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DESIGNING AND MODELLING OF AN AUTONOMOUS ROBOT FOR CLEANING LAKE SURFACE

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ABSTRACT

About 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water which leaves us with only 3.5 percent of fresh water. Almost 1.74 percent of the available freshwater is trapped in the glaciers, which accounts to almost 68.7 percent of the total fresh water. The accessible fresh water is available as groundwater, lakes, rivers, ponds etc. Lakes serve as one of the primary sources of drinking water but lately they are being contaminated by various sources such as industrial effluents, discharge of the drainage water into the lake, physical contamination etc. The cleaning process of these water bodies is a real challenge and when done manually, it is laborious coupled with inefficiency. The objective of this paper is to design an **autonomous cleaning robot** aided with deep learning and other state of the art AI techniques which will help in the removal of surface impurities (E.g.: plastic covers, bottles, weeds etc.) as well as oil spills and restore the chemical balance of the water body. Using the developed model, we will be carrying out numerical simulations .The designed robot can work with minimum human interaction which accelerate the process of cleaning.

Keywords*: robot, water surface cleaning, autonomous.*

I. INTRODUCTION

Water Waste, in general, appears in many different forms such as agricultural, biomedical, chemical, electronic, mineral, organic/inorganic, radioactive, and urban/municipal etc.Nowadays almost all the manufacturing processes are being automated in order to deliver products at a faster rate. Automation plays an important role in mass production. In this project we have designed a fully autonomous lake cleaning machine. The aim of the project is to reduce the human intervention and time consumption for cleaning the lake. In this project we have automated the operation of lake cleaning with help of motors for propelling and conveyor belt-vacuum arrangement for cleaning purposes. The need for an "automated lake cleaning system" is of high significance as every day, nearly 2 million tons of sewage and industrial and agricultural waste are discharged into the world's water (UN WWAP 2003) which is equivalent to the weight of nearly entire human population of 6.8 billion people. The UN estimates that the amount of wastewater produced annually is about 1,500 km^3 , six times more water than the water that exists in all the rivers and lakes of the world. Lack of adequate sanitation contaminates water courses worldwide and is one of the most significant forms of water pollution. Worldwide, 2.5 billion people live without improved sanitation. According to UNICEF WHO 2008 over 70% of these people who lack sanitation, or 1.8 billion people, live in Asia. In some regions, more than 50% of native freshwater fish species are at risk of extinction, and nearly one third of the world's amphibians are at risk of extinction due to the wastes produced and deposited in lakes and ponds due various factors such as industrialisation, urbanisation, etc.

Despite the vast number of solutions implemented by the competent authorities and governments, the process of garbage management is tedious. The garbage produced is relatively higher than the amount of the garbage which is managed on a daily basis. Hence forth taking all these factors into consideration, a smart lake cleaning system could present a viable and optimal solution towards efficient water waste management

The proposed solution is to generate a model to detect water waste using image processing, internet-of-things and machine learning concepts. The model used for this project is Convolutional Neural Network (CNN), a Machine Learning algorithm. This system will ensure effective automated lake water waste management and will speed up the process of cleaning without any human intervention.

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II. LITERATURE SURVEY

A number of solutions for the design of an automated as well as remote controlled waste management system have been developed over the past few years. In the last few decades, researchers and scientists have been working on accurately classifying the images into their respective classes. Traditionally, due to lack to computational power and limited image datasets, image classification was very difficult. But today, due to ever increasing processing power of the GPUs and the availability of large datasets, it has become feasible to employ computer vision techniques efficiently.

