VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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Mini Project Report on

DEVELOPMENT OF UNDERWATER BODY MONITORING SYSTEM FOR MARINE PERSONNEL

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

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CERTIFICATE

Certified that the Mini Project work entitled **"DEVELOPMENT OF UNDERWATER BODY MONITORING SYSTEM FOR MARINE PERSONNEL"** is carried out by **BHOOMIKA S JIROLI(1AY20EC014), BOLE SWETHA(1AY20EC015), DIVYA DHARSHINI R(1AY20EC027), and MADHAN KARTHICK E (1AY20EC042)** in the partial fulfillment for the award of the degree of Bachelor of Engineering in Electronics and Communication Engineering of Visvesvaraya Technological University, Belagavi during the year **2022-2023**. It is certified that all corrections/suggestions indicated for the assessment have been incorporated in the report deposited in the departmental library. The Mini Project Report has been approved as it satisfies the academic requirement in respect of Mini Project work **(18ECMP68)** prescribed for the Bachelor of Engineering Degree.

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DECLARATION

We, **BHOOMIKA S JIROLI(1AY20EC014), BOLE SWETHA(1AY20EC015), DIVYA DHARSHINI R(1AY20EC027), and MADHAN KARTHICK E (1AY20EC042)** hereby declare that the Mini project work entitled **"DEVELOPMENT OF UNDERWATER BODY MONITORING SYSTEM FOR MARINE PERSONNEL "** has been independently carried out by us under the supervision of **Mrs. Nikita Kar Chowdhury Assistant Professor**, Department of Electronics and Communication Engineering, Acharya Institute of Technology in partial fulfillment of the requirement for the award of the degree of **Bachelor of Engineering** in **Electronics and Communication Engineering** by **Visvesvaraya Technological University, Belagavi** during the year **2022-23.**

Place: Bangalore

Date:

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ABSTRACT

Diving into innovation, our system integrates cutting-edge sensors to capture vital biometric data from submerged marine personnel. With waterproof, non-invasive sensors thoughtfully positioned on their bodies, we unveil the heart rate, body temperature, and oxygen saturation.

With a steadfast focus on seamless integration, our system employs a sturdy wireless communication module. This module enables the flawless transmission of biometric data in real time. Like a symphony of information, it finds its way to a central monitoring station, where skilled algorithms and visionary data visualization techniques bring it to life. The culmination of reliability and innovation unveils a realm where marine equipment unites with cutting-edge technology, forging a path toward insightful analysis and endless possibilities.

The development of this system involves research and testing to optimize sensor accuracy and reliability in underwater conditions. Calibration procedures are implemented to ensure precise measurements and alleviate any potential sources of error.

By this, we are prepared to witness a groundbreaking shift as this remarkable underwater body parameter measuring system takes center stage. Its ecstatic implementation promises to revolutionize the monitoring and management of marine personnel across diverse sectors: offshore energy, subaquatic construction, exploration, and military operations. With its proactive nature, it becomes the guardian of health and safety, uplifting the welfare and effectiveness of those embracing the challenging unveiling of excellence in the vast depths.

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CHAPTER 1

INTRODUCTION

The technological advent of smart sensing devices has provided practical solutions in various sectors of networking, health care, public and private sector industries, and government organizations worldwide. Health monitoring is the continuous collection of individual health-related physiological parameters and related influence factors through a certain monitoring system. The health condition of the diver is critically monitored before going into the ocean with constant monitoring of the body parameters as the descension of the diver takes place. The notion of this project emphasizes healthcare and the safety of the diver.

Particularly, the application of health monitoring, positioning technology, and smart sensors is booming. Meanwhile, the expansion of the global population is demanding more efficient approaches to marine resources. Once, marine resource exploration, aquatic fishing, and underwater rescue missions mainly rely on diving technology and professional divers, which is costly, inefficient, and, worst of all, risky.

An underwater monitoring system refers to a set of technologies, equipment, and processes used to observe and gather data from underwater environments. These systems are designed to capture, measure, and transmit various parameters and activities in water bodies such as oceans, lakes, rivers, and even underwater structures.

The primary purpose of an underwater monitoring system is to collect valuable information about the aquatic environment, including water quality, marine life, physical characteristics, and human activities. This data is essential for scientific research, environmental monitoring, resource management, and a range of applications in fields like oceanography, marine biology, hydrology, and underwater infrastructure maintenance. Overall, underwater monitoring systems play a vital role in understanding and protecting our underwater environments, enabling researchers, scientists, and policymakers to make informed decisions and take appropriate actions for the sustainable management of aquatic resources.

1.1 OBJECTIVES

1. The monitoring of bodily parameters reduces expenses and monitors physiological parameters, such as heart rate, body temperature, and blood oxygen on a smartphone.

2. Monitoring the health of the diver as he/she descents can ensure the safety of the diver in the entire process.

3. Its purpose is to identify the diver and detect his/her levels of vigilance through software and alert him/her in cases of drowsiness, distractions, etc. to avert accidents.

CHAPTER 2

LITREATURE REVIEW

In the paper "An RNN-Based Delay-Guaranteed Monitoring Framework in Underwater Wireless Sensor Networks", Xiaohui Wei et al. discussed that Real-time underwater monitoring has been widely applied in many applications of underwater wireless sensor networks (UWSNs). Due to the long acoustic communication delays, real-time data collection in UWSNs is challenging. Moreover, underwater acoustic transmission faces the problem of a high data loss rate, which causes a longer delay time due to the need for packet retransmissions. Real-time underwater monitoring has been widely applied in many applications of underwater wireless sensor networks (UWSNs). Due to the long acoustic communication delays, the real-time data collection in UWSNs is challenging. Moreover, the underwater acoustic transmission faces the problem of high data loss rate, which causes a longer delay time due to the need for packet retransmissions. To address these problems, we propose a recurrent neural network (RNN)-based underwater monitoring framework with the consideration of delay, energy, and data quality. We drop the automatic retransmission mechanism applied in the MAC protocols to reduce the long end-to-end delay and energy cost. Facing high data loss, we propose an efficient RNN learning model, LSTM-Decay, to analyze the raw data with the time-related decay weights features and predict the missing values. The experiments with the real-world underwater sensing datasets show that our learning model can achieve an accurate estimation with different degrees of missing rates and can provide better performance compared with the non-RNN and RNN baselines. To reduce the end-to-end delay and improve the monitoring quality, we focus on the design of low-latency monitoring framework while ensuring the quality of collected data. In the framework, we first drop the automatic retransmission mechanism applied in transmission protocols for real-time underwater monitoring. Data loss caused by packet errors is traded off to reduce the long delay and energy consumption. Since higher rates of packet loss will degrade the quality of collected data, we move the compensation for larger data loss to the data center. When faced with varied and high-frequency missing rates in UWSNs, we propose an RNN-based data learning model to efficiently Commonly used imputation methods include smoothing, regression, interpolation, and K-nearest neighbor (KNN) methods. The main idea of these methods is to compute the missing value according to a discrete set of known data points. These methods are efficient for single static datasets but are not suitable for complex data sets. In some cases, the consecutive observation on sensor nodes brings time series data. Moreover, most environmental data are multidimensional and time series. For instance, in environmental monitoring applications, several environmental parameters such as temperature, salinity, conductivity, all need to be collected for water quality measurement. To handle missing data, we need to consider the effects of variable correlations and time series. The Pearson correlation coefficients between environmental parameters illustrate variable correlations. In feeding monitoring applications, the water quality affects the fish growth and the combinational analysis of environmental parameters can be used to predict the feeding process. [1]

The authors of the paper "Lightweight and Expressive Fine-Grained Access Control for Healthcare Internet-of Things Shengmin" discussed the encryption, cloud and edge computing, which provides an efficient, flexible, secure fine grained access control healthcare IoT network without any secure channel and enables data users to enjoy the lightweight decryption. Healthcare Internet-of-Things (IoT) is an emerging paradigm that enables embedded devices to monitor patients vital signals and allows these data to be aggregated and outsourced to the cloud. The cloud enables authorized users to store and share data to enjoy on-demand services. Nevertheless, it also causes many security concerns because of the untrusted network environment, dishonest cloud service providers and resource-limited devices. To preserve patients' privacy, existing solutions usually apply cryptographic tools to offer access controls. However, fine-grained access control among authorized users is still a challenge, especially for lightweight and resource-limited end-devices. In this paper, we propose a novel healthcare IoT system fusing advantages of attribute-based encryption, cloud and edge computing, which provides an efficient, flexible, secure fine-grained access control mechanism with data verification in healthcare IoT network without any secure channel and enables data users to enjoy the lightweight decryption. We also define the formal security models and present security proofs for our proposed scheme. The extensive comparison and experimental simulation demonstrate that our scheme has better performance than existing solutions. Internet-of-Things (IoT) is a novel paradigm for machine-to-machine communication by connecting the various physical devices through the Internet to collect, analyze and exchange data. As agreed by both the academic and industrial communities, IoT is the future of ubiquitous computing. According to the reports from International Data Corporation (IDC), there will be 80 billion connected devices in 2025. The real-time data created by embedded devices, machine-to-machine communications, and IoT networks will reach about 50 Zettabyte (ZB), and it helps to incur 163 ZB of data in that year. IoT has been extensively adapted to many fields such as smart home, environment monitoring, logistics, etc., and healthcare is certainly one of the most promising scenarios of its applications. The MGC architecture (i.e., Embedded devices, Gateways, and Cloud architecture) of healthcare IoT network Embedded devices collect information about patients by monitoring the corresponding vital signals. The gateway device aggregates these data from embedded devices and uploads them to the remote cloud server. Medical staffs are allowed to fetch the outsourced data in the cloud through end-devices. However, these devices are usually resource-limited, and the untrusted network environment is vulnerable to a variety of threats. Hence, it is not straightforward to directly apply MGC architecture in real-world applications due to a variety of practicality concerns. [2]

In the paper "A Dataset and Benchmark of Underwater Object Detection for Robot Picking", Chongwei Liu et al. explained about underwater object detection for robot picking that has attracted a lot of interest. However, it is still an unsolved problem due to several challenges. We take steps towards making it more realistic by addressing the following challenges. Firstly, the currently available datasets basically lack the test set annotations, causing researchers must compare their method with on a self-divided test set (from the training set). Training other methods lead to an increase in workload and different researchers divide different datasets. Underwater object detection for robot picking has attracted a lot of interest. However, it is still an unsolved problem due to several challenges. We take steps towards making it more realistic by addressing the following challenges. Firstly, the currently available datasets basically lack the test set annotations, causing researchers must compare their method with other SOTAs on a self-divided test set (from the training set). Training other methods lead to an increase in workload and different researchers divide different datasets, resulting there is no unified benchmark to compare the performance of different algorithms. Secondly, these datasets also have other shortcomings, e.g., too many similar images or incomplete labels. Towards these challenges we introduce a dataset, Detecting Underwater Objects (DUO), and a corresponding benchmark, based on the collection and re-annotation of all relevant datasets. DUO contains a collection of diverse underwater images with more rational annotations. The corresponding benchmark provides indicators of both efficiency and accuracy for academic research and industrial applications, where JETSON AGX XAVIER is used to assess detector speed to simulate the robot-embedded environment Underwater robot picking is to use the robot to automatically capture sea creatures like holothurian, echinus, scallop, or starfish in an open-sea farm where underwater object detection is the key technology for locating creatures. Until now, the datasets used in this community are released by the Underwater Robot Professional Contest (URPC) beginning from 2017, in which URPC2017 and URPC2018 are most often used for research. Unfortunately, as the information listed in Table 1, URPC series datasets do not provide the annotation file of the test set and cannot be downloaded after the contest. [1]Table 1 Information About All the Collected Datasets. * Denotes the Test Set'S Annotations Are Not Available. 3 In Class Means Three Types of Creatures Are Labeled, I. E., Holothurian, Echinus, and Scallop. 4 Means Four Types of Creatures Are Labeled. [3]

