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Detection of Flaws in Ship Hull Using Underwater Remotely Operated Vehicle

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Abstract: *Fatigue leads to failure of ships and also fatigue is one of the major factors which can produce cracks in a ship. To maintain safety of ship structures, an optimum..inspection plan should be done. The robotics has become an important resource in recent years in the field of engineering. Earlier the ship inspection was carried out by humans. This paper explains how it could..be improved using ROV even though if it.is not completely autonomous for time being. Since the manual approach completely depends on the experience and..specialist knowledge. So, python programming image-based crack and hole detection is done as a replacement. This paper presents a review. of inspection of a ship hull using Remoted Operated Vehicle (ROV). Several power considerations..and designs are discussed and planned as per the requirement of ROV. The main purpose of this project is to detect crack and holes using.ROV at low cost, which is safe, portable, and also it is easy. to use. It uses camera for the visuals beneath the water for detection. An Arduino board is used as microcontroller a and Bluetooth module HC-05 to navigation of ROV to front, back, left, right and stop. A lithium battery of 12V is used for power supply and .converted to 5V while giving power supply to Arduino board. The remotely operated vehicle is constructed from PVC pipes which make them to float on the surface of the water. The underwater images captured..from the camera are processed through python..coding and the result..will be appeared on the system interface.*

Keywords: Arduino board, Bluetooth, battery.

I. INTRODUCTION

The oceans cover 71% of the Earth s surface. Despite their importance only 5% of the world s oceans have been explored [1][2]. Several works on remotely operated vehicles (ROVs) have been reported for applications in marine research [3][4]. Flaws detection is the process of detecting the flaws such as cracks and holes in the structures using any of the processing techniques [7]. The major advantage of the image-based python programming analysis of the crack detection is that by using the image processing technique it provides accurate result compared to the conventional manual methods. The processing difficulty of the crack detection completely depends on the size of the image. Recent digital cameras have the image resolution beyond 10 megapixels [5]. This increase in resolution enables the acquisition of detailed images of underwater ship hull surface [6]. Surveys on board ships are generally carried out by a number of bodies such as flag states, port state authorities, insurance companies and cargo owners. The frequency of inspection on average can be estimated to be 6 inspections per year for dry bulk carriers, 11 for tankers. Even more for passenger ships with at least 50 h per year spent aboard to carry out inspections. The cost estimated and confirmed by recent private communications of authors with shipping stakeholders, that for bulk carriers costs are around 25 k$ per year and tankers costs are around 50 k$ per year[8]

The damage detection delay is caused by the uncertainties related to an inspection method and time of damage occurrence. A probabilistic approach considering these uncertainties in a rational way should be used to establish a cost-effective inspection planning associated with minimum damage detection delay. The marine environment causes fast corrosion, erosion and scour processes. The design and detection of flaws such as cracks and holes in the underwater hull surface of a ship will be discussed in this paper.

