Fish Tracking Using Acoustical and Optical Data Fusion in Underwater Environment

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ABSTRACT

Fish tracking is an important topic in computer vision. The growth of high-powered computers, the evolution of high-quality video cameras with low cost and the growing need for automated video analysis have caused more interest in the development of object tracking algorithms. In the sea things are completely different, the spread of light and sound are not uniform. Therefore, visibility becomes increasingly di cult due to the physical properties of the water. Two devices can observe underwater: camera and sonar. Each of these sensors has certain advantages and limitations. Merging features from both sensors can offer new information that cannot be provided before. In this paper, we monitor fish species to ensure their traceability by combining optical and acoustical characteristics. This process can be extended to many areas, as well as, fish recognition and monitoring. Experimental results on a suite of representative video sequences of realistic underwater scenarios demonstrate the performance of the proposed sensors fusion in terms of ac-curacy and robustness.

CCS Concepts

• Computing methodologies → Computer vision • Computing methodologies →Vision for robotics • Computing methodologies → Scene understanding • Computing methodologies → Tracking

Keywords

Fish tracking; underwater image processig; Muti-sensors fusion**;** Acoustica-optical captures fusion;

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1. INTRODUCTION

Image processing refers to a discipline that studies digital images and their transformation in order to improve their quality, reduce their storage cost, or extract semantic and relevant information from them. Computer vision and image processing have therefore been studied in this context in re-cent years in order to develop new tools for oceanography [1]. The study of biodiversity and the identification of marine populations are an important issue for the safeguarding and sustainability of underwater resources. Many technologies have been developed to monitor the evolution of the marine environment, such as autonomous underwater vehicles [2], object targeting systems [4], or aquatic life forms [3]. Spatial remote sensing methods have been implemented to acquire data for the study of marine populations [5]. Oceans cover almost 75% of the surface of the earth. They contain several animal, fish, mineral and raw material resources. The exploration of its resources is a key topic throughout the world.

Only two approaches, optical or acoustical, allow the underwater vision. These sensors have been widely used in the applications of the autonomous underwater robots, in a context of expansion of markets linked to several areas, such as security and exploitation of maritime resources [6]. The value in optical and acoustical captures comes from their high details that can offer. On the first hand, the optical devices may include visual information (such as color, and appearance) of objects close to the camera. On the other hand, acoustical captures can reach distant objects; it can also retrieve information about the target objects (such as their locations). Its information is a privileged source of in-formation, and is an essential tool for the analysis of the marine environment as well as for the navigation and tracking of underwater vehicles [7]. The images in Figure 1 and 2 are captured simultaneously by both sensors in the open sea. However, the images acquired in the oceans are often severely degraded due to water properties. This article aims to promote the use of video sensors in the underwater do-main, in order to prepare a future imaging system with a particular attention given to fish tracking. The proposed systems are now able to fuse acoustical and optical features for fish localization and tracking, in order to provide biologists a new tool for the full exploration of underwater re-sources.

The rest of this paper is organized as follows. In section 2, we present recent relevant methods from the literature. A comparison between underwater sensors will be showed in Section 3. Section 4 illustrates the proposed fish tracking approach. Experimental results will be presented in Section 5. Finally, we conclude our approach in Section6.

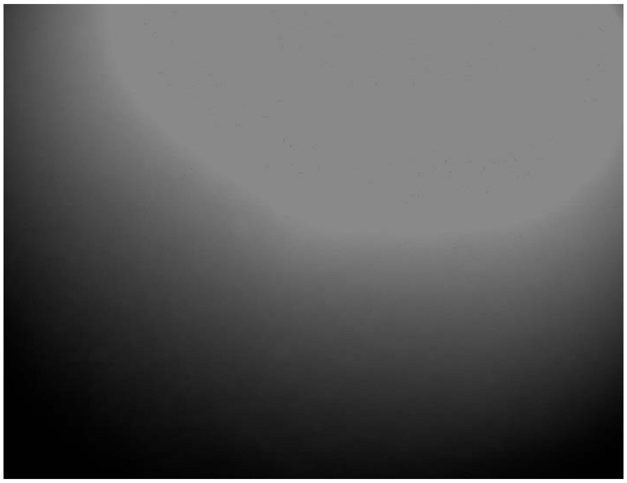

Figure 1: Scene captured by Camera.

