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Smart Traversing Sub Aquatic Vehicle

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Abstract: This paper puts forth an approach where a surveying and inspecting underwater vehicle can also be used as a cleaning robot which can be operated from a platform at the surface. The proposed system uses the radio frequency communication, which help the user to interact with the distinct robot. The real time video surveillance gives the operator an actual feel of traveling underwater. Along with monitoring and cleaning, the system can measure the presence of turbidity and also the temperature of water at various depths of water and give real time readings. Our project also has a provision which would collect the water samples from various depths so that testing and verification for the presence of hazardous pollutants can be done in the laboratories.

Index terms: AUVs (autonomous underwater vehicles), ROVs (remotely operated vehicles), Xbee, arduino, temperature sensor, etc**.**

I. INTRODUCTION

From past few years there has been a lot of development in robotics field, especially in underwater robotics. Various systems have been proposed till date regarding the underwater vehicles.

Underwater vehicles are being classified broadly as – AUVs and ROVs.

a) AUVs: means the autonomous underwater vehicles. These underwater robots have in built computers which help them to work without any connection with the surface platform.
b) ROVs: means the remotely operated vehicles. ROVs have a cable attached to them which help the operator, at a remote place from the robot, to control the movements of the robot.

Both the underwater vehicles are used for various purposes such as monitoring, observing, exploring organism and deep-sea environment, and also for inspecting the ship hulls etc.

Along with the commercial purpose, underwater robots are also used for domestic purpose such as water tank cleaning without the wastage of water. In 2007 a robot was developed in Rajasthan by Gridbots which would clean water tanks without wasting water.

II. RELATED WORK

The designing of underwater robot began from the 18^{th} century, when the first underwater vehicle torpedo (see fig.1) was designed in 1866[1]. It used compressed air for its driving mechanism.

Fig.1. First Underwater Vehicle named Torpedo.

In late 1950s, Stan Murphy, Bob Francois and Terry Ewart developed the first real underwater vehicle at the University of Washington, which was used to gather oceanographic data beneath the ice berg [2]. This further was accompanied by the evolution of Self Propelled Underwater Research Vehicle (SPURV) in the early 60s [3]. The SPAWAR developed the Advanced Unmanned Search System (AUSS) in 1983; it used acoustic communication system which sent the video images through water. The underwater robot technology enhanced expeditiously all over the world in 1990s. The first RUV named Cutlet (fig. 2) was used by the Royal Navy in the 1950s. In 1960s, the US navy sponsored ROV technology CCURV (Cable-Controlled Underwater Recovery Vehicle) which led to the deep sea search and rescue operations [4]. In 2009, Woods Hole Oceanographic Institution (WHOI) was successful in making the hybrid RUV, Nereus (fig.2) travel to the depth of around 6.8miles; but while exploring the

Kermadec Trench at nearly 10000 meters Nereus was lost in May 14.

Fig.2 . Cutlet (left) and Nereus robot (right).

III. COMMUNICATION SYSTEM

From last decade there has been a lot of research done with respect to the underwater communication. Three types of communication are possible in the water, namely, acoustic communication, optical communication and the EM wave radio communication. Each of the three has its own pros and cons. EM waves undergo large attenuation at higher frequencies. Acoustic and optical communication systems are popularly used for transfer of data in water. There are numerous limitations for these models. The flaws in the acoustic systems are as follows-

- Low data rate (0b/s to 20kb/s), limiting the amount of data that can be sent.
- Adversely effected by the multipath propagation, environmental characteristics and salinity.
- Latency period is more.
- Low propagation velocity in water.
- Performance is low in turbid water with large particles.

Limitations of optical communication models-

- Large backscattering, limiting the application area to short distances.
- Affected by the water turbidity to a significant extent.
- Implementation cost is high.
- Requires line of site.

Complementing the acoustic communication, Electromagnetic waves provide high data rate for short distances. The channel latency period is also decreased incredibly as the velocity of EM waves in water is four times faster than that of acoustic waves [5]. Also EM waves are least affected by the reflection and refraction in shallow water. Moreover EM waves do not require line of site unlike optical communication. The EM wave communication would be a best solution if there is a requirement of high data and speed for short distances.

