

# Development of Raspberry PI Based Underwater Image Capturing System

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## Abstract:

To study the habitat of underwater creatures, acquisition of images /videos to be performed for further processing. Acquisition of underwater images is done by the camera. The captured images are further processed for analysing the habitat, providing nourishment information to the cultivating farmers. The objective of this research work is to develop a low cost, low power consumption, effective image capturing system especially for aquaculture using Raspberry pi to monitor the aqua creature from anywhere, any time in the world through android mobile phone. In this research, Raspberry pi system is used as web streaming server.

**Keywords:** Aqua monitoring system, Raspberry-Pi, Underwater image capturing system, USB Camera.

## INTRODUCTION

In today's digital electronics era, capturing of still or video images are easier and leads to develop a low power tiny device capable to capture images at extreme depths. Collections of underwater images / videos play an important role in studying the habitat of underwater creature.

In this research article, we are going to focus on developing an embedded image capturing system to learn and monitor the behaviour of aquatic animals / plants in pond aquaculture, particularly, in shrimp cultivation. To capture the shrimp images / videos from the underwater we use the USB camera connected with Raspberry pi system. Then these images are sent to the farmer through smart phone. It is easy for the farmer to identify the growth, lifespan and size variations of the shrimp.

Real time video signals can be viewed on any device with the help of internet is known as live video streaming. Raspberry Pi is a small device used for live web streaming. Due to low cost, less power consumption, quick response, tiny computer, having good picture quality configurations and from the literature review, Raspberry pi is selected as processor to capture and monitor underwater images.

Divya Priya and Harish (2015), have designed a low cost, efficient underwater vehicle to monitor parameters like temperature, pressure and speed for Aquatic Ecosystem using Raspberry pi. Vehicle hull is made by PVC pipes. They used I<sup>2</sup>C and SPI communication

protocols for interfacing raspberry pi with sensors. The parameters were monitored through LCD display.

Virginia Menezes, et al, (2015), proposed a Raspberry pi based system for detecting moving objects in the surveillance area and feed the captured images of camera through online using MPEG streamer. The authenticated person can view the live video anywhere over internet. To store the screenshots of video, an external storage device can be used using USB port of Raspberry pi device.

Ali A. Abed and Sara A. Rahman, (2016), submitted CamShift (Continuously Adaptive Mean Shift) algorithm and colour detection in darkness for tracking a target with video sequences in real time. To monitor object in video, an embedded board is adopted to monitor the activity of the object of interest based on Raspberry Pi with LCD touch screen display TFT monitor. With the help of python code with OpenCV library two algorithms were executed and expressed how the style can be resolved by its flaws.

Chinmaya Kaundanya et al (2017), proposed the Smart Surveillance System using Raspberry Pi and Image Processing which serve as security module for monitoring. Proposed system consumes low energy and provides energy management by turning ON the system, based on need basis. Motion detection is performed by capturing the intruder image and send to the authorised person through internet.

A. K. Saha *et al*, (2018), have developed a remotely controlled vehicle termed as an underwater rover which not only gives an insight into aquatic habitats but also helps to locate and track or precious materials like pearls, from a valuable perspective. This can be used for getting the live video or still pictures of the underwater life and all the underwater activities to learn about the underwater life. It makes the job for divers, rescuers and gem collectors easier as the rover gives the pictures, live video and all the other relevant details necessary for having a proper knowledge about the underwater elements. A Raspberry Pi microcomputer is been used form illuminations and obtaining videos respectively.

## **HARDWARE ARCHITECTURE OF UNDERWATER IMAGE CAPTURING SYSTEM**

Fig. 1 shows the proposed image capturing system of underwater habitat using Raspberry pi architecture. The proposed system contains Raspberry pi processor, USB camera, Power supply unit, Wi-Fi adapter and Storage devices. Raspberry pi is heart of the system used for video processing of pond aquaculture. It transmits the information to the authentic aqua-farmer through internet.

Raspberry pi is an affordable computer in the size of a credit card. It has the functions almost resembles a personal computer [G. Senthilkumar et al., 2011]. Raspbian is the Linux based Operating System (OS) used. The images / videos can be transmitted to the user via smart phone with the help of OS with OpenCV.

The images / videos of underwater habitat are captured by the camera interfaced with raspberry pi via USB port. The raspberry pi kit is located on the top of the camera with environmental protection. The captured images / videos are processed and executed with the help of Linux OS software using python coding. Then, the video information will be sent to the client's display device through internet [Virginia Menezes et al., 2016].