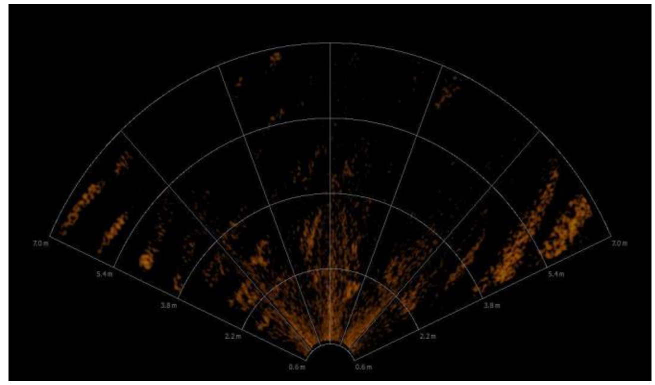

Figure 2: Scene captured by Sonar

2. STATES OF THE ARTS

In the literature, there are multitudes of algorithms and applications for merging data from multiple sensors [8]. Numerous examples can be found in the literature, applied to robotics and other fields. In practice, there are different types of fusion involving imaging sensors: laser with optics [9], acoustics with optics [10], and radar with optics [11]. In the submarine domain, early attempts to combine a lateral sonar with an optical triangulation system were established by Chantler et.al[13]. However, they did not present data fusion results from each sensor. The correspondence be-tween vision and sonar is di cult due to different models and resolutions of imagery for each sensor that represent the same function differently. Generally, there is no correspondence between optical characteristics (apparance) and acoustics (echoes). Babaeea in [14] solves the matching problem by using structural features such as contours and edges that are available in both sensor modalities. Others use ICP (Iterative Closest Point) algorithms to combine 3D point clouds or 3D characteristic mappings [12]. It is necessary to work more to choose the best type of characteristics, and to match the visual characteristics. However, fusion should not be limited to mixing the two devices, but it should also merge the characteristics of the information extracted from each sensor.

However, images acquired underwater suffer from much degradation due to the aquatic environment. Light penetrating into the water is attenuated by absorption and diffusion through the medium. In general, the longer wavelengths are the most absorbed. Therefore, the light corresponding to the red wavelengths disappears in the first place. This property explains the bluish or greenish aspect of underwater images.

The presence of large particles in natural waters and in particular seawater affects the overall behavior of absorption and diffusion, especially bodies containing chlorophyll such as phytoplankton and other dissolved organic matter. The dull aspect of the images acquired in highly turbid waters is essentially due to the phenomenon of diffusion of the incident light by these particles, thus veiling the scene observed in a similar way to the fog in the atmosphere. Under such conditions, images suffer from low contrast and low light, impaired color balance, and reduced visibility. Image preprocessing is recommended in order to improve the quality of raw images. Boudhane el.al[16] propose a new method for underwater image enhancement into real images. This method will be applied to preprocess raw optical captures.

3. ACOUSTICAL-OPTICAL FEATURES FUSION

Both acoustical and optical solutions may possess features that have been unnecessary with singular treatment. There-fore, this work extends the idea of the combination of semi-characteristics by the use of the two pieces of information. This combination opens the door to the discovery of new features, which can outperform current underwater fish identification systems. In order to merge these features, a statistical approach based on the Bayesian artificial neural network is proposed to calculate the values of interest for each data from the sensors and the distinguished classes (Figure 3).

Thus, the proposed new model presents an autonomous fusion system which allows the images from the various sensors to be processed. Based on Camera and Sonar, several features have been extracted. They are obviously decom-posed into two classes: simple (SF), and combined (FC). The simple characteristics are formed by one or more semi-characteristics coming from the same sensor. On the other hand, the FC s are characteristics formed by the two sensors. The extracted features can be presented on one or more levels. They can also build input from other FC. Artificial Neural Networks (ANNs) will be responsible for feature combination in order to build new features, and to calculate the probabilities delivered by each one. Figure 3 describes the feature fusion process.

4. DATA COLLECTION

The data used in this work is collected by the UFO (Underwater fish observatory) project. They use a special apparatus (see Figure 4) about 2 x 2 meters wide and stands on

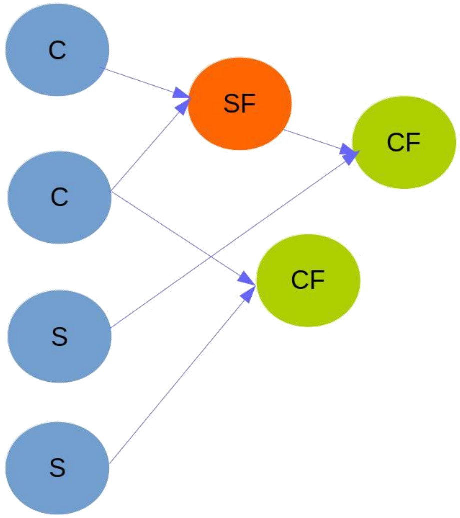

Figure 3: Features description. S: Sonar feature, C: Camera feature, SF: Simple feature, CF: Combined feature.