The only limitation of the Electromagnetic wave communication is that these waves highly attenuated in water, especially water with high conductivity such as sea water (4S/m). There are various factors which affect the propagation of EM waves in water. These factors are-

a) Conductivity: Salinity and temperature results in the variation of the conductivity. As conductivity increases more attenuation of EM wave is observed. The conductivity of sea water and fresh water is 4S/m and 0.01S/m respectively. Attenuation is directly proportional to the conductivity. The mathematical equation for attenuation in water is given as-

Attenuation (α) in dB/m = $0.0173\sqrt{(f\sigma)}$ …. (1)

Where, f= frequency, σ= conductivity.

b) Permittivity and permeability: Permeability is the capability of the water to support the production of magnetic field within itself. Permeability of sea water is equal to that of the air i.e. $\mu_{seawater} = \mu_{freespace}$.

Permittivity is the opposition to the formation of the electric field in water. Factors such as salinity, carrier frequency and temperature affect the permittivity of the sea water and it is a complex value which can be given by the following equation [6]-

$\varepsilon_r = \varepsilon' + j\varepsilon'' = 72 + j39$ (unit less), ….(2)

where, $\varepsilon = permittivity, \mu = permeability.$

c) Intrinsic impedance: It is the ratio of electric field strength to the magnetic field strength. The intrinsic impedance of sea water is a complex value and it can be expressed with the help of the equation below [7]-

η = **E/H** = $\sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}}$. ….(3)

d) Skin depth: Skin depth is the capacity of the EM wave to penetrate into the conducting medium. Skin depth mainly depends on the conductivity, if $\sigma = 0$ $then$ $\delta_s = \infty$ and $vice$ a $versa$. It is the distance that a wave can travel in that medium till its magnitude suppresses to the value nearly equal to 0.37[6]. This distance can be calculated by the following equation[8]-

$$d = \frac{1}{\omega\sqrt{\frac{\omega\varepsilon}{2}\sqrt{1+\left(\frac{\sigma}{\omega\varepsilon}\right)^2}-1}} \quad \text{....(4)}$$

IV. PROPOSED SYSTEM

In the proposed system we have tried to inculcate the use of AUVs and underwater cleaning robots into one system that to in an economic way. The current system can either do the surveillance or work as tank cleaners. Our project can perform both the tasks using same hardware and along with this it can also sense the turbidity presence and measure the temperature of water at a particular depth of the water body. In this system we are using transceiver pair and relay card which would help the operator to control the movements n give commands to the robot. Arduino atmega8 is used for giving information regarding the temperature and turbidity, while a/v receiver gives the real time video images from the wireless camera.

V. SYSTEM ARCHITECTURE

The hardware consists of relay card, arduino atmega8, Tx/Rx pair (22 MHz and 33 MHz), computer system, audio/video to USB convertor, temperature sensor (LM35), CC2500 Xbee module and USB convertor.

VI. OPERATION

The operation of our system is logically divided in three parts as can be seen in the block diagram.

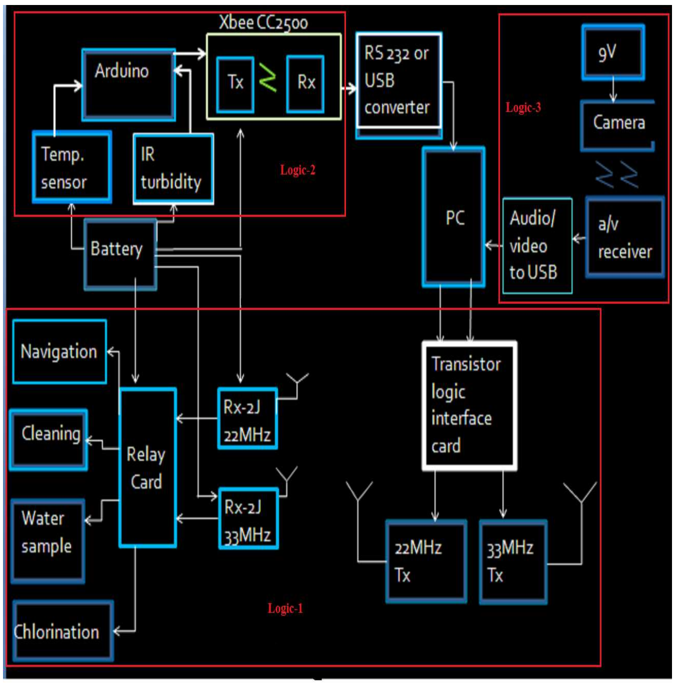

Fig.3. Block diagram of the entire system.

