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Underwater Surveillance Autonomous Boat

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Abstract

An autonomous boat with vision ability provides distinct and immeasurable benefit to mankind. This research is to further study the development of the autonomous boat for underwater surveillance. The study's primary goal is to implement image processing on the autonomous boat. By using a single vision system on a boat, complemented by some algorithms and coding, many data can be obtained from the image processing. In this endeavor, the focus will be on analyzing the use of single vision cameras in providing data for research on environmental front underwater and detecting depth and obstacles for better navigation. The system can disclose solid objects underwater for restoration and cleaning purposes in the lake or rivers. Furthermore, it can identify lost object underwater and detect obstacles in front. In addition, it can provide depth information of a lake or river providing with correct algorithm and technique. The outcome is precise enough to recognize snags or objects above and underneath the water considering the diffraction of light required for impeccable vision. In this research, Open CV library is utilized for advanced picture processing and shading highlight investigation instead of MATLAB because of the multifaceted nature for ongoing procedure. The design structure is for the most part dependent on Pontoon style on the grounds that it is progressively steady and solid particularly on the stream wave condition. Through this paper also, all the mechanical structure is simulated using the Catia V5 Edition software and the real time coordinate points is also captured using a global positioning system receiver. All above, additional sensors and actuators are implemented in this project for further improvement of this current design.

Keywords
Surveillance; Boat; Image; Underwater.

1. Introduction

This project continues the innovation and development of autonomous boat for underwater surveillance. The main purpose of the last design is to facilitate in measuring the depth of a lake or river for various purposes. Conventional methods by using manual labor in measuring water depth are dangerous, not practical, and inefficient. Therefore, the previous project improved the general landscape of the field remarkably and fit the purpose of the last study. The project development on autonomous boat will be focusing more on image processing development on the boat to image of object below and above water and to detect obstacles and the depth of a lake or river. The development of the image processing will be focused on using Open CV Library rather than MATLAB due to real time-based process (Shakil and Rashid., 2023). A small analysis had been done regarding image processing for underwater surveillance in this country. Most of the work that has been done on the images is either on ground or air vehicles. Thus, this

continuation project will focus more on imaging in real time process under and above water for various purposes. This project will try to cover advances in the following areas such as image formation and image processing methods, extended range imaging techniques, imaging using spatial coherency and multiple-dimensional image acquisition and image processing. An autonomous boat works independently as it is programmed automatically to do its job efficiently and does not need for someone to control it for the whole time of operation, but constant supervision is needed in case of any malfunction or deviation from the set point. Hence, that is where the navigation system is in place to allow manual control mode. This safety is necessary to preserve the boat and the expensive components which are mounted on the boat (Amin et al., 2022).

Furthermore, improvements on the current design on mechanical and electronics part will be made throughout this project. Moreover, with additions of sensors for research purposes and also actuators to make the boat run smoothly into the current design, the development of the underwater surveillance boat will serve its purposes. The whole walkthrough of this project require several areas of engineering knowledge such are mechanical, electronics, communication, material and software engineering. Precision, reliability and stability are the three key elements in the process of designing this project (Shabir et al., 2023). The designed and developed boat prototype should be able to sustain several series of testing in the field. In addition, the design process also must consider the economic value of the boat. The electronics, sensors and mechanical parts used must be reasonable in term of the price but at the same time maintain the quality of the system and high economic value since the electrical and electronics components used is less expensive and the navigation system is not that much complicated (Shakil and Ullah., 2022). Hence, usage of this system would be able to be implemented either to public or research purposes. Lastly and more importantly the boat must be able to maintain its original purpose which is to obtain depth measurement data and store the data inside the storage and transmit the data through wireless communications. In a nutshell, to reiterate, image processing and water quality probe systems are added as an upgrade to the systems.

