**MULTISENSORY FUSION FOR UNDERWATER ROBOT LOCALIZATIONA AND EXPLORATION**

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**UNIVERSITY OF GUJRAT**

**Session 2018-2020**

**UMAIR ALI M.Sc Electrical Engineering 2018-19**

**MULTISENSORY FUSION FOR UNDERWARTER ROBOT LOCALIZATION AND EXPLORATION**

**A Thesis Submitted in Partial Fulfillment of the Requirements for the Award of Degree of**

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**In**

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I would like to thank to Allah Almighty who blessed me with a very kind supervisor….

**(Muhammad Ramiz)**

**DEDICATION**

Dedicated to my parents who supported me to fulfil my dreams .

**(Muhammad Ramiz)**

**DECLARATION**

I Umair Ali S/O Muhammad Sajjad Haider, roll # 18016522-008, MS Electrical Engineering scholar, Department of Electrical Engineering, Faculty of Engineering & Technology, University of Gujrat, Pakistan, hereby solemnly declare that this thesis titled “Multisensory fusion for underwater robot localization and exploration” is based on genuine work, and has not yet been submitted or published elsewhere. I Furthermore, I shall not use this thesis for obtaining any other degree from this university or any other institution.

I also understand that if evidence of plagiarism is provided in my thesis at any stage, even after the award of the degree, the degree may be cancelled and revoked by the University authority.

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**ABSTRACT**

Underwater

# CHAPTER- 1

## INTRODUCTION

Pakistan has nearly 1000 kilometer long coast from Sir Creek to Jiwani. Coastal countries are allowed upto 200 neuticle miles of economic control from its territorial sea baseline. Apart from that Pakistan attained additional 150 neuticle miles of exclusive economic zone in the deep sea. This vast coastal area comes up with numerous advantages e.g., economic strength from sea food, opportunities to explore underwater resources. Besides from benefits, there are also challenges for Pakistan navy to monitor suspicious activities of significant sea area. All these encourage researchers to play their role for sake of economical growth and defense of the country.

Autonomous underwater vehicle (AUV) and remotely operated vehicle (ROV) are most commonly used for underwater operations. ROV is guided vehicle and is used specifically for sea inspection, maintenance and repairing purposes (Grøtli et al., 2016). AUV is unguided vessel and uses for general purposes like research, defense and exploration without interference or semi-interference from external guidance (Miller et al., 2018). While per-forming search operations e.g., Looking for missing planes, drowned ships, or discovering new species and natural resources self-localization of AUV is required. Collection of exploration data is meaningless if an AUV can not determine or estimate its exact location (Li et al., 2015). Self-localization plays an important role in control and monitoring of a underwater robot as well as search and rescue operations (Matos, 2016).

Consistent location is estimated with the help of some positioning and difference measuring sensors. Global positioning system (GPS) is most commonly used for self location determining and in support to GPS some force and orientation measuring sensors are added for heading correction and speed estimation. One major limitation for underwater localization is unavailability of GPS (Leonard and Bahr, 2016) and other electromagnetic signal based positioning systems e.g.,cellular networks and Wi-Fi positioning system etc. Salty conductive nature of water is highly impure to penetrate the high frequency radio signals (shen et al., 2010). Similarly, with increase in depth pressure on inertial sensor reports abrupt and noisy results. Underwater localization of robot is unalike the localization in normal territorial environment because of rapid attenuation of noise due to dynamic and unstructured nature of salty sea water (Paull et al., 2013).

Sound waves are low frequency or high wavelength signals which can effectively penetrate through the seabed water. Most of underwater communication is done on the basis of acoustic waves and an acoustic positioning system (e.g., ultrashort baseline) results absolute position measurement. Although, sound travelling speed is slower as compared to radio signals but accuracy is not compromised. Delay in acoustic positioning system is reduced with support of acoustic inertial sensor which works on principle of the Doppler effect. DVL sensor is an application of the Doppler effect in which position of agent is estimated with back-scattering acoustic waves using dead-reckoning technique where initial reference of global position is required for such sensor. There is also a network of acoustic sensors, named as wireless sensor network, for which multiple algorithms are proposed to localize a robot (Dan., 2011).