The authors of the paper "Proposal-Fusion among Multiple Images for Underwater Object Detection", said that generic object detection algorithms have proven excellent performance in recent years. However, object detection on underwater datasets is still less explored. In contrast to generic datasets, underwater images usually have color shift and low contrast; sediment would cause blurring in underwater images. In addition, underwater creatures often appear closely to each other on images due to their living habits. To address these issues, our work investigates augmentation policies to simulate overlapping, occluded and blurred objects, and we construct a model capable of achieving better generalization. Generic object detection algorithms have proven their excellent performance in recent years. However, object detection on underwater datasets is still less explored. In contrast to generic datasets, underwater images usually have color shift and low contrast; sediment would cause blurring in underwater images. In addition, underwater creatures often appear closely to each other on images due to their living habits. To address these issues, our work investigates augmentation policies to simulate overlapping, occluded and blurred objects, and we construct a model capable of achieving better generalization. They propose an augmentation, which characterizes interactions among images. Proposals extracted from different images are mixed together. Previous data augmentation methods operate on a single image while we apply RoIMix to multiple images to create enhanced samples as training data. Experiments show that our proposed method improves the performance of region-based object detectors on both Pascal VOC and URPC datasets. Generic object detection algorithms have proven their excellent performance in recent years. However, object detection on underwater datasets is still less explored. In contrast to generic datasets, underwater images usually have color shift and low contrast; sediment would cause blurring in underwater images. In addition, underwater creatures often appear closely to each other on images due to their living habits. To address these issues, our work investigates augmentation policies to simulate overlapping, occluded and blurred objects, and we construct a model capable of achieving better generalization. We propose an augmentation method called

RoIMix, which characterizes interactions among images. Proposals extracted from different images are mixed together. Previous data augmentation methods operate on a single image while we apply RoIMix to multiple images to create enhanced samples as training data. Experiments show that our proposed method improves the performance of region-based object detectors on both Pascal VOC and URPC datasets. [4]

The authors Chia-Hung Yeh et al. of the paper "Lightweight Deep Neural Network for Joint Learning of Underwater Object Detection and Color Conversion", proposed that underwater image processing exhibited significant potential for exploring underwater environments. It has been applied to a wide variety of fields, such as underwater terrain scanning and autonomous underwater vehicles (AUVs) driven applications, such as image based underwater object detection. However, underwater images often suffer from degeneration due to attenuation, color distortion, and noise from artificial lighting sources as well as the effects of possibly low end optical imaging devices. Underwater image processing has been shown to exhibit significant potential for exploring underwater environments. It has been applied to a wide variety of fields, such as underwater terrain scanning and autonomous underwater vehicles (AUVs)-driven applications, such as image-based underwater object detection. However, underwater images often suffer from degeneration due to attenuation, color distortion, and noise from artificial lighting sources as well as the effects of possibly low-end optical imaging devices. Thus, object detection performance would be degraded accordingly. To tackle this problem, in this article, a lightweight deep underwater object detection network is proposed. The key is to present a deep model for jointly learning color conversion and object detection for underwater images. The image color conversion module aims at transforming color images to the corresponding grayscale images to solve the problem of underwater color absorption to enhance the object detection performance with lower computational complexity. The presented experimental results with our implementation on the Raspberry pi platform have justified the effectiveness of the proposed lightweight jointly learning model for underwater object detection compared with the state-of-the-art approaches. Therefore, dataset augmentation methods have become a recurrent strategy to ensure the establishment of the greater image databases that are usually required to train deep neural network algorithms. For instance, a 3Dmodeling dataset augmentation method was proposed for AUV real-time operations, increasing the significance of rare underwater objects for detection algorithms. Furthermore, some simulated underwater physical effects were included in a synthetic dataset to build an underwater image-enhancement algorithm for infrastructure inspection Additionally, the enhancement process may unavoidably remove or alter critical patterns and details, which may introduce noise or artifacts into the image Therefore, there have been some works, exploring the relationship between underwater visual enhancement and object detection. These methods could be roughly categorized into two different manners: (1) preprocessing manner and (2) multi-task learning manner. Underwater image processing has been shown to exhibit significant potential for exploring underwater environments. It has been applied to a wide variety of fields, such as underwater terrain scanning and autonomous underwater vehicles (AUVs)-driven applications, such as image-based underwater object detection. However, underwater images often suffer from degeneration due to attenuation, color distortion, and noise from artificial lighting sources as well as the effects of possibly low-end optical imaging devices. Thus, object detection performance would be degraded accordingly. To tackle this problem, in this article, a lightweight deep underwater object detection network is proposed. The key is to present a deep model for jointly learning color conversion and object detection for underwater images. The image color conversion module aims at transforming color images to the corresponding grayscale images to solve the problem of underwater color absorption to enhance the object detection performance with lower computational complexity. The presented experimental results with our implementation on the Raspberry pi platform have justified the effectiveness of the proposed lightweight jointly learning model for underwater object detection compared with the state-of-the-art approaches. [5]

In the paper "YOLO Nano Underwater: A Fast and Compact Object Detector for Embedded Device" Lin Wang et al. made recent researches on Underwater object detection that have progressed with the development of deep learning methods. A large portion of Remotely Operated Vehicle(ROV) and Autonomous Underwater Vehicle(AUV) are working on constrained environments with limited power supply and computing capability. In this paper, we propose a fast and compact object detector for several marine products, such as scallop, starfish, echinus and holothurian. The novel proposed model named You Only Look Once(YOLO) Nano. Underwater is modified based on YOLO Nano architecture to reduce the inference time. The model achieves a competitive performance on edge computing devices, like NVIDIA Jetson Nano. Comparing to YOLO v3. Recent researches on Underwater object detection have progressed with the development of deep learning methods. A large portion of ROVs and AUVs are working on constrained environments with limited power supply and computing capability. In this paper, we propose a fast and compact object detector for several marine products, such as scallop, starfish, echinus and holothurian. The novel proposed model named YOLO Nano Underwater is modified based on YOLO Nano architecture to reduce the inference time. And instance normalization is introduced to replace the batch normalization in some early layers for a precision boost. The model achieves a competitive performance on edge computing devices, like NVIDIA Jetson Nano. Comparing to YOLO v3, our model can get competitive performance in precision, but with only 5% computation. Meanwhile, we re-annotated the training part of the URPC 2019 dataset and the refined annotations can be public available at https://github.com/wangsssky/Refined-training-set-of-URPC2019/. The demand for aquatic products is growing. Underwater fishing is restricted by the harsh underwater environment and the increase of human cost. Since artificial intelligence has been applied to more and more ROVs and AUVs, it is a trend to use robots to catch marine products autonomously or semi autonomously. Many object detection and recognition algorithms are transferred directly for marine research and industry use, which makes the new technology applied in this field. However, a large portion of ROVs or AUVs are working under a power constrained condition. As a result, the computing resource or computing capability is often limited at the same time. An efficient algorithm is always needed for those power consuming equipment. Recent researches on Underwater object detection have progressed with the development of deep learning methods. A large portion of ROVs and AUVs are working on constrained environments with limited power supply and computing capability. In this paper, we propose a fast and compact object detector for several marine products, such as scallop, starfish, echinus and holothurian. The novel proposed model named YOLO Nano Underwater is modified based on YOLO Nano architecture to reduce the inference time. And instance normalization is introduced to replace the batch normalization in some early layers for a precision boost. The model achieved a competitive performance on edge computing devices, like NVIDIA Jetson Nano. Comparing to YOLO v3, our model can get competitive performance in precision, but with only 5% computation. [6]

The authors of the paper “Underwater hybrid energy harvesting based on TENG-MTEG for self-powered marine mammal condition monitoring system” stated that to effectively protect endangered marine mammals, one needs to collect and monitor their biological data and living environment information. This is however a great challenge for the endurance of marine mammal condition monitoring devices. The present study is to propose a self-powered marine mammal condition monitoring system, based on the hybrid energy harvesting mode of triboelectric nanogenerator (TENG) and micro thermoelectric generator (MTEG), to address the challenge. This system not only can obtain energy from the movement of marine mammals but also harvest energy from the temperature difference between the body surface and the ambient. The system fittingly integrates oscillating-TENG (O-TENG), MTEG, and power management unit. Note that O-TENG and MTEG can produce the maximal open circuit voltages of 5.85 V and 1.821 V, respectively. In challenging underwater environments, mechanical actuators must overcome various obstacles and ensure precise and stable control when interacting with fragile and flexible targets. To address these issues, a novel pressure and slip state monitoring sensor (PS-TENG) based on the triboelectric nanogenerator principle was proposed to establish a haptic sensing system for underwater actuators. This sensor can detect pressure at the actuator during gripping and the relative slipping speed between the actuator and the target, allowing for precise control based on feedback signals from the perception system. In this study, we established a theoretical model between pressure and electrical signal, explored material preparation methods and manufacturing steps, conducted performance optimization experiments after producing the prototype, and proposed a signal processing method for the sensor output. Results demonstrated that the sensor can generate an open-circuit voltage signal of up to 45 V at a maximum operating pressure of 13 N. Moreover, within the operating pressure range, the sensor exhibited high sensitivity, reaching up to 4.5 V/N. By analyzing and processing the sensor signals, the actuator can obtain both pressure and relative slipping speed information simultaneously, essential for addressing complex underwater grasping tasks. Our research indicates that the PS-TENG sensor can serve as a reliable and efficient solution for establishing haptic sensing systems in underwater applications. With its excellent performance, this sensor holds broad potential for use in underwater robotics and electronic devices, enabling more versatile and reliable equipment in the future. In actual captured underwater images, serious color distortion, detail loss and limited visibility are common issues due to the combined influence of water medium scattering and absorption. To solve these problems, an underwater image enhancement method based on adaptive color correction and multi-scale fusion is proposed, which does not rely on any specific equipment or auxiliary information. According to the attenuation degree of underwater images, an adaptive color correction method of piecewise linear transformation is used to address the color distortion. Then, the color-corrected image is converted from RGB to CIE-Lab color space, and the luminance channel L is applied to the updated logarithmic image processing (LIP) model alone to improve contrast. The final enhanced image is created by fusing the color-corrected image with the contrast-improved image using a multi-scale fusion technique based on contrast, saliency, and saturation. The qualitative and quantitative evaluation results demonstrate that compared with some state-of-the-art methods, the proposed method can produce better visual quality and have higher average values in underwater image quality evaluation such as AG, IE, PCQI, UIQM and UCIQE. [7]