In the work carried out by **M. Mohamed Idhris et al. [1]** the motive is to automate the sewage cleaning process in drainage, to reduce the spreading of diseases to human. The black water cleaning process helps to prevent pest infestations by reducing the residues that can attract and support pests. It also improves the shelf life and sensory quality of food products. In the proposed system, the machine is operated with remote control to clean the sewage. Hence, this system avoids the impacts from the sewage waste and its harmful gases. This helps to prevent the mosquito generation from the wastage. The system has a wiper motor that starts running as soon as the set-up is switched on. Two power window motors are connected to the wheel and it is driven with the help of the remote control set-up. The process starts collecting the sewage wastes by using the arm and it throws back the waste into the bin fixed in the machine at the bottom. An arm is used to lift the sewage and in turn a bucket is used to collect them. The set-up runs even in sewage area with water (limited to a particular amount) so that the wastages which floats on the water surface also gets collected. The garbage which affects the drainage is also picked up and removed. This system has limited human intervention in the process of cleaning and in turn reduces spreading of diseases to mankind. Modern services are becoming polarized.

Mr. P. M. Sirsat, et al.[2] in their work emphasized on design and fabrication details of the river waste cleaning machine. Conventional methods used for collection of floating waste are manual basis or by means of boat, thrash skimmers etc. and deposited near the shore of rivers. These methods are risky, costly and time consuming. By considering all the parameters of river surface cleaning systems and eliminating the drawback of the methods used earlier, the remote operated river cleaning machine has designed which helps in river surface cleaning effectively, efficiently and eco-friendly. The “River waste cleaning machine” is used where there is waste debris in the water body which are to be removed. This machine consists of DC motors, RF transmitter and receiver, propeller, PVC pipes and chain drive with the conveyor attached to it for collecting wastage, garbage & plastic wastages from water bodies.

Prof. N.G.Jogi, [3] : The main motive of their project is to clean the lake water for that purpose we are making efficient lake garbage collector by using pedal operated boat. In this we are using pedal operated boat with the conveyor attached to it for collecting garbage from the lake. Several companies offer equipment to garbage out of river lakes and harbors .The water surface trash collection boat can work in river or lake, it can collect the floating garbage and some other equipment for weed cutting, it harvest the aquatic weed from lake. This is really a good solution for the aquatic weed management. Many says they could build larger dustcarts for the sea and ocean, if there was a demand of them those seen here may not be ideal for collection on large scale but it is food for thought. We are making the boat which is operated by pedal and clean the waste present in the lake. In this boat the conveyor collect the waste present in lake and then collect it in box like structure present in lower side of the boat

III. COMPONENTS OF THE SYSTEM

Mechanical components:

1. Base plate: It is the surface on which the bot is mounted. And of made up of aluminium.

2. Propeller : A propeller is a type of fan that transmits power by converting rotational motion into thrust.A pressure difference is produced between the forward and rear surfaces of the blade, and a fluid (such as air or water) is accelerated behind the blade causing the body to move forward.

Here , we use the 3 blade propeller for its high performance at low costs which is generally made of stainless steel alloy.

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3. Hopper : It is used for collecting the waste material once it passes through the belt drive which is placed inclined to the conveyer belt so that when the garbage moves up the conveyer it can collect it from the other end .It is made up of aluminium having a capacity of 50cc.

4. Waste gathering arms: These extend on either side of the robot and move sideways gathering the waste in front of the conveyer belt for increasing the concentration of the waste in front of the conveyer belt. It moves by the meshing of the gears and it extends upto 500 cm on each side

5. Conveyer belt: The conveyor is mounted on the two shafts such a way that it collects the waste debris to be lifted upwards and collect inside the machine. It works on a cross belt drive and the conveyer belt is mounted on it which is generally made up of nylon or rubber.

Electrical and electronic components:

1. Sensors/ modules:

1. The Raspberry pi 3 is the brain behind the automation and acts as the the central unit managing all the I/O devices .
2. Ardiuno operates the motors which run various mechanisms.
3. Camera aids the object detection process.