The three parts are namely,

1) Control section.(Logic 1)
2) Measurement section.(Logic 2)
3) Monitoring section.(Logic3)

1) Control section:

This section controls the movements of the robot. The robot acts to the commands given to it by the operator using transmitter/receiver pairs and the relay cards. Specific keys on the keyboard refer to the specific commands. The fig shows the flowchart for the logic 1 i.e. control section.

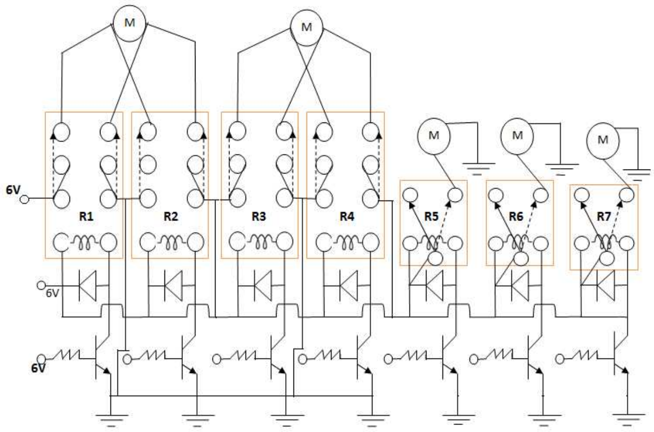

Fig.4. Circuit diagram of logic 1.

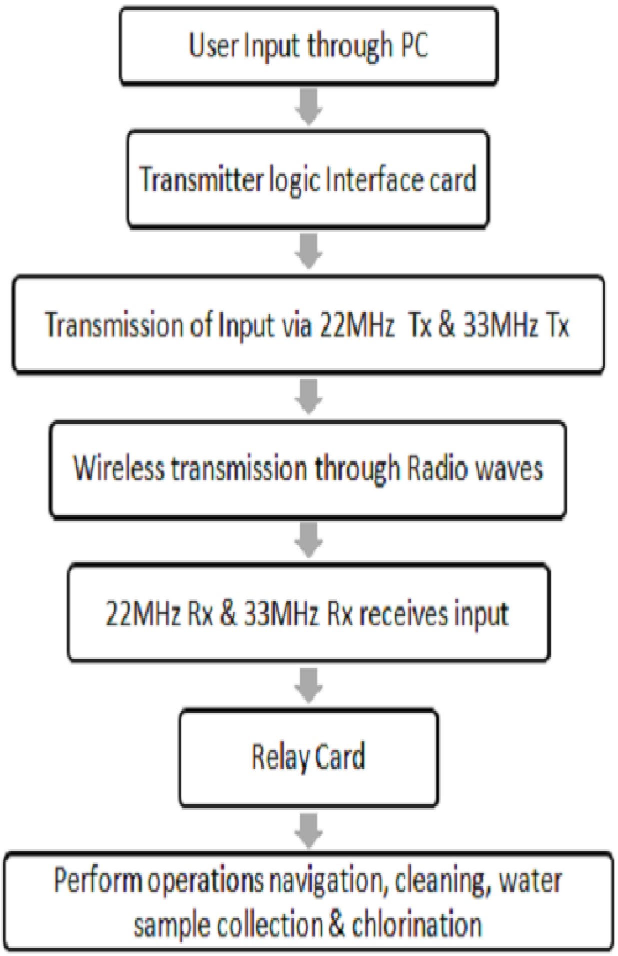

Fig.5. Flowchart for Control section.

2) Measurement section:

Logic 2 measures the temperature and the presence of turbidity in the water body, hence the name measurement section. The result is transmitted wirelessly using Xbee module and is therefore displayed on the computer screen. The temperatures at various bottom levels differ and so there is a need of its measurement at these depths for knowing about the aquatic habitat. The figure downside shows the flowchart of logic 2.

