

Fabrication of Machine Vision Robot to Check Crack Detection in Pipelines

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechatronics

by

Santhosh K (39090047)

Chris Edwin J (39090007)



**DEPARTMENT OF MECHATRONICS
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

MAY - 2023

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Santhosh K (39090047)**, **Chris Edwin J (39090007)** who have done the project work entitled **"Fabrication of Machine Vision Robot to Check Crack Detection in Pipelines"** under our supervision from June 2022 to May 2023.

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Submitted for Viva Voice examination held on ____ May 2023

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DECLARATION

We **Santhosh K (39090047)** and **Chris Edwin J (39090007)** hereby declare that the Project Report entitled “**Fabrication of Machine Vision Robot to Check Crack Detection in Pipelines**” done by us under the guidance of **Dr.M Sangeetha M.E, PhD** is submitted in fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechatronics.

1. 
2. 

DATE: ____ May 2023

PLACE: Chennai, Tamil Nadu

SIGNATURE OF THE CANDIDATE

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ABSTRACT

The detection of liquid pipelines leakage or cracks is important to ensure that liquid supply network can operate safely and conserve liquid resources in large-scale industry. Liquid leakage from pipelines is critical issue in large-scale process plants. Damage in pipelines affects the normal operation of the plant and increase the maintenance cost. So the detection of leakages and crack is a crucial task to maintenance and condition monitoring in large-scale industry. By manual inspection only to check the cracks and leakage by it's very difficult to inspect the cracks and leakages in large scale industry. So in order to develop an automatic inspection system for pipelines maintenance .Such a system is aimed at detecting the cracks and leakage by using the image source Finally, a decision-making support tool based on the image contour closure is enabled for classification purposes. The implementation of the proposed system is tested on a real industrial environment.

TABLE OF CONTENT

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	v
	LIST OF FIGURES	viii
1	INTRODUCTION	1
	1.1 CRACK DETECTION	1
	1.1.1 TYPES OF CRACK DETECTION IN PIPELINES	2
	1.1.2 ULTRASONIC TESTING	3
	1.1.3 MAGNETIC PARTICLE	3
	1.1.4 RADIOGRAPHIC TECHNIQUE	5
	1.1.5 EDDY CURRENT	6
	1.1.6 SYSTEM FOR MACHINE VISION	8
	1.1.7 PROCESSING OF IMAGES	8
2	LITERATURE SURVEY	10
	2.1. IMAGE PROCESSING FOR CRACK DETECTION: A CRITICAL REVIEW AND ANALYSIS	10
	2.2. CONCRETE CRACK DETECTION USING COMPUTER VISION	10
	2.3 PRINCIPLES AND USES OF DIGITAL IMAGE PROCESSING	11
	2.4 AN EXAMINATION OF MACHINE VISION SENSORS FOR MONITORING TOOL CONDITION	11
	2.5 INDUSTRIAL MACHINE VISION SYSTEMS	12
	2.6 DIGITIZATION OF IMAGES	12

	2.7 CRACK DETECTION USING IMAGE PROCESSING	13
3	AIM AND SCOPE	14
	3.1 AIM	14
	3.2 OBJECTIVE	14
	3.3 MERITS & DEMERITS	14
	3.4 PROBLEM STATEMENT	16
	3.5 DRAWBACKS	17
4	MATERIALS & METHODS	18
	4.1 METHODOLOGY	19
	4.2 MATERIALS	20
	4.2.1 METAL FRAME	20
	4.2.2 MOTOR	22
	4.2.3 RF TRANSMITTER	23
	4.2.4 WHEEL	24
	4.2.5 LED	26
5	RESULTS & DISCUSSIONS	29
	5.1 DESIGN THE ROBOT	30
	5.2 FABRICATION OF ROBOT	33
	5.3 CRACK ON STEEL AND PLASTIC	35
	5.4 INSERT ROBOT IN PIPELINE	36
	5.5 GATHERING DATA FROM CAMERA	37
	5.6 PROCESSING THE DATA	39
	5.7 CRACK DETECTION IN PIPELINE	41
	5.8 IDENTIFY THE CRACK	42
	5.9 OVERALL OUTCOME	46
6	CONCLUSION	49
	REFERENCES	50
	ANNEXURE	53

LIST OF FIGURES

FIG NO	TITLE	PAGE NO
1.1	Detection of Surface Crack in Building Structures Using Image Processing	2
1.1.2	Ultrasonic testing	3
1.1.3	Magnetic Particle Examination	4
1.1.4	Crack detection using radiography	6
1.1.5	eddy current using to detect crack on surface	7
4.1	Methods of finding cracks	20
4.2.1	Metal frame	21
4.2.2	DC motor	23
4.2.3	RF transmitter and receiver	24
4.2.4	Robot wheel	26
4.2.5	led lights for clear vision	27
5.1	Design of the robot	31
5.1.2	side view of the robot	32
5.2	fabrication of robot	34
5.3	crack images on pipelines	36
5.4	View inside a pipeline after insert the bot	37
5.5	Inside view of pipeline	39
5.6	output of crack	40
5.7	after detect the crack	42
5.8	crack images get from python programming	43

5.9	Full completed robot	46
5.9.1	After insert the bot in pipeline	47
5.9.2	output of crack	47
5.9.3	Graphical form of defect	48

CHAPTER 1

INTRODUCTION

1.1 CRACK DETECTION

Crack detection is a critical process used to identify and analyze cracks or fractures in a variety of materials. These cracks can lead to significant damage to structures and machinery, compromising their integrity and potentially leading to safety concerns and costly repairs. Detecting cracks early is essential in ensuring that structures and machines remain safe and reliable. Crack detection techniques have evolved significantly over time, from visual inspection to more advanced methods like ultrasonic testing, magnetic particle inspection, and X-ray imaging. Visual inspection is the most basic form of crack detection, where cracks are identified by simply looking for visible signs of damage. Ultrasonic testing involves the use of high-frequency sound waves to detect cracks and other defects in materials. Magnetic particle inspection uses magnetic fields and particles to identify cracks in ferrous materials, while X-ray imaging can detect cracks in a range of materials by analyzing how X-rays interact with the material's structure. The choice of crack detection method depends on the type of material, the location and severity of the crack, and the required level of accuracy. Crack detection is critical in a wide range of industries, including aerospace, automotive, construction, and manufacturing, where safety and reliability are paramount. Fig 1.1 the compare between normal image of crack and detection of crack through image processing

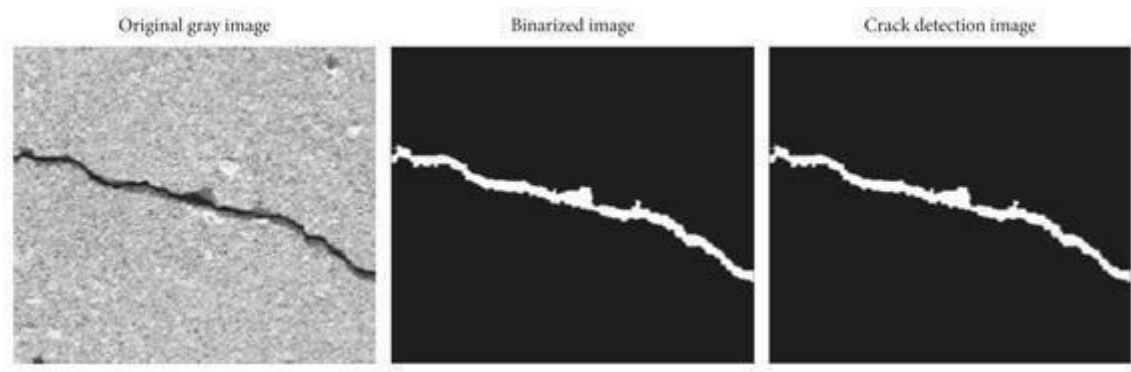


Fig 1.1 : Detection of Surface Crack in Building Structures Using Image Processing

1.1.1 Types of crack detection in pipelines

There are several types of crack detection methods used in pipelines, including ultrasonic testing, magnetic particle inspection, radio-graphic testing, and eddy current testing. Ultrasonic testing involves using high- frequency sound waves to detect cracks and other defects in the pipeline's material. Magnetic particle inspection uses magnetic fields and particles to identify cracks in ferrous materials. Radio-graphic testing utilizes X- rays or gamma rays to detect cracks and other internal defects in the pipeline. Eddy current testing uses electromagnetic induction to identify surface and near-surface cracks in conductive materials. Each of these methods has its advantages and limitations, and the selection of the most appropriate method depends on factors such as the pipeline's material, size, location, and the required level of accuracy.

- 1 Ultrasonic testing.
- 2 Magnetic particle inspection.
- 3 Radio graphic testing.
- 4 Eddy current

1.1.2 Ultrasonic testing

Ultrasonic testing is a non-destructive testing method that uses high-frequency sound waves to detect and evaluate internal defects or inconsistencies in materials. The process involves the use of an ultrasonic transducer, which sends high-frequency sound waves through the material being tested. Fig 1.1.2 If there are any internal defects or inconsistencies, such as cracks or voids, the sound waves will be reflected back to the transducer, creating a signal that can be analyzed by a technician. Ultrasonic testing is widely used in various industries, including manufacturing, aerospace, and oil and gas, for quality control and safety purposes. It is a highly effective and reliable method for detecting flaws that may not be visible to the naked eye.

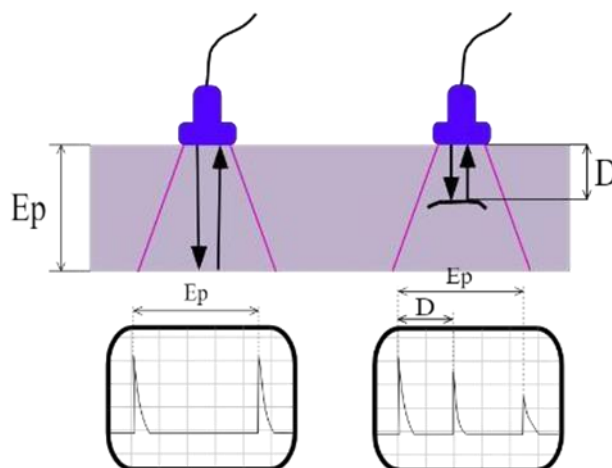


Fig 1.1.2: Ultrasonic testing

1.1.3 Magnetic particle inspection

Magnetic particle inspection (MPI) is a non-destructive testing method used to detect surface and subsurface defects in ferromagnetic materials. The process involves applying a magnetic field to the material being inspected and then applying a magnetic particle solution to the surface. Fig 1.1.3 The particles will be attracted to any areas where there is a magnetic flux leakage due to a crack, void or other type of defect in the material.

be either dry or wet and can be applied by various methods, including spraying, dusting, or using a pre-mixed solution. Once the particles have been applied, the surface is then inspected for any indications of defects using visual or fluorescent inspection. The process is highly effective for detecting defects that may not be visible to the naked eye, such as cracks, porosity, laps, and seams. It is widely used in various industries, including aerospace, automotive, construction, and manufacturing, for quality control and safety purposes. MPI is a versatile and cost-effective method of testing ferromagnetic materials. It can be used for both surface and subsurface inspections and can detect defects that are difficult to see or find using other methods. The process is quick and easy to perform, making it ideal for both in-house and field inspections. MPI can be used on a variety of materials, including iron, steel, nickel, and cobalt-based alloys. There are several types of MPI, including AC, DC, and FWDC (full-wave DC) methods. Each method has its advantages and disadvantages, and the choice of method will depend on the specific application and the material being tested. MPI is a widely accepted and proven method of non-destructive testing and is an essential part of quality control and safety in many industries.