2. Motors:

1. Stepper motors are used to operate the waste gathering arms.
2. High torque dc motors are used to run the conveyer belt .
3. DC motors are used to run the propellars

IV. TWO DIMENSIONAL MODEL OF THE ROBOT

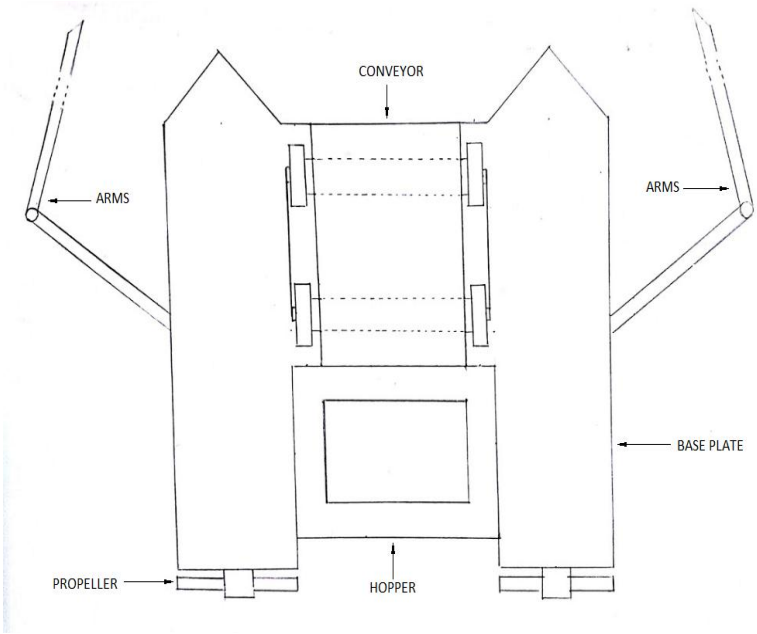

Fig 1: The model of the robot

The above figure (fig1) represents the 2D version of the robot which is modelled from the top view.

V. METHOD OF WORKING

Waste removal

This autonomous robot was primarily meant to remove the contaminants on the surface of water which is achieved by installing a conveyer belt mechanism which is generally used to carry materials from one place to another in factories , airports etc here its used to lift the contaminants and guide it to the hopper (waste storage site) which is present at the other end of the conveyer belt . Waste gathering arms are provided at either sides of the robot which move linearly forming a sector of both sides of the robot , this helps to increase the density of waste collection .Once the hoopers are full , it is emptied in the bunkers which are present at the banks of the lake. After that the robot returns to the work area to start over the waste removal process. The propellers which are mounted on the two ends of this robot aids in the movement of the robot on the surface of water. The sequence of the process is represented in figure 2.

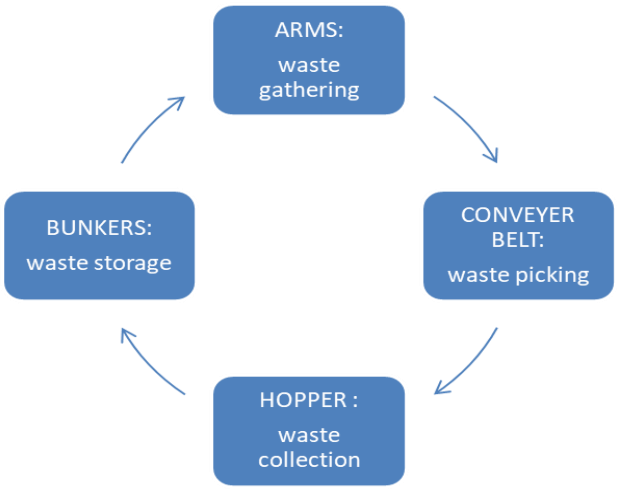

Fig 2: Sequence of operations involved in the surface cleaning of lake water

Powering system

There are two major powering system implemented in this project.

1. Solar power
2. Batteries

The three mechanisms movement in water , waste gathering and waster removal are creatively assigned either one of these powering system. The movement of the robot in the water in entirely solar power and the other two mechanisms is battery powered . Once the batteries are drained the bot leads its way to the dock where the cells are recharged .