Syed Agha et al. in the paper "NOMA-Based VLC Systems: A Comprehensive Review" , said that oceans cover more than 70% of the earth's surface. For various reasons, almost 95% of these areas remain unexplored. Underwater wireless communication (UWC) has widespread applications, including real-time aquatic data collection, naval surveillance, natural disaster prevention, archaeological expeditions, oil and gas exploration, shipwreck exploration, maritime security, and the monitoring of aquatic species and water contamination. The promising concept of the Internet of Underwater Things (IoUT) is having a great influence in several areas, for example, in small research facilities and average-sized harbors, as well as in huge unexplored areas of ocean. The IoUT has emerged as an innovative technology with the potential to develop a smart ocean. Wireless communication refers to data transfer in an unguided propagation medium through wireless carriers such as visible light (VL) and radio frequency (RF). The rapidly growing demand for high data rates overloads conventional RF wireless communication. Therefore, technologies such as cognitive radios and millimeter waves (mm Waves) have been utilized to overcome capacity limitation and spectrum scarcity of RF systems. In parallel, optical wireless communication (OWC) is a promising alternative solution to its radio frequency (RF) compeer. OWC has been revolutionized to support fifth generation (5G) wireless communication and Internet-of-Things (IoT) terminals. In addition, OWC has no health hazard, low power consumption, unlicensed spectrum and shows immunity to interferences from electromagnetic sources. As RF and OWC are compatible, so a joint application scenario is referred as an excellent solution to support 5G and beyond systems. Hybrid optical/optical and RF/optical system is a promising approach to remove the limitations of each system as well as to enable supporting features of each technology. An optical/optical hybrid system is based on two or more OWC technologies while RF/optical hybrid system contains both RF and OWC technologies. The hybrid systems can enhance system performance in terms of energy efficiency, reliability and throughput of each system. Thus, hybrid RF/optical systems are envisioned as a key enabler to enhance user mobility and data rate on the one hand and to optimize power consumption, network load, interference and network capacity on the other hand. This survey seeks to provide the state-of-the-art and future research directions regarding optical wireless hybrid networks. This paper represents a technological overview of existing optical wireless hybrid networks. They have discussed optical-based free-space optics (FSO), optical camera communication (OCC), light fidelity (LiFi) which extends the concept of visible light communication (VLC) to attain bi-directional and fully networked wireless communication, as well as RF-based Bluetooth, wireless fidelity (WiFi), small cell, macro cell, mm Wave and microwave. In addition, we have also considered underwater acoustic communication for acoustic/optical and acoustic/RF hybrid networks. An extensive range of applications such as indoor, vehicular communication, eHealth, backhaul connectivity solution and underwater communication is considered. We have addressed potential challenges and open research issues for design and successful deployment of hybrid wireless networks. n the past few decades, the academic research and industrial synergy is dramatically accelerating to conceptualize high data rate services. The congestion in the radio frequency (RF) spectrum has imposed many inherent limitations in the growth of future wireless networks. These limitations have spurred global research activities to open new parts of the electromagnetic wave spectrum. More researches and developments in new modulation schemes, channel modelling and signal processing techniques are yet to be explored. Optical wireless communication (OWC) has appeared as an emerging complementary technology to RF systems. It is deemed as a promising alternative to address RF spectrum congestion and enhance system's capacity. OWC has gained widespread attention due to its high confidentiality, large spectrum resources and strong resistance to electromagnetic interference (EMI). In this paper, we envisage OWC systems as a promising solution for the bandwidth shortage of RF spectrum. We have also discussed the current upsurge of diversified OWCs in fifth generation (5G) and Internet-of-Things (IoT) solutions which has spurred heated discussion for future technologies. In this study, we have outlined a holistic vision of several OWC enabling technologies and survey of potential issues in OWC systems. We investigate visible light communication (VLC) and free space optics (FSO) as potential implementation approaches for OWC systems. Generally, the intent of this extant study includes (i) potential features and classifications of OWC systems, (ii) key enabling technologies, (iii) link design requirements and modulation schemes, (iv) main impairments and solutions to reduce the impairments, and (v) security issues and techniques to secure OWC. At last, open research challenges and future research directions in OWC systems are investigated. In this regard, we believe this survey will be helpful to aggregate the research efforts and eliminate the technical uncertainties towards breakthrough novelties of OWC technologies. [8]

In the paper "A Systematic Review on Recent Trends, Challenges, Privacy and Security Issues of Underwater Internet of Things" Delphin Raj et al. said that owing to the hasty growth of communication technologies in the Underwater Internet of Things (UIoT), many researchers and industries focus on enhancing the existing technologies of UIoT systems for developing numerous applications such as oceanography, diver networks monitoring, deep-sea exploration and early warning systems. In a constrained UIoT environment, communication media such as acoustic, infrared (IR), visible light, radiofrequency (RF) and magnet induction (MI)are generally used to transmit information via digitally linked underwater devices. However, each medium has its technical limitations: for example, the acoustic medium has challenges such as narrow-channel bandwidth, low data rate, high cost, etc., and optical medium has challenges such as high absorption, scattering, long-distance data transmission, etc. Moreover, the malicious node can steal the underwater data by employing blackhole attacks, routing attacks, Sybil attacks, etc. Moreover, the malicious node can steal the underwater data by employing blackhole attacks, routing attacks, Sybil attacks, etc Owing to the hasty growth of communication technologies in the Underwater Internet of Things (UIoT), many researchers and industries focus on enhancing the existing technologies of UIoT systems for developing numerous applications such as oceanography, diver networks monitoring, deep-sea exploration and early warning systems. In a constrained UIoT environment, communication media such as acoustic, Infrared (IR), visible light, Radio Frequency (RF) and Magnet Induction (MI) are generally used to transmit information via digitally linked underwater devices. However, each medium has its technical limitations: for example, the acoustic medium has challenges such as narrow-channel bandwidth, low data rate, high cost, etc., and optical medium has challenges such as high absorption, scattering, long-distance data transmission, etc. Moreover, the malicious node can steal the underwater data by employing blackhole attacks, routing attacks, Sybil attacks, etc. Furthermore, due to heavyweight, the existing privacy and security mechanism of the terrestrial Internet of Things (IoT) cannot be applied directly to UIoT environment. Hence, this paper aims to provide a systematic review of recent trends, applications, communication technologies, challenges, security threats and privacy issues of UIoT system. Additionally, this paper highlights the methods of preventing the technical challenges and security attacks of the UIoT environment. Finally, this systematic review contributes much to the profit of researchers to analyze and improve the performance of services in UIoT applications. The inherent complexities of Industrial Internet of Things (IIoT) architecture make its security and privacy issues becoming critically challenging. Numerous surveys have been published to review IoT security issues and challenges. The studies gave a general overview of IIoT security threats or a detailed analysis that explicitly focuses on specific technologies. However, recent studies fail to analyze the gap between security requirements of these technologies and their deployed countermeasure in the industry recently.

Whether recent industry countermeasure is still adequate to address the security challenges of IIoT environment are questionable. This article presents a comprehensive survey of IIoT security and provides insight into today's industry countermeasure, current research proposals and ongoing challenges. We classify IIoT technologies into the four-layer security architecture, examine the deployed countermeasure based on CIA+ security requirements, report the deficiencies of today's countermeasure, and highlight the remaining open issues and challenges. As no single solution can fix the entire IIoT ecosystem, IIoT security architecture with a higher abstraction level using the bottom-up approach is needed. Moving towards a data-centric approach that assures data protection whenever and wherever it goes could potentially solve the challenges of industry deployment. [9]

The paper "Real-time Water Quality Monitoring of Lakes using IoT based Remotely Operate Underwater Vehicle" explained that water degradation has become a critical theme of concern in recent years. Water is necessary for biological species survival and living activity is strikingly dependent on the quality of the water (i.e., physical, chemical, and biological aspects of water). The aim of the paper is to develop Internet-based Water Quality Monitoring System to determine the water quality parameters namely turbidity, pH, temperature etc. The developed model encompasses ESP32 Wi-Fi & Bluetooth Microcontroller with appropriate sensors and communication circuitry. The paper proposes a cost effective Remote Operated Underwater Vehicle which can monitor the parameters successively for prolonged period. The developed model is tested for three different cases and the parameters inferred are communicated through Thing Speak analytics platform. 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This review sums up the outcomes of various research studies conducted for drinking water quality status of different areas of Pakistan by taking into account the physicochemical properties of drinking water as well as the presence of various pathogenic microorganisms. About 20% of the whole population of Pakistan has access to safe drinking water. The remaining 80% of population is forced to use unsafe drinking water due to the scarcity of safe and healthy drinking water sources. The primary source of contamination is sewerage (fecal) which is extensively discharged into drinking water system supplies. Secondary source of pollution is the disposal of toxic chemicals from industrial effluents, pesticides, and fertilizers from agriculture sources into the water bodies. Anthropogenic activities cause waterborne diseases that constitute about 80% of all diseases and are responsible for 33% of deaths. This review highlights the drinking water quality, contamination sources, sanitation situation, and effects of unsafe drinking water on humans. There is immediate need to take protective measures and treatment technologies to overcome unhygienic condition of drinking water supplies in different areas of Pakistan**.** Water is one of the renewable resources essential for sustaining all forms of life, food production, economic development, and for general well being. It is impossible to substitute for most of its uses, difficult to de pollute, expensive to transport, and it is truly a unique gift to mankind from nature. Water is also one of the most manageable natural resources as it is capable of diversion, transport, storage, and recycling. All these properties impart to water its great utility for human beings. The surface water and groundwater resources of the country play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities etc. The freshwater ecosystems of the world comprise only about 0.5% of the earth’s surface and have a volume of 2.84x105 Km. Rivers constitute an insignificant amount (0.1%) of the land surface. Only 0.01% of the waters of the earth occur in river channels. Inspite of these low quantities, running waters are of enormous significance (Wetzel, 2001). India receives annual precipitation of about 4000 km,including snowfall. Out of this, monsoon rainfall is of the order of 3000 km Rainfall in India is dependent on the south-west and north-east monsoons on shallow cyclonic depressions and disturbances and on local storms (Kumar et. al., 2005). Most of it takes place under the influence of south-west monsoon between June and September except in Tamil Nadu, where it is under the influence of north-east monsoon during October and November (Kumar et. al., 2005). India is gifted with river system comprising more than 20 major rivers with several tributaries. Many of these rivers are perennial and some of them are seasonal. Although India occupies only 3.29 million km geographical area, constituting 2.4% of the world's land area, it supports over 15% of the world's population. The population of India as on 1 March 2001 stood at1,027,015,247 persons. Thus, India supports about 1/6th of world population, 1/50 of world's land and 1/25th of world's water resources (Water Management Forum, 2003). In the last few decades, there has been a tremendous increase in the demand for freshwater due to rapid growth of population and the accelerated pace of industrialization. Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions. Anthropogenic activities related to extensive urbanization, agricultural practices, industrialization, and population expansion have led to water quality deterioration in many parts of the world. In addition, deficient water resources have increasingly restrained water pollution control and water quality improvement. Water pollution has been a research focus for government and scientists. Therefore, protecting river water quality is extremely urgent because of serious water pollution and global scarcity of water resource. [10]

CHAPTER 3

PROPOSED METHODOLOGY

3.1 THE MECHANISM OF THE BODY MONITORING SYSTEM

1.Fig 3.1 Shows the flowchart of the monitoring system or the proposed methodology.

2.Here, we check the bodily parameters like heart rate, body temperature, oxygen saturation in blood of the diver before diving. If the bodily parameters are not appropriate, the diver is not fit to dive.

3. If all the bodily parameters are appropriate continuous monitoring of the body parameters of the diver is done as he descents.