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II. LITERATURE REVIEW

Roman Kalvin et.al [1], proposed Design and Fabrication of Under Water Remotely Operated Vehicle in which he described an unmanned underwater remotely operated vehicle (ROV) for measuring water contamination in marine areas. It consists of a remotely controlled vehicle, a cable wire for powering optical fibres, four DC motors, and pivoting, carefully designed propellers for managing the vehicle's depth, placement on a level surface, and caption. Arun Mohan et.al [2], proposed Crack detection using image processing: A critical review and analysis Engineering structures in which he described a fundamental architecture for the crack detection method based on image processing. The main benefit of employing image processing instead of traditional manual methods for crack detection is that the results are more accurate with image-based analysis. Adam Muc et.al [3], proposed Methods of cracks detection in marine structures welded joints based on signals time waveform analysis in which he explained the methods are dedicated for structural health monitoring (SHM) of responsible welded joints. The system will be based on vibrodiagnostic - signals will be measured by piezoelectric accelerometers and/or fibre optic sensors. Rajni et.al [4], proposed Crack Detection on Metal Surfaces with an Array of Complementary Split Ring Resonators in which she described a cutting-edge sensor with a Complementary Split Ring Resonator (CSRR) array that operates at 10 GHz for the purpose of detecting metal fatigue. The scanning process of an advanced sensor is based on creating a significant shift in resonant frequency by perturbing the electromagnetic field close to a negative effective dielectric permittivity.
Atle Dyregrov et.al [5], proposed A Maritime Disaster system: Reactions and Follow-up in which he described 69 people survived a maritime disaster on the Norwegian coast, during which 16 additional people perished. In addition to providing immediate psychosocial support, post-disaster intervention included psychological debriefings after one week, follow-up debriefing after one month, screening for people who needed one-on-one assistance, and assistance for people who were going back to the catastrophe site.
Sunyong Kim et.al [6], proposed Optimum inspection planning for minimizing fatigue damage detection delay of ship hull structures in which he explained a method that is applied to ship hull structures that are fatigued. The resultant inspection plan is the result of solving an optimization issue focused on reducing the anticipated delay in fatigue damage detection. Romano Capocci et.al [7], proposed Inspection-Class Remotely Operated Vehicles A Review in which he described a review of Remotely Operated Vehicles of the Inspection Class (ROVs). The classification of inspection-class ROVs is divided up in the review, with the vehicles being arranged according to size and capability. A survey of cutting-edge technology is conducted, and different popular ROV subsystems are covered. Laura Poggi et.al [8], proposed Recent developments in remote inspections of ship structures in which He created it to demonstrate how ship inspections are currently conducted by humans, how they could be improved using RAS, even if it isn't fully autonomous for the time being, at least in some operational scenarios, and how the capabilities of RAS platforms can be tested to determine how well they perform surveys onboard. Oscar Adrian

III. METHODOLOGY

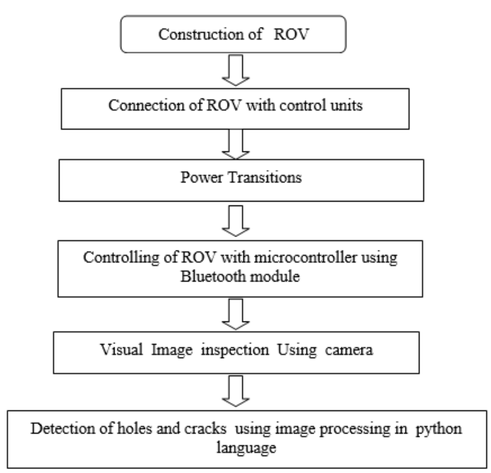

Fig 1. Flow Chart of ROV

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3.1 Construction of ROV

The underwater remotely operated vehicle is constructed using PVC (poly vinyl chloride) pipes of dia 63mm. We have used tee-joints and convertors in constructions of ROV. The design is done in a such way that the ROV should float on water. The 45 rpm 4 DC motors are placed at each end of the ROV which are used for the movement of the ROV. A separate box is fitted on the top of the pipe construction to place the microcontroller, battery, motor driver, and Bluetooth transmitter.

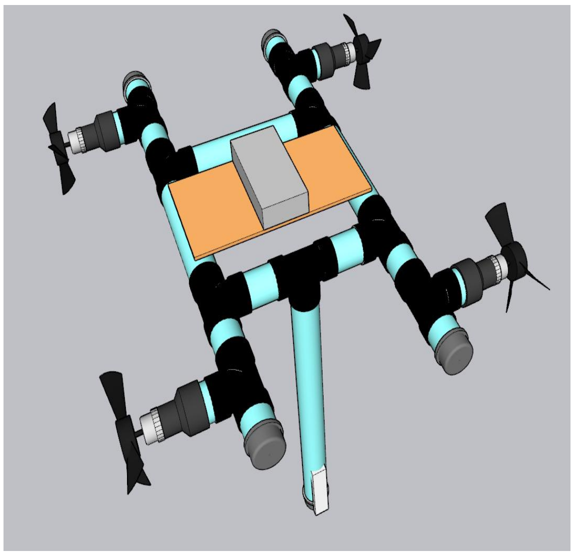


Fig 2. Model and prototype of ROV

Vehicle Parameter	Value	Unit
Body material	PVC pipe, PMMA, fiberglass	
Length	0.96	m
Breadth	0.81	m
Depth	0.08	m
Height	0.47	m
Density	2.3	kg
Nominal speed	0.70	m/s
Velocity	0.75	m/s
Overall area	8.34	m^2

Table 1. Component Specification

3.2 Arduino board

The Arduino board is an microcontroller which is based on open source electronics and easy to use hardware and software, it is capable of reading inputs, light on a sensor, control DC motors on the basis of inputs given.Arduino consist of both a physical programmable circuit board and a piece of software that runs on your computer, used to write, and upload computer code to the physical board

3.3 HC-05 Bluetooth module

It is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard and many more consumer applications. It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions. It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air. It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART).

