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Soft Corrosion

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Abstract

This dissertation focuses on using edge detection techniques for partitioning the digital image of corroded metallic objects into corroded and non-corroded regions. This image based analysis is a form of non-destructive testing and is used to identify geometric irregularities, surface discoloration or other features of interest in materials from which the presence of damage is inferred. A grayscale is a digital image, in which the value of each pixel is a single value that carries colour intensity information [1]. Grayscale or so-called monochromatic images are composed exclusively of shades of gray, varying from black (lowest intensity) to white (highest intensity).

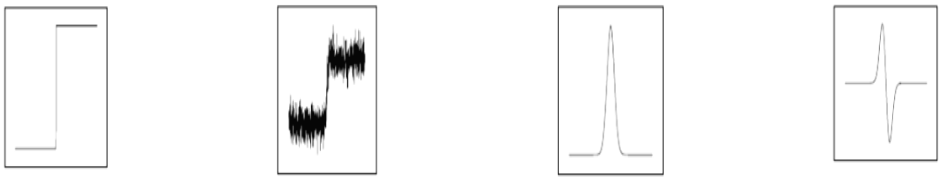
1. Introduction

1.1 Introduction to digital images

A digital image is a binary representation of a two-dimensional (2D) image, and can be in form of a vector or raster type. Raster uses a finite set of digital values, called pixels, to present an image. It contains a fixed number of rows and columns of pixels. Digital images can be classified according to the number and nature of those values. A binary image is a digital image that has only two possible values (i.e. 0 or 1) for each pixel. Typically, the two colours used for a binary image are black and white; though any two colours can be used. A grayscale is a digital image, in which the value of each pixel is a single value that carries colour intensity information [1]. Grayscale or so-called monochromatic images are composed exclusively of shades of gray, varying from black (lowest intensity) to white (highest intensity)

1.2 Edges in a digital image

Edge is a part of an image that contains significant variation. The edges provide important visual information as they correspond to major physical or geometrical variations in scene object. Physical edges are produced by variation in the reflectance, illumination, orientation, and depth of scene surfaces. As image intensity is often proportional to scene radiance, physical edges are represented by changes in the intensity function of an image [2]. The most common edge types are steps, lines and junctions, as shown in Fig. 1.1 below.



(a) **(b)** **(c)** **(d)**

1.3 Introduction to edge detection

Edge detection is a process that detects the presence and location of edges constituted by sharp changes in colour intensity (or brightness) of an image. The discontinuities in image brightness are likely to correspond to: discontinuities in depth, discontinuities in surface orientation, changes in material properties and variations in scene illumination. In the ideal case, the result of applying an edge detector to an image may lead to a set of connected curves that indicate the boundaries of objects, the boundaries of surface markings as well curves that correspond to discontinuities in surface orientation. However, it is not always possible to obtain such ideal edges from real life images of moderate complexity. Edges extracted from non-trivial images are often hampered by fragmentation (i.e. edge curves are not connected), missing edge segments, as well as false edges, which all lead to complicating the subsequent task of image interpreting. The edge representation of an image drastically reduces the amount of data to be processed, yet it retains important information about the shapes of objects in the scene. An important property of the edge detection method is its ability to extract the accurate edge line with good orientation.

1.4 Key edge detection techniques

The key techniques for edge detection are:

1. **Sobel operator:** One kernel is simply the other rotated by 90°. These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations.

(1.1)

2. **Canny:** This method was proposed by John F. Canny in 1986. The main advantage of this method is elimination of multiple responses to a single edge. It can detect the true weak edge. For two-dimensional image, Canny operator can produce two information including the border gradient direction and intensity. The Canny operator edge detection is to search for the partial maximum value of image gradient. The gradient is counted by the derivative of Gaussian filter. The Canny operator uses two thresholds to detect strong edge and weak edge respectively. Hysteresis uses two thresholds and if the

magnitude is below the first threshold, it is set to zero (made a non-edge). If the magnitude is above the high threshold, it is made an edge. And if the magnitude is between the 2 thresholds, then it is set to zero unless there is a path from this pixel to a pixel with a gradient above threshold 2.

3. **Robert's cross operator:** The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator. These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations
4. **Prewitt's operator:** Prewitt operator is similar to the Sobel operator with a slight variation in the mask coefficients and is used for detecting vertical and horizontal edges in images.

-1	**0**	**+1**		**+1**	**+1**	**+1**
-1	**0**	**+1**		**0**	**0**	**0**
-1	**0**	**+1**		**-1**	**-1**	**-1**
Gx				**Gy**		

2. Methodology

The methodology used in this dissertation for partitioning the digital image of corroded metallic objects into corroded and non-corroded regions . The key steps involved are discussed below.

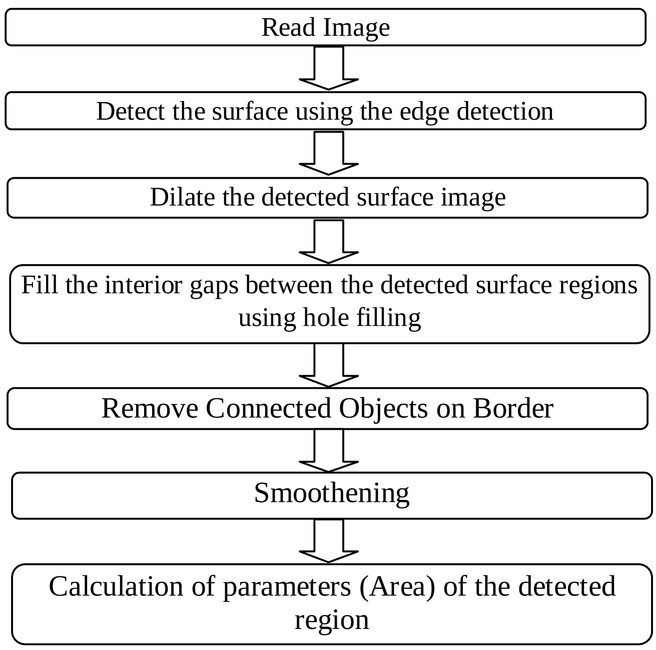


Fig. 1: Research methodology to detect area of corroded surfaces in an image of metallic surface.

3. Results

In particularly, the results obtained are divided into the following three parts:

1. The first part discusses the efficiency of the proposed edge detection algorithm based on morphological erosion operation.
2. The second part investigates the accuracy of the proposed corrosion based algorithm using various edge detection algorithms (including the proposed edge detection algorithm) on the images of objects with known area.
3. In the third part, the corrosion detection algorithm is tested for various real pictures of corroded surfaces.

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