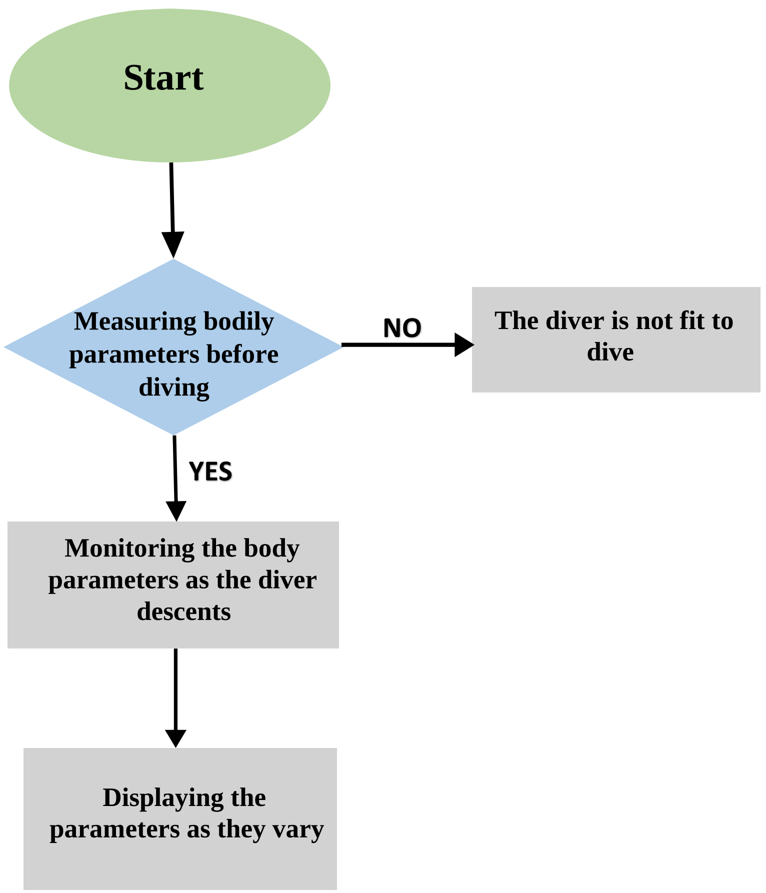

Fig 3.1 Schematic flowchart of the monitoring system

3.2 UNDER WATER TECHNOLOGY

Underwater technology refers to the various tools, equipment, and systems designed for use in underwater environments. These technologies enable exploration, research, construction, communication, and other activities beneath the water's surface. Sonar (Sound Navigation and Ranging) systems use sound waves to navigate and detect objects underwater. They are used for mapping the seafloor, locating underwater structures, and detecting submarines. Sonar technology includes both active sonar (emitting sound waves and measuring their reflections) and passive sonar (listening for sounds produced by other sources).

To make the underwater Internet of Things happen, light is the answer, some say, they are proposing underwater optical communications. They're investigating Simultaneous Light wave Information and Power Transfer (SLIPT) configurations, which they're using to transmit energy and data to underwater electronic devices. Recently, the researchers announced a breakthrough experiment in which they were able to achieve an underwater, two-way transmission of data and power over 1.5 yards between a solar panel-equipped sensor and a receiver. The SLIPT system will be more usable than wires strung. And in the case of human underwater equipment inspections, for example, SLIPT will be less prone to error than hand signals and less prone to audible confusion than ultrasound voice-based communicators. Remarkably, to this day, hand signals are still a common form of communication between divers.

Underwater Communication:

Underwater communication systems are necessary for transmitting data, voice, or video signals between underwater platforms and the surface. Acoustic modems, which use sound waves, are commonly used for underwater data transmission. Other technologies, such as optical communications, are also being developed to overcome the limitations of acoustic communication. Communication underwater is challenging due to the limited range and attenuation of electromagnetic waves in water. Underwater communication systems use acoustic waves to transmit signals between underwater vehicles, divers, and surface vessels.

Here are some common techniques used for underwater communication:

1. Acoustic Communication: Acoustic communication is the most widely used method for underwater communication due to its ability to travel long distances in water. It involves the transmission and reception of sound waves through the water medium. Underwater acoustic communication systems use specialized transducers that convert electrical signals into acoustic waves and vice versa. These systems can transmit data through various modulation schemes and encoding techniques, allowing for reliable communication over long ranges.

2. Optical Communication: Optical communication utilizes light to transmit data through water. It involves the use of lasers or LEDs to encode information onto light signals, which can then be transmitted through optical fibers, free space, or even water itself. Optical communication offers higher data rates compared to acoustic communication but is limited to shorter distances and requires clear water with good visibility for effective transmission.

3. Electromagnetic Induction: Electromagnetic induction can be used for short-range underwater communication. It involves the use of low-frequency electromagnetic fields to induce currents in conductive objects or underwater antennas, allowing for wireless communication. However, this method is limited in range and bandwidth due to the high attenuation of electromagnetic waves in water.

4. Underwater Modems: Underwater modems are specialized devices used for transmitting and receiving data underwater. These modems are designed to operate with specific communication protocols and modulation schemes suitable for underwater conditions. They typically incorporate error-correction techniques and signal processing algorithms to improve the reliability and efficiency of underwater communication.

5.Underwater Networking: Underwater networks involve the establishment of communication links between multiple underwater devices or nodes, enabling data exchange and coordination among them. This can be achieved using various network topologies and protocols designed specifically for underwater environments. Underwater networking allows for collaborative tasks, such as distributed sensing, underwater robotics, and coordinated operations.

6. Hybrid Approaches: In some cases, a combination of different communication techniques is employed to overcome the limitations of individual methods. For instance, a hybrid system may use acoustic communication for long-range transmission and optical communication for short-range, high-bandwidth communication in localized areas.

Underwater Sensors:

Various types of sensors are employed underwater to measure physical and chemical properties of the water, monitor environmental conditions, and collect data for scientific research. Examples include temperature sensors, pressure sensors, salinity sensors, pH sensors, and dissolved oxygen sensors. However, a high number of cables would have been required to be routed along the diver. All the cables would have posed a safety hazard, such as possible entanglement, and seemed to be uncomfortable for the diver.

1. Temperature Sensors: These sensors measure the temperature of the water. They are crucial for monitoring changes in water temperature, which can affect aquatic ecosystems and provide insights into oceanic and climatic patterns.

2. Conductivity and Salinity Sensors: These sensors measure the electrical conductivity of water, which is used to calculate salinity. Salinity measurements are essential for understanding water composition, ocean circulation patterns, and the mixing of freshwater and seawater.

3. pH Sensors: pH sensors measure the acidity or alkalinity of the water. Monitoring pH levels is crucial for assessing water quality and determining the health of marine life. It helps identify the presence of acidification or alkalization that may impact marine ecosystems.

4. Dissolved Oxygen Sensors: These sensors measure the concentration of oxygen dissolved in water. Oxygen levels are essential for the survival of aquatic organisms, and monitoring them helps identify areas of low oxygen, which can lead to hypoxic conditions and affect marine life.

5. Turbidity Sensors: Turbidity sensors measure the clarity or cloudiness of water caused by suspended particles. They are used to assess water quality, monitor sedimentation, and detect changes in light penetration, which can impact aquatic ecosystems.

6. Chlorophyll Sensors: Chlorophyll sensors measure the concentration of chlorophyll-a, a pigment found in plants and algae. Chlorophyll measurements provide insights into phytoplankton biomass and primary productivity, crucial indicators of the health and productivity of aquatic ecosystems.

7. Pressure Sensors: Pressure sensors measure the hydrostatic pressure at different depths in the water column. They help determine water depth, monitor tides, and assess changes in ocean currents.

8. Optical Sensors: Optical sensors can measure various parameters using light-based techniques. For example, they can measure water color, turbidity, dissolved organic matter, or the presence of specific substances or pollutants.

Underwater Imaging:

Advanced imaging technologies are used to capture high-resolution images and videos of underwater environments. These include underwater cameras, video cameras, and imaging systems that can withstand the high-pressure conditions underwater and provide clear visuals in challenging light conditions. Advanced imaging systems, including cameras and video equipment, are used to capture high-quality images and videos in underwater environments. These systems aid in scientific research, documentary filmmaking, and underwater inspections. Underwater technology is also involved in the design, construction, and maintenance of offshore structures, underwater pipelines, cables, and other submerged infrastructure. These are just a few examples of the many technologies and applications in the field of underwater technology. The advancements in this field continue to expand our understanding of the underwater world and enable various industries to operate in challenging underwater environments.

Here are some common techniques and technologies used in underwater water imaging:

1. Underwater Cameras: Underwater cameras are specifically designed to capture high-quality images and videos in aquatic environments. They are built to be waterproof, pressure-resistant, and often include features like auto white balance and manual exposure control to compensate for the unique lighting conditions underwater.

2. Underwater Housings: Many cameras used for underwater imaging are housed in specialized waterproof enclosures or housings. These housings provide protection against water pressure and allow the cameras to function underwater at various depths. They often have transparent domes or ports to maintain optical clarity.

3. Underwater Lights: Due to the rapid loss of light underwater, additional lighting is often required to illuminate the subject and improve image quality. Underwater lights, such as strobes or continuous LED lights, are used to provide artificial lighting and restore natural colors in underwater scenes.

4. Underwater Remotely Operated Vehicles (ROVs): ROVs are robotic devices equipped with cameras and controlled remotely from the surface. They are used for deep-sea exploration, underwater research, and inspections in areas that are difficult for humans to access. ROVs are often equipped with advanced imaging systems, including high-definition cameras, sonar, and other sensors.

ADVANTAGES:

1. Resource Extraction: Underwater technology enables the extraction of valuable resources from the ocean, such as oil, natural gas, minerals, and even renewable energy sources like offshore wind farms.

2. Environmental Monitoring: Underwater technology allows for continuous monitoring of marine environments, helping to assess water quality, track pollution, detect harmful algal blooms, and monitor the health of marine ecosystems.

3. Infrastructure Development: Underwater technology plays a crucial role in the construction and maintenance of underwater infrastructure.

4. Search and Rescue: Underwater technology assists in search and rescue operations by providing tools and vehicles to locate and retrieve people in distress underwater.

5. Data Collection in Challenging Environments: Underwater monitoring systems enable the collection of valuable data from underwater environments that are otherwise inaccessible or challenging for humans to reach. These systems can operate in deep-sea areas, remote locations, and harsh underwater conditions, allowing for data collection in real-time or over extended periods.

6. Real-Time Monitoring: Underwater monitoring systems provide the capability for real-time data acquisition, enabling researchers, operators, and decision-makers to monitor underwater conditions continuously. Real-time data allows for timely responses to changes, ensuring prompt action can be taken in critical situations.

7. Comprehensive and Continuous Data: Underwater monitoring systems can gather comprehensive and continuous data over extended periods, providing a more detailed understanding of underwater processes and phenomena. This longitudinal data can be valuable for trend analysis, identifying patterns, and making informed decisions based on long-term observations.

8. Remote and Autonomous Operation: Many underwater monitoring systems are designed to operate remotely or autonomously. This eliminates the need for human presence in hazardous or inaccessible underwater environments, reducing risks to human operators. Remote and autonomous operation also allows for greater flexibility and efficiency in data collection and monitoring.

DISADVANTAGES:

1. High Cost: Underwater technology often involves high development, operation, and maintenance costs. Developing, deploying, and maintaining underwater monitoring systems can be expensive. The specialized equipment, sensors, and vehicles required for underwater operations often come at a significant cost. Additionally, the costs of data collection, processing, and analysis can add up over time.

2. Operating in underwater environments poses unique technical challenges. Factors such as high pressure, temperature extremes, corrosive saltwater, limited visibility, and communication difficulties make the development and operation of underwater technology complex and demanding.

3. Maintenance and Repair Challenges: Maintaining and repairing underwater technology can be challenging due to the corrosive nature of seawater, accessibility issues, and the need for specialized expertise. Regular maintenance and repairs are necessary to ensure the reliability and longevity of underwater equipment.

4. Technical Challenges: Underwater environments present unique technical challenges for monitoring systems. The properties of water, such as high pressure, buoyancy, and limited visibility, can impact the performance and reliability of sensors, communication systems, and equipment. Operating in harsh conditions and extreme depths can also increase the risk of equipment failure and damage.

5. Limited Access and Remote Locations: Underwater monitoring often requires physical access to underwater locations, which can be challenging and time-consuming. Remote or isolated areas may have limited infrastructure for deployment, data retrieval, and maintenance of monitoring systems. This can result in delays in data collection and limited coverage in certain areas.