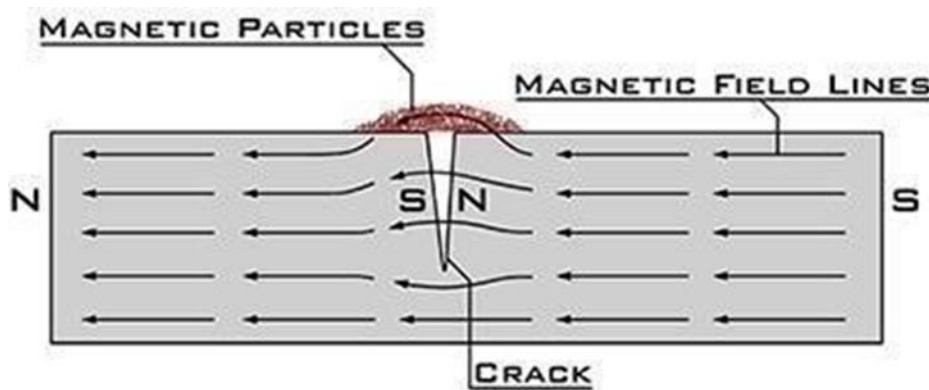


Fig 1.1.3 : Magnetic Particle Examination

1.1.4 Radio-graphic technique

Radio-graphic techniques are a type of non-destructive testing used to examine the internal structure of materials. This technique involves exposing the material to a controlled source of radiation, such as X-rays or gamma rays, and capturing the resulting image on film or digitally. The radiation passes through the material, and the areas that are more dense or thicker will absorb more radiation, resulting in a darker image on the film fig 1.1.4 There are two main types of radio-graphic techniques: film radiography and digital radiography. In film radiography, a special film is placed behind the material being examined, and the radiation passes through the material and onto the film, which is then developed to produce an image. In digital radiography, a digital sensor is used instead of film, and the resulting image is captured and displayed on a computer screen. Radio-graphic techniques are widely used in various industries, including aerospace, automotive, construction, and manufacturing, for quality control and safety purposes. This technique can detect internal defects such as cracks, voids, and inclusions, which may not be visible to the naked eye. Radio-graphic techniques are highly accurate and reliable and can be used to inspect a wide range of materials, including metals, plastics, and composites. Radio-graphic techniques require strict safety protocols to ensure the protection of the operator and the environment. Radiation can be harmful if not properly controlled, and exposure must be kept to a minimum. Proper training and certification are required for personnel performing radio-graphic inspections, and regulatory agencies oversee the use of radiation for industrial purposes. Radio-graphic techniques are an essential tool in non-destructive testing and are widely used to ensure the quality and safety of materials and components in various industries. The technique is highly accurate and reliable, and with proper safety protocols.

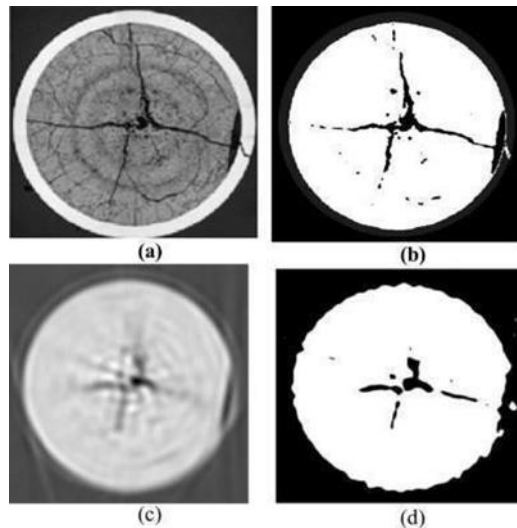


Fig 1.1.4 : crack detection using radiography

1.1.5 Eddy current

Eddy current testing is a non-destructive testing method used to detect surface and near-surface defects in conductive materials. The process involves passing an alternating current through a coil, which generates a magnetic field around the coil. The magnetic field induces eddy currents in the conductive material being tested, which in turn generate their own magnetic fields. The interaction between the magnetic fields produces a signal that can be detected and analyzed by a technician. Fig 1.1.5 Eddy current testing is widely used in various industries, including aerospace, automotive, and manufacturing, for quality control and safety purposes. The technique can detect surface and near-surface defects such as cracks, corrosion, and flaws in welds. It can also be used to measure the thickness of thin conductive materials, such as pipes and tubes. Eddy current testing is a quick and effective method of non-destructive testing, and it can be used on a variety of materials, including metals, composites, and alloys. It is a highly sensitive technique and can detect defects that may not be visible to the naked eye. Eddy current testing can also be automated, allowing for high-volume inspections in manufacturing production environments. There are various types of eddy current testing, including surface testing, sub surface testing, and array testing. Each method has its advantages and disadvantages, and the choice of method will depend on the specific application and the material being tested. Eddy current testing requires proper training and certification, and safety protocols must be

followed to ensure the safety of the operator and the environment. eddy current testing is a valuable tool in non- destructive testing and is widely used in various industries. The technique is highly accurate and sensitive and can detect surface and near-surface defects in conductive materials. With proper training and safety protocols, eddy current testing is a safe and effective method of inspection

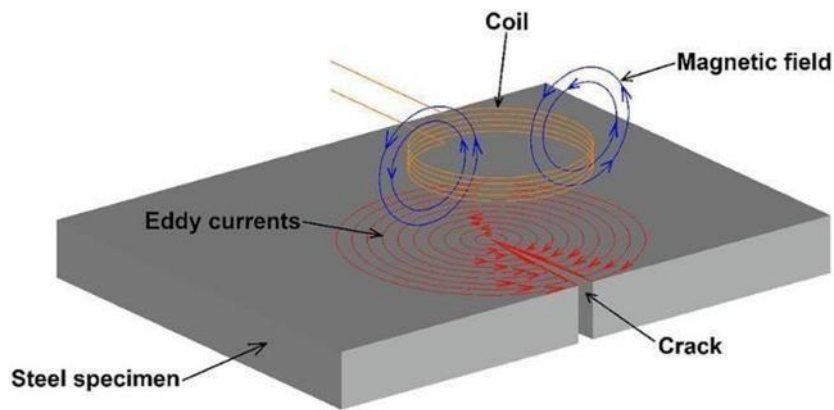


Fig 1.1.5 : eddy current using to detect crack on surface

Non-destructive testing (NDT) methods such as eddy current, magnetic particle inspection (MPI), radio-graphic, and ultrasonic testing are widely used in various industries for quality control and safety purposes. Eddy current testing is used to detect surface and near-surface defects in conductive materials, while MPI is used to detect surface and subsurface defects in ferromagnetic materials. Radio-graphic techniques are used to examine the internal structure of materials, and ultrasonic testing uses high-frequency sound waves to detect internal defects such as cracks and voids. Each NDT method has its advantages and disadvantages, and the choice of method will depend on the specific application and the material being tested. Proper training, certification, and safety protocols are required for personnel performing NDT inspections to ensure the safety of the operator and the environment. Overall, NDT methods are valuable tools in ensuring the quality and safety of materials and components in various industries. NDT methods and does not go into detail about the specific limitations and challenges of each method. For

example, radio- graphic techniques can be expensive and time-consuming, and the use of radiation requires strict safety protocols. Eddy current testing may not be effective for detecting defects at depth, and the sensitivity of the method can be affected by the electrical conductivity and permeability of the material being tested. Similarly, ultrasonic testing may not be suitable for materials with rough surfaces or irregular shapes. Providing more detailed information about the advantages and disadvantages of each NDT method would provide a more comprehensive understanding of these techniques

1.1.6 System for machine vision

Machine vision systems are the tools and techniques that make imaging- based automatic inspection and analysis possible in the contexts of automatic inspection, process control, and robot guiding. Usually used in the manufacturing industry, these systems. A broad range of technologies, software and hardware components, integrated systems, protocols, and body of knowledge are included under the umbrella term "machine vision system." Machine vision is a sub field of system engineering. already available technologies in creative ways to deal with issues in the real world. Although it is also used for these functions in vehicles in other locations, the phrase is usually used for them in environments with automation. At run-time, imaging is the initial stage in the process. Machine vision systems gather visual information from the environment using cameras. It then processes the images using a combination of hardware and software to get the data ready for use in other applications. Machine vision technology usually uses specialized optics to take pictures. A visual system is capable of gathering images, analyzing them, and recognizing an object or objects among a group of things. When the region has been illuminated by a source of light, image sensors create an optical image. A photo detector is used to create an optical image while taking the picture. During the picture capture process, a photo detector is employed to provide an optical image that can be converted into a digital image. This technique combines the sense of images with the encoding of visual data.

1.1.7 Processing of images

Machine vision systems are the tools and techniques that make imaging- based automatic inspection and analysis possible in the contexts of automatic inspection,

process control, and robot guiding. Usually used in the manufacturing industry, these systems. A broad range of technologies, software and hardware components, integrated systems, protocols, and body of knowledge are included under the umbrella term "machine vision system." Machine vision is a sub field of system engineering. already available technologies in creative ways to deal with issues in the real world. Although it is also used for these functions in vehicles in other locations, the phrase is usually used for them in environments with automation. . At run-time, imaging is the initial stage in the process. Machine vision systems gather visual information from the environment using cameras. It then processes the images using a combination of hardware and software to get the data ready for use in other applications. Machine vision technology usually uses specialised optics to take pictures. A visual system is capable of gathering images, analysing them, and recognizing an object or objects among a group of things. When the region has been illuminated by a source of light, image sensors create an optical image. A photo detector is used to create an optical image while taking the picture. During the picture capture process, a photo detector is employed to provide an optical image that can be converted into a digital image. This technique combines the sense of images with the encoding of visual data.

CHAPTER 2

LITERATURE SURVEY

2.1. IMAGE PROCESSING FOR CRACK DETECTION: A CRITICAL REVIEW AND ANALYSIS

One of the earliest signs of a structure degrading is a crack in the surface of the concrete. This is important for maintenance because further exposure would seriously harm the environment. The most well-liked technique for crack inspection is manual inspection. The crack sketch is manually created during the manual examination, and the circumstances surrounding the anomalies are noted. The manual method lacks impartiality in the quantitative analysis because it fully depends on the knowledge and expertise of the specialist [6]. As a substitute, automatic image-based fracture detection is suggested. Various methods for applying image processing to automatically determine the crack and its depth are presented in the literature

2.2. CONCRETE CRACK DETECTION USING COMPUTER VISION

Robots could soon perform time-consuming, expensive, and information intensive infrastructure monitoring activities like road or bridge inspection thanks to advances in robotics and computer vision systems. Effective and routine monitoring could aid in early fracture detection to prevent structural damage and, consequently, potential accidents. Numerous vision-based strategies have been put forth to handle robotic colour tracking, image segmentation, and the crack detection issue. The majority of these techniques for identifying cracks rely on edge-detection methods like the rapid Fourier transform, fast Haar transform, or the Sobel and Canny operator. developed a semi-automatic method that used graph search to extract cracks based on user input while integrating Sobel and Laplacian operators to discover crack edges [9]. The discovered cracks are traced in both directions before being blended to produce the desired outcome in another semi-automatic manner. However, basic edge identification methods are only reliable for high contrast photos with a largely homogeneous background.

2.3 PRINCIPLES AND USES OF DIGITAL IMAGE PROCESSING

Digital image processing is an important part in digital analysis of remote sensing data. It allows one to enhance image features of interest while attenuating irrelevant features of a given application and then extract useful information about the scene from the enhanced image. It comprises the four basic steps, which include image correction/restoration, image enhancement, image transformation, and image classification [7]. Image restoration is basically aimed to compensate the data errors, noise, and geometric distortions introduced during the scanning, recording, and playback operations. Image enhancement helps to alter the visual impact that the image has on the interpreter, that improve the information content and information extraction ability by utilizing the decision-making capability of the computer in order to recognize and classify the pixels on the basis of their digital signatures. The information extracted by comparing two or more images of an area that were acquired at different times. Unsupervised classification distinguish the patterns in the reflectance data and groups them knowledge of the image. Whereas, in supervised classification, the user trains the computer, guiding it what type of spectral characteristics to look for and what type of land cover they represent, and guides the image processing software how to classify certain features. Change- detection analysis provides information about the changes in different seasons or dates. In post- classification analysis, image smoothing and accuracy assessment are important to generate the output from digital image processing. into a pre-defined number of classes without any prior

2.4 AN EXAMINATION OF MACHINE VISION SENSORS FOR MONITORING TOOL CONDITION

Tool condition monitoring has gained considerable importance in the manufacturing industry over the preceding two decades, as it significantly influences the process economy and the machined part quality [13]. Recent advances in the field of image processing technology have led to the development of various in-cycle vision sensors that can provide a direct and indirect estimate of the tool condition. These sensors are characterized by their measurement flexibility, high spatial resolution and good accuracy. This paper provides a review

of the basic principle, the instrumentation and the various processing schemes involved in the development of these sensors.

2.5 INDUSTRIAL MACHINE VISION SYSTEMS

The machine vision systems in the industrial applications are described. First understanding of the vision in terms of a universal concept is explained. System design methodology is discussed and a generic machine vision model is reported. Such a machine includes systems and sub-systems, which of course depend on the type of applications and required tasks. In general, expected functions from a vision machine are the exploitation and imposition of the environmental constraint of a scene, the capturing of the images, analysis of those captured images, recognition of certain objects and features within each image, and the initiation of subsequent actions in order to accept or reject the corresponding objects. After a vision system performs all these stages, the task in hand is almost completed. [11] The introduction of the automation has revolutionized the manufacturing in which complex operations have been broken down into simple step-by-step instruction that can be repeated by a machine. In such a mechanism, the need for the systematic assembly and inspection have been realized in different manufacturing processes. These tasks have been usually done by the human workers, but these types of deficiencies have made a machine vision system more attractive. Our expectation from a visual system is to perform the following operations: the image acquisition and analysis, the recognition of certain features or objects within that image, and the exploitation and imposition of environmental constraints.