Manual monitoring needs skilled person to monitor multiple properties continuously and 24/7 continuous monitoring is difficult. This leads to develop a low cost, high efficient real time remote monitoring system.

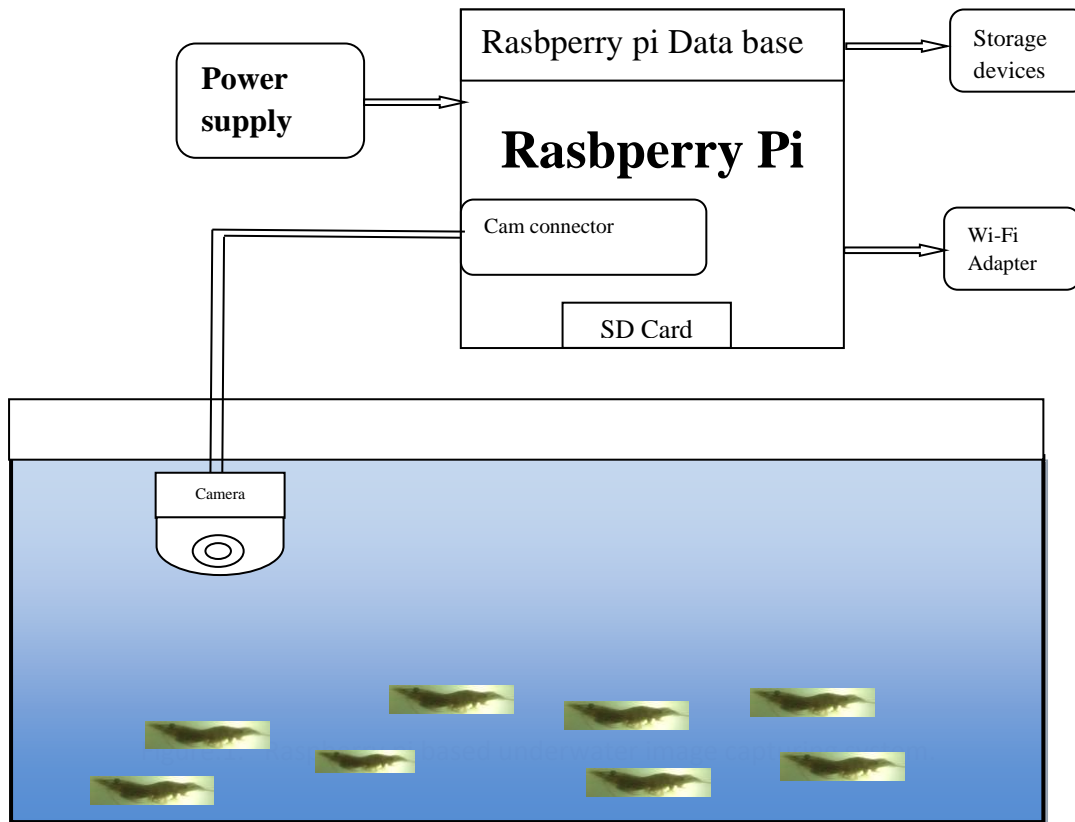


Figure.1. Raspberry pi based underwater image capturing system.

## FUNCTIONAL DESCRIPTIONS OF COMPONENTS USED

Brief descriptions of Raspberry pi model 3B, USB camera, Power supply and Wi-Fi adapter, Python programming, Smart phone as Screen display are presented in the subsequent sections.

### RASBPERRY PI MODEL 3B

Raspberry pi (Fig.2) is low cost, low power consumption single board computer of credit card sized electronic device. Broadcom BCM2837 “system-on-a-chip (SoC),” is the brain of the raspberry pi which contains the components needed for a computer. Raspberry pi will not work under windows OS and it needs LINUX OS for programming [Vanitha, et al., 2016].

