Detection of closed cracks in highly attenuative materials

Research Background

Closed fatigue cracks in metal components are difficult to inspect using traditional ultrasonic non-destructive testing methods. With defects occurring during manufacture, construction or operation it is essential that there are appropriate methods in place to allow for detection, sizing and location before irreparable damage occurs. A number of factors lead to the introduction of crack-like defects within a component, often these are invisible to the eye and ultrasonically undetectable and can grow over time. This multidisciplinary project deals with the development of novel and advanced ultrasonic inspection techniques to assist in the detection of crack-like features, through the development of appropriate post-processing algorithms. The core objective of the project is to analyse the raw ultrasonic data to extract information in order to visually identify crack-like feature.

The Challenge

In recent years, a new ultrasonic technology has emerged commonly referred to as Full Matrix Capture (FMC). Unlike previous inspection methods, FMC offers the ability to apply post-processing algorithms on acquired data to extract features that would traditionally be undetectable. A limiting factor in widespread adoption of FMC is speed of processing and development of appropriate imaging algorithms. Computer vision, machine learning, general purpose GPU programming and Virtual Source Aperture (VSA) all offer great potential in this field.

Developments

The researchers previously explored methods of computational efficiency in the process of FMC data [1] and alternate VSA methods for ultrafast high speed inspection [2]. Algorithms were developed further to allow for detection of crack-like features using a self-tandem technique, calibration methods for VSA were developed and computer vision combined with machine learning explored as a method of automatic defect detection.

In the development of an automated defect recognition system, three basic steps were explored: image processing, feature extraction and defect classification.

The ultrasonically-generated image often requires some initial image processing to assist with the feature extraction process.

The selection of features is a key factor in the success of automatic defect recognition. For this work, size, position and orientation are explored. The final stage was to develop a defect classification system based on the features extracted from the ultrasonic images utilising a neural network based solution. This research was published September 2016 [3].

For high speed VSA inspection algorithms were developed incorporating calibration methods and solutions to the VSA beam traversing a refractive boundary [4].

Impact and Outcomes

One of the key features of this project is its industrial focus and multidisciplinary nature involving techniques from a range of disciplines including physics, ultrasonic inspection and computer science.

The Future

Initial algorithms and code were developed within the context of the project. As the technology matures, the next challenge is to provide validation methods to allow widespread adoption within industry.

"This Sêr Cymru NRN project has led to the development of a number of novel algorithms and updated computer code which allows for real-time inspection of traditionally difficult or previously ultrasonically invisible components. This marks a significant development for industry, providing researchers with the tools for real-time FMC inspection and the VSA technology."

- Phavan Dosanjh, Project Leader