6. Data Transmission and Storage: Transmitting and storing large volumes of data collected by underwater monitoring systems can be a logistical challenge. Bandwidth limitations and the need for reliable underwater communication systems can hinder real-time data transmission. Additionally, storing and managing vast amounts of data in underwater environments can be challenging due to limited power and storage capabilities.

CHAPTER 4

REQURIMENTS

4.1 ESP8266

The ESP8266 is a Wi-Fi System on a Chip (SoC) produced by Espressif Systems. The ESP8266 is a low-cost Wi-Fi chip. It can be used as a standalone device, or as a UART to Wi-Fi adaptor to allow other microcontrollers to connect to a Wi-Fi network. For example, you can connect an ESP8266 to an Arduino to add Wi-Fi capabilities to your Arduino board. The most practical application is using it as a standalone device. With the ESP8266, you can control inputs and outputs as you would do with an Arduino, but with Wi-Fi capabilities. Node MCU has 4MB of storage and 128 Kb of Memory. It has several GPIO (General Purpose Input Output) pins for device connectivity. It has only one Analogue pin for Analogue input.

Fig 4.1 ESP8266

Pin configuration of ESP8266

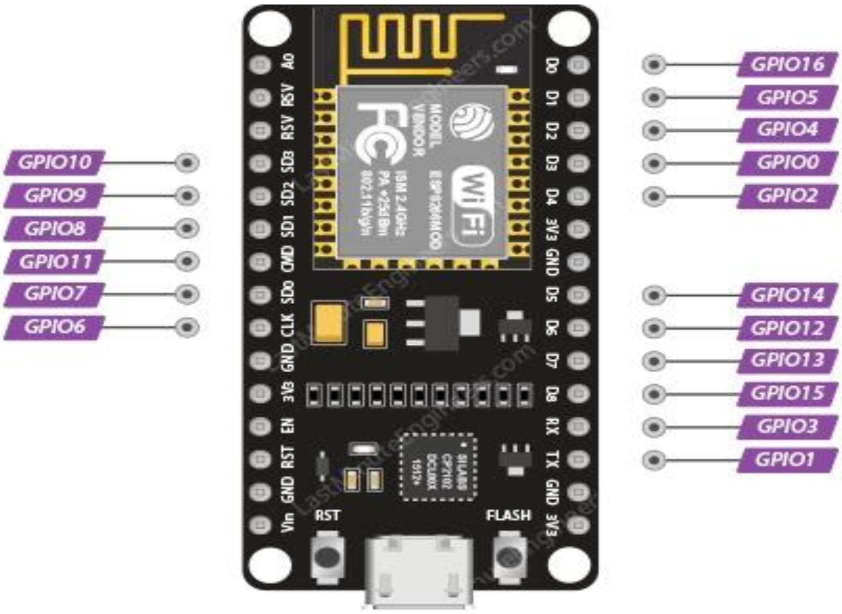

Fig:4.2 Pin Configuration of ESP8266

1. VCC (3.3V): This pin is used to power the ESP8266 module. It requires a stable 3.3V power supply, as higher voltages can damage the module.

2. GPIO16: Also known as D0, this pin can be used as a general-purpose input/output (GPIO). Additionally, it has special functionality related to wake-up from deep sleep mode.

3. RX (UART RX): This pin is used for receiving data in UART (Universal Asynchronous Receiver/Transmitter) communication. It is used to receive data from external devices.

4. TX (UART TX): This pin is used for transmitting data in UART communication. It is used to send data to external devices.

5. GPIO5: Also known as D1, this pin can be used as a general-purpose input/output (GPIO).

6. GPIO4: Also known as D2, this pin can be used as a general-purpose input/output (GPIO).

7. GPIO0: This pin is used as a general-purpose input/output (GPIO) and also has a special role in the boot process. Its state during power-up determines the boot mode of the ESP8266. If pulled low during power-up, it enters programming mode, allowing for firmware updates. If pulled high, it boots into the user program.

8. GPIO2: This pin is used as a general-purpose input/output (GPIO) and also has a special role in the boot process. It should be pulled high to enable normal operation after booting, or pulled low to enter programming mode.

9. EN (CH_PD): Also known as Enable or Chip Power-Down, this pin is used to enable or disable the ESP8266 module. It must be pulled high (connected to VCC) for normal operation.

10. GND: This pin is connected to the ground (0V) reference of the power supply.

Working principle of ESP8266

The ESP8266 is not a sensor itself, but rather a Wi-Fi module with a microcontroller that can be used to interface with various sensors. The ESP8266 module enables communication with other devices and the internet, making it a popular choice for IoT (Internet of Things) applications. To understand the working of an ESP8266 module with a sensor, let's consider a basic example using a temperature sensor:

1. Hardware Setup:

- Connect the temperature sensor (e.g., DHT11, DHT22, DS18B20, etc.) to one of the GPIO pins of the ESP8266 module.

- Power the ESP8266 module using an appropriate power supply (usually 3.3V) and connect its ground (GND) pin to the common ground of the sensor.

2. Software Setup:

- Program the ESP8266 module using Arduino IDE or other programming environments, depending on the firmware you choose.

- Install necessary libraries to communicate with the temperature sensor. For example, for the DHT11 or DHT22 sensor, you'll need the DHT sensor library.

3. Data Acquisition and Processing:

- In the firmware, read data from the temperature sensor connected to the GPIO pin.

- Process the sensor data (if needed) to convert it into meaningful temperature values, depending on the sensor used.

4. Communication:

- The ESP8266 module has built-in Wi-Fi capabilities, allowing it to connect to your Wi-Fi network or act as an access point (AP) for other devices to connect to it.

- Establish a Wi-Fi connection and, if required, connect to a cloud service or web server.

- Send the acquired temperature data to the cloud service, web server, or other devices via HTTP, MQTT, or other communication protocols.

5. Data Display or Analysis:

- If you're using a cloud service, the temperature data can be stored and accessed from anywhere with an internet connection.

- You can also configure the ESP8266 to control actuators based on the temperature readings, such as turning on a fan or heater.

Applications of ESP8266

1. **Wi-Fi Connectivity:** Utilize the built-in Wi-Fi capabilities of the ESP8266 to connect to your local network or create an access point. You can build applications that interact with web services, send/receive data, or control devices remotely over Wi-Fi.
2. **Internet of Things (IoT) Projects:** Develop IoT projects by connecting sensors, actuators, and other devices to the ESP8266. You can build smart home systems, environmental monitoring devices, home automation solutions, and more.
3. **Web Server:** Use the ESP8266 to create a web server that serves web pages or an API for controlling connected devices. You can build a simple web interface to monitor and control your projects through a browser.
4. **Home Automation:** It can be utilized to control lights, appliances, and other devices remotely via Wi-Fi, enabling home automation and smart home solutions.
5. **Industrial Automation:** In industrial settings, the ESP8266 can be integrated into machinery and systems to enable remote monitoring and control.

4.2 The DHT22

The DHT22 sensor incorporates a thermistor, a type of temperature-sensitive resistor. The thermistor's resistance changes with temperature variations.

The DHT22 sensor is connected to a microcontroller or other compatible devices through a digital interface. The DHT22 sensor uses a single-wire communication protocol called "one-wire" or "single-bus" protocol. The microcontroller sends a start signal to initiate communication with the sensor, and the sensor responds with the data.

The DHT22 sensor communicates data using timing-based signals. It sends a series of pulses with varying durations to represent binary values (0 or 1).

Once the microcontroller receives the data from the DHT22 sensor, it interprets the timing-based signals and extracts the temperature and humidity values.

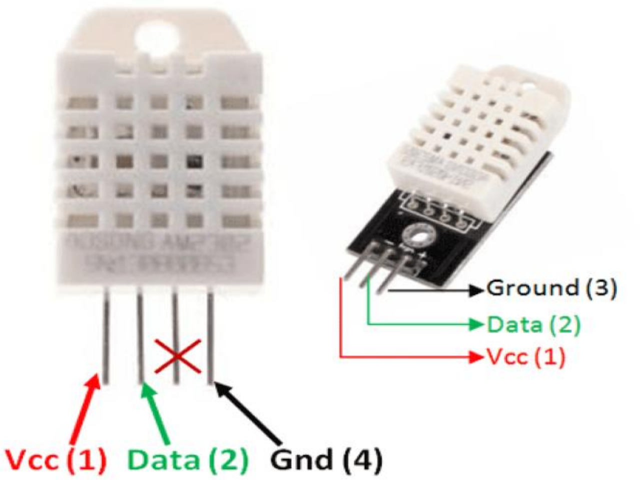

Fig:4.3 DHT22 sensor

Pin configuration of DHT22

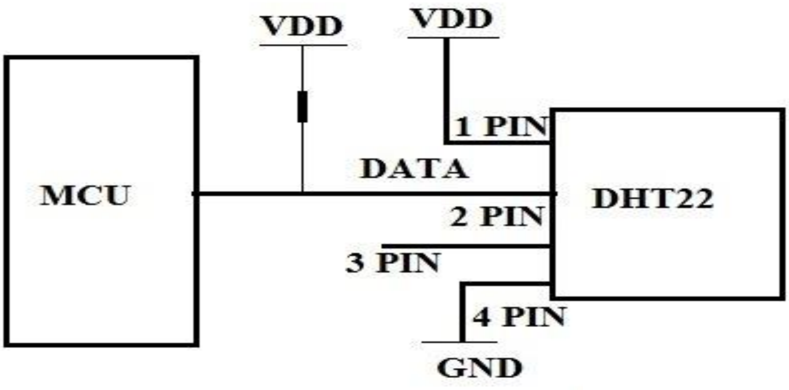

Fig 4.4 Pin Configuration DHT22 Sensor

VCC pin supplies power for the sensor. Although supply voltage ranges from 3.3V to 5.5V, 5V supply is recommended.

Data pin is used to communication between the sensor and the microcontroller.

NC Not connected.

Ground should be connected to the ground of the microcontroller that you are using.

Working Principle of DHT 22Sensor

The DHT22 sensor, also known as AM2302, is a digital humidity and temperature sensor that combines a humidity sensor and a thermistor (temperature sensor) in a single package. It operates based on the principle of capacitance and utilizes a digital signal to communicate with microcontrollers or other devices.

Here's a step-by-step explanation of how the DHT22 sensor works:

1. Sensing Element: The DHT22 contains a humidity sensing element and a thermistor. The humidity sensing element measures the moisture in the air, while the thermistor measures the ambient temperature.

2. Capacitive Humidity Measurement: The humidity sensing element is based on a capacitive humidity sensor. It consists of a thin polymer layer that absorbs water molecules from the surrounding air. As the water content in the polymer layer changes with the humidity level, the capacitance of the sensor also changes.

3. Temperature Measurement: The thermistor, a type of temperature-sensitive resistor, is used to measure the temperature. The electrical resistance of the thermistor changes with temperature variations.

4. Analog-to-Digital Conversion: Inside the DHT22 sensor, an analog-to-digital converter (ADC) is used to convert the analog signals from the humidity sensor and thermistor into digital values.

5. Signal Processing: The sensor's internal microcontroller processes the digital values from the ADC and compensates for any temperature influence on the humidity readings, providing accurate humidity and temperature values.

6. Digital Signal Output: The DHT22 communicates with external devices (such as microcontrollers or Arduino boards) through a single-wire digital interface. It sends data in the form of a series of digital pulses.

7. Timing Protocol: To initiate communication with the sensor, the external device sends a start signal to the DHT22. The sensor responds by transmitting the data in a time-protocol format.

