



---

## Implementing Mathematical Morphology Techniques to Detect Cracks in Underground Pipeline Images Automatically

A. Prema<sup>a\*</sup>, M. V. Ramana Murthy<sup>b</sup>

<sup>a</sup>Research Scholar, Department of Computer Science, Karpagam University, Coimbatore, Tamilnadu, India,

<sup>b</sup>Chairman and Heaad, Department of Computer Science and Mathematics, Osmania

University, Hyderabad, India,

<sup>a</sup>Email id: unjanai@gmail.com

<sup>b</sup>Email id: mv.rm50@gmail.com

### **Abstract**

An oil pipe buried under needs to be checked for their current quality before oil transportation takes place through it. The method involved for all these days were manual using "PIGS". The manual work done by a human operator was hectic, to overcome this situation, a computerized automated image processing technique is introduced through this paper, where the image analysis or pattern analysis is evaluated using the Mathematical Morphology. Mathematical Morphology accomplishes to detect the cracks using Set Theory and also Curvature evaluation for segment images with respect to a precise geometric model to define crack like patterns. This paper describes the method, background of the theory discussed and evaluation of the theory used to identify the defects. Based on the Mathematical Theories of sets and topological notations, its principle lies in studying the Morphological properties (Shape, Size, Orientation and other forms) of the object(Patterns) through non-linear transformations associated with a reference object(SE-Structuring Element). At the end of this paper, image processing to detect the cracks is achieved.

**Keywords:** Defect detection technology, Dilation, Erosion, Linear Filters, Mathematical Morphology, Structuring Element(SE), Opening & Closing, PIG.

---

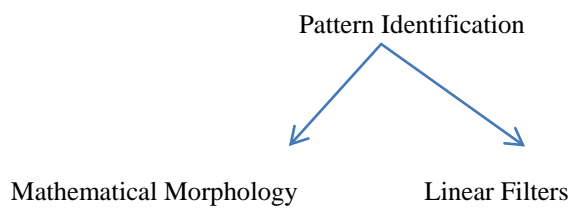
\*Corresponding author  
Email address: unjanai@gmail.com

## 1. Introduction

### 1.1 Locating Cracks

This is an important first step to keep the pipeline infrastructure in proper shape(quality-wise).The PIG[1] used needs a lot of manual operation and there are differences between the image photographed and the picture marked manually. To overcome this problem an automated defect detection technology, for more reliable and accurate Results independent of the manual operation is required. The basic task for automated operation is to detect the cracks, holes, joints and fissures in the images taken by the camera. These cracks have their own specific patterns(images described as such),matching the Gaussian profile on which Pattern Recognition has to be performed.

The techniques used to perform this task are as follows:



Mathematical Morphology [2] is used to extract image components with regard to geometric features of these components. An image is not taken under assumption; the features are extracted from the image that is used for representation and description of the image. This is possible by taking the values form the image domain and this can be used as semantic information).

Mathematical morphology is a set theory method of image analysis providing a quantitative description of geometrical structures .It was first developed to analyse geological data and to detect the structure of the given material(to find inclusions in geological images).



Figure 1:Showing a crack in the oil-pipeline. Source Shutterstock.com

## 2. Research Method

### 2.1 Design

Morphological operations are used mainly to detect expanding and shrinking images to a given structuring element. When first operated the images were only black and white called binary images and later after technical development, now they are applied for colour images-called grey-scale images.

The image domain is mapped as 2D co-ordinates from minimum to maximum range, which defines the possible intensity values of the image. The values for a binary image (black and white) ranges from [0-1], for grayscale images (taken as 8 bit), it ranges from [0-255].

### 2.2 Selection

Mathematical Morphology basically operates on non-linear structures and thus uses totally different type of algebra, required for 2D attributes than the Linear Algebra.

As defined the 2D image  $F$  is defined as follows:

$$F = Z^2 \rightarrow [I(\min); I(\max)]$$

That maps 2D co-ordinates to the range  $[I(\min) \text{ to } I(\max)]$ , which defines the possible intensity values.

If an image is black and white, so far it is dark colours are considered as background and white are parts of the image.

But now to locate a perfect crack position, white parts are background and dark ones are parts of an image.

When the image is photographed and sent to the system, with the leak software, the data is read for pixel image and it is analysed for picture perfection.

(\*)Leak Software is a tool that helps to find the leak values with leak detection methods

In case of Grey-scale image, to differentiate the colours, homogeneous technique is followed, where same colours are grouped together as white and the remaining as dark colour.

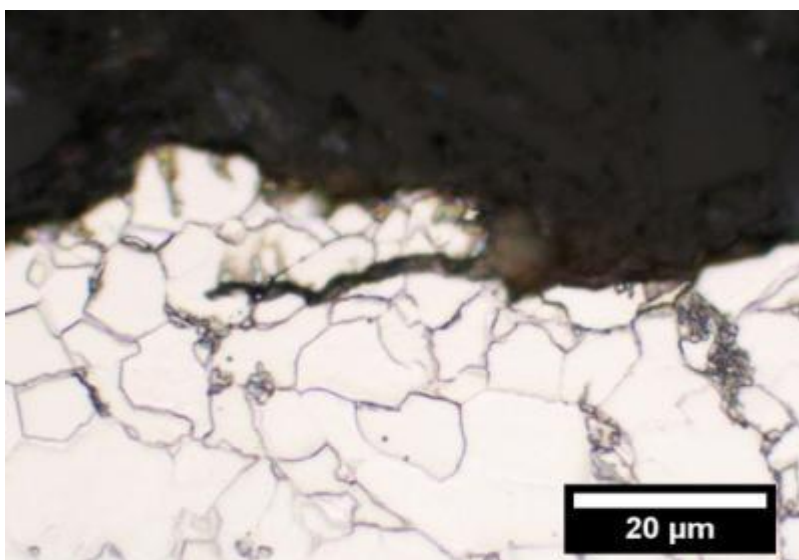


Figure 2: Cracks in Branches (Picture showing the white and dark colour image)

