.** |  |  | 172 | 68 |
| **4.** |  |  | 168 | 59 |

# 9. CONCLUSION AND FUTURE WORKS

The manual approach for the estimation of cracks in concrete surfaces is tedious. So, the proposed automatic crack detection algorithm identifies the cracks on concrete surfaces with better results compared to manual approach. In the proposed crack detection algorithm the cracks are identified using the canny edge detector algorithm which provides a better results for any kind of an image The proposed algorithm is tested with nearly 100 images and the different parameters related to crack such as length, width are measured, this can be used by various construction workers so that necessary remedies can be taken from the degradation of concrete material. Direction of Propagation and Life Span of the concrete material are measured further with different high-quality techniques.

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# APPENDIX

## MATLAB

The name MATLAB stands for MATrix LABratory. 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. 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. 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.

It has powerful built-in routines that enable a very wide variety of computations. It also has easy to use graphics commands that make the visualization of results immediately available. Specific applications are collected in packages referred to as toolbox. There are toolboxes for signal processing, symbolic computation, control theory, simulation, optimization, and several other fields of applied science and engineering.

When to use MATLAB?

1. For rapid prototyping of numerical algorithms.
2. For quick data analysis and visualization.

Here are some of MATLAB's advantages:

1. The language is intuitive and mathematically expressive.
2. The documentation is excellent.
3. Many toolkits are available which extend the functionality.
4. The debugger and proler are integrated and easy to use.
5. MATLAB is an industry standard.
6. MATLAB matrix manipulation algorithms (esp. for sparse matrices) are the state of art.
7. MATLAB may behave as a calculator or as a programming language.
8. MATLAB combine nicely calculation and graphic plotting.
9. MATLAB is relatively easy to learn.
10. MATLAB is interpreted (not compiled), errors are easy to fix.

MATLAB's disadvantages:

1. The scripting system is somewhat primitive.
2. For complex tasks (especially ones which require for loops), MATLAB can sometimes be slower than hand-coded C or Fortran.
3. MATLAB is expensive.
4. MATLAB is not a general-purpose programming language such as C, C++, or FORTRAN.

5. MATLAB is designed for scientific computing, and is not well suitable for other applications.

**Creating MATLAB variables:**

MATLAB variables are created with an assignment statement. The syntax of variable as- segment is

variable name = a value (or an expression)

For example,

>> x = expression

where expression is a combination of numerical values, mathematical operators, variables, and function calls. On other words, expression can involve:

- manual entry
- built-in functions
- user-defined functions

**Overwriting variable:**

Once a variable has been created, it can be reassigned. In addition, if you do not wish to see the intermediate results, you can suppress the numerical output by putting a semicolon (;) at the end of the line. Then the sequence of commands looks like this:

```
>> t = 5;
>> t = t+1
ans    t=6
```

**Error messages:**

If we enter an expression incorrectly, MATLAB will return an error message. For example, in the following, we left out the multiplication sign, *, in the following expression

```
>> x = 10;
>> 5x
??? 5x
|
Error: Unexpected MATLAB expression.
```

**Making corrections:**

To make corrections, we can, of course retype the expressions. But if the expression is lengthy, we make more mistakes by typing a second time. A previously typed command can be recalled with the up-arrow key. When the command is displayed at the command prompt, it can be modified if needed and executed.

**Controlling the hierarchy of operations or precedence:**

Let's consider the previous arithmetic operation, but now we will include parentheses. For example, 1 + 2 × 3 will become (1 + 2) × 3

```
>> (1+2) *3
ans   = 9
```

and, from previous example

```
>> 1+2*3
ans   = 7
```

By adding parentheses, these two expressions give different results: 9 and 7.

The order in which MATLAB performs arithmetic operations is exactly that taught in high school algebra courses. Exponentiations are done first, followed by multiplications and divisions, and finally by additions and subtractions. However, the standard order of precedence of arithmetic operations can be changed by inserting parentheses. For example, the result of 1+2 3 is quite different than the similar expression with parentheses (1+2) 3. The results are 7 and 9 respectively. Parentheses can always be used to overrule priority, and their use is recommended in some complex expressions to avoid ambiguity. Therefore, to make the evaluation of expressions unambiguous, MATLAB has established a series of rules.

**Managing the workspace:**

The contents of the workspace persist between the executions of separate commands. There- fore, it is possible for the results of one problem to have an effect on the next one. To avoid this possibility, it is a good idea to issue a clear command at the start of each new independent calculation.

>> clear

The command clear or clear all removes all variables from the workspace. This frees up system memory. In order to display a list of the variables currently in the memory, type

>> who

while, who will give more details which include size, space allocation, and class of the variables.

**Keeping track of your work session:**

It is possible to keep track of everything done during a MATLAB session with the diary command.

>> diary

or give a name to a created file,

>> diary FileName

where FileName could be any arbitrary name you choose.