8. Data Transmission: The DHT22 transmits the humidity and temperature data in 40-bit binary format. The first 16 bits represent the humidity value, the next 16 bits represent the temperature value, and the remaining 8 bits are used for checksum verification.

9. Checksum Verification: The sensor sends a checksum value along with the data to ensure data integrity. The receiving device calculates its own checksum from the received data and verifies it against the transmitted checksum. If they match, the data is considered valid.

10. Readout by External Device: The external device receives the digital data and decodes it to obtain the humidity and temperature values, which can then be used for various applications, as described in the previous answer. It's essential to note that during operation, the DHT22 requires a specific timing and protocol for communication with the external device. If the timing is not precisely followed, the sensor might fail to provide accurate readings. Therefore, when interfacing with the DHT22, it's crucial to adhere to the timing requirements specified in the datasheet or manufacturer's guidelines.

Applications of DHT Sensor

The DHT22 is a popular digital humidity and temperature sensor used in various applications for measuring ambient humidity and temperature levels. It is also known as the AM2302. Here are some common applications of the DHT22 sensor:

1. Weather Stations: DHT22 is commonly used in weather stations to monitor and record temperature and humidity data. Weather enthusiasts and hobbyists often build their weather monitoring systems using this sensor.

2. Home Automation: DHT22 sensors can be integrated into home automation systems to trigger various actions based on temperature and humidity levels. For instance, turning on fans or air conditioners when the temperature rises or activating humidifiers when the humidity drops.

3. Data Logging and Analysis: The DHT22 sensor can be used in combination with microcontrollers and data loggers to record temperature and humidity data over time. This data can be analysed to study patterns and trends.

4. Industrial Automation: In industrial settings, the DHT22 can be used for monitoring environmental conditions to ensure proper working conditions for equipment or products that are sensitive to temperature and humidity.

5. Agriculture: In agricultural applications, the DHT22 sensor is utilized to monitor humidity and temperature levels in soil or inside greenhouses to optimize crop growth conditions.

6. IoT (Internet of Things) Projects: DHT22 is commonly used in IoT projects for monitoring and transmitting environmental data to cloud platforms for analysis and visualization.

4.3 MAX30100 Oximeter

The MAX30100 emits both red and infrared light from its LEDs into the tissue or blood vessels. These wavelengths are chosen because they can be absorbed differently by oxygenated and deoxygenated haemoglobin in the blood.

The emitted light passes through the tissue and reaches the photodetector. As the light passes through the blood vessels, some of it gets absorbed by the haemoglobin in the blood.

The analog signal from the photodetector is processed by the MAX30100's built-in digital signal processing circuitry. This circuitry filters, amplifies, and converts the analog signal to a digital form for further analysis.

The MAX30100 uses algorithms to analyze the intensity of the red and infrared light and calculates the oxygen saturation (SpO2) level. This calculation is based on the differences in light absorption by oxygenated and deoxygenated hemoglobin.

Heart Rate Monitoring: In addition to measuring SpO2, the MAX30100 also calculates the heart rate. It does this by analyzing the variations in the photodetector's signal caused by the pulsatile blood flow as the heart beats. The MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor module. It combines two main components: an optical sensor and an analog-to-digital converter (ADC).

Fig 4.5 MAX30100 Oximeter

Pin configuration of MAX30100

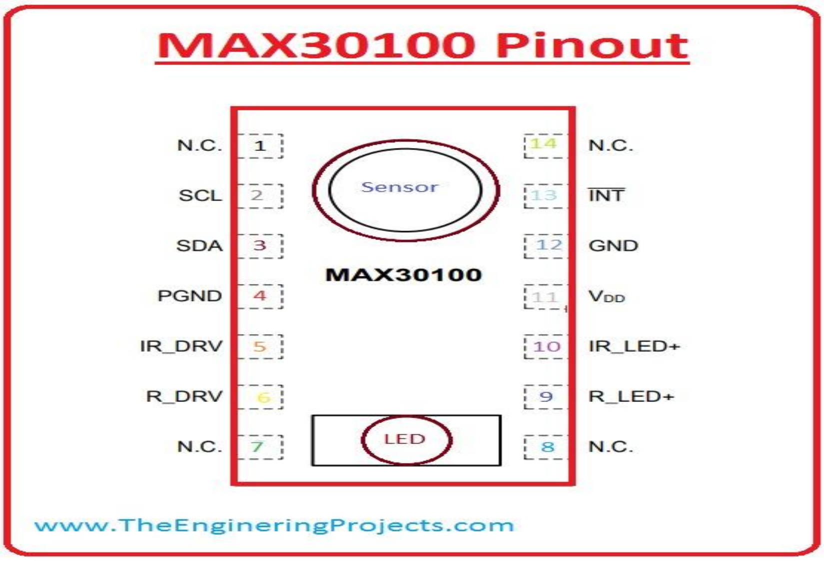

Fig 4.6 Pin Configuration of MAX30100 Oximeter

VCC: This pin is used to power the MAX30100 sensor module. It requires a stable power supply of 3.3V.

SCL (I2C Clock): The Serial Clock Line is used for I2C communication. It synchronizes data transfer between the MAX30100 and the microcontroller.

SDA (I2C Data): The Serial Data Line is used for I2C communication. It carries data between the MAX30100 and the microcontroller.

INT (Interrupt): The Interrupt pin is an output pin from the MAX30100 to the microcontroller. It signals when data is available or when an interrupt condition occurs (e.g., heart-rate measurement complete).

Working principle of MAX30100

1. Optical Sensor: The MAX30100 module utilizes an optical sensor to measure the absorption of light by the blood vessels in the body. It emits two types of light: red and infrared. The emitted light passes through a body part (typically a finger or earlobe) and is detected by the sensor.

2. Photodetectors: The sensor contains two photodetectors, one for the red light and another for the infrared light. These photodetectors convert the received light into electrical signals.

3. Reflection and Absorption: When the emitted light passes through the body part, some of it is absorbed by the blood vessels and surrounding tissue, while the rest is reflected back to the photodetectors. The ratio of absorbed to reflected light provides information about the oxygen saturation level in the blood and the heart rate.

4. Analog-to-Digital Conversion: The analog electrical signals from the photodetectors are converted into digital values using an analog-to-digital converter (ADC) within the MAX30100 module. The ADC samples the analog signals at a high rate, typically in the range of tens to hundreds of samples per second.

5. Signal Processing: The digital signals obtained from the ADC undergo various signal processing techniques to filter out noise and extract the desired physiological information. Algorithms are used to analyze the signal characteristics, such as peaks and troughs, to calculate the heart rate and estimate oxygen saturation levels.

6. Communication Interface: The MAX30100 module has a built-in communication interface, typically I2C or SPI, which allows it to communicate with microcontrollers or other devices. This interface is used to configure the sensor settings, initiate measurements, and retrieve the processed data.

7. Output Data: The processed data, including heart rate and oxygen saturation measurements can be read from the MAX30100 module through the communication interface. The data can then be used for various applications, such as health monitoring, fitness tracking, and medical diagnostics.

8. It's important to note that the MAX30100 is a highly integrated module that simplifies the implementation of pulse oximetry and heart-rate monitoring. It provides a convenient and accurate solution for non-invasive measurement of vital signs, making it suitable for a range of applications in healthcare, wearable devices, and fitness tracking.

Applications of MAX30100

1.Wearable Health and Fitness Devices: The MAX30100 can be used in fitness trackers, smartwatches, and other wearable devices to monitor heart rate and blood oxygen levels during physical activities.

2.Medical Monitoring Devices: It can be integrated into medical devices for continuous monitoring of vital signs, especially for patients with respiratory or cardiovascular conditions.

3.Pulse Oximeters: The MAX30100 is commonly used in standalone pulse oximeters to measure blood oxygen saturation (SpO2) non-invasively.

4.Healthcare and Hospital Settings: In healthcare facilities, the MAX30100 can be used for spot-checking vital signs or for continuous monitoring of patients.

5.Sleep Monitoring: The sensor can be utilized in sleep-tracking devices to monitor heart rate and blood oxygen levels during sleep, providing insights into sleep quality and potential sleep disorders.

6.Stress Monitoring: It can be used to monitor stress levels by measuring heart rate variability (HRV).

4.4 DS18B20

Each DS18B20 sensor has a unique 64-bit address burned into its memory during manufacturing. This address is used to identify and communicate with the sensor in a multi-sensor network. The DS18B20 sensor uses the 1-Wire communication protocol, which allows multiple sensors to be connected to a single data line. The data line is bidirectional and requires a pull-up resistor to the power supply voltage.

To measure temperature, the DS18B20 sensor internally performs an analog-to-digital conversion. It uses an integrated analog-to-digital converter (ADC) to convert the analog voltage from the temperature sensing element into a digital value. The DS18B20 sensor has a parasitic power mode, where it can draw power from the data line instead of a separate power supply line. This mode simplifies the wiring by requiring only two connections (data and ground) instead of three (data, power, and ground).

To read the temperature, the controller (such as a microcontroller or a computer) initiates communication with the DS18B20 sensor using the 1-Wire protocol. It sends specific commands to the sensor to start a temperature conversion.

The DS18B20 sensor responds by transmitting the temperature data over the 1-Wire data line. The temperature reading is sent as a sequence of bits, with the least significant bit (LSB) transmitted first.

The DS18B20 is a digital temperature sensor that operates using the Dallas Semiconductor 1-Wire protocol. It is commonly used in various applications that require accurate temperature measurements.

Fig 4.8 DS18B20 Temperature Sensor

Pin configuration of DS18B20

Fig:4.7 pin configuration of DS18B20

VCC: This pin is used to provide power to the DS18B20 sensor. It requires a power supply in the range of 3.0V to 5.5V.

DQ (Data/1-Wire): This is the data pin used for communication with the sensor. The DS18B20 sensor uses the one-wire protocol, which allows multiple DS18B20 sensors to be connected to the same data bus. Each sensor has a unique 64-bit ROM code, allowing individual sensors to be addressed on the same data line.

GND: This pin is connected to the ground (0V) reference of the power supply.

Working principle of DS18B20

1. Sensor Configuration: The DS18B20 is a digital sensor that consists of a temperature sensor, an analog-to-digital converter, and a 1-Wire interface. Each DS18B20 sensor has a unique 64-bit ROM code that serves as its device identifier.

2. Power Supply: The DS18B20 can be powered using the same 1-Wire interface that is used for communication. It can be operated with a power supply ranging from 3.0V to 5.5V.

3. 1-Wire Interface: The DS18B20 uses the Dallas Semiconductor 1-Wire protocol, which allows multiple devices to be connected to a single data line. Each DS18B20 sensor is connected to a 1-Wire bus, which consists of a data line, ground, and power supply

4. Temperature Conversion: To measure temperature, the DS18B20 initiates a temperature conversion. This is done by sending a command over the 1-Wire bus from the master device (e.g., microcontroller or computer) to the DS18B20 sensor.

5. Temperature Reading: Once the temperature conversion is complete, the DS18B20 sensor stores the temperature value in its internal registers. The master device then sends a series of commands to read the temperature value from the DS18B20.

6. 12-Bit Resolution: The DS18B20 provides a temperature resolution of 12 bits, allowing for high accuracy temperature measurements. The temperature value is represented in a digital format, and the master device can convert it to a temperature value in Celsius, Fahrenheit, or Kelvin.

7. Parasitic Power Mode (Optional): The DS18B20 also has a parasitic power mode, where it can draw power solely from the 1-Wire bus without an additional power supply connection. In this mode, the data line is used for both communication and power.