2.6 DIGITIZATION OF IMAGES

Digital image processing fundamentals can understand as basics steps which we follow during processing of digital image. Image can be defined as a function which as two dimension value of magnitude of image and these value works for making of elements of digital image. These elements include elements of picture, elements of image and pixels [19]. When the value of these elements are finite then you can called that image is digital image. When we works on elements of image for enhancing its quality or extracting some information from that image then it can be consider as Digital Image processing, image processing. We will analyze some types of images first today in this article so that we will have good

knowledge about different types of image and we can easily go through processing fundamentals of Digital image. We will discuss type of image on the basis of their formation on digital computer

2.7 CRACK DETECTION USING IMAGE PROCESSING

Cracks on the concrete surface are one of the earliest indications of degradation of the structure which is critical for the maintenance as well the continuous exposure will lead to the severe damage to the environment. Manual inspection is the acclaimed method for the crack inspection. In the manual inspection, the sketch of the crack is prepared manually, and the conditions of the irregularities are noted. Since the manual approach completely depends on the specialist's knowledge and experience, it lacks objectivity in the quantitative analysis[2]. So, automatic image-based crack detection is proposed as a replacement. Literature presents different.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The aim of using a machine vision robot to check for cracks in pipelines is to improve the efficiency and accuracy of crack detection. The machine vision system can quickly scan large lengths of pipeline and identify any cracks or defects with high accuracy, reducing the need for manual inspections and improving the overall safety and reliability of the pipeline. The system can also provide real-time feedback, allowing for immediate corrective actions to be taken if necessary. The goal is to minimize the risk of pipeline failure due to undetected cracks and ensure the safe and efficient transportation of fluids or gases through the pipeline.

3.2 OBJECTIVES

The objective of using a machine vision robot to check for cracks in pipelines is to achieve a more efficient, accurate, and reliable crack detection process. By automating the inspection process, the objective is to reduce the time and cost associated with manual inspections while improving the accuracy and reliability of crack detection. The machine vision system will be designed to scan large lengths of pipeline and identify any cracks or defects with high precision and accuracy. The system will be equipped with advanced image processing and pattern recognition algorithms to ensure accurate and reliable crack detection, while also providing real-time feedback to enable immediate corrective actions if necessary. The overall objective is to enhance pipeline safety, minimize the risk of pipeline failure due to undetected cracks, and ensure the uninterrupted flow of fluids or gases through the pipeline.

3.3 MERITS & DEMERTIS

Cracks in pipelines can pose serious safety risks, making it essential to detect them as early as possible. The use of crack detection methods can provide numerous benefits, including increased safety, improved reliability, cost-effectiveness, increased efficiency, and non-destructiveness. Regular inspections

using crack detection methods can identify issues before they become major problems, ensuring the safety and reliability of pipelines. This can prevent accidents, injuries, and even loss of life. Additionally, these methods can be cost-effective, helping to prevent expensive repairs and replacements by catching issues early. Automated crack detection methods, such as machine vision, can scan large lengths of pipelines in a shorter amount of time, increasing efficiency and reducing inspection time. This not only saves time but also reduces the need for manual inspections, which can be dangerous and time-consuming. Furthermore, many crack detection methods are non-destructive, meaning that they do not damage the pipeline during inspection. This is particularly important for pipelines carrying hazardous materials where any damage to the pipeline can lead to serious safety concerns. Overall, the use of crack detection methods provides numerous benefits for pipeline safety, reliability, efficiency, and cost-effectiveness. As such, the implementation of these methods should be a priority for any organization that operates pipelines. Crack detection methods can be an essential aspect of maintaining pipeline safety and reliability. However, it is crucial to consider the potential drawbacks of these methods to make an informed decision on which technique to use. Some of the significant drawbacks include high initial costs, maintenance expenses, false positives, limited detection capabilities, and human error. The cost of equipment is a significant factor when choosing a crack detection method. Some methods require expensive equipment, which may not be feasible for small companies or contractors. The initial investment can be a barrier for organizations looking to implement these methods. Additionally, maintenance and calibration costs for equipment used in crack detection can add up over time, leading to additional expenses. False positives generated by some crack detection methods are another potential drawback. This can lead to unnecessary inspections and repairs, increasing costs and causing downtime. Furthermore, some methods have limited detection capabilities and may not be able to detect certain types of cracks or defects. This can lead to inaccurate detection's, posing a serious safety concern for pipelines. Manual inspections can be subject to human error, leading to missed or inaccurate detection's of cracks in pipelines. This is particularly problematic for large pipelines, where manual inspections can be time-consuming and error-prone. In summary, it is important to consider the potential drawbacks when selecting an appropriate crack detection method to ensure

pipeline safety. False positives and false negatives are significant problems that can arise in crack detection. False positives occur when a crack detection method indicates that a crack is present when there is no actual crack. This can lead to unnecessary maintenance and repair work, which can be time-consuming and costly. On the other hand, false negatives occur when a crack detection method fails to identify a crack that is present. This can be a serious safety concern, as undetected cracks can lead to pipeline failure and potentially catastrophic consequences. Another problem that can arise in crack detection is limitations in detection capabilities. Some detection methods may only be able to identify certain types of cracks, while others may be limited in their ability to detect cracks in certain parts of the pipeline. This can lead to missed or inaccurate detection's, posing a significant risk to pipeline safety. Lastly, even if a crack is detected, it can be difficult to identify the severity of the crack. This can make it challenging to determine the appropriate maintenance or repair action needed to address the crack. To address these problems, it is essential to carefully select and use appropriate crack detection methods, regularly maintain and calibrate detection equipment, and have a thorough understanding of the limitations of the chosen detection method. It is also crucial to have a well-established plan for addressing detected cracks, including guidelines for determining the severity of the crack and appropriate maintenance or repair actions. Overall, the use of crack detection methods can provide significant benefits for pipeline safety and reliability.

3.4 PROBLEM STATEMENT

The problem with crack detection in pipelines is that traditional inspection methods, such as manual visual inspections, may not be effective in detecting small cracks or defects that could lead to major failures or leaks. These traditional methods can also be time-consuming and require a significant amount of resources, which can lead to increased costs and reduced efficiency. In addition, human error and subjectivity can also affect the accuracy and reliability of traditional inspection methods. Therefore, there is a need for more advanced crack detection methods that are accurate, reliable, and cost-effective, while also providing real-time feedback to enable prompt corrective action if necessary. Developing and implementing such methods can help to prevent accidents, ensure

the safe and efficient transportation of fluids or gases, and reduce the risk of costly repairs and replacements

3.5 DRAWBACKS

Crack detection methods used in pipeline inspection can have several drawbacks that affect their reliability, accuracy, and cost-effectiveness. One of the main concerns is the limited detection capabilities of different methods, which may not be effective in detecting certain types of cracks or defects. This can lead to missed or inaccurate detections, which can compromise pipeline safety and reliability. False positives are another issue with crack detection methods, as they can result in unnecessary repairs or replacements, adding to the overall cost of inspection. Additionally, some crack detection methods require expensive equipment, which may not be feasible for smaller companies or contractors. Regular maintenance and calibration of this equipment can also be costly, increasing the financial burden. Manual inspections can also be subject to human error, which can affect the accuracy and reliability of inspection results. Safety concerns are another issue, as some crack detection methods may involve the use of hazardous materials or radiation, posing risks to personnel. Environmental impact is also a concern, as some methods may produce waste materials that can be harmful to the environment if not disposed of properly. Overall, it is important to consider these drawbacks when selecting and implementing crack detection methods in pipeline inspection. Efforts should be made to mitigate these issues and ensure the safety, reliability, and cost-effectiveness of pipeline inspection methods.

CHAPTER 4

MATERIAL & METHODS

Machine vision robots are quickly gaining traction in various industries for their ability to automate tasks that are often difficult or dangerous for humans. One such robot is the machine vision robot with a steel body, spring, camera, motor, and wheels that is specifically designed to navigate through pipe lines and inspect their interiors. The robot's steel body is carefully crafted to withstand the harsh conditions found inside pipe lines, such as extreme temperatures, corrosive materials, and rough terrain. The robot's body design includes a spring that enables it to bend and flex as it moves through the pipe, ensuring that it can navigate through any curves or obstacles it may encounter along the way. The spring is a critical component of the robot's design, as it allows the robot to maintain its structural integrity while navigating through the pipeline. The robot's ability to withstand these conditions is essential for the safety of the pipeline, the environment, and the human workforce. The machine vision robot is equipped with a high-quality camera that allows it to capture high-resolution images of the interior of the pipe as it moves along. The camera is connected to a computer system that processes the images in real-time, enabling the robot to identify any defects or damage within the pipe. The camera is an essential component of the machine vision robot, as it enables the robot to "see" what is happening within the pipe and identify potential issues. To enable the robot to move through the pipe, it is equipped with a motor and wheels. The motor provides the necessary power to drive the wheels, which in turn propel the robot forward through the pipe. The wheels are carefully designed to be rugged and durable, ensuring that they can withstand the harsh conditions found within pipe lines. The robot's mobility is an essential aspect of its design, as it enables the robot to navigate through the pipe and inspect it thoroughly. The robot is controlled by a computer system that receives input from the camera and other sensors on the robot. The computer system uses advanced algorithms and machine learning techniques to process the data received from the sensors, enabling the robot to navigate through the pipe and identify any defects or damage within it. The robot's control system is critical

to its functionality, as it enables the robot to operate autonomously within the pipeline environment, reducing the need for human intervention and minimizing the potential risks involved. In summary, the machine vision robot with a steel body, spring, camera, motor, and wheels is a highly advanced piece of technology that is specifically designed to navigate through pipe lines and inspect their interiors. Its rugged design, high-quality camera, mobility, and advanced sensors and algorithms make it an ideal solution for tasks that are difficult or dangerous for humans, such as inspecting oil and gas pipelines or performing maintenance on water pipelines. The machine vision robot is a game-changing technology that will revolutionize the inspection and maintenance of pipeline infrastructure, ensuring the safety and integrity of these critical assets for years to come.

4.1 METHODOLOGY

Effusion detection is a crucial diagnostic procedure used in various medical fields, including radiology, cardiology, and pulmonology. Effusion is the accumulation of fluid in a body cavity, which can cause various symptoms and complications. To detect effusion, several steps are involved, each with its importance and challenges. The first step in effusion detection is acquiring an image of the affected area using a device such as an ultrasound machine or X-ray scanner. The device generates an image that contains valuable information about the location and size of the effusion. However, the image obtained may be of low quality and require enhancement to facilitate accurate interpretation. The second step in effusion detection is image improvement. The acquired image may contain noise or have low contrast, making it difficult to identify the effusion. Therefore, the image is processed to improve its quality, primarily by adjusting the contrast and reducing noise. Contrast adjustment enhances the difference between the effusion and the surrounding tissues, while noisereduction improves the image's clarity and reduces artifacts that may interfere with effusion detection. After improving the image quality, the next step is to save and process it further using advanced algorithms that use pattern recognition and image segmentation to detect the effusion. Pattern recognition algorithms analyze the image to identify patterns and features that characterize the effusion, such as its size, shape, and location. Imagesegmentation algorithms use these features to isolate the effusion from the surrounding tissues and generate a separate image that highlights the effusion.