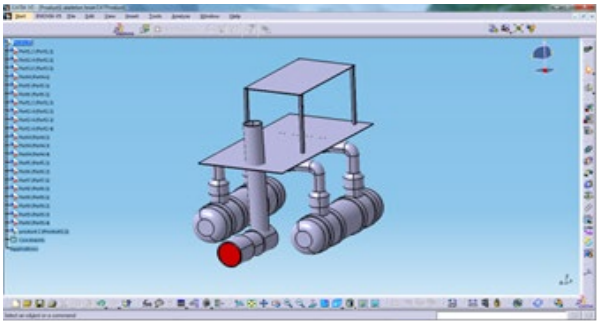

Figure 1. Autonomous Boat Design using Catia V5R17

2. Overview and Definition

Image is defined as a representation of an optical counterpart or an object's appearance, produced by reflection from a mirror, the passage of luminous rays through a small aperture, reception on a surface and the refraction of light through a lens. The spatial coordinate of an image is two dimensional and each position holds information on intensity (Kmar and Prabhak., 2011). Autonomous Underwater Vehicles (AUV) and Remotely Operated Vehicles (ROV) are one of the actively researched fields nowadays by many fields with many different purposes such as environmental pollutions, biological studies, historical discoveries, and surveillance purposes. The data such as underwater mines, shipwrecks, coral reefs, pipelines, and telecommunication cables from the underwater environment are the usual suspects collected for their investigations (Frank et al., 2010).

Light is rapidly reduced as it passes through water, resulting in underwater photos that are low in contrast and cloudy overall. Visibility is reduced to around 20 meters in clear water and to about 5 meters or less in muddy water due to light attenuation. Absorption and dispersion contribute to the gradual dimming of light, which in turn affects the effectiveness of underwater cameras. The image's details are often muddled due to forward scattering. Backscattering, on the other hand, often reduces the contrast of the pictures, creating a signature veil that superimposes itself over the image and conceals the scene. Components, such as dissolved organic matter, in water can contribute to absorption and scattering effects. Moreover, the visibility range can be increased with artificial illumination of light on the object, but it produces non-uniform of light on the surface of the object and producing a bright spot in the Centre of the image with poorly illuminated area surrounding it. When we go deeper, there is less light, and certain hues may fade

altogether if we're not careful. The blue color travels across the longest in the water due to its shortest wavelength. Underwater image suffers from limited range visibility, low contrast, non-uniform lighting, blurring, bright artifacts, color diminished and noise (Shabir and Ullah., 2022). Higher accuracy imaging equates to increased pixel resolution requiring much greater bandwidth and storage capability. High definition (HD) and ultra-high-definition video (UHD or super hi-vision) produce images having 1920 x 1080 and 7,680 x 4,320 pixels, respectively. Image compression formats such as HDV, MPEG-4 AVC/H.264 and VC-1 reduce data rate and memory demands by up to a factor of nearly 50. Although these reductions help make requirements more manageable, losing data is incomprehensible for users. A primary goal of extended range underwater imaging is to improve image contrast and resolution at greater distances than what is possible with a conventional camera and underwater lighting (Iqbal et al., 2007).

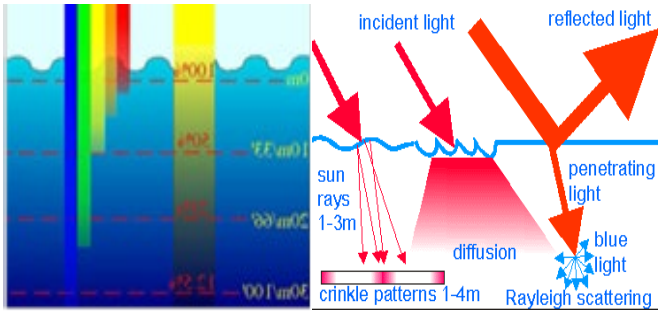

Figure 2. Refraction of Light Underwater and Underwater Wavelength (Sasso et al., 2011).

3. Image Processing Algorithm

Image processing can be divided into two parts which are image restoration and image enhancement. Image restoration is to recover back original image after properties of the image is degraded by certain effects. Whereas image enhancement is to enhance the quality of an image or to focus aspect on the image to produce images that are better from the previous one. For image processing, it does not reduce the amount of data present but rearranges it. Image processing needs to undergo steps of analysis to restore or enhance images. Some of analysis steps are discussed in this sub-topic.

3.1 Spatial Filtering

A spatial channel is a picture activity where each pixel is changed by a limit of the powers. A picture could be sifted to dispense with a band of spatial frequencies. High frequencies exist within the sight of quick splendor transitions while low frequencies exist within the sight of slowly evolving brilliance. High pass, low pass and edge detection channels are tasks in spatial separating. Each of this activity influence pictures that are broke down. In each image preparing, this progression will be completed to upgrade or to reestablish back pictures. In (Shabir et al., 2022), they utilized this strategy to calibrate and to adjust picture of embellishment items. The alignment methodology depends on design coordinating and utilizes a cross relationship calculation. This strategy is regularly utilized in applications where there is having to gauge the closeness between pictures or parts of pictures. Other technique that can be utilized is convolution spatial separating. In any case, the veil is first flipped both on a level plane and vertically before picture is compared.