Tracking system

The lake cleaning system is built according to ARM(Advanced RISC machines) based architectures as ARM processors are extensively used in small scale computers because of their reduced instruction set, they support the use of fewer transistors, which enables a smaller die size for the integrated circuitry . It's smaller in size, less complexity and lower power consumption makes it suitable for increasingly miniaturized devices such as a raspberry pi 3 on which the system will be built. The Raspberry pi 3 is the "brain" behind the automation and acts as the the central unit managing all the I/O devices such as motors, conveyer belt etc.

The project is divided into 2 major activities: detection and collection. The detection is done by using convolutional neural networks-a machine learning algorithm. Raspberry pi camera will capture an image of a particular area, and will store it as default image. Raspberry pi camera will continue capturing images and will compare the captured

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images with default image .Once an object has been detected, the camera will capture its image. It will identify the object as garbage, and then further send the signals to move the motors via arduinouno.

Object detection

A simple Convolutional neural Network(CNN) is a sequence of layers, and every layer of a CNN transforms one volume of activations to another through a differentiable function. We use three main types of layers to build ConvNet architectures: **Convolutional Layer**, **Pooling Layer**, and **Fully-Connected Layer** (exactly as seen in regular Neural Networks). We will stack these layers to form a full CNN **architecture**.

We train the architecture to detect trash objects in water with the help of a water waste dataset created by combining the trash dataset[12] and necessary parts of the object dataset-MSCOCO along with the aid of adobe photoshop.

Motivation for using CNN - There are various machine learning algorithms besides CNNs for classifying images like Artificial neural networks (ANNs), SVMs. It is observed that CNN outperforms most of the ML algorithms when it comes to image classification provided there are large number of images present in the dataset.

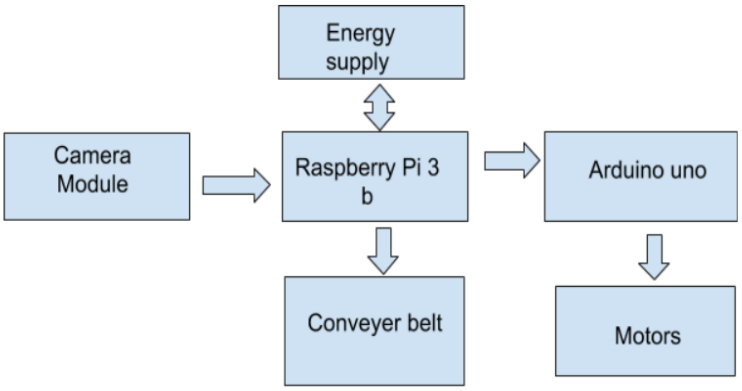

Fig 3:System Architecture

Comparision between the existing robot and newly proposed robot:

Table1: Shows the comparison of various factor between the existing robots and newly designed robot

COMPARISON FACTORS	EXISTING ROBOTS	NEWLY PROPOSED ROBOT
Density of the waste removal	Less	More
Time spent on water	Less	More
Autonomous	Partially	Fully
Initial Cost	Low-Moderate	Moderate - High
Working cost	High	Low