the seabed. The device has special feet to its three legs which allow in the ground and preventing it from owing. Thanks to its considerable weight of approximately 600 kg, it can hold in the current of its position and to monitor its sound and visual environment. The data collected by this device are divided into two categories: sonar data, optical data that are captured simultaneously. Researchers can detect all (larger) creatures that swim past at a distance of up to 200 meters. Usually, fishing sonars work with frequencies between 80 and 200 kilohertz, the sonar of UFO works with 900 kilohertz. This allows a very high resolution, so that we can already distinguish from the fish echogram of the porpoises or the seals. The camera has a stereo camera for recording video data.

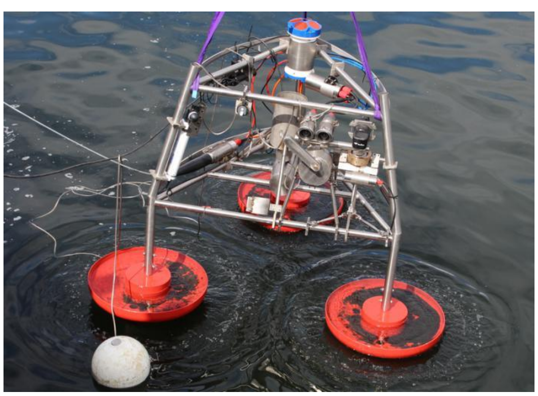

Figure 4: The underwater observer UFO.

5. EXPERIMENTAL RESULTS

5.1 Fish localization:

By looking at Sonar and Camera captures, each has specific symbols for the representation of the information. The first one is based on echoes and the other one is based on the appearance of the detected objects. The sonar echoes can give us the location of the objects in a wide range. However the sonar is not able to detect objects close to it (in the first meters). The camera can detect objects close to the camera (minus 20 meters under the right conditions and minus 7 meters in the turbid water). A combination is necessary for full localization. To do this, we studied the overlapping areas of the two catches, in order to measure a scale between the two catches. This scale has a relationship with time and length, because in time the sonar uses 20 frames per second, secondly the camera uses 12 frames per second. As well as length scales are not similar to one another. In fact, sonars give the location only on the two axes X and Y (which rep-resent respectively the door and the width). If one manages the position of the camera on the sea, one can have two information about the Y and Z axes (respectively the width and the depth). By this combination of features, we can get a three-dimensional localization of the detected objects. Figure 5 represents the schema for prevised results.

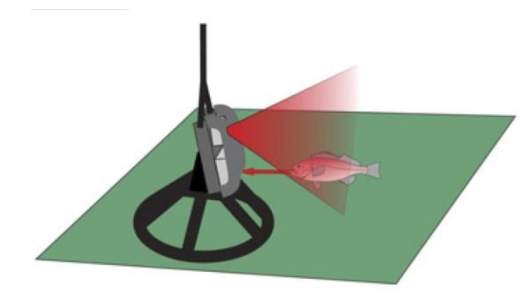

Figure 5: 3D localization.

5.2 Fish tracking

The system is tested on a standard PC (Intel Core i5), in which we test all the work. The optical images both size 1024x680. In the first place, a scale between the acoustic and optical catches was made in order to guarantee the treatment of the catches coming from the two equipment's at the same time. Therefore, fish trajectory measurement will allow us to observe underwater in order to monitor this environment. The tracking is made by KALMAN filter [15] into both captures. Figure 6 contains the trajectory tracking results from the proposed system. Figure 7 describes the proposed three dimensional representations of fish trajectories formed by the combination of features provided by both sensors. With this fusion of characteristics, we can follow the species in tens of meters, calculate their speeds, and recognize their behavior in the open sea.