In spatial reference system egocentric and allocentric localization techniques are used for underwater localization of robot. Using egocentric frame of reference location of agent is referred for localization of other objects where as known underwater landmarks and predefined maps are referred for self location of agent with aid of a camera (Al-Rawi et al., 2017). Visual positioning system reports an accurate global self location but with lagging efficiency due to recognition of objects. Laser based positioning systems with aid of some inertial sensor are previously used for location estimation in limited area and shallow water.

Acoustic positioning systems report global position of agent with some delay due to limitation of sound traveling speed. Similarly, visual positioning systems are dependent on some predefined locations and are not capable to estimate location in an unknown environment. Inertial sensors measure change more abruptly with depth of water and the accuracy of velocity measuring acoustic sensors vary with depth as they need underwater land for back-scattering of sound waves (Medagoda et al., 2011). Due to limitation of each sensor multisensory data fusion is required to estimate optimal location of robot and it ensures redundancy and better location estimation as compared to single sensor (Rigby et al., 2006). Anyhow, Majorly global positioning system (e.g., visual or acoustic positioning systems) and dead-reckoning are combined to locate underwater robot more efficiently and accurately.

### 1.1: Problem Statement

Collection of exploration data is meaningless if self location of vehicle is unknown. For underwater self localization of robot every available sensor has limitations. Some of the dead-reckoning based sensor works more accurately near the surface of water than depth e.g, inertial measurement unit (IMU) and some works more accurately near the bottom land of water e.g., doppler velocity log (DVL). In middle of sea there is ambiguity for location estimation. Radio waves can not travel through salty water of sea due to its conductive nature and high density so it is required to rely low frequency non-electromagnetic waves such as sound waves. Acoustic positioning systems are better alternative for underwater locally global position estimation but results are produced with delayed measurements because of lower speed of sound as compared to electromagnetic signals. Similarly, vision based positioning systems are needed some known object to refer its location and there will be no measurements in unknown environment. Multisensory fusion is needed for redundancy and optimal location estimation instead of a single sensor for underwater localization. Conventional fusion policies such as Kalman filter can not model underwater abrupt noise due to which it predict wrong estimations because of high pressure, high density, dynamic and unstructured nature of seabed environment.

### 1.2: Objectives and Scope of Study

To Main objective of the research are

* To analyze the indigenous and international power systems to find the major causes of power system losses
* To investigate the constraints of distribution system for power loss reduction
* To suggest new effective techniques to overcome power losses in the distribution network
* To elaborate the economic aspects of the proposed techniques of more efficient power distribution system

The research is aimed to study the indigenous power system of Pakistan for which GEPCO is selected as a role model and main focus is on improving the efficiency of the distribution system through latest power loss reduction techniques. After achievement of desired result the proposed model would be used by the Electrical distribution companies in the country to improve the efficiency of the power system by power loss reduction and to overcome the previous drawback due to which losses are being increased to maximum value.

For successful completion of research work it is required to have scheduled visits to power grid stations, testing labs and sub divisional offices of the GEPCO Company for collection of required data, collaboration with staff of planning department for software based evaluation, analyzing the performance of technical equipment with the standard figures to estimate the power loss factor and final comparison of outcome data with present data will provide the expected results.

# **CHAPTER– 2**

## **LITERATURE REVIEW**

**2.1: Power Sector Background of Pakistan**

In 1947, when Pakistan came into existence, its total population was 31.5 million and the total power production was only 60MW which means that every individual was able to consume only 4.5 units of electricity (Javaid, Hussain, Arshad, Arshad, & Idrees, 2011). Since 1913 Karachi Electric Supply Company (KESC) had been working as a private organization and was supplying the electricity to the Karachi and its nearby villages. After intendance of Pakistan in 1947, The Government of Pakistan took the charge of KESC in 1952 and handed over the responsibility of generation, T&D of electric power to the residential, commercial and industrial consumers of the country (Iqbal, Nawaz, & Anwar, 2013).