3.2 Blurring

This circumstance is otherwise called smoothing. It happens because the special visualization of a low pass channel. The sharp brightness changes had been diminished to little brilliance transitions. Accordingly, it looks hazy. Reason for obscuring picture is to lessen the impacts of camera clamor and missing pixel values. For obscuring impact, two procedures are utilized which are neighborhood averaging (Gaussian channels) and edge preserving (middle filters) (Jeong et al., 2001).

3.3 Sharpening

Pictures can be upgraded by honing technique. By honing, fine detail of the picture can be featured. Blurry pictures because of commotion or different impacts are decreased in this procedure. Honing stresses edges in the picture and makes them simpler to see and perceive (Ebihara et al., 2009). No new subtleties are really made in taking a honed

picture. The nature of honing is impacted by the obscuring sweep utilized. Notwithstanding that, contrasts between each pixel and its neighbors as well, can impact the honing impact.

3.4 Edge Detection

Edges in picture are characterized as neighborhood changes of power in a picture. Edges happen on the limit between two different locales in a picture. Reason for edge recognition is to produce a line drawing from a picture that is examined. Some significant highlights that can be removed from the edges of a picture are corners, lines and bends (Bazelle et al., 2006). In this edge detection technique is utilized. In this paper, the edge recognition method utilized Vertical Sobel Operator to suit the application. The edge identification result is being utilized for dissecting and determining size of the item. Other administrator, for example, Robert administrator, Prewitt administrator, Canny administrator and Krish administrator are additionally frequently utilized as edge indicators (Hamid et al., 2009). Some of detriments in edge identification is it channels data that might be viewed as less pertinent. It just jams the important auxiliary properties of a picture. From this statement, still little piece of data in that picture is missing because of the sifting procedure.

4. Color Detection

In shading location, there are a couple of decisions that can be characterized, for example, RGB shading pixel and histogram extraction, wavelength identification and some more. These methods can be completed utilizing uncommon sensors and apparatuses that are intended for shading detection (Wuthishuwong et al., 2009).

4.1 Pixel Extraction

For pixel extraction of a picture, the shade of an object can be separated through breaking down the pixel esteem. For model, by separating the RGB esteem, the shade of a single pixel can be identified.

4.2 Color Histogram

Color histogram is a portrayal of color distribution in a picture. The quantity of pixels that each color has are spoken to in the color histogram. Each shading has a fixed rundown of reaches that length the color space of a picture. The shading histogram of a picture is built by the check of pixels of each shading. In picture preparing, shading histogram consists of three segments regarding to the RGB shading space. It is quick to control, store, think about, and insensitive to revolution and scale (Kerley et al., 2011).

4.3 Wavelength

Colors most dominatingly characterize through wavelength of light range that sparkles down on the surface of this world. The movement of the shading range wavelength is from the long wavelength as red to short wavelength as violet, or from low to high recurrence (Shakil and Ullah., 2023). A shading range wavelength is commonly communicated regarding nanometer unit (1 nm=10^-9m). Figure 5 shows the wavelength of noticeable light ranging from 380nm to 780nm.

4.4 HSV Color Space

To follow the object of enthusiasm utilizing shading-based methods, the shade of the object of intrigue and the background ought to have a huge shading contrast. The representation of shading data is performed by tint and immersion esteems in the HSV framework. The HSV (tint saturation-esteem) framework is a shading space that is progressively suitable for shading-based division contrasted with the RGB color space as it has the capacity of speaking to the shading of human observation and effortlessness of calculation. HSV color space comprises of three lattices; the shade, immersion and esteem in which tone speaks to the shading, immersion represents the shading profundity and worth speaks to the shading brightness (Liu et al., 2013). Given that human is considerably touchier to brilliance than immersion and hue, immersion, and worth parts of HSV shading space have been received to characterize shading saliency. Figure 3 shows the unique picture in RGB shading space on the left and the saliency map registered utilizing worth and immersion components on the correct picture. From Figure 3, saliency map registered utilizing worth and immersion brings about more saliency in the red-shaded region while foundation results in less remarkable worth. Consequently, worth and immersion components of HSV shading space are demonstrated to be reasonable to process saliency map. Additionally, these parts help to decrease the multifaceted nature of saliency calculation (Shabir et al., 2022).