Overall, the DS18B20 operates by converting temperature to a digital value, storing it internally, and allowing the master device to retrieve the temperature reading through the 1-Wire interface. Its simplicity, accuracy, and compatibility with the 1-Wire protocol make it a popular choice for temperature sensing in various applications.

Applications of DS18B20

1.Temperature Monitoring and Control: The DS18B20 is often used for temperature monitoring and control in various applications, including home automation systems, industrial processes, and climate control in buildings.

2.Weather Stations: It can be integrated into weather stations to measure outdoor and indoor temperatures accurately.

3.HVAC Systems: The DS18B20 is used in heating, ventilation, and air conditioning (HVAC) systems to monitor temperatures and adjust the system's operation accordingly for energy efficiency.

4.Smart Thermostats: It is commonly used in smart thermostats to regulate heating and cooling systems based on temperature readings and user preferences.

5.Data Logging: The DS18B20 can be used in data logging applications to record temperature data over time for analysis and monitoring.

CHAPTER 5

SOFTWARE REQUIED

5.1 Arduino IDE

The Arduino IDE (Integrated Development Environment) is an open-source software platform used for programming Arduino microcontrollers. It provides a user-friendly interface and a set of tools for writing, compiling, and uploading code to Arduino boards

Writing and Editing Code: The Arduino IDE provides a text editor where you can write and edit your Arduino code. The code is written in the Arduino programming language, which is based on C/C++. The editor includes features like syntax highlighting, auto-completion, and code snippets to assist with code development.

Libraries: Arduino IDE has a library manager that allows you to easily install and manage libraries. Libraries contain pre-written code that provides additional functionalities and

simplifies complex tasks. The library manager enables you to search for and install libraries directly from within the IDE.

Compiling: Once you have written your code, you can compile it by clicking the "Verify" button. The Arduino IDE will check the syntax of your code and convert it into machine-readable instructions for the Arduino board.

Uploading Code: After successful compilation, you can upload the compiled code to the Arduino board using a USB connection. Select the correct board and port from the "Tools" menu, then click the "Upload" button. The IDE will transfer the compiled code to the Arduino board, making it ready for execution.

Serial Monitor: The Arduino IDE includes a Serial Monitor tool that allows you to communicate with your Arduino board through the serial port. It displays data sent by the Arduino board and allows you to send data back for debugging or interaction.

CHAPTER 6

DESIGN AND IMPLEMENTATION

Fig 6.1 shows the circuit diagram of the proposed model. Here, ESP8266 development board is connected to MAX30100 sensors as shown in the Fig 6.1.

DHT22 is connected to ESP8266, by the help of Adafruit dht22 libraries.

DS18B20 is connected to ESP8266, by the help of libraries.

Here, 4.7 kΩ resistor is connected in between BS18B20 and ESP8266.

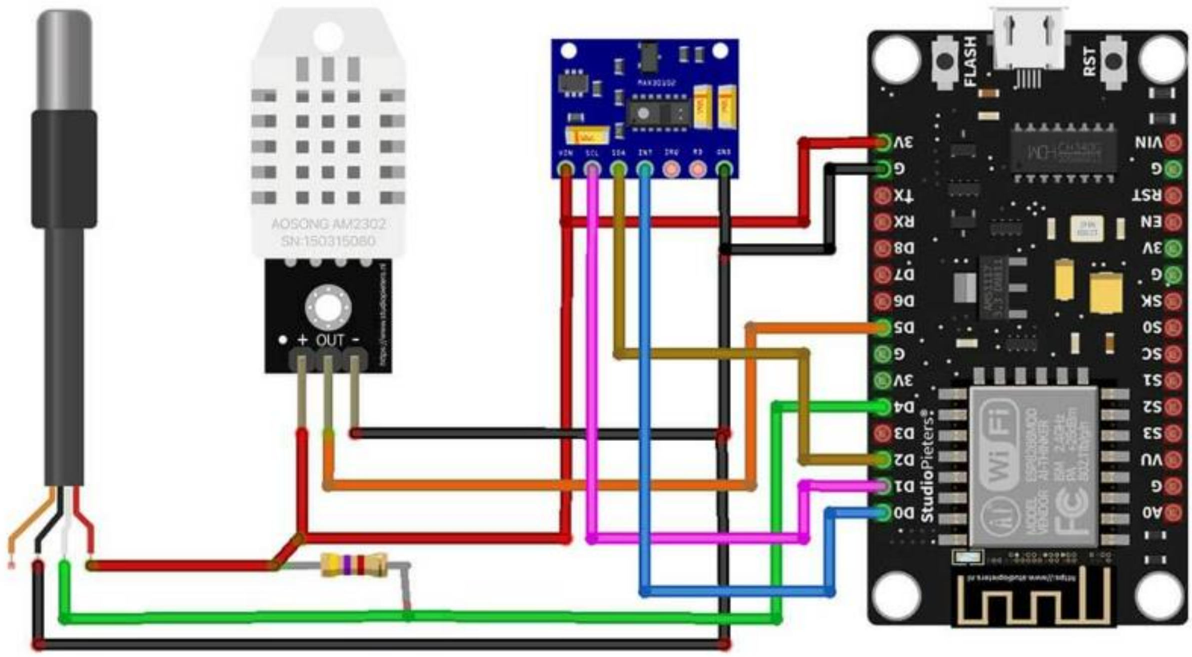

Fig 6.1 Circuit Diagram

Table 6.1, 6.2 and 6.3 describes the pin connections between NodeMCU ESP8266 and the sensor.

MAX30100 Pins	NodeMCU ESP8266 Pins
SDA	D2
SCL	D1
INT	D0
VCC	3.3V
GND	GND

Table 6.1 Pin connections between
ESP8266 and MAX30100

DS18B20 Pins	NodeMCU ESP8266 Pins
VCC	3.3V
GND	GND
Signal	D4

Table 6.2 Pin connections between
ESP8266 and DS18B20

DHT22 Pins	NodeMCU ESP8266 Pins
VCC	3.3V
GND	GND
Signal	D5

Table 6.3 Pin connections between
ESP8266 and DHT22

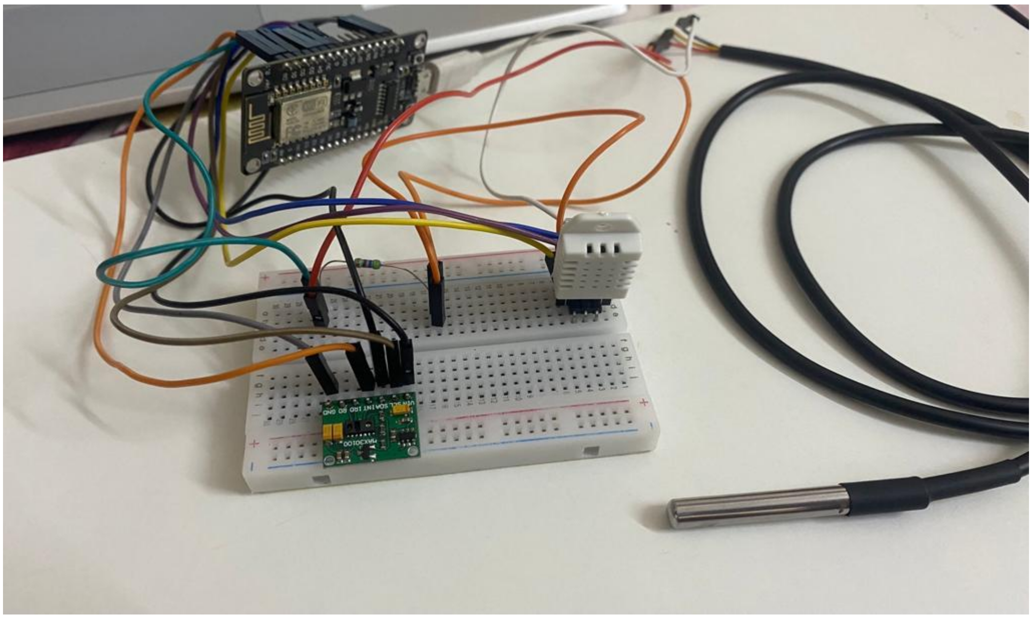

Fig 6.2 Implementation(a)

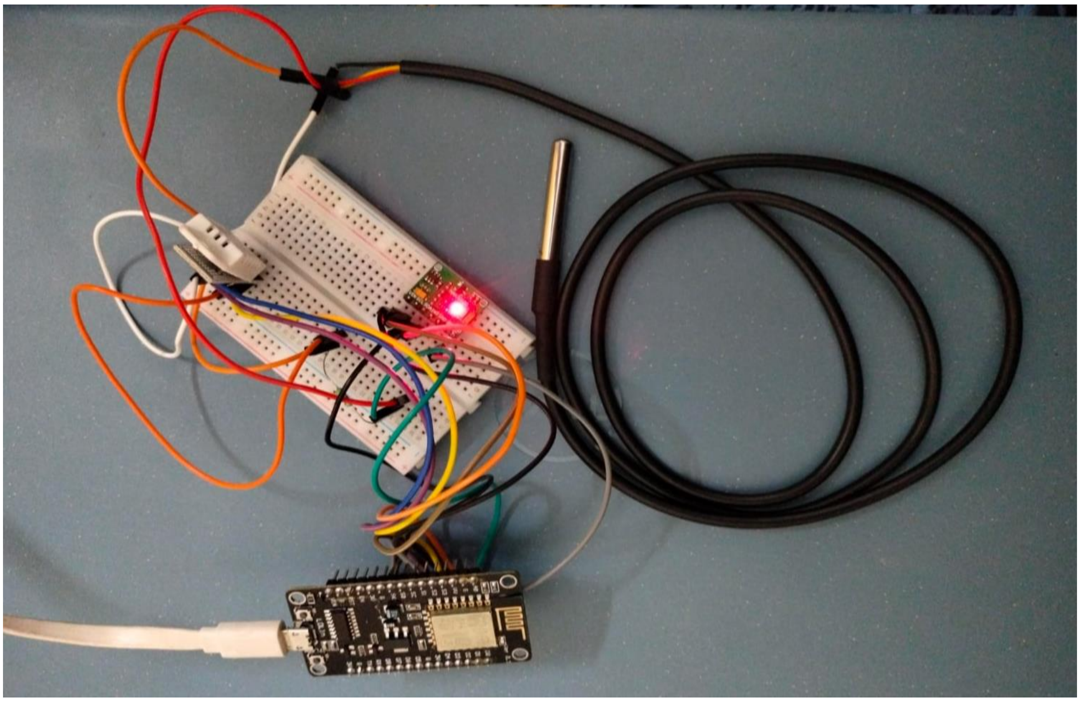

Fig 6.3 Implementation(b)

CHAPTER 7

RESULT AND DISCUSSION

Once the code is uploaded to your NodeMCU ESP8266 board, you can open the serial monitor to see the program into action. The NodeMCU ESP8266 will connect to your Wi-Fi Network. Once connected, it will display the ESP8266 IP Address.