# CHAPTER- 3

## RESEARCH METHODOLOGY

3.1: Introduction to GEPCO

Gujranwala Electric Power Company (GEPCO) was established in 1977 as Area Electricity Board Gujranwala under the supervision of WAPDA. In 1998, GEPCO was declared as Distribution Company due to bifurcation of WAPDA and overall

# CHAPTER- 4

## RESULTS AND DISCUSSION

In this chapter two types of analysis have been performed. First one is the NL loss analysis in which NL losses of silicon core transformer and amorphous core transformer has been practically compared in the transformer testing lab. After performing NL analysis we shall be able to know the more efficient transformer between silicon core and amorphous core transformers. We are considering only NL loss analysis because we have only changed the core of the transformer and rest of parameter will remain the same therefore ON load losses are assumed to be same for both categories. The second analysis is the economic analysis which is a combination of initial cost of transformer and cost of NL losses of transformer. After performing economic analysis we shall be able to reveal the economic aspects of both types of transformers.

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# CHAPTER- 5

## CONCLUSIONS AND RECOMMENDATIONS

Currently the power sector of Pakistan is facing the major challenge of controlling line losses and electricity theft due to which load shedding is being applied on high loss feeders. On the other hand, overall losses in power distribution system are not only dropping the efficiency of the power system but also causing the massive economic loss for the power distribution companies. According to the literature review, power generation of Pakistan was 24828MW till 2018 in which 68% power is generating from the thermal resources. As the cost of thermal generation is very much high as compared to other type of generations therefore, for providing the electricity to the consumers at affordable rates Government of Pakistan has to bear the extra cost of thermal generation as compared to hydel generation. In such situation it is required to produce cheap electricity by installing new hydel projects, however due to present economic crisis in the country it is difficult to attain the financial resources. Hence the best strategy for optimization of power system is to save the available electric power except of generating more electricity.

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**APPENDIX-01**

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| **Abbreviations Used in the Thesis** | | | | |
| **S #** | **Items** | | | **Abbreviations** |
| **1** | Transmission and Distribution | | | T&D |
| **2** | Gujranwala Electric Power Company | | | GEPCO |
| **3** | Karachi Electric Supply Company | | | KESC |
| **4** | Water and Power Development Authority | | | WAPDA |
| **5** | Pakistan Atomic Energy Commission | | | PAEC |
| **6** | Karachi Nuclear Power Plant | | | KANUPP |
| **7** | Independent Power Producers | | | IPPs |
| **8** | Captive Power Producers | | | CPPs |
| **9** | Small Power Producers | | | SPPs |
| **10** | Gross Domestic Product | | | GDP |
| **11** | National Transmission and Dispatch Company | | | NTDC |
| **12** | Alternative Energy Development Board | | | AEDB |
| **13** | Pakistan Electric Power Company | | | PEPCO |
| **14** | Private Power Infrastructure Board | | | PPIB |
| **15** | Generation Companies | | | GENCOs |
| **16** | Distribution Companies | | | DISCOs |
| **17** | National Electric Power regularity Authority | | | NEPRA |
| **18** | Chashma Nuclear Power Plant Unit | | | CHASNUPP |
| **19** | Government of Pakistan | | | GoP |
| **20** | Supervisory Control and Data Acquisition | | | SCADA |
| **21** | Non-Technical Losses | | | NTLs |
| **22** | No Load | | | NL |
| **23** | Advanced Metering Infrastructure | | | AMI |
| **24** | Distributed Generation | | | DG |
| **25** | Volt VAr Optimization | | | VVO |
| **26** | Electrical Transient Analyzer Program | | | ETAP |
| **27** | Mian Muhammad Panah | | | MMP |
| **28** | Small Industrial Estate | | | SIE |
|  | |  |  | |

**APPENDIX-02**

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| --- | --- | --- | --- | --- |
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