5. Stereo Matching

Registering saliency map by static monocular picture are mostly costly as the connected procedures are significantly intricate. In this manner, binocular picture is picked to figure shading difference and surface complexity of every region. Left and right picture of stereo vision framework are utilized as the source picture to register saliency map. Subtraction process in the left and right pictures is evaluated to discover the difference of the binocular picture. This procedure is fundamental to wipe out foundation of the pictures and results in the less saliency map for low shading complexity parts and more saliency for high shading difference parts. In the wake of covering the left image and the correct picture of the stereo pair during picture subtraction, data as far as shading difference and disparity can be acquired. Figure .3 shows the left and right image with immersion and worth parts of HSV shading space separately. The first picture can be found in Figure 3 (Liu et al., 2013).

Figure 3. Left and Right Images of Stereo Vision System (Liu et al., 2013).

The subtraction picture in the Figure features the items or areas from Figure 6 with high shading complexity as foundation with low shading differentiation have been disposed of. This gives better results contrasted with the saliency map processed utilizing monocular picture in Figure 3.

Figure 4. The subtraction image between left and right images (Liu et al., 2013).

6. Color Detection Device

For color location device, there are numerous sensors or devices that can be utilized as vision sensor. Every one of them has their possess detail that can even straightforwardly identify and differentiate between hues. For instance, camera or webcam sensor, shading sensor and spectrometer are the commonly utilized.

6.1 Camera/Webcam Sensor

The general working thought of a camera is that it utilizes an electronic sensor to change pictures into advanced information. The most normal sensors utilized are Complementary Metal-Oxide Semiconductor (CMOS) and Charge-Coupled Device (CCD) (Axis Communications, 2010). The working rule of a CMOS picture sensor utilizes the Bayer design as arrangements of shading channels that are put over the photo sites (Datta et al., 2023). For the course of

action of photo sites, the line at the top and base are blue and green channel separately. While green and red channels are set on the contrary side of photo sites (Axis Communications, 2010). The CMOS imaging chip has somewhat preferable execution over the CCD (Madiha M., 2023). The picture delivered has a framework with moderate clamor. In addition, the utilization of the chip is induced in Logitech Webcam. Additionally, the farthest point shade of a light is predefined recurrence to go through the channel and be recorded as luminance information. What's more, the yellow and green frequencies are delicate to human eyes, thus the ratio of advanced picture are equivalent to how human see colors. The green channel has a high number of neighboring red and blue filter.

7. Methods for Image Processing Underwater

In this part, the general perspective on probably the latest methods that address the theme of submerged picture processing giving a presentation of the issue and enumerating the troubles found. The signs of the available techniques concentrating on the imaging conditions for which it is created (lighting conditions, profundity, environment where the methodology was tried, quality evaluation of the outcomes) and considering the model characteristics and suppositions of the methodology itself (Yoon et al., 2006). Furthermore, this area will audit Jaffe-McGlamery's model of the optical properties of the light proliferation in water and the picture arrangement. At that point, pursued with a report of the picture rebuilding strategies that take into account this picture model. Next, works that tended to image improvement and shading redress in submerged environment are exhibited in addition to brief portrayal of some of the latest techniques. In conclusion, this area will consider the lighting issues and spotlights on picture quality measurements and quality control of image.