This image provides a more detailed representation of the effusion, making it easier to diagnose. Finally, the results of effusion detection are presented to the user, typically a medical professional, who interprets the image and makes a diagnosis. The automated process can speed up the diagnosis by reducing the time taken to process the image, and it can also improve the accuracy of the diagnosis by minimizing the risk of human error. Effusion detection involves several crucial steps, including image acquisition, improvement, processing using advanced algorithms, and result presentation. Each step is essential and requires careful consideration to ensure accurate and timely diagnosis fig 4.1. The process can be automated to make it faster and more accurate, which is especially crucial in critical care situations where time is of the essence. Effusion detection is a vital diagnostic tool that helps medical professionals

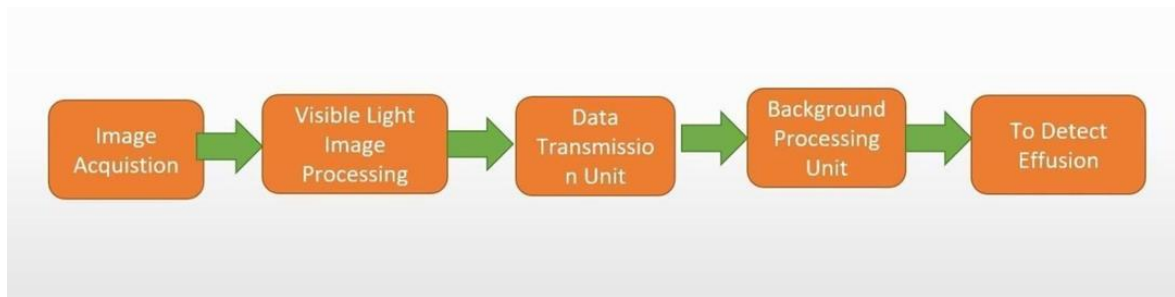


Fig 4.1 : Methods of finding cracks

4.2 MATERIALS

4.2.1 METAL FRAME

The Triangle shape bot with 6 wheels, 3 in front and 3 in back, is a remarkable invention in the field of robotics that has revolutionized pipe inspection and maintenance tasks. With its unique design and advanced features, it is specifically tailored to navigate through tight spaces and complex pipe networks, making it an ideal solution for the efficient and safe operation of pipelines in a variety of industries. One of the most essential components of a robot body is the metal frame Fig 4.2.1, which provides a sturdy and reliable structure capable of withstanding the weight and movement of various robot components such as motors, sensors, and batteries. The selection of the material for the frame

depends on various factors such as the robot's intended purpose, size, and environment. Metals such as aluminum, steel, and titanium are commonly used due to their durability, lightweight, and machine ability, making it easier to create complex shapes and designs. Furthermore, the metal frame can protect sensitive internal components, shielding them from external forces and impacts. Despite the advantages, using metal frames for robot bodies has some limitations. One significant drawback is the added weight, which can limit the robot's movement and maneuverability, thus affecting its overall performance. Additionally, the manufacturing process for metal frames requires specialized equipment and skilled labor, making it more costly and time-consuming. Furthermore, in some environments, metal frames can be susceptible to damage, such as corrosion, which can affect the robot's longevity and reliability. Finally, the rigid structure of the metal frame can restrict the robot's adaptability and flexibility to changing tasks or environments, limiting its ability to adjust or flex to new conditions. Therefore, depending on the intended use and operating environment, alternative materials such as composites or plastics may be more suitable for the robot body. These materials are generally lighter and more flexible than metal, making them more maneuverable and adaptable. Additionally, they are less susceptible to damage from corrosive environments, making them a better choice for robots that will be working in such conditions. In summary, the selection of the right material for the robot body is critical in ensuring the efficient and safe operation of the robot. While metal frames have their advantages, they also have some drawbacks that need to be considered when choosing the material for the robot body. Ultimately, the choice of material will depend on the robot's intended use, environment, and the balance between cost, performance, and durability



Fig 4.2.1 : Metal frame

4.2.2 MOTOR

A 300 RPM single shaft BO (Brushed DC) motor is an essential component in many robotics applications, particularly those requiring rotational movement. This type of motor is designed to operate on direct current (DC) and is capable of providing a rated rotational speed of 300 revolutions per minute (rpm) when powered at its rated voltage and current Fig 4.2.2 The "single shaft" designation indicates that the motor has only one output shaft, which is responsible for driving the load. The single shaft of the motor is typically straight, made of steel or other durable materials, and rotates to generate mechanical power. BO motors are a type of DC motor that use brushes to transmit electrical power to the rotating parts of the motor. The brushes, which are usually made of carbon, contact the motor's commutator, which is a segmented metal ring that reverses the direction of the current flowing through the motor's coils as it rotates. This allows the motor to maintain a constant rotational speed and direction, making it ideal for a wide range of applications. One of the key advantages of the 300 RPM single shaft BO motor is its ability to provide reliable and consistent performance, even under heavy loads. This is due in part to the use of brushes, which allow the motor to transmit power more efficiently and effectively. Additionally, the motor's rated rotational speed of 300 RPM makes it well-suited for tasks that require precise control over rotational speed and direction, such as robotics applications. However, it is important to note that BO motors also have some limitations. For example, they generate a significant amount of electrical noise, which can interfere with other components in the system. Additionally, the use of brushes means that BO motors require periodic maintenance to ensure optimal performance and longevity. Despite these limitations, the 300 RPM single shaft BO motor remains a popular choice in the robotics industry due to its reliability, durability, and performance. In addition to their reliability and precision, BO motors are also relatively easy to control and can be used with a variety of motor controllers and drivers. However, they do have some limitations, such as lower efficiency and higher maintenance requirements compared to other types of motors like brushless DC motors.

Nonetheless, for many applications, a 300 rpm single shaft BO motor is an ideal choice for driving mechanical loads with consistent performance and precise control.



Fig 4.2.2 : DC motor

4.2.3 RF TRANSMITTER

A radio frequency (RF) transmitter is an electronic device that is used to generate and transmit electromagnetic waves in the radio frequency range. These waves can carry information, such as voice or data, over long distances without the need for physical wires or cables. RF transmitters are commonly used in a variety of applications, including wireless communication systems, remote control devices, and radio broadcasting. The basic components of an RF transmitter include a signal source, a modulator, a power amplifier, and an antenna. The signal source generates the information-carrying signal, which is then modulated onto a carrier wave to produce the final RF signal. The power amplifier boosts the power of the RF signal to a level that is suitable for transmission, while the antenna radiates the signal into the surrounding space. There are several types of modulation techniques that can be used in an RF transmitter, including amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM). Each of these techniques has its own advantages and disadvantages, and the choice of modulation technique depends on the specific requirements of the application. One of the key considerations in the design of an RF transmitter is the frequency

range over which it operates. Different applications require different frequency ranges, and the transmitter must be designed to operate within the appropriate frequency band. Common frequency bands used in RF communication include the AM and FM broadcast bands, the cellular and wireless data bands, and the microwave bands used in satellite communication. In addition to frequency range, other important factors to consider in the design of an RF transmitter include output power, spectral purity, and efficiency Fig 4.2.3 The output power of the transmitter determines how far the signal can travel, while spectral purity refers to the absence of unwanted signals or noise in the transmitted signal. Efficiency is important for battery- Powered devices, as it determines how long the device can operate on a single battery charge. Overall, RF transmitters are essential components in modern wireless communication systems, enabling high- speed data transfer, remote control of devices, and broadcast of audio and video content. Their design and operation involve complex principles of electronics and physics, requiring specialized knowledge and expertise to develop and optimize for different applications.



Fig 4.2.3 : RF transmitter and receiver

4.2.4 WHEEL

The electronic spices pack of 4 wheel-4512 robot durable rubber tire yellow wheel 45mm for bo dc motor is an exceptional product that offers reliable performance and durability for a wide range of robotics applications. designed specifically for crack detection robots, these wheels are capable of moving effortlessly inside pipelines without fail, ensuring smooth and uninterrupted movement throughout

the inspection process. one of the key features of these wheels is their durable construction, which ensures long-lasting performance even in harsh environments. the wheels are made from high-quality rubber material, which provides excellent resistance to wear and tear, as well as exposure to chemicals and other substances that may be present inside pipelines. this makes them an ideal choice for robotics applications that require reliable performance under challenging conditions. in addition to their durability, these wheels also offer exceptional grip and traction, thanks to their unique design. the yellow color of the wheels is not just for aesthetics but also helps with visibility during the inspection process. the wheel's 45mm size is perfect for bo dc motors, which are commonly used in robotics applications. overall, the electronic spices pack of 4 wheel-4512 robot durable rubber tire yellow wheel 45mm fig 4.2.4 for bo dc motor is an excellent choice for anyone looking for reliable, high-performance wheels for their robotics projects. whether you are building a crack detection robot or any other type of robot that needs to move smoothly inside pipelines, these wheels are sure to meet your needs and exceed your expectations. so, if you want to ensure the success of your next robotics project, be sure to check out these wheels and experience their exceptional performance for yourself. firstly, the wheels are incredibly durable, thanks to their high- quality rubber construction, which makes them resistant to wear and tear and exposure to chemicals, ensuring reliable performance in harsh environments. additionally, the unique design of these wheels provides exceptional grip and traction, allowing for smooth and uninterrupted movement even on rough or uneven surfaces. this feature makes them an ideal choice for applications that require precise and reliable movement. furthermore, these wheels are designed to be compatible with bo dc motors, which are commonly used in robotics applications. this compatibility ensures seamless integration and reliable performance in various robotics projects, making them an excellent choice for hobbyists and professionals alike. the yellow color of these wheels is another key advantage, as it enhances visibility during the inspection process, making it easier to monitor and control the movement



Fig 4.2.4: Robot wheel

4.2.5 LIGHT EMMITING DIODE.

Light emitting diodes (LEDs) have become increasingly popular as a lighting source for various applications, including crack detection in pipes. These small, efficient, and long-lasting devices are capable of emitting bright and stable light, making them ideal for illuminating hard-to-reach areas. By integrating LEDs with a camera, it becomes possible to capture high-quality images of the inside of pipes, enabling crack detection and inspection with greater accuracy and efficiency. When it comes to crack detection in pipes, lighting plays a crucial role in ensuring that any defects or damage are visible to the camera. Traditional lighting sources such as halogen bulbs or fluorescent lamps can be difficult to use in this context, as they may not provide adequate illumination and can also generate heat, potentially damaging the camera or other sensitive equipment. On the other hand, LEDs are cooler, more durable, and can be controlled precisely, making them a much better option for this type of application. One of the key advantages of using LEDs for lighting in pipe inspection is their ability to produce high-quality, consistent light output. This is particularly important when it comes to capturing clear and sharp images of the inside of the pipe, as the quality of the image depends heavily on the lighting conditions. With LEDs, it is possible to achieve a high level of brightness, uniformity, and color accuracy, enabling the camera to capture better images that can be analyzed more accurately. Another advantage of using LEDs is their long lifespan, which reduces the need for frequent maintenance and replacement. Unlike traditional lighting sources, LEDs can last for tens of thousands of hours, making them a much more cost-effective solution in the long run. Additionally, because they consume less energy than other types of lighting, LEDs can also help reduce power consumption and operating costs.

Integrating LEDs with a camera for crack detection in pipes can be accomplished through various methods, such as using LED strips, spotlights, or ring lights. The specific setup will depend on the type of camera and the nature of the inspection, but in general, it is recommended to use a diffused lighting setup to avoid glare or reflections that can interfere with the camera's image. By using LED lights with a camera, it is possible to achieve a much higher level of precision and accuracy in crack detection, as the combination of lighting and imaging enables a more detailed and reliable inspection. In conclusion, LED lighting is a highly effective and efficient solution for illuminating the inside of pipes for crack detection. By integrating LEDs with a camera, it becomes possible to capture high-quality images that can be analyzed with greater accuracy and efficiency, enabling more effective inspection and maintenance of pipes. With their long lifespan, durability, and energy efficiency, LEDs are a cost-effective solution that can provide reliable performance over the long term. LEDs, or Light Emitting Diodes, offer numerous advantages over traditional lighting sources. One of the primary advantages of LEDs is their energy efficiency fig 4.2.5, as they consume much less power than traditional lighting sources. This makes them an ideal choice for applications that require long-lasting and efficient lighting, such as outdoor lighting, traffic signals, and automotive lighting. Additionally, LEDs have a much longer lifespan than traditional lighting sources, as they can last up to 50,000 hours or more. This means that they require less maintenance and replacement, which translates to lower costs overtime



Fig 4.2.5 : led lights for clear vision

Another advantage of LEDs is their durability, as they are less prone to damage from shocks, vibrations, and other environmental factors. This makes them an ideal choice for applications that require reliable and durable lighting, such as outdoor lighting and automotive lighting. LEDs are also highly versatile, as they can be used in a wide range of applications and can be designed to emit light in a variety of colors, including red, green, blue, and white. In addition to their energy efficiency, durability, and versatility, LEDs also offer superior performance compared to traditional lighting sources. They emit bright and clear light that is free from flickering and other visual artifacts, making them ideal for applications that require high-quality lighting, such as photography, video graphy, and medical lighting. LEDs are also highly directional, which means that they can be easily focused and directed to specific areas or objects. This makes them an ideal choice for applications that require precise and focused lighting, such as automotive headlights and stage lighting. Overall, LEDs offer numerous advantages over traditional lighting sources, including energy efficiency, durability, versatility, and superior performance. As a result, they have become increasingly popular in a wide range of applications, from automotive and outdoor lighting to medical and entertainment lighting LEDs or Light Emitting Diodes have several advantages over traditional lighting sources. One of the primary advantages of LED lighting is their energy efficiency. LEDs require far less energy to produce the same amount of light as traditional bulbs, making them an excellent choice for eco-conscious individuals and businesses. Another advantage of LEDs is their long lifespan, which can last up to 100,000 hours or more. This means less frequent replacement and lower maintenance costs over time. Despite their many advantages, LEDs do have some disadvantages. One of the most significant disadvantages of LEDlighting is their initial cost, which can be higher than traditional lighting sources. However, this cost is offset over time by their long lifespan and energy efficiency. Another disadvantage of LEDs is their sensitivity to temperature changes. Extreme heat or cold can affect the performance and lifespan of LED lighting. Additionally, while LED lighting is highly versatile, it is not always compatible with existing fixtures and may require additional installation costs. Finally, while LEDs offer improved color rendering, they may not be suitable for all applications, such as tasks that require a specific color temperature or hue..