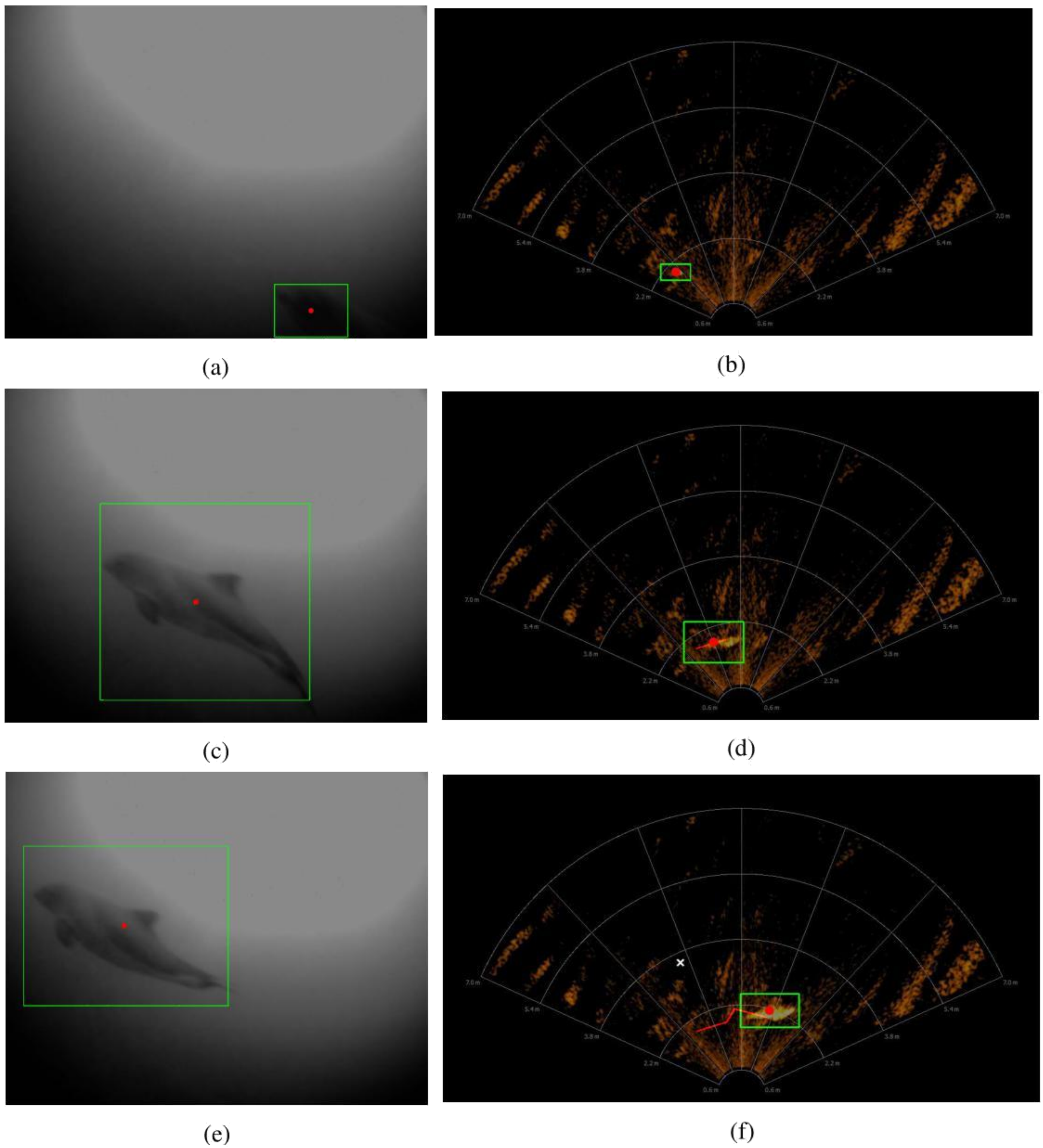

Figure 6: Trajectory tracking of a fish species at the same time by camera (in left) and its corresponding captures by sonar (in right).

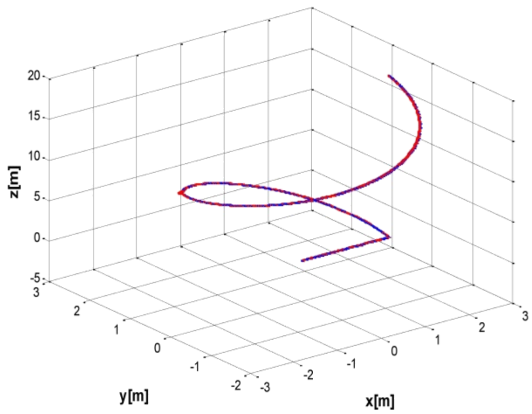

Figure 7: 3D trajectory by merging both captures.

6. Conclusion

In this paper, we present a novel method for fish tracking using data from multiple sensors. We combined acoustical and optical features in order to build a new system for under-water fish observation. We extracted new features formed by this combination, and we have integrated them in the proposed system, where we isolate the model of interest for each capture based on the two sensors. Experimental results gave us a good precision comparing with the existing fish tracking technologies. In the future, we plan to apply these concepts for underwater object recognition, by working on large dataset.

7. REFERENCES

[1] David Kriegman, Benjamin L. Richards, Hanumant Singh, *Computer Vision in Oceanography*, Vol: 15-16, pp:1-160 (April-July 2016), ELSEVIER: Methods in Oceanography, 2016.