8. Autonomous navigation boat

An autonomous boat is a self-exploring sea-going vehicle above water that is predefined with guidance codes. Several techniques could be utilized to explore a vehicle such as Behavior based route. It can oversee intricacy tasks and simple to program and investigate practices (Rossetti et al., 2011). Some of the route framework utilize the GPS module and Compass sensor to explore from one point to the next points dependent on the scope and longitude (Shabir and Ullah., 2022). A portion of the Unmanned ground vehicle (UGV) likewise due furnish with the self-sufficient navigation framework however the route framework that they use may fluctuate with one another. Route strategy must be divided into two section which is the initial segment incorporate the direction of the UGV and guiding edge to wanted way, and the other part is that the UGV experiences an objective as named way point (WP). During the activity, the way point should be refreshed to the following objective. The UGV can be classified into around five sections. The UGV framework is composed of vehicle framework that is controlled vehicle, remote control framework that is directed and checked of vehicle from a far distance, deterrent framework that is detected obstruction, vision framework that is detected snag and picked up information of arrangement of the ground, and toward the end, navigation framework that is setting up the data of position (Shabir A., 2023). Every framework data is transmitted to mix framework, and every datum gain the need. So, reconciliation frameworks offer request to vehicle system about the development, shirking and stop. The utilization of unmanned ground vehicle can be applied to the structure of the self-sufficient boat likewise however the vessel is move by utilizing the engine (Shakil and Ullah., 2023). The movement from one point to the next can be determined based on triangular strategy since the compass sensor is always indicating the north in this way the vector edge to the following point can be determined and offer sign to the microcontroller to begin the push to adjust the vessel toward that next point. The vessel will advance toward the following point inside the heading and will keep up that position until it arrives at the position. At whatever point the pontoon face some of the obstruction on the outside of the stream the vessel will attempt to avoid that snag by turning just one push and the pontoon will marginally turn and return to the first bearing toward the point. The structure of the self-governing route framework must actualize the shut circle framework thusly there must be an input from the sensors that used to the primary controller (Shabir et al., 2022). The shut circle system will give the whole framework about the present position of the vessel and where the pontoon should make a beeline for. Microcontroller is generally utilized with the end goal of mix of the sensors and actuators. It likewise will decide in which way or conduct they will work to.

8.1 GPS and Compass Navigation System

This framework is fundamentally joined the two modules which are GPS recipient and compass to get the heading point and movement focus of the gadget. GPS (Global situating system) is a module that skilled to get the situation in term of scope and longitude arranges though the compass sensor is a module that competent to yield the heading point from the earth attractive north and the worth is gathered by figuring the crude information from the magnetometer. Essentially, magnetometer accompanies X, Y, and Z earth attractive dipole esteems. By actualizing the triangle computation and proper condition, the heading angle could be determined and yield an incentive somewhere in the

range of 0 and 360 degree. The GPS and Compass module are a shut circle transfer work. The information is in term of facilitate point which is scope and longitude, and this point will be predefined in the programming code and store it inside the internal memory of microcontroller. The yield of this nearby loop control framework will give the four engines to run and will turn the vessel either left or right and will run every one of the four of the engines when the pontoon is making a beeline for the desired point (Shakil and Ullah., 2023). The microcontroller utilized in this task is Arduino Mega 2560 and the program language utilized is essential C language. The sensors which are GPS and Compass will feed the present situation of the vessel to the microcontroller and then the microcontroller will ascertain the edge required to turn the leader of the pontoon with the goal that it will confront the desired point. Fundamentally the yield of the GPS module is a standard yield called as NMEA 0183 (National Marine Electronics Association) and as ASCII esteem. The yield type that is normally used to get the arrange point is in the structure RMC (Recommended Minimum Specific GNSS Data) for instance $GPRMC, 111636.932, A,2447.0949, N,12100.5223, E,000.0,000.0, 030407,,, A*61<CR><LF> and to interpret these yield the RMC yield table is required. The yield of the compass sensor is fundamentally as crude information magnetometer, and a portion of the compass sensor has been tilting redressed and the flood of the water would not affect the exactness of sensor. A magnetometer is a device used to determine the strength and, potentially, the direction of attracting fields.

9. Water PH Sensor

Underwater sensor networks can be deployed for industrial and scientific benefits such as pollution monitoring. Theoretically, PH measurements can vary greatly and are affected by several environmental factors including, climate, ecosystem, geographical surface, and human exploitation. In general, pH readings between (1-6) are considered acidic, (7) is neutral, and (8-14) are basic. The average PH are between (5.5 and 8.5), hence outside the range indicates the water is polluted and unhealthy for living organisms (Shakir et al., 2012). Traditionally, the usual methods in reading the PH values are using litmus paper or strips for cheaper and elementary level but for research and more accurate purposes, a PH probe or meter is used.

10. Discussion

This section discusses about the outcomes acquired from experiments with respect to in picture preparing. The trials are directed utilizing Microsoft Visual Studio 2010 and OpenCV as its libraries of preparing the picture. These experiments are examined extravagantly in definite in this chapter which are catching pictures from individual workstation webcam, shading recognition and finally shape discovery. Future work in FYP 2 is additionally remembered for this chapter.