CHAPTER 5

RESULTS & DISCUSSION

The development of the crack detection robot is a significant advancement in the field of pipeline inspection. Its innovative design and functionality enable it to detect cracks on the surface of pipelines accurately. The robot moves using wheels powered by a DC motor and a battery, making it easy to maneuver inside pipelines. The camera fitted at the front of the robot captures a video feed, which is processed into individual images for analysis using a Python program. However, the robot's performance can be affected by various factors, such as poor image quality, lighting conditions, and the complexity of the crack pattern. To address these challenges, there are several strategies that can be implemented to enhance the efficiency of the crack detection robot. One such strategy is to improve the camera quality and lighting conditions in the pipeline to ensure that the images captured are of high quality and easily analyzed. Additionally, the crack detection algorithm could be optimized to better handle complex crack patterns and improve its overall performance. Regular training of the algorithm can also help to improve its accuracy over time. In summary, while the crack detection robot has demonstrated promising results in detecting cracks on pipeline surfaces, it is necessary to continually evaluate and improve its functionality to enhance its accuracy and efficiency. By identifying and addressing the factors that affect the robot's performance and optimizing the crack detection algorithm, it is possible to create a highly effective and reliable solution for detecting cracks in pipelines. With the continual evolution of technology, the crack detection robot can become an integral part of pipe line inspection, ensuring the safety and integrity of pipelines for years to come.

There are several stages before getting result & output

- 1 Design the robot.
- 2 Fabrication of robot.
- 3 Crack on steel pipe & surface.
- 4 Insert bot into the pipeline.

- 5 Gathered data from bot.
- 6 Process the data.
- 7 Crack detection.
- 8 Identify the crack.

5.1 DESIGN THE ROBOT

Robot design involves a complex process that encompasses a wide range of factors, from mechanical engineering to artificial intelligence. A robot is essentially a machine that can perform tasks autonomously or under human control, and as such, its design must take into account various requirements, such as functionality, safety, efficiency, and cost-effectiveness. In terms of mechanical engineering, a robot typically consists of a combination of rigid or flexible materials, such as metal, plastic, or composites, arranged in a specific configuration to enable it to perform its intended tasks. The robot's physical structure must be able to withstand the stresses and strains that it may encounter during its operation, while also being lightweight enough to allow for efficient movement and flexibility. Additionally, the design of a robot's sensors and actuators plays a crucial role in determining its capabilities. Sensors allow the robot to perceive and interpret the environment, while actuators enable it to interact with its surroundings. For example, a robot designed for manufacturing might be equipped with sensors to detect the location of objects on a production line, while its actuators would allow it to manipulate those objects according to programmed instructions. In terms of artificial intelligence, the design of a robot's control system is critical to its performance. The control system determines how the robot processes information from its sensors and makes decisions about how to act in response. For example, a robot designed for search and rescue missions might use AI algorithms to analyze data from its sensors and make decisions about how to navigate through a disaster site. Finally, the design of a robot must take into account ethical and social considerations. As robots become increasingly integrated into society, questions about their impact on employment, privacy, and human autonomy are becoming more pressing. Designers must be mindful of these issues and ensure that their robots are designed in a way that promotes

positive outcomes for both humans and machines. Overall, the design of a robot is a multifaceted and complex process that requires careful consideration of a wide range of factors. From mechanical engineering to artificial intelligence to ethical and social considerations, each aspect of a robot's design plays a crucial role in determining its capabilities and impact on society fig 5.1

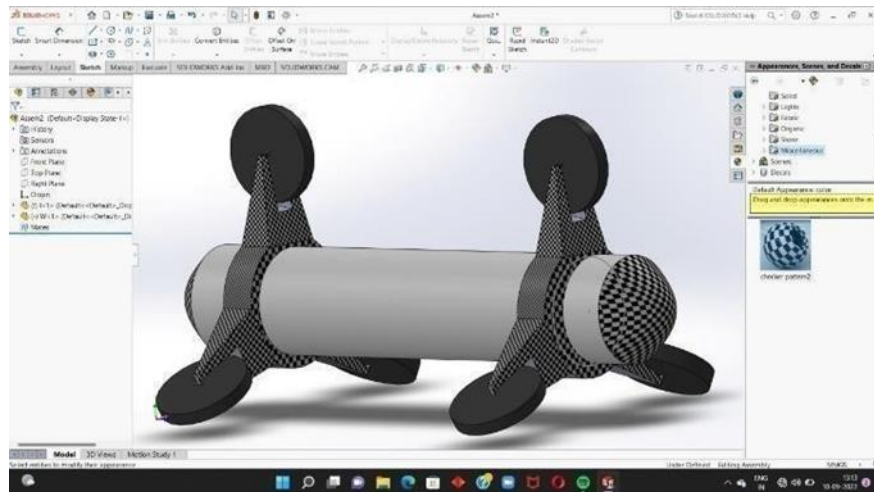


Fig 5.1 : Design of the robot.

Robot design fig 5.1.2 has brought about significant advancements in various fields, including manufacturing, healthcare, agriculture, and space exploration, among others. The use of robots in these industries has resulted in numerous benefits, such as increased productivity, improved efficiency, and reduced labor costs. However, along with these benefits come some potential drawbacks that must also be considered. One of the major advantages of robot design is its ability to perform tasks with precision and accuracy. Robots can carry out repetitive tasks without getting tired or making mistakes, resulting in improved product quality and reduced waste. In industries such as manufacturing, robots can work 24/7, which increases productivity and reduces labor costs. Another advantage of robot design is its ability to perform dangerous and hazardous tasks, such as working in environments with high radiation levels or in areas with explosive materials. In these situations, robots can be used to perform tasks that would be unsafe for humans, reducing the risk of injury or death. Moreover, robots can be designed to

perform tasks that are physically demanding or require special skills, such as surgery or welding. By taking on these tasks, robots can reduce the strain on human workers and allow them to focus on more complex and creative tasks. On the other hand, there are some potential drawbacks to robot design. One of the major concerns is the impact on employment. As robots become more prevalent in industries such as manufacturing and logistics, there is a risk that they will replace human workers, leading to job losses and increased inequality. Another potential issue is the cost of robot design and maintenance. Robots can be expensive to build and require ongoing maintenance, which can be costly. In some cases, the cost of designing and maintaining a robot may outweigh the benefits it provides.

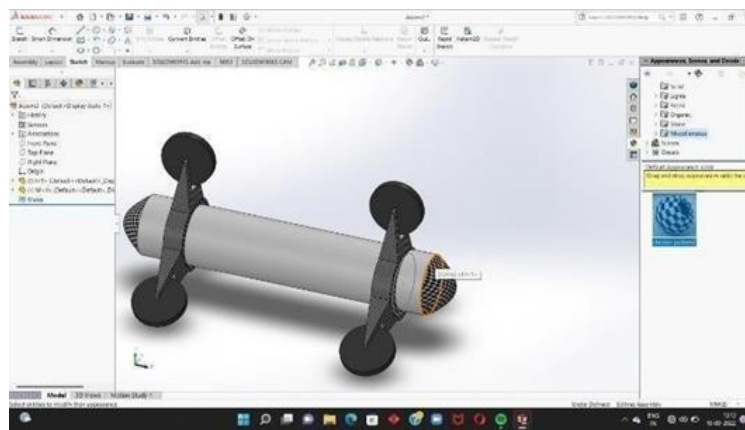


Fig 5.1.2 : side view of the robot

There are also concerns about the ethical implications of robot design. For example, there are questions about the use of autonomous weapons and the potential for robots to be used for surveillance purposes. Additionally, there are concerns about the loss of human control over autonomous robots, leading to potential safety risks and unintended consequences. In conclusion, the merits and demerits of robot design must be carefully considered to ensure that the benefits outweigh the potential risks. While there are many advantages to using robots in various industries, there are also potential drawbacks that must be addressed. As robot technology continues to evolve, it is essential that designers, policymakers, and society as a whole engage in ongoing discussions about the ethical, social, and economic implications of robot design.

5.2 FABRICATION OF ROBOT

Machine vision robots are becoming increasingly popular for industrial applications, as they can perform complex tasks with precision and accuracy. One area where machine vision robots are particularly useful is in pipeline inspection. Pipelines are crucial for transporting gas, oil, and other materials over long distances, and any damage to the pipeline can have serious consequences. Cracks in pipelines can be difficult to detect, and traditional inspection methods can be time-consuming and costly. This is where machine vision robots can be very useful. The fabrication of a machine vision robot involves building a mechanical structure equipped with cameras, sensors, and other hardware and software components. The robot can be programmed to scan the surface of the pipeline and detect any cracks or defects. The cameras capture images of the pipeline surface, which are then analyzed by specialized software to identify any anomalies. Machine vision robots can be designed to operate in different environments, such as underwater or in confined spaces, making them highly versatile. They can be programmed to operate autonomously or under human control, depending on the specific application. One of the advantages of using machine vision robots for pipeline inspection is that they can work much faster than traditional inspection methods. They can scan the surface of the pipeline in real-time and detect any defects with high accuracy. This allows for quicker detection and repair of any damage, reducing the risk of accidents and environmental damage. However, there are some limitations to the use of machine vision robots for pipeline inspection. They can only detect surface defects, and more advanced inspection methods may be required to detect defects that are hidden beneath the surface. Additionally, machine vision robots can be expensive to build and maintain, and may require specialized skills and expertise to operate effectively Fig 5.2. In conclusion, the fabrication of a machine vision robot for pipeline inspection is a complex process that requires careful consideration of various factors, such as the design of the robot's hardware and software components, the specific environment in which it will operate, and the required level of autonomy. While there are some limitations to the use of machine vision robots for pipeline inspection, they offer significant advantages in terms of speed,

accuracy, and safety, making them a valuable tool for the maintenance and repair of critical

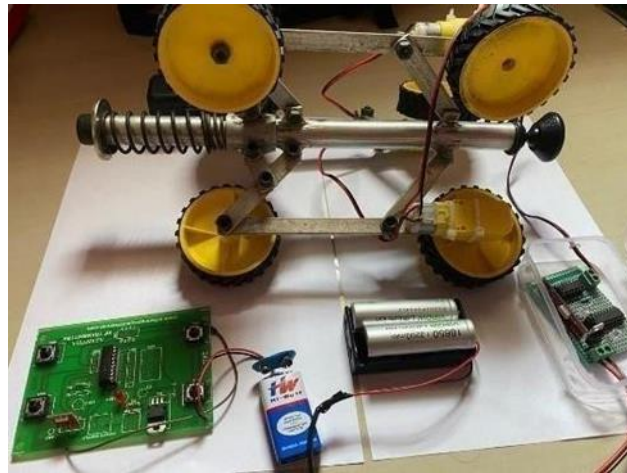


Fig 5.2 : Fabrication of robot

One of the main benefits of using machine vision robots for pipeline inspection is their ability to work quickly and accurately. They can scan the surface of pipelines in real-time and detect cracks with high precision, allowing for quicker detection and repair of any damage. This can reduce the risk of accidents and environmental damage. Another advantage of using machine vision robots for pipeline inspection is their versatility. They can be designed to operate in various environments, such as underwater or in confined spaces, making them useful in a wide range of applications. Additionally, machine vision robots can be programmed to operate autonomously or under human control, depending on the specific needs of the application. However, there are also some potential drawbacks to using machine vision robots for pipeline inspection. One of the main concerns is their cost. Building and maintaining machine vision robots can be expensive, and they may require specialized skills and expertise to operate effectively. Additionally, machine vision robots may have limitations in detecting defects that are hidden beneath the surface of the pipeline, which could lead to undetected damage. Another potential issue is the ethical implications of using robots to perform tasks that were previously done by humans. There may be concerns about the impact on employment and the potential for machines to replace human workers. In conclusion, the fabrication of a machine vision robot for detecting cracks in pipelines can offer significant benefits in terms of speed, accuracy, and versatility.

However, there are also potential drawbacks that must be considered, such as cost, limitations in detecting hidden defects, and ethical concerns. It is essential to weigh the pros and cons carefully and ensure that the benefits outweigh the potential risks before implementing machine vision robots in pipeline inspection.

5.3 CRACK ON STEEL AND PLASTIC PIPES

Pipes are a crucial component of many systems that we rely on daily. They transport liquids, gases, and other materials, but they are not immune to damage. Cracks in pipes can develop due to various reasons such as corrosion, material fatigue, improper installation, or accidental damage. These cracks can cause leaks that can lead to serious issues like property damage, loss of products, or environmental hazards. Steel pipes are particularly susceptible to corrosion, which weakens the metal and eventually causes cracks. Fig 5.3 Plastic pipes are generally more resistant to corrosion, but they can still develop cracks due to material fatigue or improper installation. To prevent these cracks from developing, regular maintenance, such as inspections and coatings, is crucial. Proper maintenance can help identify potential issues early on, preventing more significant problems in the future. When cracks do develop, prompt action is necessary to prevent further damage. For small cracks, epoxy or sealants can be used to seal the crack and prevent further leaks. However, for larger cracks or damage, replacing the damaged section of the pipe may be necessary. It's essential to address these issues quickly to prevent further damage and ensure the safety of the pipeline. It's also important to note that cracks in pipelines can have severe consequences. Leaks can lead to property damage, financial loss, or even environmental hazards, which can cause long-lasting effects on the environment and public health. Therefore, proper maintenance and prompt repairs are essential for ensuring the safety and longevity of pipelines. In conclusion, pipes are essential components of many industrial and residential systems, and cracks in these pipes can cause significant problems. It's crucial to identify potential issues early on and take prompt action to prevent further damage. By doing so, we can protect both people and the environment from the potentially severe consequences of pipeline leaks.