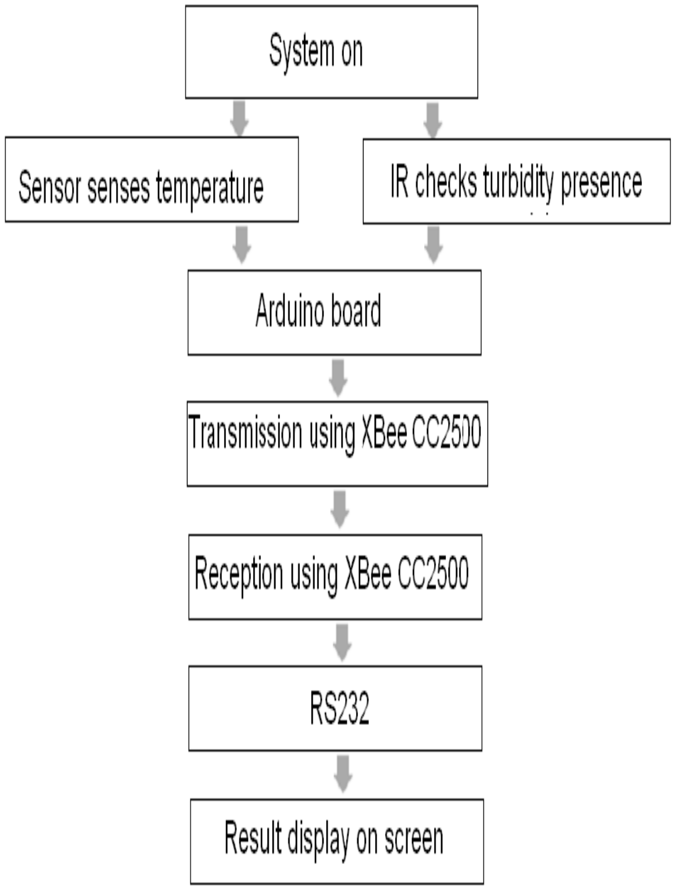

Fig.6. Flowchart for Measurement section.

3) Monitoring section:

Real time surveillance is carried out by using the wireless camera, which transmits the signal to a/v receiver which in turn send it to the computer for the monitoring purpose

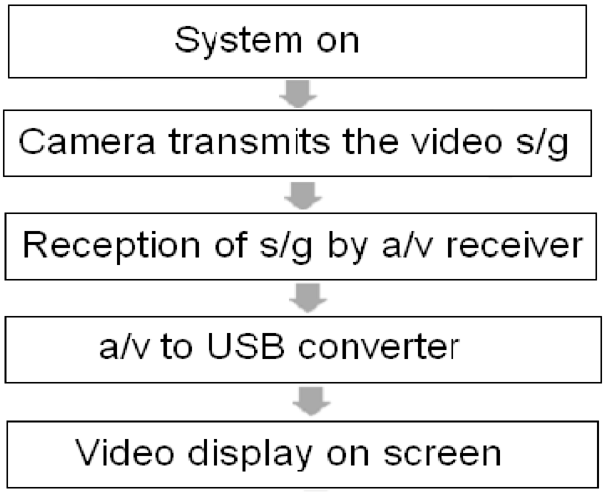

Fig.7. Flowchart for the Monitoring section.

VII. EXPERIMENTAL RESULTS AND SIMULATION

The simulation for the motor was carried out using the software tool Proteus. The Pick devices dialog box was used for component selection. The figure shows the simulation in ISIS professional version7.7 SP2.

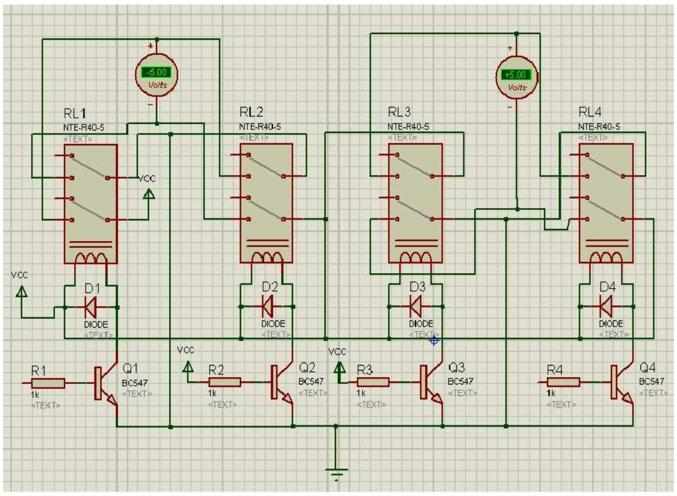

Fig.8. Simulation in proteus.