10.1 Read and Displaying the Image from File

The initial step to picture preparing is figuring out how to comprehend the programming that will be utilized to control the images that will be taken. At that point, figuring out how to catch and load the picture to the accompanying programming should be done in order to additionally build up the pictures. The fundamental goal of the venture the undertaking is to catch submerged picture sample as video picture and the program will process the video as a picture by picture. Program that catches video image submerged from the camera arrangement will be incorporated and run utilizing the coding that will be predefined. As Open CV is utilized, a constructor to see picture from the webcam is presented. What's more, a progression of tests will be done on this program. Any advanced picture comprises of pixels that contains some worth. Each pixel has a fixed number of bits apportioned in it. At the point when the estimation of the pixel is expanded, the power of that pixel is additionally expanded. The base value for a pixel is 0 and it speaks to dark. At that point, the maximum number that a pixel can have been 255 (11111111 in binary). Fig.5 picture's is a picture taken through a personal webcam to identify and show shaded pictures through video constructor (Madiha M., 2023). This constructor opens the camera recorded by the contention of this constructor and initializes the Video Capture object for perusing the video stream from the predetermined camera. Here the '0' signifies the index of the camera to be utilized. Rather than 0, no 1,2,3 likewise can be utilized if your PC is joined to more than one camera. Color picture should comprise of at any rate 3 planes: Red, Green, and Blue. Any shading can be made utilizing a particular mix of these 3 hues. Any pixel is a combination of three 3 esteems. (255, 0, 0) speak to unadulterated red. (0, 255, 0) speak to unadulterated green. (255, 0, 255) speaks to pure violet.

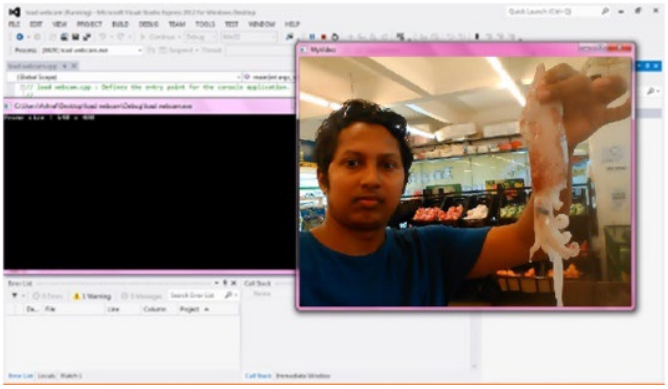

Figure 5. My Image Displayed

10.2 Color Detection

One of the most major strategies to distinguish and fragment an article from a picture is the shading-based methods. There ought to be a huge shading contrast colors in the item and the foundation to portion objects effectively utilizing shading-based strategies. This software (OpenCV) catches pictures and recordings in 8-piece, unsigned whole number, BGR group. A typical working capacity is used to change over the shading space of the first picture of the video from BGR to HSV picture. HSV shading space comprises of 3 lattices, 'tone', 'immersion' and 'worth'. Implying that, a captured pictures can be considered as 3 frameworks, BLUE, RED and GREEN with whole number qualities ranges from 0 to 255. Almost solely, BGR shading space is progressively reasonable for color based division yet HSV shading space is the most suitable shading space for shading based picture segmentation. In OpenCV, esteem scope of 'shade', 'immersion' and 'worth' are individually 0-179, 0-255 and 0-255. 'Tint' speaks to the shading, 'immersion' speaks to the sum to which that respective shading is blended in with white and 'worth' speaks to the sum to which that separate shading is blended in with black.