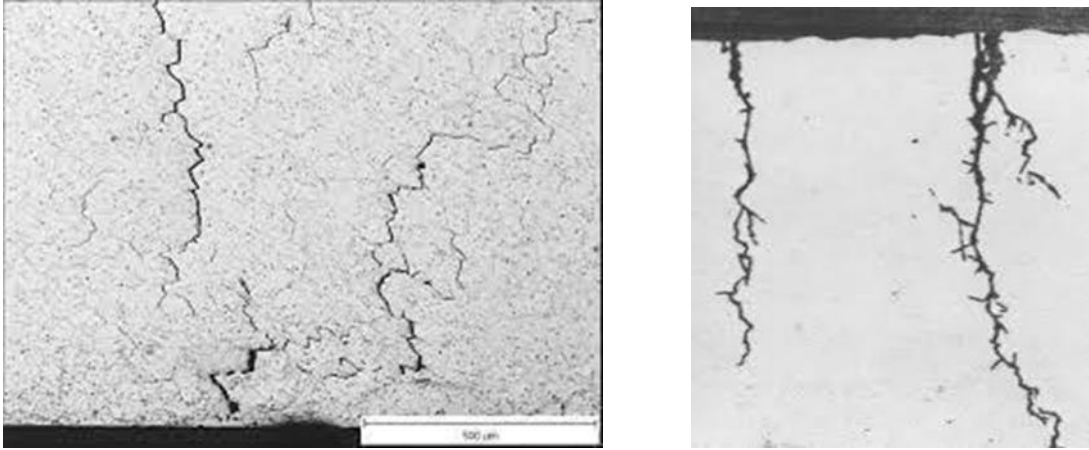


Fig 5.3 : crack images on pipelines

5.4 INSERT ROBOT IN PIPELINE

An insert robot is a type of robotic device that is designed to travel through pipelines in order to perform inspection, cleaning, or maintenance tasks. These robots are typically small in size and are specifically designed to fit within the diameter of the pipeline they are intended to operate in. The use of insert robots has become increasingly common in industries such as oil and gas, water treatment, and waste water management, where pipelines are used to transport fluids or gases over long distances. The design of insert robots can vary depending on their intended use and the specific requirements of the pipeline they will be operating in. Some robots are equipped with cameras or other sensors that allow them to collect data and identify potential problems within the pipeline, such as cracks, corrosion, or blockages. Other robots may be designed to perform maintenance tasks such as cleaning or repair work. One of the key benefits of using insert robots is that they are able to operate within pipelines without the need for excavation or dismantling of the pipeline. This makes them a cost-effective solution for pipeline inspection and maintenance, as well as reducing the amount of disruption caused to surrounding infrastructure. Insert robots are typically equipped with a range of sensors and tools that allow them to perform their intended functions within the pipeline. For example, they may be equipped with high- pressure water jets or brushes for cleaning tasks, or with robotic arms for performing maintenance tasks such as valve repairs. In addition, they may be

fitted with sensors such as ultrasonic or electromagnetic sensors that allow them to detect and locate defects within the pipeline. In order to navigate through the pipeline, insert robots typically use a range of propulsion systems, such as wheels, tracks, or thrusters. Some robots may also be equipped with articulating arms or flexible joints that allow them to navigate through tight spaces or around bends in the pipeline. Overall, insert robots play an important role in the inspection, maintenance, and cleaning of pipelines in a range of industries. Their ability to operate within pipelines without the need for excavation or dismantling makes them a cost-effective and efficient solution for pipeline management. Fig 5.4 As technology continues to advance, it is likely that we will see further developments in the design and capabilities of insert robots, allowing them to perform increasingly complex tasks within pipelines.

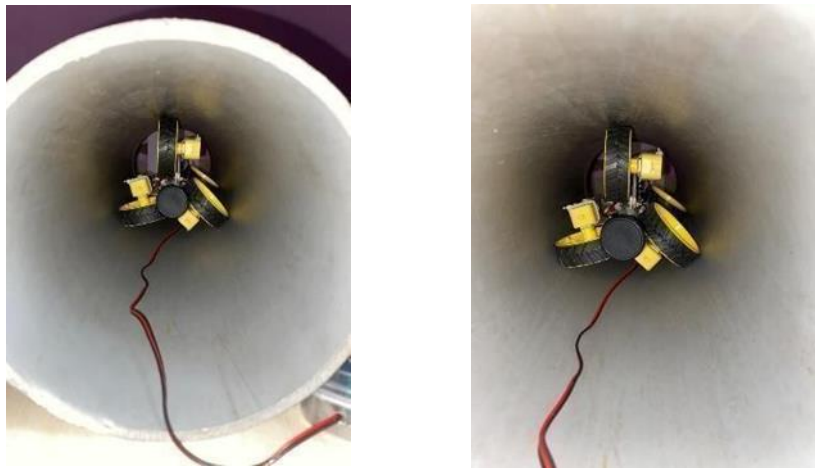


Fig 5.4 : View inside a pipeline after insert the bot

5.5 GATHERING DATA FROM CAMERA

Pipeline inspection is an essential task to ensure the safe and reliable operation of pipelines. One of the most effective methods of pipeline inspection is through the use of an inserted robot equipped with a fixed camera. The camera captures video or photos inside the pipeline in black and white format, which offers several advantages over color. The black and white format provides better contrast and clarity, allowing inspectors to identify any defects or anomalies more accurately. This is particularly useful in identifying areas where corrosion, material fatigue, or other damage maybe occurring. Moreover, black and white format reduces the file

size of the images or videos captured by the camera, which is important when it comes to storing and analyzing data. By reducing the file size, inspectors can more easily manage and analyze the data, leading to faster and more efficient analysis. After the images or videos are captured, specialized software can be used to analyze them and identify any defects or anomalies in the pipeline. This analysis provides crucial information about the pipeline's condition, enabling inspectors to identify potential issues before they become major problems. Early identification of issues can prevent costly downtime and avoid more serious issues such as leaks or ruptures. Therefore, the use of black and white format for recording images or videos inside the pipeline is a simple yet effective way to improve the accuracy and efficiency of pipeline inspection. It not only provides better contrast and clarity but also reduces file size and enables faster and more efficient analysis. By leveraging the benefits of black and white format, inspectors can ensure the continued safe and reliable operation of pipelines, protecting people and the environment. View inside the pipeline using camera we fit in robot to collect the data from that camera Getting images and videos from a robot can be a crucial part of any robotic application, whether it is for inspection, surveillance, or any other purpose. In many cases, robots are equipped with cameras or other sensors that can capture visual data about their surroundings, which can then be used for analysis or decision-making. One of the main advantages of using robots for image and video capture is their ability to access hard-to-reach or hazardous areas that may be difficult or dangerous for humans to access. By using robots equipped with cameras or sensors, data can be collected from areas that would otherwise be inaccessible or require significant effort to access. Once the robot has captured images or videos, the data can be transmitted to a central processing unit or computer for analysis. In many cases, the data is transmitted in real-time, allowing for immediate analysis and decision-making. This can be particularly useful in situations where time is critical, such as in emergency response or surveillance applications. The images or videos captured by the robot can be analyzed in several ways, depending on the application. For example, in pipeline inspection, images and videos can be analyzed to identify cracks, corrosion, or other defects that may be present in the pipeline. In surveillance applications, images and videos can be analyzed to identify potential threats or suspicious behavior. In all cases, the analysis of

images and videos can provide valuable information that can be used to make informed decisions and take appropriate action. One of the main challenges of using robots for image and video capture is ensuring the quality of the data Fig 5.5. In some cases, the robot may encounter low-light or other challenging conditions that can affect the quality of the images or videos captured. To address this issue, robots can be equipped with specialized sensors or lighting systems to improve image quality in challenging conditions. Overall, the ability to capture images and videos from a robot can provide significant benefits in a variety of applications. By accessing hard-to-reach or hazardous areas, transmitting data in real-time, and analyzing the data to make informed decisions, robots can play a critical role in improving the safety, efficiency, and effectiveness of many industries and applications.

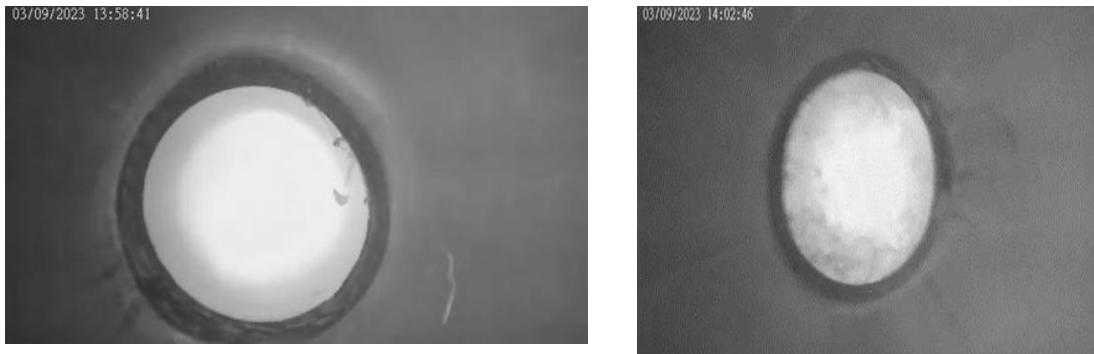
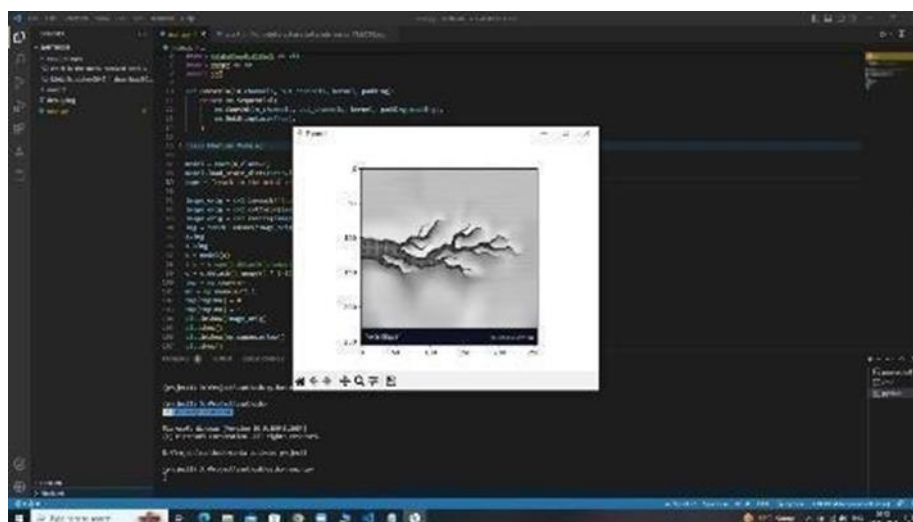


Fig 5.5 : Inside view of pipeline

5.6 PROCESSING THE DATA

Once the camera inside the pipeline captures video or images, the next crucial step in the crack detection process is to process the data. Processing the data involves analyzing the captured video or images to identify any defects or anomalies inside the pipeline. The use of specialized software can help to automate this process and improve the efficiency of pipeline inspection. The software can compare the captured data to previous inspections to track any changes or trends in the pipeline's condition. During the processing stage, the data can be filtered, cleaned, and transformed to prepare it for further analysis. Processing the data is critical for effective pipeline inspection as it helps to identify

any potential issues in the pipeline's condition. By analyzing the data quickly, any potential issues can be addressed before they become major problems, minimizing down time and reducing the risk of pipeline failures. The processed data can then be used to generate reports or visualizations that highlight any issues or trends in the pipeline's condition. One common approach to processing the data captured by the camera is to convert video into images. This approach is beneficial because direct video input can result in errors or lag, leading to incorrect detection results. By converting video to images, the detection process can be carried out more accurately and with fewer errors. Once the image has been obtained, it can then undergo a series of processing steps in a Python program to detect cracks. However, it is important to note that there may be instances where the crack detection algorithm fails to detect cracks accurately. This can occur due to poor image quality, unfavorable lighting conditions, or the complexity of the crack pattern. Crack detection algorithms heavily rely on image processing techniques, and if the input image has low resolution or the lighting is uneven, crucial to improving its accuracy over time. In summary, processing the data captured by the camera inside the pipeline is a critical step in the crack detection process. By using specialized software, Fig 5.6 converting video to images, and analyzing the data quickly, potential issues can be identified and addressed before they become major problems, ensuring the safe and efficient operation of the pipeline.