The function diary is useful if you want to save a complete MATLAB session. They save all input and output as they appear in the MATLAB window. When you want to stop the recording, enter diary off. If you want to start recording again, enter diary on. The file that is created is a simple text file. It can be opened by an editor or a word processing program and edited to remove extraneous material, or to add your comments. You can use the function type to view the diary file or you can edit in a text editor or print. This command is useful, for example in the process of preparing a homework or lab submission.

**Getting help:**

To view the online documentation, select MATLAB Help from Help menu or MATLAB Help directly in the Command Window. The preferred method is to use the Help Browser. The Help Browser can be started by selecting the ? icon from the desktop toolbar. On the other hand, information about any command is available by typing

>> help Command

Another way to get help is to use the lookfor command. The lookfor command differs from the help command. The help command searches for an exact function name match, while the lookfor command searches the quick

summary information in each function for a match. For example, suppose that we were looking for a function to take the inverse of a matrix. Since MATLAB does not have a function named inverse, the command help inverse will produce nothing. On the other hand, the command lookfor inverse will produce detailed information, which includes the function of interest, inv.

```
>> lookfor inverse
```

NOTE - At this particular time of our study, it is important to emphasize one main point. Because MATLAB is a huge program; it is impossible to cover all the details of each function one by one. However, we will give you information how to get help. Here are some examples:

- Use on-line help to request info on a specific function

```
>> help sqrt
```

In the current version (MATLAB version 7), the doc function opens the online version of the help manual. This is very helpful for more complex commands.

```
>> doc plot
```

- Use lookfor to find functions by keywords. The general form is

```
>> lookfor FunctionName
```

**MATLAB for Images:**

Another extensively used 2D visualization of data is image. Image could come from an actual image le, a processed image by some of your MATLAB program, or maybe a matrix of data. Here we introduce a few simple commands related to images.

**Read images:**

Suppose myImageFile.jpg is an image under your current working folder (other image extensions .bmp, .cur, .gif, .hdf4, .ico, .jpg, .jp2, .pbm, .pcx, .pgm, .png, .ppm, .ras, .tiff, .xwd work as well).

Use the command imread to read the image:

```
A = imread('myImageFile.jpg');
```

Now, in the typical situation, A is a 3-dimensional array (like matrix, but matrix is 2-dimensional array) that stores the intensity of the image for each pixel and each color channel.

**Show images:**

Suppose we have an image A (read from an image using imread command mentioned above), one may view the image by

imshow(A) or

image(A) or

imagesc(A)

Both imshow and image display the color of the image using the standard scale: for A of class uint8, 0 is darkest and 255 is brightest; for A of class double, 0 is darkest and 1 is brightest. On the other hand, imagesc displays the color that is scaled; it is usually used for visualizing a matrix of class double as an image.

In many image processing experiments, it is handier if A is just a matrix (instead of 3-channel array) of class double. To turn A into such form,

```
B = rgb2gray(A);
```

```
C = double(B)/255;
```

B will be a matrix (1-channel indicating grayscale). C will be of class double ranging from 0 to 1. It is notable that rgb2gray does a better job than just averaging the intensity of the 3 channels; it takes account of the human sensation of vision; for example, yellow (RGB= (1,1,0)) looks brighter than magenta (RGB= (1,0,1)):

```
>>rgb2gray (reshape ([1,1,0],1,1,3))

ans = 0.8860

>>rgb2gray (reshape ([1,0,1],1,1,3))

ans = 0.4130
```

**Write images:**

Use imwrite(C,'myImage2.jpg') to export a matrix C as an image.

**CONTROL STRUCTURES:**

MATLAB is also a programming language. Like other computer programming languages, MATLAB has some decision-making structures for control of command execution. These decision-making or control flow structures include for loops, while loops, and if-else-end constructions. Control flow structures are often used in script M-files and function M-files.

By creating a file with the extension .m, we can easily write and run programs. We do not need to compile the program since MATLAB is an interpretative (not compiled) language. MATLAB has thousands of functions, and you can add your own using m-files.

MATLAB provides several tools that can be used to control the flow of a program (script or function). The commands are executed one after the other.

Here we introduce the flow control structure that make possible to skip commands or to execute specific group of commands.

MATLAB has four control flow structures: the if statement, the for loop, the while loop, and the switch statement.

1. The ‘‘if...end’’ structure

MATLAB supports the variants of “if” construct.

- if ... end
- if ... else ... end
- if ... elseif ... else ... end

The simplest form of the if statement is

```
if expression
   statements
end
```

It should be noted that:

- elseif has no space between else and if (one word).
- no semicolon (;) is needed at the end of lines containing if, else, end.
- indentation of if block is not required, but facilitate the reading.
- the end statement is required.

2. The ‘‘for...end’’ loop

In the for ... end loop, the execution of a command is repeated at a fixed and predetermined number of times. The syntax is

```
for variable = expression
    statements
end
```

3. The ‘‘while...end’’ loop

This loop is used when the number of passes is not specified. The looping continues until a stated condition is satisfied. The while loop has the form:

```
while expression
    statements
end
```