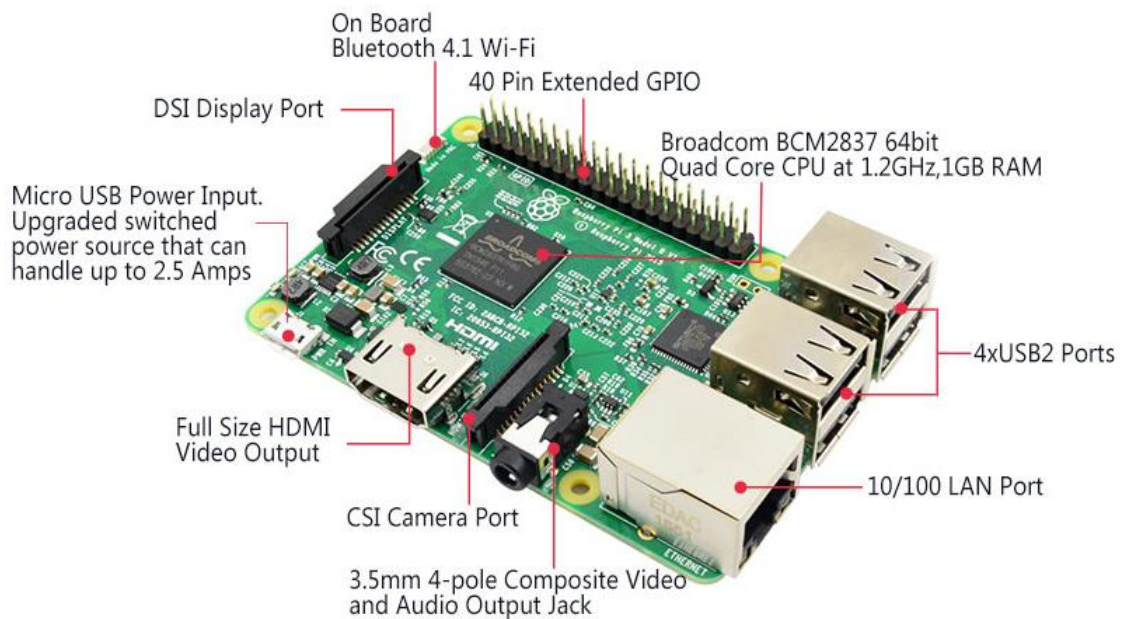


Fig. 2. Raspberry PI 3 model B

The internal components of raspberry pi which are built in a single board are Ethernet port, camera connector, GPIO pins, USB ports, HDMI port, Micro SD and USB port, Audio / Video output, Display connector and Broadcom BCM2837 System on Chip. The pi 3B model has on board Bluetooth and Wi-Fi 802.11 b/g/n. There is no internal storage device like hard disk or solid state drive. Hence this device uses an SD card for operating and long lasting storage. SD card used in this device is a preloaded version of Linux Operating System. This device has an excellent feature like image processing, video streaming and work with internet of things [Wei Chen, et al., 2010].

## USB CAMERA

USB camera is used to capture images / videos. It uses USB 2.0 technology with 480 Mb/s to transfer the image data to raspberry pi for further processing. The principal factors to be considered for selecting the camera are size, pixel pitch and its sensitivity [Patil V.P., et al., 2018]. In this research work, DMG Sports Action Camera (Fig.3) is used. It is low power consumption, low cost, miniature in size and compatible with raspberry pi. This is a high definition digital motion, compact and rugged action camera designed to record the action while on the move. The camera comes with a waterproof housing shell cover. With image stabilization in place, the pictures and videos are mostly blur-free, anti-shaking and provide accurate colours. It can also connect to smart phone through the app. Full HD allows shooting quality pictures and videos with a depth of 100 feet (30m). It has 170° wide-angle lens which allows shooting wider scenes and catching more amazing moment of their surroundings. Featuring 1080P @ 60FPS video resolution and 12MP photos, DMG action camera enables to take incredible photos and clear HD videos. It uses Micro SD HC Class10 for storage ranges from 4GB to 32 GB.



Fig. 3. USB connected DMG Action camera to capture underwater environment..

Rather than using the raspberry pi camera module, a standard USB camera module can be used to take pictures and videos using Raspberry pi [G.Divya Priya, I Harish, 2015]. Raspberry pi module can be connected to the device using 15 pin CSI ribbon cable. The following steps to be performed for using other camera than raspberry pi camera module.

First, install the “fswebcam” package.

Enter the command “fswebcam” followed by a filename and picture will be taken using the webcam are saved to the filename specified.

Specify the resolution of the image taken using `-r` flag.

Example: `fswebcam -r 1280 x 720 image2.jpg`.