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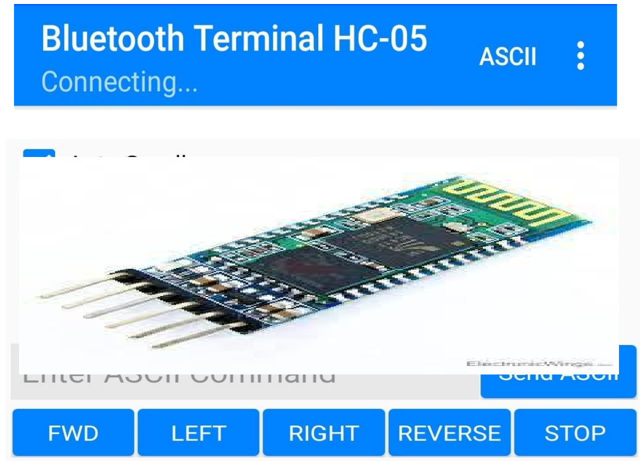

Fig 3. Bluetooth operating interface.

3.4 DC motor

A Geared DC Motor is made by attaching a gear assembly to an ordinary DC motor. This will increase the torque by decreasing the speed of motor. The speed of motor is counted in terms of RPM, rotations of shaft per minute. The speed can be reduced to any desired RPM by using correct combination of gears. This motor is geared down to 45RPM and will provide torque about 2.7kgcm.45 RPM 12V DC Geared Motor is high-quality low-cost DC geared motor. It has steel gears and pinions to ensure longer life and better wear and tear properties. The gears are fixed on hardened steel spindles polished to a mirror finish. The output shaft rotates in a plastic bushing. The whole assembly is covered with a plastic ring. Gearbox is sealed and lubricated with lithium grease and require no maintenance. The motor is screwed to the gear box from inside. Although motor gives 45 RPM at 12V, but motor runs smoothly from 4V to 12V and gives wide range of RPM, and torque. These precision gearmotors are incredibly tough and feature full metal gears to help you drive wheels, gears, or almost anything else that needs to turn. They have a gear ratio of 100:1 and operate up to 12 volts and deliver a stall torque of 278 oz-in. and a max speed of 45 RPM. Each precision gearmotor sports a 6mm diameter D-shaft that protrudes from them

3.5 Rechargeable Li-ion battery

A lithium-ion…battery or Li-ion..battery is…a...type of.. rechargeable…battery.. composed….of…cells…in which lithium ions move..from the negative electrode through..an electrolyte to the positive electrode during discharge and back when charging. Li-ion cells use an intercalated lithium..compound as the material at the positive electrode and typically graphite at the negative..electrode. Li-ion batteries have a high energy density, no memory effect (other than LFP cells)..and low self-discharge. Cells can be manufactured to prioritize either energy or power density. They can however..be a safety hazard since they contain flammable electrolytes and if damaged or incorrectly charged can lead to explosions and fire..

2.6 Motor driver

Motor drivers acts as an interface between the motors and the control circuits. Motor requires high amount of current whereas the controller circuit works on low current signals. So, the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor.

2.7 Code for image processing

The visuals captured from the camera are processed with the python code, which will identify the flaws like cracks and holes on the surface of the hull of the ship. The brief explanation of the code is as follows.

1.capture the video.

2.set it in a frame.

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3.Convert the captured video into gray scale.
4.Blur the background.
5.Detect the edges.
6.Show the edges in tiny RGB colors.

IV. RESULTS AND DISCUSSIONS

Fig 4. Detection of Hole in ship hull

The fig 4. shows the hole detected by the ROV, when the setup kept at 5cm away from the hole surface. The image is obtained at the screen with highlights as shown in the figure. Also, its pixel area was noted at the top of the image, which is the circumference of the hole. The readings are taken at different distance from the surface of the hole and tabulated.