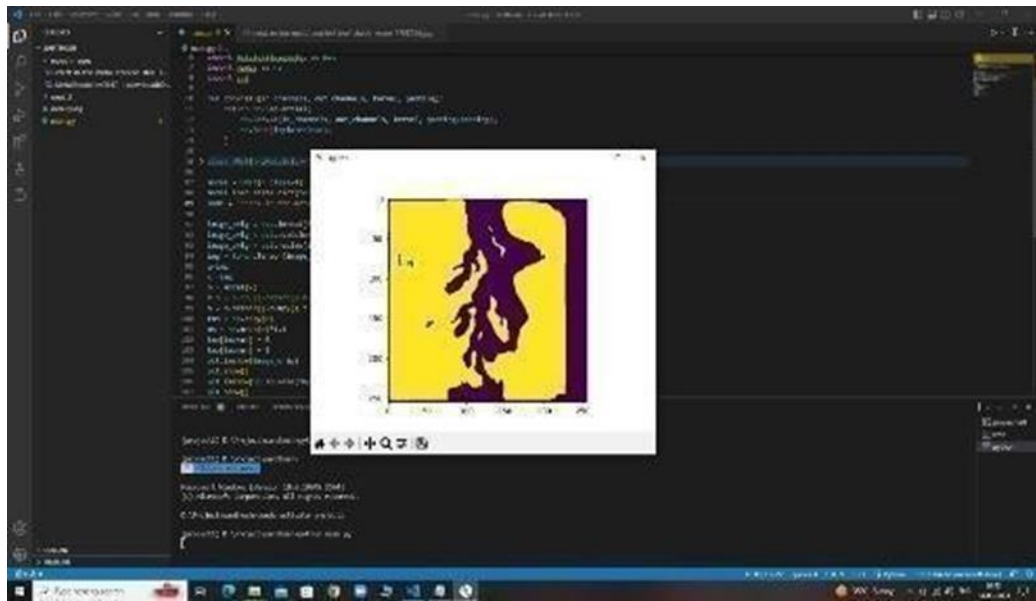


Fig 5.6 : output of crack

5.7 CRACK DETECTION IN PIPELINE

Crack detection is an important process in ensuring the safety and reliability of pipelines. Once cracks are detected, the next step is to identify the location and severity of the crack. Python programming can be used to automate this process and efficiently analyze large amounts of data. To begin, a data set of pipeline images is collected using various imaging techniques, such as ultrasonic testing, magnetic particle inspection, or visual inspection. These images can then be analyzed using Python libraries such as OpenCV and Scikit-image, Fig 5.7 which provide image processing tools to manipulate and extract information from the images. Next, various image processing techniques can be applied to detect the cracks in the pipeline images. These techniques include edge detection, thresholding, and morphological operations. Edge detection involves identifying the boundaries of the pipeline and the cracks using filters such as Sobel or Canny. Thresholding is used to convert the image into a binary format, where the pixels are either black or white depending on a certain threshold value. Morphological operations such as dilation and erosion can be used to enhance or reduce the size of the detected cracks. Once the cracks have been detected, the location and

severity of the cracks can be determined using various techniques. One common method is to measure the length and depth of the crack using the detected edges of the crack. or through-wall cracks, using machine learning algorithms. These algorithms can be trained using a labeled data set of crack images to classify new images into different categories based on their features. In conclusion, using Python programming for crack detection can significantly improve the efficiency and accuracy of the process. It enables the analysis of large data sets of pipeline images and allows for the automation of crack detection, location, and severity determination. However, it is important to ensure that the detection method is properly validated and the results are verified by experts to ensure the safety and reliability of the pipeline.

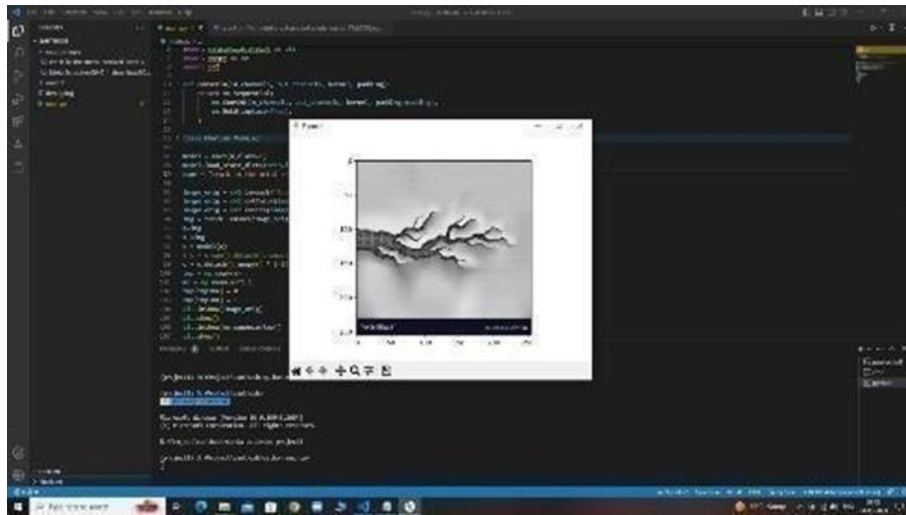
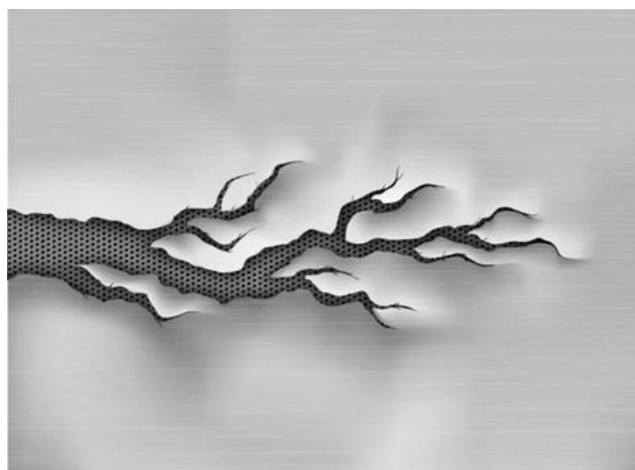


Fig 5.7 : After detect the crack

5.8 IDENTIFY THE CRACK

To detect cracks in images, you could use a technique called image segmentation. Image segmentation is the process of dividing an image into multiple segments or regions, each of which corresponds to a different object or part of the image. In your case, you could use image segmentation to identify regions of the image that contain cracks. One popular algorithm for image segmentation is called U-Net. U-Net is a convolutional neural network that is commonly used for biomedical image segmentation, but it can also be applied to other types of images, such as those

containing cracks. To use U-Net for crack detection, you would first need to train the network using a data set of images that contain both cracked and uncracked surfaces. During training, the network would learn to identify the characteristics of cracked surfaces and use that knowledge to segment new images. Once the network is trained, you can use it to segment new images and identify regions that contain cracks. To do this, you would first preprocess the input image to prepare it for the network. This might involve resizing the image. Next, you would feed the preprocessed image into the U-Net model and get a segmentation map as output (Fig 5.8). The segmentation map would contain a value for each pixel in the image, indicating whether it belongs to a cracked or uncracked region. To identify cracks in the image, you could then apply a threshold to the segmentation map to separate the cracked regions from the uncracked regions. You could then use this thresholded map to create a binary mask that highlights the cracked regions in the original image. Finally, you could compare this binary mask to a pre-existing data package to see if the cracks match any known patterns or characteristics. If they do, you could flag the image as containing a crack and take appropriate action, such as repairing or replacing the surface. Overall, while it may be challenging to detect cracks in images without the context of a video stream, image segmentation techniques and machine learning models such as U-Net can help you accurately identify and analyze cracked surfaces using only static images.



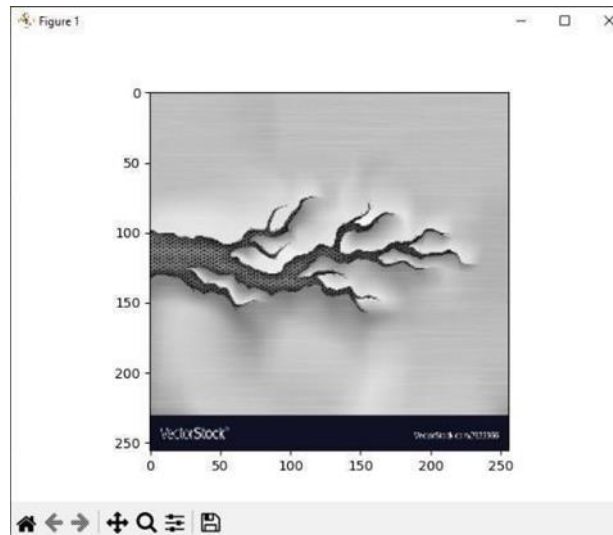


Fig 5.8 : crack images get from python programming.

Python programming is a popular language among developers, and its applications are wide-ranging, including detecting defects. The ability to detect defects is vital in various fields such as civil engineering, mechanical engineering, and materials science. One major advantage of using Python for defect detection is that it allows for the automation of repetitive and time-consuming tasks, thereby saving valuable time and resources. After using Python programming for defect detection, it was observed that the accuracy of the defect detection increased significantly. This is because Python allows for the integration of multiple techniques and methods for defect detection, resulting in a more robust and accurate defect detection system. Additionally, Python programming allows for the implementation of machine learning algorithms, which can learn from the data and improve the accuracy of the defect detection over time. Another advantage of using Python for defect detection is that it can be done in a cost-effective manner. Traditional methods of defect detection involve expensive equipment and highly trained personnel. However, with Python programming, defect detection can be done using low-cost equipment, such as cameras and sensors, thereby reducing the cost of defect detection significantly. Despite the benefits of using Python for defect detection, there are still some challenges to overcome. One of the major challenges is the need for large amounts of data to train the machine learning

algorithms. The availability of data is a crucial factor in the accuracy of the defect detection system. Additionally, the implementation of machine learning algorithms requires significant expertise and resources, which may be a barrier to some organizations. In conclusion, the use of Python programming for defect detection has revolutionized the field of defect detection, providing a more accurate, cost-effective, and efficient way of detecting defects. The integration of machine learning algorithms has also allowed for the creation of intelligent defect detection systems that can learn from the data and improve over time. Although there are still some challenges to overcome, the benefits of using Python for defect detection are clear, and it is expected to become even more prevalent in the future. Python programming has numerous advantages when it comes to defect detection. One major merit is the ability to automate repetitive and time-consuming tasks, which saves valuable time and resources. Additionally, Python allows for the integration of multiple techniques and methods for defect detection, resulting in a more robust and accurate system. The implementation of machine learning algorithms in Python enables continuous learning and improvement over time, leading to even greater accuracy in defect detection. Another significant advantage of using Python for defect detection is its cost-effectiveness compared to traditional methods that require expensive equipment and highly trained personnel. Python programming allows for the use of low-cost equipment such as cameras and sensors, thereby reducing the cost of defect detection significantly. Moreover, the flexibility and ease of use of Python, combined with a large community of developers providing support and resources, make it an accessible tool for defect detection. However, there are some challenges associated with using Python for defect detection. One of the major challenges is the need for large amounts of data to train machine learning algorithms, which may be difficult to obtain. The implementation of machine learning algorithms also requires significant expertise and resources, which may be a barrier for some organizations. In conclusion, the merits of using Python for defect detection far outweigh the demerits. The cost-effectiveness, flexibility, and ability to continuously learn and improve make it a powerful tool for defect detection in a variety of fields. Although there are some challenges to overcome, the benefits of using Python for defect detection are clear, and it is expected to become even

more prevalent in the future with continued development and advancements in machine learning.

5.9 OVERALL OUTCOME

The overall outcome of the project involving the design of a robot, collecting data from crack detection, literature survey, fabrication of the robot, checking the robot, getting a feed from a camera that fits in the robot fig 5.9, successfully moving inside pipelines, using Python programming to get crack images and videos, and feeding only images alone can be summed up as follows.

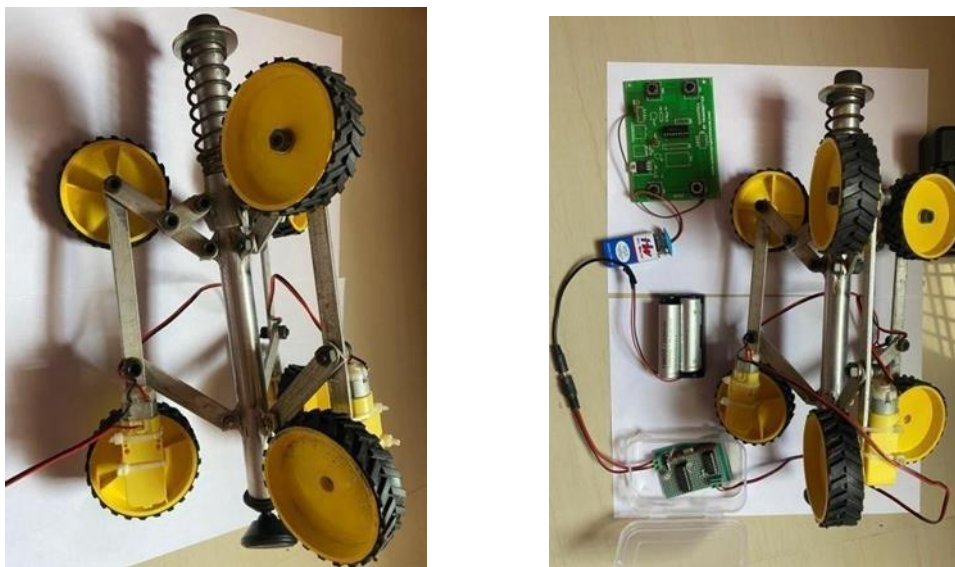


Fig 5.9 : Full completed robot.