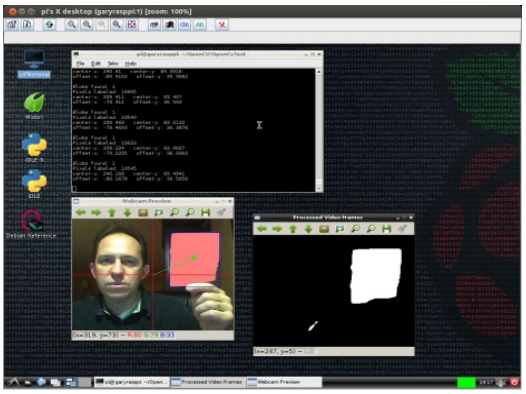

Figure 6. Red Color Detection

10.3 Shape Detection

In this part, the goal is to follow the state of the ideal object. The shape and position of article is identified utilizing color forms with Open CV. Utilizing shading forms, a sequence of purposes of vertices of each white fix that are considered as polygons. For a shape like triangle and quadrilaterals, each will have three and four edges respectively. Along these lines, any polygon can be recognized by the number of vertices. Polygons, for example, convexity, concavity and furthermore symmetrical can be perceived by calculating and looking at separations between vertices. The image is changed over from the first picture into dim scale. It is on the grounds that this strategy works just with dim scale picture with single channel. To show signs of improvement results, the dim scale image is edge utilizing 'cv Threshold' work. At that point, almost all forms (triangles, quadrilaterals, and heptagons) in the thresholder picture can be distinguished and followed utilizing this technique.

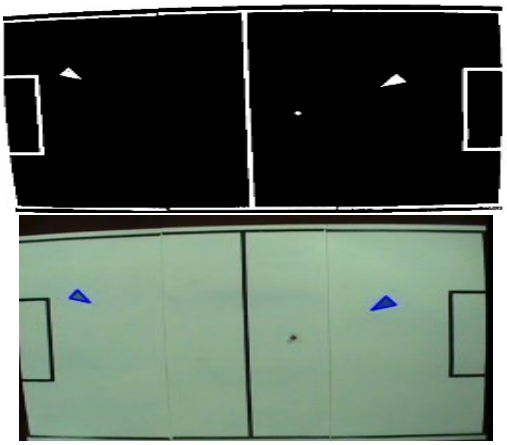

Figure 7. Triangle Shape Detection

11. Conclusion

This section will talk about on the accomplishments of this research, confinements, and difficulties of this undertaking and furthermore recommendations for future advancements of this experiment. The impediments and arrangements of the issues ought to be identified as it will redress and ad lib the current design and produce a superior and proficient result.

11.2 Achievements and Limitations

All in all, the self-ruling vessel will have many capacities and components that will fulfill the client for different purposes. This undertaking comprises of numerous subsystems, for example, submerged imaging, route framework, depth estimation framework, PH estimating framework and furthermore wireless information transmission and capacity framework. Even though this inquiries about spotlights more on the picture handling and PH measurement framework. By the by, other created subsystems functioned admirably connected at the hip with the current system. This exploration has exhibited various methods for constructing a self-governing vessel with an imaging framework implemented in it. Besides, this examination has talked about about different kinds of tactile and tests that can be integrated in the self-governing vessel to build up a multi-functional instrument. Calculations and computations for image improvement submerged are displayed and some preliminary results are appeared. The mechanical piece of this autonomous pontoon is structured utilizing the Catia V5 Edition. Meanwhile, the picture handling tests tried are using the Visual Studio programming with OpenCV library. The process of recognizing picture has been performed via conveying experiment with the webcam in the PC utilizing different types of pictures preparing procedures. From this analysis, the RGB and HSV run has been resolved for a couple colors of the object of intrigue. Among systems utilized are Edge Detection Method and Template Matching and the most reasonable strategies utilized submerged are shading enhancement utilizing edge identification technique because of the complexity and furthermore precision on picture upgrade. There are a couple of constraints in this exploration. The first is the trying on the electronic contraptions was done in a little scale utilizing a webcam above water.

Consequently, the outcomes won't be comparative underwater. This is because of research time expected to understand the calculations and furthermore finding the correct instruments to lead it submerged. Understanding the template coding and calculations from different sources and research was a test since it is excessively convoluted. Additionally, the outstanding burden that different subjects bring likewise make time spent on this venture is of the quintessence. By and by, the calculations and procedures are properly characterized hence in FYP 2 results and information from submerged imaging can be acquired. To finish up, this examination has hypothetically met a portion of its objectives. Moreover, this paper has effectively managed to answer the best technique to get the best picture and calculations submerged just as to coordinate new sensors with current framework. Additionally, improving the current design of the vessel that fits well with the new framework that will be implemented.

11.3 Recommendations

For future recommendation, the system also can be upgraded by using 4 obstacle avoidance sensors so that the boat can avoid the obstacle in front more accurately. Furthermore, the camera used for image processing can be replaced using a better-quality camera than the webcam from laptop with higher capture pixels and sharpness. Moreover, the

casing of camera should be watertight to prevent from water damaging the camera and circuit. Lastly, the motor propeller should be replaced with faster and better motor to facilitate movement of the boat faster.

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