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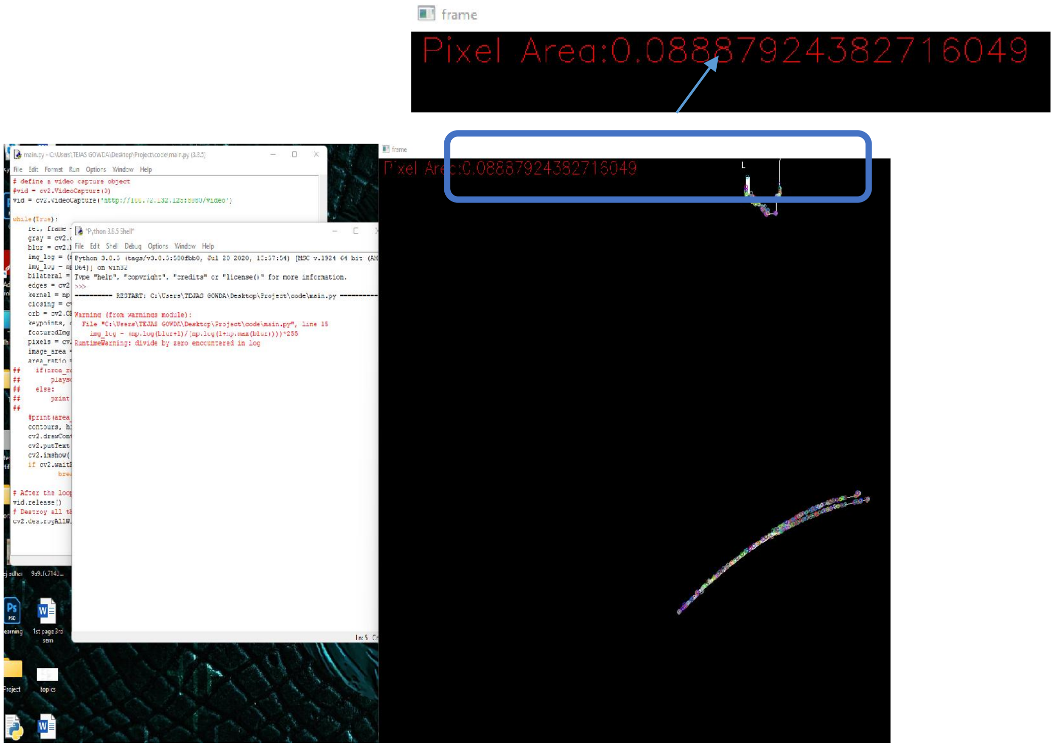

Fig 5. Detection of crack in ship hull

Sl. no	Type of flaw	Distance from the surface (cm)	Result	
			Actual length (cm)	Length (cm)
1	Crack	5	5	4.86
		8		3.97
		11		3.45
2	Crack	5	7	6.79
		8		5.64
		11		4.73
3	Crack	5	10	9.72
		8		8.05
		11		7.12
4	Hole	5	3.14	3.06
		8		2.54
		11		2.21
5	Hole	5	6.28	6.11
		8		4.98
		11		4.43
6	Hole	5	9.42	9.21
		8		7.62
		11		6.37

Fig 6. Results of ROV at various locatio

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The fig 5 shows the crack detected by the ROV, when the setup was kept at 5cm away from the crack surface. The image is obtained at the screen with highlights as shown in the figure. Also, its pixel area was noted at the top of the image, which is the length of the crack. The readings are taken at different distance from the surface of the hole and tabulated.

Form the table 2. It can be seen that the camera closer to the surface the efficiency of the image processing is greater (5cm ≤ 70%). As the camera distance gets larger from the surface the efficiency of the result will be reduced, due to visibility reduces underwater and image quality obtained by the camera will be affected.

Correction Factor Foe The First 5cm Is ±3 Percent As The Distance Increases To 8cm The Correction Factor Is 20 Percent And As The Distance Increases To 11cm The Correction Factor Increases To 30 Percent

We can calculate the length of the crack and hole using the correction factor

V. CONCLUSION

Underwater ROV is a technology that is used to explore the things underwater. It is a technology that needs further upgrading, which may be a lot helpful in future for underwater exploration and detecting the flaws automatically using the ROV is very much helpful for seafarers in the future.

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