The temperature sensor and the IR transmitter and receiver were interfaced with arduino atmega8 kit using breadboard. This breadboard testing gave the depicted outcomes.

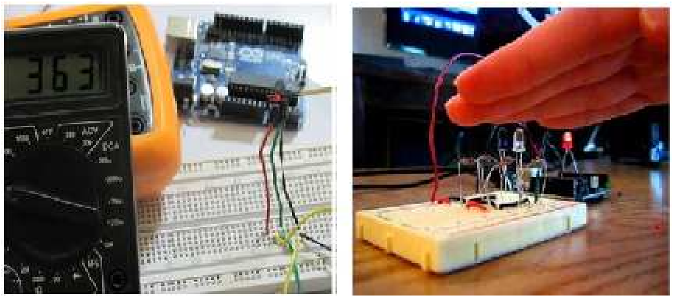

Fig.9. Interfacing of LM35 Sensor and IR Tx & Rx.

The robot was tested in distinct water bodies and the temperature was measured for the respective water body. The presence of turbidity was also verified for these water bodies. The results for logic 2 is shown in the table below-

Type of water	**Nature of water**	**Temperature of water (in degree Celsius)**	**Turbidity**
Tap water	Neutral	26	absent
Factory outlet water	Acidic	30	present
Sea water	Basic	25	Clear

Table.1. Turbidity and Temperature measurement.

The output of the temperature and turbidity can be seen on the computer using visual studio software. As EM waves suffer from attenuation to a great extent and so we tested the range of the proposed system for few frequencies and the outcomes are as shown below.

Attenuation (in dB)	Distance (in m)
2dB	0.2m
-2dB	0.4m
-10dB	0.6m
-10dB	0.8m
-11db	1m

Table.2. Range in fresh water for 5MHZ frequency.

Attenuation (in dB)	Distance (in m)
-10Db	0.2m
-17dB	0.4m
-20dB	0.6m
-21dB	0.8m
-25dB	1m

Table.3 Range in fresh water for 25MHz frequency.

Attenuation (in dB)	Distance (in m)
-12dB	0.2m

-21dB	0.4m
-28dB	0.6m
-35dB	0.8m
-42dB	1m

Table.4. Range in fresh water for 40MHz frequency.

Attenuation (in dB)	Distance (in cm)
-18dB	0.2cm
-32dB	0.4cm
-46dB	0.6cm
-55dB	0.8cm
-62dB	1cm

Table.5. Range in salt water for 5MHz frequency

Attenuation (in dB)	Distance (in cm)
-28dB	0.2cm
-45dB	0.4cm
-58dB	0.6cm
-62dB	0.8cm
-66dB	1cm

Table.6. Range in salt water for 25MHz frequency

Attenuation (in dB)	Distances (in cm)
-28dB	0.2cm
-40dB	0.4cm
-58dB	0.6cm
-68dB	0.8cm
-70dB	1cm

Table.7. Range in salt water for 50MHz frequency.

It can be observed from above tables that attenuation of EM waves in salt water is more as compared to that of the fresh water; this is because of the high conductivity of the sea water.

The Xbee module and wireless camera operate at 2.4 GHz frequency and their effective range of operation is upto 0.17m which can give us a data rate from 1Mbps to 11Mbps [9].

VIII. CONCLUSION

The concept put forth has given the satisfactory results in terms of control, measurement and monitoring. The presented system can work in any utilized for various underwater applications. The use of wireless system had spread out the region of operation in the water bodies. The approach is influential and hence can be operation. The camera acts has a helping hand in the monitoring and surveillance purpose, which indeed helps to gain more knowledge about aquamarine life.

The simulation part shows the control of the robot. In future, we can utilize electrode grids for inspecting and measuring the level of hazardous pollutants in the water bodies. By applying proper thrust and maintaining appropriate pressure the robot can go deeper in the water. This has to be done yet.

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