Current State of the Art: *(Please describe the current state of the art specific to this research topic.* ***Maximum 500 words.****)*

This research topic is named as Multisensory fusion for Underwater exploration and acoustic localization using PCBC-DIM Neural Networks. It consists on Autonomous Underwater vehicle with different sensors. Focus of world is now exploration of the marine resources and strengthens the boundaries of its countries. At the same time this topic deals with Commercial Exploration, Scientific Research, Defense and Miscellaneous. Underwater Localization and exploration is an active and challenging research topic. People all-over the world are practicing new techniques to make localization and sea exploration optimum with minimal effect of unstructured noise of Sea.

Special autonomous underwater vehicles, also called as underwater drones are used for a variety of applications such as subsea inspection, pipeline installation, maintenance, and others.

From <http://bigtimesnews.com/2019/03/13/unmanned-underwater-vehicles-market-trend-2019/>

There are examples of some following recent work related to our topic

1. Researchers at IMDEA Networks (Spain) in collaboration with University of Haifa (Israel) developed new technique using a single hydrophone. This system works on variation of submarine topography. On behalf of changes the source is localized.

A publication is available on it

Dubrovinskaya, Elizaveta, Roee Diamant, and Paolo Casari. "Anchorless underwater acoustic localization." *2017 14th Workshop on Positioning, Navigation and Communications (WPNC)*. IEEE, 2017.

2. Researchers at Carnegie Mellon University's School of Computer Science in Pittsburgh are examining how to create systems that can perform autonomously underwater and provide a clearer view of the subsurface environment. Such capabilities offer important applications to the U.S. services, the Navy, Coast Guard and Marines Corps, as well as to the commercial shipping industry for ship and harbor inspections, among other activities.(December 1, 2018)

From <https://www.afcea.org/content/perceptive-underwater-robots>

3. U.S. Military researchers are asking the defense industry to develop a deep-diving unmanned underwater vehicle (UUV) and control system able to find and manipulate objects in deep-ocean environments.

From <https://www.militaryaerospace.com/articles/2019/01/unmanned-deep-sea-machine-autonomy.html>

4. Undersea company that found Air France 447 black boxes buys unmanned underwater vehicle (UUV) from Bluefin Robotics

From <https://www.militaryaerospace.com/articles/2012/05/phoenix-buys-bluefin-21-uuv.html>

5. For underwater localization researchers proposed a neural network framework named B-PR-F which heuristically performed adaptable fusion of information, based on the principle of contextual anticipation of the localization signal within an ordered processing neighborhood.

From <https://www.sciencedirect.com/science/article/pii/S0921889018302926>

Challenges: (Please describe the challenges, specific to this research topic, currently being faced

internationally. Maximum 500 words.)

<type here>

In Air the frequency signals works finely so GPS and other frequency based systems works without massive trouble. Localization just need a sound signal we can predict it's location. There are so many high resolution cameras available for exploration like recognition of objects and faces. In deep water frequency signals do not work same like air and same for cameras.

The development of Autonomous underwater vehicles started in 1970s and still researchers are working on size, computing performance and potential of it. Main challenge for underwater localization and exploration is the harsh environment of sea. The high attenuation of frequency and unstructured nature of water disturb the original estimates. For underwater acoustic localization the coming sound signal contains non linear noise. Removal of that noise to obtain original signal is really tough. To predict current state the knowledge of past states and current disturbance is required. Estimation of actual location after disturbance is done using different mathematical and AI techniques but still they are not hundred percent accurate and optimum . With the passage of time prediction deviates

from actual estimate because of noise and our coming signal becomes more and more crude so we can not obtain information from it without a very intelligent algorithm. People have been presenting different simulation based and hardware based method for years. Still it is an active and challenging research topic.

Cameras perform poorly underwater. For mapping and perception of object imaging sonars are used but most of the existing classification methods cannot be widely used underwater.

Sensors are also improving with the passage of time because accuracy, scalability and precision of sensors also matters. We can use the latest available sensors but without an intelligent algorithm exact localization is not possible because of dynamic environment of water. One sensor can not do alone anything. To describe exact and precise location multiple sensors are used. Now there is problem of fusion of data. Kalman filters are good with fusion but not below water. For underwater sensory fusion there is need of using best available techniques. Neural networks techniques are proving relatively good techniques but there is need to design neural network specially for this problem. Different researchers are working on it but still this topic is in transient state.

Motivation and Need: (Please describe the motivation and need for this work. Maximum 500 words.)

Our topic covers two important subtopics of scientific exploration and defense. This project is initialized by considering the importance of offshore area of Pakistan. 1000km of the distance from sir creek(Sindh) to Jiwani(Blochistan) touches the sea including many important

areas of two provinces of Pakistan. No one is unaware of the importance of china Pakistan Economic Corridor in Gawadar.

Pakistan offshore area has increased, to 350 NM after addition of 150 NM in march 2015, officially by United nations. Pakistan used to earn 1.2 Billion dollar by sea food and 240 million dollar by foreign Exchange. Now with extension of 150 NM area of deep blue sea more possibilities of earning have built up like fuel and many important elements at the same time defensive boundary requires smart and less expensive system for unusual activity detection.

World is trending towards the exploration of water but due to sea environment it is more difficult to built efficient autonomous vehicle underwater than above water. To estimate the exact location underwater is a challenging and important research topic. We use multiple sensors like Inertial sensors, velocity sensor, position sensors etc. There is need to fuse the data of all these sensors. Available techniques may better work above water but underwater environment fails them. Deep neural network techniques are proving very efficient for multisensory fusion and reduction of noise. Still there is need to present actual working system which can perform better than current techniques. This project is feasible and there is lot of data available which is extremely helpful to implement this idea to reality. This project will prove very beneficial for Pakistan financially and it will improve the security of sea boundary of

Pakistan. It will create opportunities and motivations for other researchers of Pakistan to work on this topic.

2.2 Outcomes and Benefits

Expected Outcomes: (Provide a list of proposed project outputs including publications, databases

etc.)

<type here>

There are so many benefits of this project some of them mentioned

6. Scientific Exploration
7. Underwater surveys
8. Localization of living and non living objects
9. Unmanned defensive robot of sea boundary
10. Discovery of new species
11. Sea food diversity
12. Detection of unusual activity(spy)
13. Implementation of Neural Network technique
14. Publication on Multisensory fusion using PCBC-DIM neural network technique
15. Practical Autonomous underwater vehicle

And many more because 71 percent of earth is covered with water.

Key Benefits and Beneficiaries: (Please identify clearly the benefits and potential

customers/beneficiaries of the project.)

<type here>

There are two types of customers for this

A) Commercial customers

16. Sea inspection companies
17. Sea survey companies
18. Sea food companies
19. Tourism companies(for inspection of danger)
20. Environmental companies
21. Oil inspection and localization companies

B) Military

22. Navy of Pakistan
23. Armies who have sea areas

Technology Transfer/Diffusion Approach: (Please describe how the outbputs of the project will be

transferred to the beneficiaries/customers. Maximum 500 words.)

<type here>

There are so many ways to advertise this project because it is not only the simulation. It is a hardware based project. The technique which we shall introduce can be patent. Companies who will use our technique will have to pay.

Investors are taking interest in Pakistan because of China-Pakistan Economic corridor. We can present our project in such conferences.

We have plan to publish at least one paper on this project. Wherever we shall present over paper there will be investors.

We have advantages of our university in different festivals and competition we can present our project.

It can be presented it in technical exhibitions in different universities.

It can be presented to different naval forces and so on