[2] Mohcine Boudhane, Deike Fietz, Dennis Hagedorn, Mattes Jahne, Andreas Kaschube, Sebastian Noack, Lars M.Wol , Ansgar Zimnak, and Sabah Badri-Hoher, *AUV Team TomKyle at euRathlon 2015, Scenario I: Navigation and Environmental* Survey, Eurathelon15 Journal, 2015.

[3] Ryan Kastner, Albert Lin, Curt Schurgers, Jules Ja e, Peter Franks, Brent S. Stewart, *Sensor platforms for multimodal underwater monitoring, International Green Computing* Conference (IGCC) 2012, pp:1-7, DOI:10.1109/IGCC.2012.6322263.

[4] Neetika Bansal, Karan Shetti, Timo Bretschneider, Konstantinos Siantidis, *Hardware e cient underwater mine detection and classi cation*, International Symposium on Ocean Electronics, Year:2011, pp:137-144, DOI:10.1109/SYMPOL.2011.6170510.

[5] DR Goethel, TJ Quinn, SX Cadrin, *Incorporating spatial structure in stock assessment: movement modeling in marine sh population dynamics*, Reviews in Fisheries Science, 2011 - Taylor and Francis, Year: 2011.

[6] SS Bernfeld, *Developing the Bernfeld of the Sea-Security of Investment*, The International Lawyer, 1967 - JSTOR.

[7] Huan Duan; Jia Guo; Yan Song; Qixin Sha; Jingtao Jiang; Tianhong Yan; Xiaokai Mu; Bo He, *The application of AUV navigation based on cubature Kalman f lter*, IEEE Underwater Technology (UT), Year: 2017, pp:1-4, DOI: 10.1109/UT.2017.7890310.

[8] T. Nicosevici; R. Garcia; M. Carreras; M. Villanueva, *A review of sensor fusion techniques fior underwater vehicle navigation*,OCEANS'04, MTTS/IEEE TECHNO-OCEAN'04, Year: 2004, Vol:3, pp:1600-1605, DOI: 10.1109/OCEANS.2004.1406361.

[9] J. Morrison; D. Cowling; S. Takel, *Development of a non-acoustic sensor platform (NASP)*, OCEANS '98 Conference Proceedings, Year: 1998, Vol:3, pp:1224-1229, DOI: 10.1109/OCEANS.1998.726263.

[10] Fausto Ferreira, Diogo Machado, Gabriele Ferri, Samantha Dugelay, John Potter, *Underwater optical and acoustic imaging: A time for fusion? a brief overview of the state-of-the-art*, OCEANS 2016 MTS/IEEE Monterey, Year:2016, pp:1-6, DOI:10.1109/OCEANS.2016.7761354.

[11] Joshi, N.; Baumann, M.; Ehammer, A.; Fensholt, R.; Grogan, K.; Hostert, P.; Jepsen, M.R.; Kuemmerle, T.; Meyfroidt, P.; Mitchard, E.T.A.; Reiche, J.; Ryan, C.M.; Waske, B. A *Review of the Application of Optical and Radar Remote Sensing Data Fusion to Land Use Mapping and Monitoring*. Remote Sensor. 2016, 8, 70.

[12] Lagudi A., Bianco G., Muzzupappa M., Bruno F., *An Alignment Method for the Integration of Underwater 3D Data Captured by a Stereovision System and an Acoustic Camera*, Sensors (Basel). 2016 Apr 14;16(4). pii: E536. doi: 10.3390/s16040536.

[13] M. J. Chantler; D. B. Lindsay; C. S. Reid; V. J. C. Wright, *Optical and acoustic range sensing for underwater robotics*, OCEANS '94. 'Oceans Engineering for Today's Technology and Tomorrow's Preservation.' Proceedings, Year: 1994, Vol:1, pp:-210, DOI:10.1109/OCEANS.1994.363924

[14] M. Babaeea, 1, S. Negahdaripourb, *3-D object modeling from 2-D occluding contour correspondences by opti-acoustic stereo imaging*, Elsevier Journal: Computer Vision and Image Understanding, Vol:132, March 2015, pp: 56-74.

[15] R.E. Kalman, *A New Approach to Linear Filtering and Prediction Problems*, Journal of Basic Engineering, Transaction of the ASME, (1960), pp35-45.

[16] M. Boudhane, b. Nsiri, *Underwater Image Processing Method for Fish Localization and Detection in Submarine Environment*, Elsevier Journal: Journal of Visual Communication and Image Representation (JVCIR) vol:39, June 2016, DOI:10.1016/j.jvcir.2016.05.017.