### **POWER SUPPLY AND WI-FI ADAPTER:**

#### **Power supply:**

Power supply is a device that supplies electrical energy to one or more electrical loads. The power supplied to the raspberry pi device is the use of 12V battery. The required 5V supply is converted with the help of attenuation circuits and kept safely. On full charge of 5V battery, can keep easily the raspberry pi powered up to minimum of 3 hours duration due to low power consuming processor is used in raspberry pi [Arnab Kumar Saha, et al., 2018].

#### **Wi-Fi Adapter / GSM Modem:**

Wi-Fi USB dongle can be used to transmit the video stream to the clients display device through internet. It acts as a GSM modem which allows the display device to connect internet wherever mobile signal is available [Sanjana Prasad, et al., 2014]. The IOT Board consists of a GSM/GPRS modem connected together with power supply circuit and interfaces like RS 232, USB for communication. Modem is built with Quad Band GSM/GPRS based SIM900A

module. It works on frequencies 850/900/1800/1900MHz. SIM900A can search these bands automatically. The frequency bands can also be set by AT Commands. The baud rate is configurable from 1200-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. Presence of RS232 chip in the GSM modem allows connecting Raspberry pi processor using MAX232 [Raguvaran, Thiyagarajan, 2015].

## **PYTHON PROGRAMMING**

Raspberry pi uses Raspbian Operating system. It is free software, based on Debian (LINUX). It is user friendly and optimized for Raspberry pi hardware. It supports all programming languages like Python, C.

During 1985- 1990, Guido van Rossum created Python language. Compared to other languages like C / C++ or JAVA, programming code to express concept by the programmers is less and occupy less storage space. It is an Object-oriented, general purpose, interactive and high level programming Language. Python language is used for communication with General Purpose Input Output ports of Raspberry pi. Python language is connecting easily with MYSQL database as well as OpenCV module. Video streaming, analysis and alert the user were programmed in Python using OpenCV [R.Chandana, et al., 2015].

OpenCV (Open source Computer Vision) is a library principally focused for real-time computer vision that integrates with Python. It supports variety of programming languages like C++, Java, Python, etc., and works on different platform like Windows, Linux, Android, iOS, etc. More than 2500 optimized algorithms used for Image processing, detection and tracking, analysis of image / video stream, classification and other functions are available in OpenCV.

## **MOBILE PHONE AS SCREEN DISPLAY**

Display devices for Raspberry pi are TV, Laptop, Computer, smart phone, etc. Now a day usage of smart phone is increased and easily handled by farmer also. Without spending extra money for display device and no need to carry extra device to monitor, Smart phone can be used as display device [Mallikarjun Anandhalli, Vishwanath P. Baligar, 2018]. The procedure for making smart phone as Raspberry pi display device is as follows:

1. Both client smart phone and raspberry pi must be connected to the same network
2. Check the raspberry pi IP address
3. Setting up SSH (secure socket shell) client: It is a protocol for accessing the raspberry pi. SSH client must be installed in smart phone using play store. Creation of new host must be done by entering the following parameters like Alias, hostname, username, password.
4. Installation and setup of VNC server must be done on raspberry pi. Use the following commands: (a) Sudo apt-get install tightvncserver (b) Run Tightvncserver You will be asked to enter password
5. A script file must be created to start the VNC server. Use the following script in NANO editor (a) `#!/bin/sh` (b) `vncserver :1 -geometry 1920x1080 -depth 24 -dpi 96`

Use CTRL+O to save the file, extension should be “.sh”. Now for executing the file use the following command (a) `sudo chmod +x <saved file name>.sh` with this file name we can start VNC server for our mobile device by sending a command via `SSH./vnc.sh`

6. Now installation of VNC viewer on Mobile device. Many VNC viewers are available in play store for android platform. Download and install VNC viewer app and set it up by giving raspberry pi IP address followed by 1. 1 indicates display no.1, then you will be prompted to enter VNC server password that we have created.

## **RASBPERRY PI - INITIAL SETUP**

Raspberry pi uses NOOBS (New Out Of the Box Software) as an operating system install manager. The following Operating Systems are currently included in NOOBS:

Raspbian, Pidora, OpenELEC, RaspBMC, RISC OS, Arch Linux

### **Procedure to install NOOBS is as follows:**

1. NOOBS software can be downloaded freely from the raspberry pi website: [raspberrypi.org/downloads](http://raspberrypi.org/downloads)
2. Format the SD card and install NOOBS into the SD card.
3. Download and install WIN32DISKIMAGER software which is a windows program for store and restore images of removable drives like USB, SD memory card, etc. Micro SD card of raspberry pi can be made ready to extract the downloaded image, using this software.
4. Operating system of new raspberry pi B+ model is not compatible with WIN32DISKIMAGER software. So, the software called “PUTTY” is used to solve this problem by upgrading / updating the OS.
5. PUTTY is a free, open source terminal emulator and network file transfer application. It is windows platform software. It supports protocols like SCP, SSH, TELNET, RLOGIN and RAW SOCKET connection. To configure and setting up the raspberry pi, download and install into the micro SD card.
6. Now upgrade and update the operating system using PUTTY software to make raspberry pi B+ model compatible using the following commands :
  1. `sudo apt-get update;`
  2. `sudo apt-get upgrade;`
7. These upgrade and update can be done with the help of either laptop or PC using internet sharing facility.
8. TIGHTVNC software to be used for working NOOBS on windows platform. It is a free, open source cross platform for remote desktop software application.
9. To control another computer’s screen (Display) remotely, extend the RFB protocol of Virtual Network Computing (VNC). Hence this software also be downloaded and installed.

