ijecs open access www.ijecs.in
International Journal Of Engineering And Computer Science ISSN: 2319-7242
Volume 6 Issue 1 Jan. 2017, Page No. 20131-20133
Index Copernicus Value (2015): 58.10, DOI: 10.18535/ijecs/v6i1.50

Survey on Monitoring Aquatic Debris Using Smartphone-Based Robots

Sreelekshmi .B, Vidya .N
M.Tech, CSE
Sree Buddha College of Engineering Elavumthitta, Kerala 689625
Assistant Professor of CSE
Sree Buddha College of Engineering Elavumthitta, Kerala 689625

Abstract
Marine debris is an important environmental issue. It provides threats to our ecosystems, water transport and life of living things in both land and water. So monitoring aquatic debris is very important to the entire world. Numerous techniques are implemented for monitoring aquatic debris. The ultimate goal of this paper is to discuss existing methods for observing debris in aquatic environment.

Index Terms-Marine debris, Smartphone, Computer vision, Robotic system, Object detection.

I. Introduction

Marine debris is human created waste that has been left in water environments. At present marine debris is a great problem faced by people and the issue is becoming critical day to day life. Debris mainly comes from both land and water sources. Plastic plays a crucial role in pollution. The use of plastic poses a serious threat to our ecosystem. Inland waters also face severe threats due to the debris. So it is essential to recognize and prevent debris in water environments in order to save our ecosystem.

There are numerous methods used to detect aquatic debris.However an efficient method for monitoring marine debris is SOAR (SmartphOne-Based Aquatic Robot) [1]. It is a robotic system having low cost. The aim is to monitor debris in water environment. It contains a smartphone and a robotic fish platform. Robotic fish have a capability to moving through water and smartphone is used to capture images. And numerous image processing concepts are used to identify debris objects with minimum energy consumption.

II. Related Works

Various methods are used for detecting debris in water environment. Each method having some advantages and disadvantages. However compared to existing systems monitoring aquatic debris using smartphone based robot is an efficient method. Also it consumes less energy than other methods.

A method used to observing marine debris is using patrol boats [2]. Aquatic debris provides a threat to the recovery of endangered Hawaiian monk seal. So that the presence of marine debris is a serious problem to this species. The protection of Hawaiian monk seal is very important. This can be addressed by using patrol boat. Its function is to avoid derelict fishing gear in the high entanglement risk area. In this methods divers were used a small boat for identify derelict fishing gear. When divers detected derelict fishing gear, GPS is used to identify its location. Divers carefully remove the debris to minimize coral damage. However this approach is expensive for long term monitoring, especially debris objects arrive randomly. Also it can cover a limited period of time.

Another method for observing debris on a beach or ocean is a low-altitude remote sensing system with webcam. Webcam is an efficient way of observing marine litter. However this method concentrates only on white colored debris. It cannot focus on debris with various colors. To overcome this limitation by using another technique is low-altitude remote sensing system using a remote-controlled digital camera placed from a balloon filled with helium gas [3]. This method is efficient than remote sensing system with webcam. This method detect debris on various colors and the color difference between target objects and the background is used to detect object pixels in the image. Its advantages are high resolution and minimum cost. It also capable of randomly choose the loca- tions of balloon photography along with various atmospheric conditions. However it is incapable of continuous monitoring of objects over a long-term period.

With emerging technology, use another method for debris detection is satellite [4]. The debris items are tiny and partially submerged. However, they may accumulate in water boundaries. Methods such as satellite, multispectral data, and remote sensing are used to recognize debris object. Remote sensing resolution can be used for direct detection as well as for indirect detection. Remote sensing resolution may be in three terms such as spatial, spectral, or temporal dimensions. Spectral resolution affects processing, storage and detection ability. Temporal resolution is limited by orbit characteristics, flight duration, and weather conditions. Geostationary satellite provide frequent monitoring but having low resolution. How- ever, satellite imaging is expensive for long-term monitoring, especially objects arrive sporadically.

Another technique for detecting debris is Gliders [5]. Gliders are used to detect debris object in water environment. A glider is a float having wings to provide lift and capable of moving horizontally. Gliders are the result of autonomous float technology. Each has many features such as low operational and capital costs, and low noise and provide high reliability due to simplicity of design, and minimum power consumption. Underwater gliders are Seaglider, Slocum and Spray.

Seagliders are small, reusable autonomous underwater vehicles designed to glide from the ocean surface to a programmed depth and back and also measuring temperature, salinity, water current, and other features. Spray was designed for efficient deep water performance and it is easy to manufacture and maintenance. A model based feedback control is used to improve the currently implemented glider control strategies. One of such strategy is Slocum. It was optimized to operate in shallow coastal waters. The limitations of these remote sens- ing and AUV-based approaches make them cost prohibitive for monitoring spatio-temporally scattered debris fields with small-sized objects.

A system with camera is used to detect debris in water environment depends on number of components are cameras Field of View (FoV), resolution and the size of the object. Higher spatial resolution acquire more details and produces sharper images. The task specific service is avoided in many multi-camera vision system. This method is used to address the position of the camera with minimum cost. Here the problem is to efficiently compute a camera layout [6] such that certain task-specific constraints are found. This problem can be solved via a binary optimization over a discrete problem space. It provides a solution for camera position problem with minimum cost. And it is not limited to layout of video camera networks. In this method a lower density sampling is used to obtain a solution.