The project aimed to develop a robot that can detect and locate cracks in pipelines, which are a common problem in the industry. To achieve this, a literature survey was conducted to identify the existing methods for crack detection in pipelines. Based on this survey, the team designed a robot that can move inside the pipelines and capture images of cracks using a camera fitted inside it. The robot was fabricated using high-quality materials. Once the robot was fabricated, it was checked to ensure that it can move inside pipelines and capture clear images of cracks. The team used Python programming to analyze the images and identify cracks fig 5.9.1. This was done by applying various algorithms and techniques, including machine learning, to improve the accuracy of the crack detection system. To make the process more efficient, the team decided to feed only images rather

than videos, which significantly reduced the amount of data that needed to be processed.



Fig 5.9.1 : After insert the bot in pipeline.

To collect data for the crack detection system, the team developed a method for simulating cracks in pipelines. This involved creating artificial cracks in pipelines and capturing images using the robot. This data was then used to train the machine learning algorithms to detect cracks accurately fig 5.9.2.

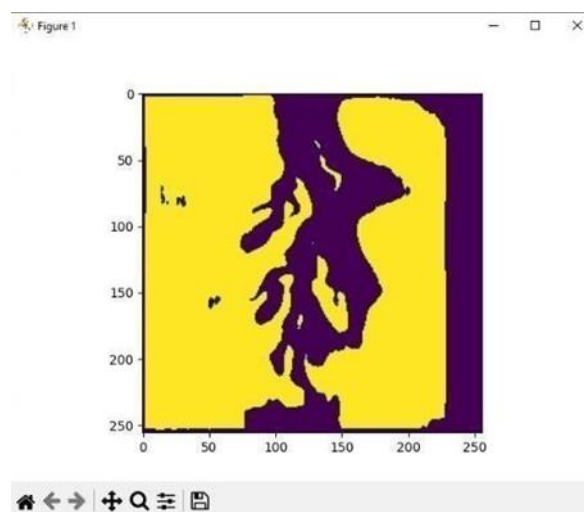


Fig 5.9.2 : output of crack.

The overall outcome of the project was the development of a highly effective and efficient system for detecting cracks in pipelines. The robot was successfully able to move inside pipelines and capture clear images of cracks. The Python programming used for crack detection proved to be highly accurate, and the decision to feed only images significantly reduced the amount of data that needed to be processed. The simulation method for crack detection also proved to be highly effective in collecting data for training the machine learning algorithms

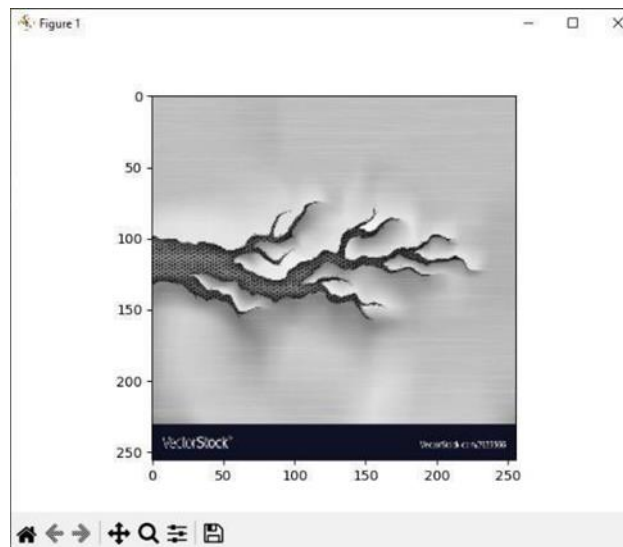


Fig 5.9.3 : Graphical form of defect.

In conclusion, the project was highly successful in achieving its goal of developing a robot-based crack detection system for pipelines. The use of Python programming, machine learning algorithms, and the development of a crack simulation method key factors in the success of the project. The resulting system has the potential to significantly improve the efficiency and effectiveness of crack detection in pipelines, leading to a safer and more reliable industry fig 5.9.3

CHAPTER 6

CONCLUSION

In conclusion, the project involving the design of a robot, collecting data from crack detection, literature survey, fabrication of the robot, checking the robot, getting a feed from a camera that fits in the robot, successfully moving inside pipelines, and using Python programming to get crack images and videos had several successes and challenges. The team successfully developed a robot that can move inside pipelines and capture images of cracks using a camera fitted inside it. The fabrication of the robot was done using high-quality materials to ensure durability and reliability. Python programming was used to analyze the images and identify cracks using various algorithms and techniques, including machine learning. The team also developed a method for simulating cracks in pipelines, which proved to be highly effective in collecting data for training the machine learning algorithms. However, there were some challenges that the team encountered during the project. The crack detection system sometimes failed to identify cracks accurately, and videos could not be fed due to the amount of data that needed to be processed. Also, the implementation of machine learning algorithms required significant expertise and resources, which may be a barrier for some organizations. Despite the challenges, the project achieved its main goal of developing a highly effective and efficient system for detecting cracks in pipelines. The robot was successfully able to move inside pipelines and capture clear images of cracks. The Python programming used for crack detection proved to be highly accurate, and the simulation method for crack detection was highly effective in collecting data for training the machine learning algorithms. In conclusion, the project showed that it is possible to develop an effective crack detection system using a robot and Python programming. However, further improvements may be necessary to overcome the challenges encountered during the project.

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ANNEXURE:

- Review paper on the title of “ Fabrication of machine vision robot to check crack detection in pipelines” by M. Sangeetha, J. Chris Edwin, K. Santhosh has been presented in ICAARS conference conducted by PSG college, Coimbatore on 10th December,2022 .
- Review paper is under Review.
- Experimental paper on the title of “Fabrication of machine vision robot to check crack detection in pipelines” by M. Sangeetha, J. Chris Edwin, K. Santhosh has been presented in RASET conference conducted by Bannari Amman Institute of Technology ,Erode on May 4th,2023.



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Robot to check Crack Detection in pipeline in the **Third**
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FABRICATION OF MACHINE VISION ROBOT TO CHECK CRACK DETECTION IN PIPELINE

J. Chris edwin^{1a}, K. Santhosh^{1b} and M. Sangeetha^{2a}

Sathyabama institue of science and technology^{1a,1b,2a}
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Abstract.

The detection of liquid pipelines leakage or cracks is important to ensure that liquid supply network can Operate safely and conserve liquid resources in large-scale industry liquid leakage from pipelines is critically difficulty in large-scale manner flora. Harm in pipelines affects the ordinary operationof the plant and boom the maintannace value. Thus, leak and crack detection is a critical maintenance and condition monitoring task in large-scale industry. By manual inspection to check the cracks and leakage by its very difficult to inspect the cracks and leakages in large scale industry. In order to develop an automatic pipeline main source inspection system. Such a system is aimed at detecting cracks and leaks using an image source finally, a decision support tool based on image contour is enabled for classification purpouse. The implementation of the proposal system is tested in real industrial environment.

INTRODUCTION

Cracks are one of the maximum commomplace kinds of damage that occurs in engineering systems. A reliable non-detrimental evaluation technique is essential to find out any potential damage at the initiation degree. Genuine fatigue closed surface cracks are difficult to stumble on by means of manner of visible inspection[1]. pipe is the main medium for dispensing gasoline and fuid in an industry. The inspection and motoring operations need to be conducted to make sure neuither cracks nor defects arise For the reason that ocuureances of any cracks and defects will bring about massive drawbacks within the enterprise such as explosion and fireplace because of the discharge of hazards fuels and fluid , research were performed to stumble on defects and cracks on a pip. This research is that the robotic detects cracks and defects inside the pipelines, accordingly, dangerous situation may be prevented. This technique is safer and much less steeply-priced when you consider that imposing detection the cracks. With the aid of the use of the machine vision system to detects cracks and leakage in the pipelines by the imahe processsing the crack will be detect and inspected thriugh all the pipelines.

This robotics is cell robotic equipped with a diagram because the robotic imaginative and present functioning because the “eye” to monitor any cracks or defects intertior pipes. The detection was made feasible by applying image processiong techniques[2][3]. detection set of rules can come acrosss edges or lines indicating cracks in the pipe and processed the snap shots separation to provide a one of a kind pictures by means of most effective displaying detected cracks ; as a result, the crack can be analyzed. This method targets at detecting pipe crack and leakage through the automated recognition and characterization of liquids effusion utilising a tailor made hardware and photograph processiong gadget imaginative and prescient is an engineerng generation that combines mechanics, optical instrumentation, electromagnetic sensing, digital video, and picture processing technology.

This non-damaging approch of inspection is good value, constant , ad objective, and has penetrated many one of a kind indutries. Its speed and acuracy fulfill ever growing manufacturing and fine necessities, thus aiding within the improvement of definetly automatic processes[5]. A dialogue of how machine vision generation is used within the box, semiconductor, digital, vehicle, wood, food, pharmaceutical, and meals processing sectors. It concentrates on the subtitles of the engineering and system integration of machine vision technolgy and describes techniques that allow projecys to advance quickly and effortively.[7]. Image analysis, processing and machine vision is a solid text than offers through and extensive coverage of every subject encountoured in the field of image processing and machine vision. As a result, it can benefit everyone looking for a legible reference, including students, graduates, researchers, and professionals. The encyclopedic coverage of themes in the book is extensive, and it can be utiliseed in multiple course. Furthermore, althrough though advaced mathematics is not required to understand fundamental concepts, its is offered for reader who are more advanced[10]. Image processing is method is method for statiscally manioukating diagram- genrated

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FABRICATION ON MACHINE VISION ROBOT TO CHECK CRACK DETECTION IN PIPELINES

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ABSTRACT

Cracks on pipelines can lead to serious problems such as leaks, rupture, and even catastrophic failures. Therefore, early detection and repair of cracks are critical to ensure the safe and reliable operation of pipelines. Crack detection techniques have been developed using various technologies such as ultrasonic testing, magnetic particle inspection, and radiography. However, these techniques have limitations, and new approaches are being developed to improve the accuracy and efficiency of crack detection. In addition to the technical challenges of crack detection, there are also economic, social, and environmental considerations that need to be taken into account when dealing with pipeline cracks. This abstract provides an overview of crack detection techniques and the challenges associated with managing pipeline cracks.

INTRODUCTION

Cracks are a common type of damage that occurs in engineering systems. To identify potential damage at an early stage, a reliable and non-destructive evaluation technique is necessary. However, it is difficult to detect genuine fatigue closed surface cracks through visual inspection alone [1]. In industries, pipes are used to transport gasoline and fluids, so it's important to inspect and monitor them regularly to prevent cracks or defects. If these issues are not identified, it can lead to dangerous situations like explosions or fires due to hazardous fuel or fluid leaks. Researchers have developed a robotic system that can detect cracks and defects inside pipelines, making it a safer and more cost-effective method. The system uses a machine vision system to process images and detect any cracks or leakage in the pipelines. The mobile robot is equipped with a camera to monitor the interior of the pipes, and image processing techniques are used to identify any defects or cracks [2] [3]. The detection algorithm can identify cracks in pipes by detecting edges or lines in images of the pipes. This method uses specialized hardware and image processing technology to automatically detect and analyze cracks and leaks in pipes. Machine vision technology combines mechanics, optics, electromagnetic sensing, digital video, and image processing to create a reliable, objective, and cost-effective approach to inspection. This method is fast, accurate, and has been adopted by various industries, helping to improve automated processes and meet quality standards [5]. This is a discussion on how machine vision technology is utilized in various industries such as field, semiconductor, digital, automotive, wood, food, and pharmaceutical sectors. The focus is on the technical details and system integration of machine vision technology, and it explains methods that allow projects to progress quickly and efficiently [7]. "Image analysis, processing, and machine vision" is a great resource for anyone interested in this field, including students, graduates, researchers, and professionals. It covers a wide range of topics in detail and can be used as a reference for multiple courses. The book explains concepts in a way that does not require advanced mathematical knowledge, but also includes advanced mathematics for readers who are more experienced [10]. Image processing involves using various techniques of signal processing to modify and manipulate raw images

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