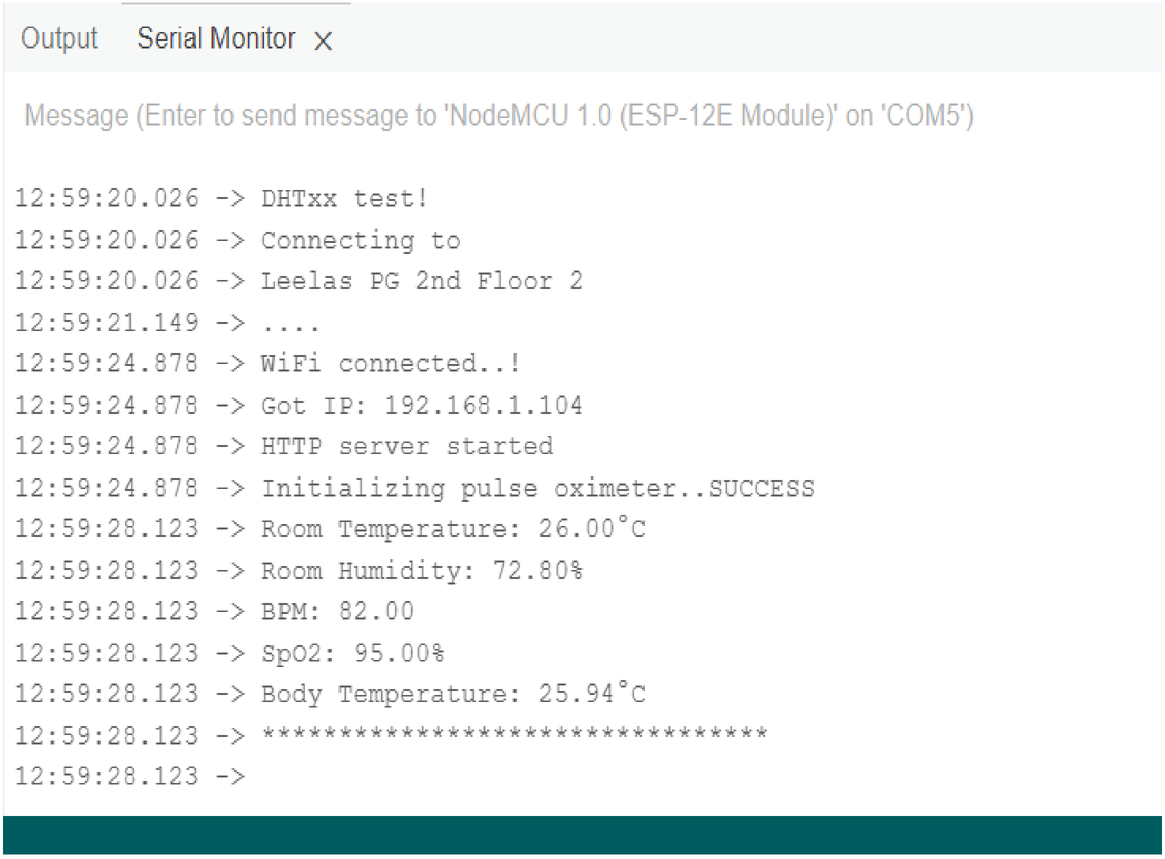

Fig 7.1 Output in Serial Monitor

Now, copy the ESP8266 IP Address and paste it on your Web Browser. It will display the room temperature, room humidity, Heart Rate, Blood Oxygen Level, and body temperature, etc., as shown in the images below. Similarly, you can monitor your patient's health from any device that features browsing capability. You simply need to copy the IP Address and paste it on the browser of any device.

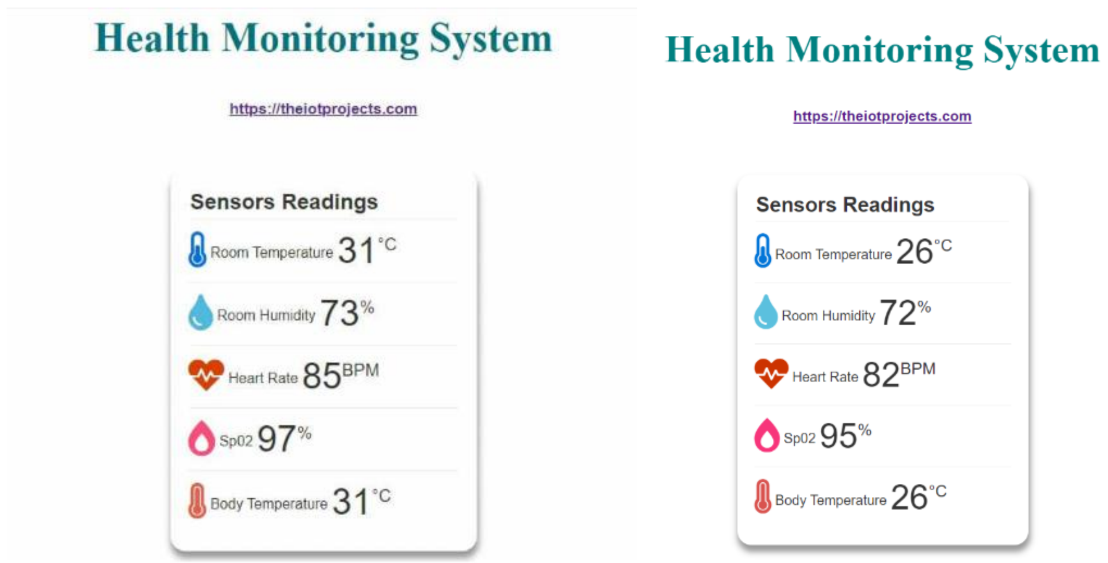

Fig 7.2 Web Browser

CHAPTER 8

APPLICATIONS OF THE BODY MONITORING SYSTEM

1. Preventing the heart attack and high blood pressure of the diver.
2. Helps to collect real-time health-related data effortlessly.
3. The body parameters of the diver are monitored continuously.
4. Body monitoring systems have a wide range of applications across various fields, including healthcare, sports and fitness, research, and personal well-being. Here are some notable applications of body monitoring systems:
5. Body monitoring systems are used in healthcare settings to monitor patients' vital signs, track specific health conditions, and provide real-time data to healthcare professionals. These systems can monitor heart rate, blood pressure, body temperature, oxygen saturation levels, and respiratory rate. They are especially useful for remote patient monitoring, chronic disease management, and post-operative care.
6. Body monitoring systems play a crucial role in tracking and optimizing physical performance. Athletes and fitness enthusiasts use wearable devices to monitor their heart rate, calorie expenditure, sleep patterns, and activity levels. This data helps individuals make informed decisions about their training programs, set goals, and track their progress.
7. Body monitoring systems are employed to monitor and analyze sleep patterns, including sleep duration, sleep stages, and sleep quality. By tracking sleep parameters, individuals can gain insights into their sleep habits, identify sleep disorders, and make adjustments to improve their overall sleep health.
8. Some body monitoring systems measure physiological parameters like heart rate variability (HRV) to assess an individual's stress levels. HRV monitoring can help individuals identify patterns and triggers related to stress and develop strategies for stress management and relaxation.
9. Body monitoring systems are extensively used in research studies to collect data on physiological responses, activity levels, and sleep patterns. These systems aid researchers in studying human behavior, health outcomes, and the impact of interventions or treatments.
10. Body monitoring systems provide individuals with personalized data about their health and well-being, empowering them to make informed decisions about their lifestyle choices.

They can track physical activity, nutrition, stress levels, and overall wellness parameters, helping individuals optimize their health and adopt healthier habits.

11. Body monitoring systems can assist in monitoring the health and well-being of elderly individuals, especially those living independently. These systems can detect falls, monitor vital signs, and alert caregivers or emergency services in case of emergencies or sudden health events.
12. Body monitoring systems find applications in occupational settings to monitor workers' health and safety. They can track physiological parameters, assess fatigue levels, monitor exposure to hazardous substances, and provide early warning systems for potential health risks in high-risk industries such as mining, construction, and manufacturing.
13. These applications highlight the versatility and potential benefits of body monitoring systems in various aspects of life, promoting proactive health management, performance optimization, and well-being.

FUTURE SCOPE

The future scope of underwater monitoring systems is vast and holds great potential for advancements in various areas. Here are some potential areas of growth and development:

1. Environmental Monitoring: Underwater monitoring systems can be utilized to continuously monitor and assess the health of marine ecosystems, including water quality, temperature, salinity, pH levels, and pollution levels. These systems can help detect changes in marine biodiversity, identify harmful algal blooms, monitor coral reef health, and track the impact of climate change on underwater environments.

2. Oceanographic Research: Underwater monitoring systems can aid in advancing our understanding of the oceans and their complex processes. They can be used to collect data on ocean currents, tides, waves, and underwater acoustics. These systems enable scientists to study the interactions between physical, chemical, and biological aspects of the marine environment, contributing to climate research, oceanography, and marine ecology.

3. Underwater Energy Infrastructure Monitoring: With the increasing development of offshore wind farms, tidal energy projects, and underwater power cables, there is a growing need for efficient monitoring systems to ensure the safety, stability, and optimal performance of these installations. Underwater monitoring systems can provide real-time data on structural integrity, corrosion levels, power transmission, and environmental impacts, facilitating preventive maintenance and early detection of potential issues.

4. Underwater Security and Defense: Underwater monitoring systems can play a crucial role in enhancing security and defense capabilities in maritime environments. These systems can be used to detect and track underwater threats such as submarines, mines, and unauthorized underwater activities. They can also assist in monitoring and protecting critical underwater infrastructure, ports, and coastlines.

5. Underwater Communication Networks: Developing robust and efficient communication networks underwater is a significant challenge. Future underwater monitoring systems may focus on improving underwater communication capabilities, enabling faster data transmission, and enhancing connectivity between underwater vehicles, sensors, and surface stations. This can facilitate real-time monitoring, data sharing, and remote control of underwater operations.

6. Underwater Archaeology and Exploration: Underwater monitoring systems are vital for archaeological research and exploration of submerged cultural heritage sites. These systems can capture high-resolution images, map underwater structures, and provide valuable data for the preservation and study of underwater archaeological sites, shipwrecks, and ancient civilizations.

7. Deep-Sea Exploration: The exploration of the deep sea and its unique ecosystems remains largely unexplored. Future underwater monitoring systems may focus on advancements in deep-sea technologies, including improved pressure-resistant sensors, high-resolution imaging systems, and autonomous vehicles capable of operating at extreme depths. These systems can help uncover new species, geological features, and further our understanding of the deep-sea environment.

8. Underwater Robotics and Autonomy: The development of more advanced and intelligent underwater robotic systems can revolutionize underwater monitoring. Future systems may incorporate artificial intelligence, machine learning, and advanced autonomy to enable underwater robots to perform complex tasks, adapt to changing environments, and make independent decisions based on real-time data.

As technology continues to advance, the future scope of underwater monitoring systems holds great potential for expanding our knowledge of the underwater world, protecting marine ecosystems, improving industrial operations, and enhancing security and defense capabilities in underwater environments.

CONCLUSION

These systems combine advanced technologies such as sensors, data transmission, and analytics to collect real-time data on various parameters that affect the health of underwater ecosystems and organisms.

This ability to collect data over extended periods provides a more comprehensive understanding of the dynamics and changes occurring underwater. Enables divers to be safe and sound in underwater conditions, underwater health monitoring systems offer high precision and accuracy in data collection, allowing for the detection of subtle changes and abnormalities. This enables early detection of potential threats to underwater ecosystems, such as pollution, and temperature changes.

Monitoring systems play a vital role in environmental monitoring, oceanographic research, energy infrastructure maintenance, security and defense, communication networks, archaeology, and deep-sea exploration. They enable real-time data collection, analysis, and remote control, providing valuable insights into underwater ecosystems, maintaining the integrity of infrastructure, ensuring safety and security, and advancing scientific knowledge. As technology continues to evolve, the future of underwater monitoring systems holds immense potential for further advancements, leading to enhanced capabilities in monitoring, exploration, and preservation of the underwater environment. These advancements will contribute to our understanding of the oceans, facilitate sustainable resource management, and support various industries that rely on underwater operations. Overall, underwater monitoring systems are essential tools that enable us to unlock the mysteries of the underwater world and leverage its resources responsibly for the benefit of humanity and the environment.

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