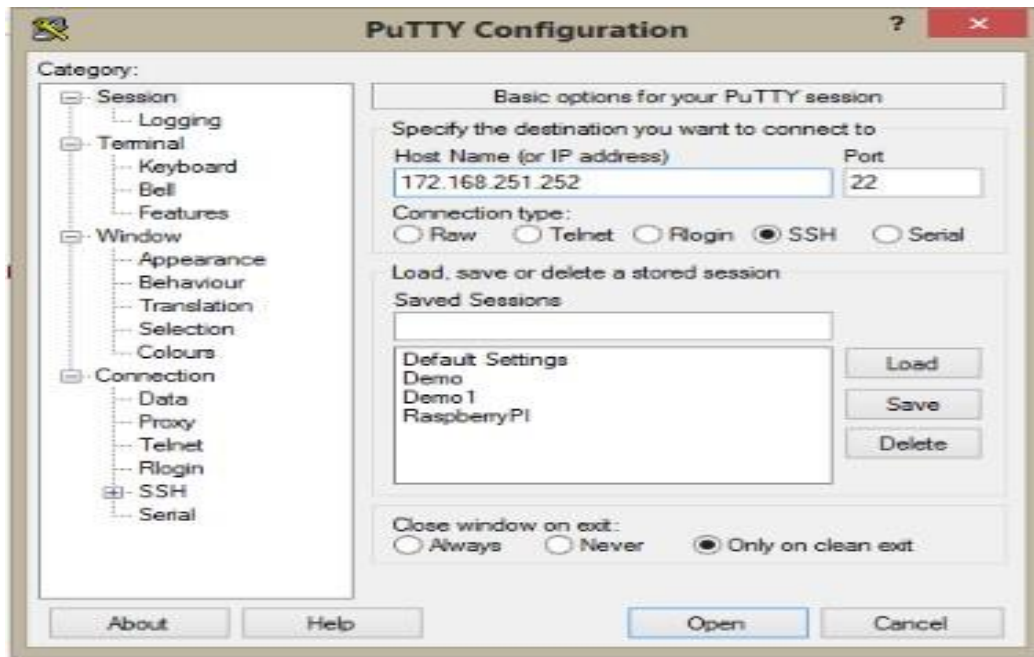


Fig.4. Putty configuration settings

10. NOOBS in windows platform will be shown by commanding in PUTTY to open TightVNC server as: “sudotightvncserver”.

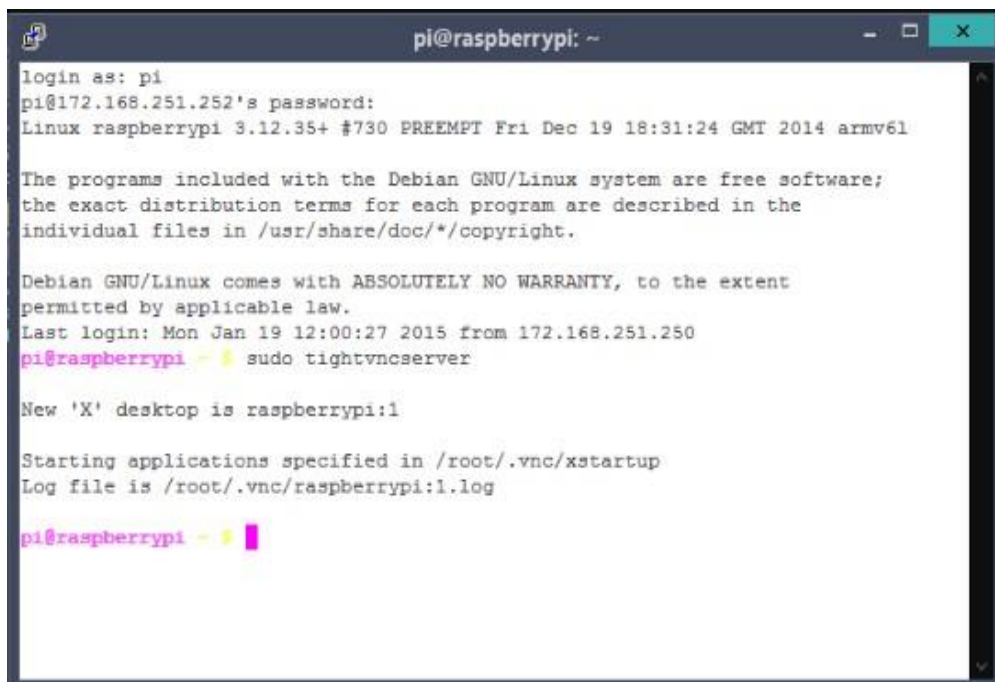


Fig. 5. TightVNC command given in Putty

11. In built GENNY software in Raspbian OS is used further for program interfacing. LXterminal is use as command prompt in Raspbian OS.



## RESULT AND DISCUSSION:

In a SD card, PYTHON, OPENCV and NOOBS are installed. Raspberry pi is booted with the help of SD card. All initial steps and procedures are performed to capture images / videos of underwater environment. During night time and cloudy atmosphere with the help of external lights fitted with camera is used for capturing images / videos.

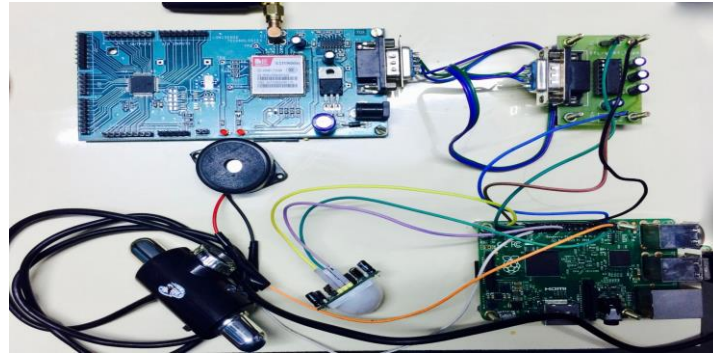


Fig.6 Hardware setup for underwater image capturing system.

Hardware setup for capturing images in underwater is shown in fig.6. Here we use a minimum of 4GB SD card with class 10. But we recommend 16GB memory capacity so that, there is a provision for storing videos and images that were captured by USB camera. USB submerged camera is utilized for catching pictures and recordings. With the help of built in functions like SMTP [simple mail transfer protocol which is an internet standard for electronic mail transfer] and FTP [file transfer protocol which is a built on client-server model architecture used to transfer the files in computer between a client and server on a computer network], we can send images and videos to user mobile phone from raspberry pi. Time to time updating of data to the server can be performed by camera connected to the raspberry pi, for monitoring purpose.

The performance of the designed Raspberry pi model is tested by capturing the real time images from the pond aquaculture at Nagapatinam of Tamilnadu state in India. The captured image of shrimp in underwater environment is shown in figure 7.



Fig 7 Images taken with the help of USB Camera connected with Raspberry pi.

The images / videos obtained from USB camera is poor quality due to low illumination, presence of suspended particles, light refraction and attenuation of light effect. To obtain best visual quality of images / videos, the captured images / videos must be enhanced for further analysis and monitoring purpose.

## CONCLUSION

We have designed and implemented a low cost, highly efficient remote monitoring system of the aqua fauna / plants in underwater environment, which can be monitored from anywhere in the world at any time. Live video streaming can be clearly visualized on the smart phone of authenticated person. Raspberry pi board can act as a web streaming server, which receives videos from the camera periodically. Such videos are transmitted to the concerned aqua-farmer to know the size, growth and survivability of the shrimp. With the help of static camera we got underwater image / video capturing for monitor and analysis purpose. As a future work, moving camera to be designed for capturing images / videos to monitor and analysis purpose

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