Picture showing the crack being locked with a red line indicating the location of a crack in the pipe



Figure 3: Portion marked for re-pair-picture from shutterstock.com

### 3. Materials and Methods

Dilation-Basic Morphological expansion operation; this takes place both for binary as well as grey-scale image.

Binary Images: Structural element is moved over the image when the dilation takes on binary images. The dilation operator takes two pieces of data as inputs.

#### 3.1 Data gathering procedure

First is image which is to be dilated is collected form the images sent by the camera (A digitized-fibre optic cable is connected) [3]. (Fibre optic cables carry communication signals using pulses of light))

The second step is to collect the samples from the image; it is a (usually small) set of coordinate points known as a structuring element also known as a kernel. It is this structuring element that determines the precise effect of the dilation on the input image. Thus the data is gathered by the images that are sent by the camera (for one second minimum 500 images). Then the images are scanned for pixels as follows:

Foreground pixels are represented by 1's and background pixels by 0's. An example of a structuring element with a 3 X 3 square and origin in the centre

**Table 1: showing the values for evaluation**

1	1	1
1	1	1
1	1	1

#### 3.2 Gray-scale images(Colour Images)

Here dilation is described as a function for an image  $F$  at point  $P_0$  and a given structured element  $B$ , with  $e$  as a scaling factor

### 3.3 Mode of Analysis

#### 3.3.1 Erosion-Basic morphological shrinking operation

In binary images Structural element is moved over the images, here pixel is taken to the result image and it is written as:

$$F - E = \{x \in Z^2 \mid E_x \subseteq F\}$$

**Dilation** is one of the basic operations in mathematical morphology. Originally developed for binary images, it has been expanded first to grayscale images, and then to complete lattices [4]. The dilation operation usually uses a structuring element for probing and expanding the shapes contained in the input image.

Where  $F$  is an image and  $E$  is structured element for evaluation In case of greyscale, each pixel touched by  $E$  is considered and the minimum intensity for all pixels is calculated

#### 3.3.2 Opening and Closing Techniques

Dilation and erosion can be combined to form two important higher order operations. The opening technique is used to remove small objects from the image and closing removes small holes (for original images). For defected images closing removes small objects and opening removes small holes

## 4. Findings

Now with all these techniques, cracked image is to be located. First a subtraction is performed to obtain the defected image as follows:

$$OI - CI = UDI$$

Where  $OI$  stands for original image,

$CI$  stands for cracked image

$UDI$  stands for un-defected image

So the remaining  $DI$ (defected image as called) is taken for Morphological evaluation

#### 4.1 Two or more cracks

If there are 2 or more cracks (Multiple), then Mathematical Morphology deals with two image processing technique. In this method 2 images are considered, in which the first one is taken as input and uses an Isotropic structural element, for a dilation or erosion process. This is always the same for any number of cracks. Now to precede further with multiple cracks GEODESIC Reconstruction technique is applied, whereas stated earlier the first one is taken as input and the second one is used to confirm the result.

This process is repeated (Iteration) until the stability of the image is obtained. By applying the original image is either reduced or expanded in size by one pixel, for every iteration. Such an image called as the Marker image is then confirmed by a mask image. The number of iterations gives a measure for the distance of the pixels in a cracked image. Again dilation and erosion takes place

## **5. Discussion**

With the continued iterative operation method along with Morphological operations, the defected image is identified and further evaluation and analysis takes place. The technique of linear filters will be used only when we need linear algebra for evaluation.

Linear algebra can be used if this process comes across more elevated picture images. But so far, the camera has sent only dilated images for evaluation. In case if there are more than 500 pictures per second, randomized picture selection along with linear algebra can be used with proper testing.

## **6. Conclusion**

In the light of the above mentioned description of the various aspects of Oil pipeline related issues, both technically and economically, a referral problem with Mathematical morphology is formulated and evaluation takes place as required for the current issue, to identify the damaged part of an image. This research can be further extended with the specific Objectives, related to the application of Image processing to make this more comfortable to the system, which is under construction.

With this research paper, an idea of how to track an image, to detect cracks with the help of mathematical morphology technique is achieved. This initiative process opens door for more analysis and evaluation, one such novel opening is linear algebra, which will be discussed as the next step to continue the research with more findings.

## **References**

- [1]WSJ."Oil Pipeline Cracks evading Robotic 'Smart pigs'.online.wsj.com,August 16,2013
- [2] Jean Serra.An introduction to Mathematical Morphology.1994,pp. 369-374.
- [3]S.Tannenbaum.Computer networks.Chap 2,McGraw Hill Publishing.India.2001,pp 14-89,672-689
- [4]DivyenduSinha.Fuzzy mathematical morphology.Journal visual communication and image representation. vol 3.issue 3.1992.,pp 286-302