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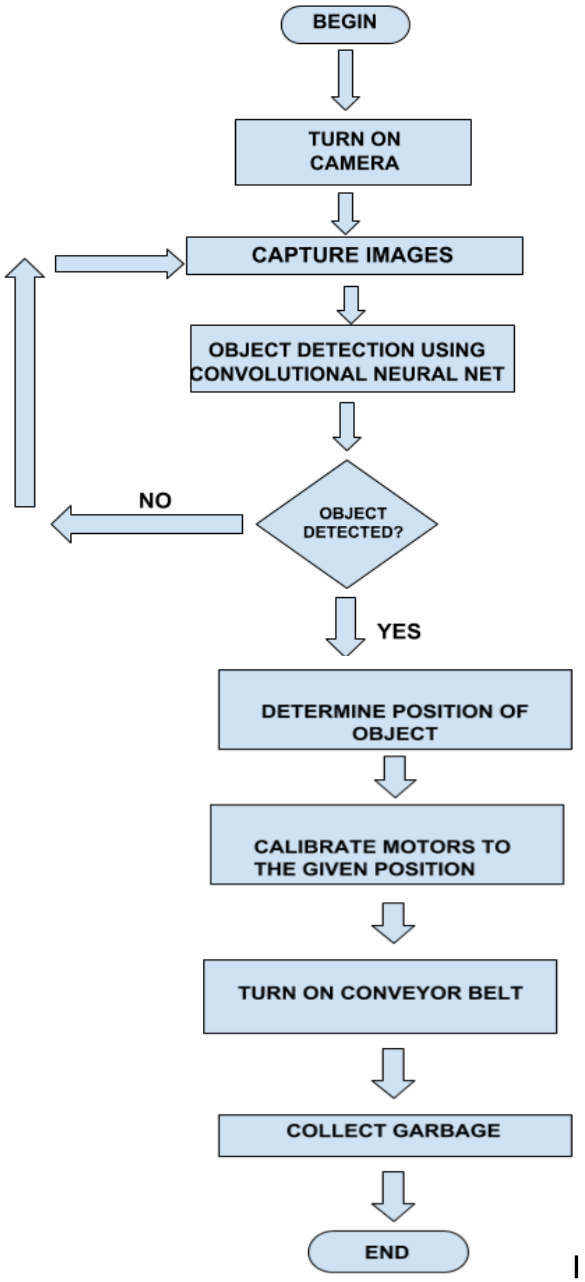

Fig 4: Flow chart of the object detection

Algorithm:

The CNN algorithm is different in many ways as compared to the normal artificial neural network algorithm. Although, the basics like training, testing, backpropagation, error reduction are the same. The CNN algorithm is designed to be explicitly used for classifying images. The algorithm starts with input as some image from the dataset. CNNs operate over volumes, i.e. some input which has spatial dimensions. They take input as volumes of activations and also produce the output as volumes of activations [4]. Thus, in CNN the intermediates are not normal

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vectors as normal ANN but the intermediates have spatial dimensions of height, width and depth. The algorithm is divided primarily into three layers – Convolutional Layer, Max pooling Layer and the fully connected layer [4].
Convolutional Layer –The Convolutional layer works in the following manner - the layer receives some input volume, in this case an image which will have a specific height, width and depth. There are filters present which are basically matrices which are initialised with random numbers at first. The Filters are small spatially, but have depth same as channels of the input image. For RGB the Filters will have depth 3, for Greyscale, the Filters will have depth 1 and so on. The Filter is convolved over input volume. It slides spatially through the image and computes dot product throughout the image. The Filters end up producing activation maps for the input image. The dot product is calculated in the following manner –
WTx + b
Where W = Filter
x = the input image
b = bias

At the end of each convolutional layer, CNNs end up taking out an activation map of the filters. The activation function is Relu (Rectified Linear Units.)
F(x) = max(0,x)

This Activation function ends up discarding values below zeroes, i.e. thresholds the minimum at zero. The next layer is the max pooling layer [4].

Max pooling - Max pooling is basically just down sampling of the activation maps. Usually, Max pooling layers of 2x2 filter and stride 2 are used, which end up reducing the input activation maps in half spatial maps [4].

Fully Connected Layer – The Fully Connected layer takes the volume as input at the very end. It has neurons for computing class scores and they are fully connected to the entire input volume, just like a normal Neural Network. This layer does the last matrix multiplier to compute the output, i.e. scores of how likely the image belongs to each class [4].

VI. CONCLUSION

The autonomous robot designed can complete the task more efficiently in optimal time. The time spent on the water can be considerably increased by using two sources of power (battery and solar) to charge the robot .It also reduces the amount of man power involved which in turn decreases the working cost of the robot in the lake cleaning process and it simplifies the rather tedious process.

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