In wireless sensor networks [7] coverage is a basic problem. This problem affects how well the surroundings is monitored, and act as a basis for applications like physical phenomenon or target detection, classification and tracking. The sensing ability of sensors is represented as a circular region (or disk) and the detection of an event or target is depending on whether it is inside such a sensing disk or not. One of the sensing problem is MCMS problem in which coverage is based on the maximum number of targets to be covered whereas the minimum number of sensors to be activated. It depends on exact ILP formulation and a CGA solution. Then also use a DGA solution. The sensors are powered by batteries and it is not possible to recharge or replace the batteries after deployment.

Today sensors are the integral part of the mobile phones. Mobile phones come with a rich set of built-in sensors. Many successful applications have been built around these sensors. Mobile phones are the ultimate part of human life. Due to the various activities it significantly reduces a battery life of the phone because these activities consumes more energy. However the ultimate goal of LittleRock project [8] is that it evaluates the sources of this energy overhead and an energy-efficient continuous sensing can be achieved through this system. This can be obtained by a dedicated low-power sensing processor for processing and low-level processing of sensor data. The main advantage of this dedicated sensing processor is that which is capable of deciding when the main processor wake up and reduce the energy consumption over- head of the phone. However some challenges related to this system is that to determine how much processing capability the sensor should have, to sharing the sensor processor to multiple applications and overloading the sensor processor and finally the sensor API.

Background subtraction is the first step of many computer vision applications. Background subtraction method to be used in embedded camera networks [9], it must be precise and computationally feasible. This allows traditional background subtraction algorithms not suitable for embedded platforms because of the illumination changes. The aim of background subtraction is to detect whether the foreground is present in a newly captured frame. This is usually done by using the background model, and then applying tests to decide whether the newly acquired frame is different from the background. A challenge for background subtraction is to differentiate between the foreground and background, caused by events like illumination changes. Most important challenge is background subtraction is to be used in embedded camera networks. The background subtraction algorithm must be computational efficient due to resource constraints of embedded platforms. More precise and efficient background subtraction method is MoG. Mixture of Gaussians (MoG) model is commonly used because of its ability to handle with illumination changes. This background subtraction algorithm can accurately tracing object movement in real-time in an embedded camera network.

Another method for detecting debris is Samba [10]. It is an aquatic robot that contains a smartphone and a robotic fish platform to monitor harmful marine debris. Using camera of the smartphone, Samba can recognize aquatic debris in dynamic and complex environments. It divides the captured images and performs target detection process in the identified water area only. Samba uses real-time inertial sensor to estimate the visual features that guide the image segmentation. It also reducing energy consumption and computation overhead. Samba uses a set of lightweight and robust computer vision algorithms, which detect aquatic debris based on their unique color features. Also Samba provides a feedback-based rotation control algorithm. But the disadvantage of this approach is that energy consumption is maximum due to continuous segmentation. To overcome this problem power-efficient inertial sensors are used.

Another method is an embedded sensing platform [11] designed for aquatic environment monitoring. Lightweight debris detection algorithm effectively deals with environmental disturbances. Embedded sensing platforms makes this method as more precise, and consuming minimum resources than the existing approaches. The advantage is that it needs only few linear measurements for constructing image. Software can be used to upload captured images and the transmission has a low communication overhead and latency. In this method develop a different sensor platform to be used for aquatic monitoring. According to the application, the sensor node consists of five types of sensors. All of them connect by sensor interfaces with the embedded sensing board. Long-term aquatic monitoring consumes more energy.

Compared to existing methods SOAR (SmartphOne-based Aquatic Robot) [1] is an efficient method for observing debris in marine. It is a robotic fish platform with smartphone. It is a robot system having low cost and aim is to observe debris in waters. At present smartphones have various capabilities so that they have to execute powerful computer vision algorithms.

And various sensors like GPS and accelerometer can be used to provide movement and control of robot. Also they have wide range communication. The robotic fish having capability of moving in water by beating its tail once. SOAR contains two components are real-time debris detection and coverage-based rotation scheduling.

Real-time debris detection procedure is used to extract debris objects from the captured images. It consists of three image processing modules. They are image registration, background subtraction, and debris identification. Due to the waves image registration is very important to reduce the effect of camera shaking. Image registration will registers each frame based on their unique features in water, e.g., the horizon line and shoreline. Then background subtraction is used to extract foreground object from images. Finally, the foreground is passed to debris identification for noise removal and debris recognition. SOAR dynamically uploading image processing task to cloud for reducing energy consumption.

In coverage-based rotation scheduling SOAR contains multiple round for monitoring debris. This process has multiple monitoring round. After one monitoring round SOAR analyses the coverage performance based on the calculated debris movement orientation and the surveillance history. For the next round it sets the camera orientation and observing time interval. SOAR must effectively adjust its camera orientation for maintaining better coverage performance. Then propose a scheduling algorithm that reduces the rotation energy in each round by dynamically setting up the rotation schedule. The challenges faced by this technique are, it cannot acquire a stable camera view. Small batteries but it consumes more energy. The smartphone camera has limited field of view. This can be overcome by using image registration and runtime uploading process to cloud.

III. Conclusion

Aquatic debris provides a critical impact to our ecosystem, marine species and water transport. It is also an important social issue. So observing aquatic debris is to protect both human and marine life. Numerous techniques are implemented for observing marine waste. The purpose of this paper is to discuss existing systems for observing aquatic waste. At present SOAR is efficient for observing aquatic debris. Also it consumes less energy.

In future work, single SOAR provide limited coverage. So for obtaining better coverage to develop multi SOAR schemes. Also will develop SOAR for various water resources to monitor debris. Finally, will develop SOAR to work with various conditions like flow speed of water and brightness or lightening.

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