

Distributed WSN SHM with RF Wake-Adaptive Sleep Energy Saving & Artificial Intelligence Based Fatigue/Threat Perception with Early Warning System

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Abstract— As technology is emerging, & with the advent of secure wireless digital communication protocols such as digital communication protocols such as wifi (IEEE 802.11), The Trend of using wireless devices is gaining wide momentum of Using wired devices Sensor Network are also going popularity & are using latest wireless technologies. Use of wireless sensor networks (WSN) for structural Health monitoring is a promising avenue due to low maintain & easy deployability, but simultaneously deploying wireless sensors has addition challenges such as energy efficiency due to their essentially battery operated nature, battery life scarce bandwidth allocation & security concerns. This work is aimed at development a hierarchical wireless sensor network with intelligent energy conservation techniques employing multiple sleep modes with full wakeup & partial wakeup.

Also other challenge is analysis of huge data collected by widely deployed wireless sensor networks, thus this work incorporates usage of artificial intelligence for processing of sensor data. Innovative methods have been deployed to process neural network results, to obtain structural health prediction, immediate structural threat & cumulative structural fatigue.

Index Terms— Hierarchical WSN, Structural Health Monitoring, Artificial Intelligence Structural Prediction, Multi Sleep Modes.

I. INTRODUCTION

As an alternative to existing wired networks, wireless sensor networks (WSNs) have become an increasingly compelling platform for Structural Health Monitoring (SHM) due to their relatively low cost, easy installation and so on. However, there is still an untreated challenge: application reliability for fault detection and tolerance. Reliability is also affected by reduced monitoring quality when mitigating WSN limitations (for example, limited power, narrow bandwidth). We deal with these by designing a reliable WSN distributed framework for SHM (called Depend SHM) and then checking their ability to handle sensor errors and limitations. We find evidence that faulty sensors can spoil the results of a health event (for example, damage) in a structural system without being detected. More specifically, we draw attention to an

undiscovered but interesting fact, that is, the true measured signals provided by one or more faulty sensors may cause a damaged location to be identified as damaged (false positive) or a damaged location as undamaged (negative). This can be caused by sensor connectivity errors, accuracy degradation, amplification gain, bias, deviation, noise, etc. At Depend SHM, we offer a distributed automated algorithm to detect such types of errors, and we offer an algorithm for reconstructing the signal online to recover it from the faulty diagnosis. Through comprehensive simulations and the implementation of the typical WSN system, we evaluate the effectiveness of Depend SHM.

II. OBJECTIVES OF STUDY

[1] Design & Development of a multi protocol, energy efficient, Structural Health Monitoring system using Distributed Wireless Sensor Network.

[2] The proposed system shall be supportive of multiple protocols for wireless communications such as Zigbee, Z-Wave, WiFi (802.11.4), along with long distance protocols such as LORA WAN.

[3] Exploration of probability of powering of WSN Node's by harvesting energy from the surrounding by means of Photovoltaic or Thermal Gradient & Piezo Electric Force Effects.

[4] Implementation of multiple sleep modes, with various power/energy requirements, variable data acquisition & transmission rates, along with RF Interrupt/Internal Timer or Sensor Event based wakeup, to conserve energy & enhance battery life.

[5] Integration of the above system implemented as Embedded System using 8-bit microcontroller as Slave & MATLAB server acting as Master Node, for coordinated multi sensor data collection, plotting & data logging solution.

[6] Usage of advanced Machine Intelligence or Artificial Intelligence algorithms along with high performance clustering algorithms to interpret Structural data, predict fatigues & breakdowns, & correlate with seismic & weather data.

[7] Integration of GPS with the existing setup may enhance the understanding of micro weather & micro seismology phenomenon & its role in structural integrity & safety.

[8] Implementation of an Early warning system with elaborate detailing & user alarming using E- Mail/SMS notification along with accurate information armed with GPS

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III. EXISTING TECHNIQUES

In this paper, we proposed a dependable WSN-based SHM scheme, Depend SHM, by making the best use of resource-constrained WSNs for SHM and incorporating requirements of both engineering and computer science domains. Depend SHM includes two complementary algorithms for sensor fault detection and faulty sensor's signal reconstruction. It is able to provide the quality of SHM in the presence of sensor faults automatically, which does not need any network maintenance for the fault detection and recovery, and does not consume significant WSN resources for the recovery. In the future, we plan to study decentralized computing architectures in WSNs, which can be integrated by the computing system issues and structural engineering system techniques in conjunction. Such an architecture is highly expected to reduce data traffic for data-intensive SHM and energy cost in WSNs [1]

The ability to monitor the health of complex structures such as aeronautic or civil engineering structures in real time is becoming increasingly important. This process is referred to as structural health monitoring (SHM) and relies on onboard platforms comprising sensors, computational units, communication resources, and sometimes actuators. Many of such platforms have been developed within the last years but there is still a lack of structuration and knowledge exchange regarding the software and hardware architectures of such platforms. The aim of the present paper is to introduce an open hardware and open software platform dedicated to SHM within the fields of aeronautics and civil engineering. The platform presented here will be made available in an open hardware and open source framework to allow SHM researchers to run concurrent detection, localization, classification or quantification algorithms using simple interpreted languages such as Python.[2]

Today, BIM adoption and implementation is the main challenge with several social implications which require optimized work processes. At the same time, research is trying to figure out new solutions in order to optimize the management of built heritage. The management processes enabled by new innovative studies and advanced technologies are changing various operational procedures related to the generation of Building Information Modelling for built heritage. The proposed method addresses social and operational implications of working in a BIM environment, including new shared procedures for different phases: from the survey, cloud sharing, implementation of complex models and specific new structural 3D objects. This paper described a new methodology able to simplify the generative process of a medieval bridge as well as the sharing of related multimedia data into a new repository for structural health monitoring. [3]

This paper surveyed the existing WSN technology that can be used in health care monitoring. The current state of the art technologies were analysed based upon how well they can meet the information requirements laid by the dictatorial authorities. In existing, researchers raised the major social implications like security problem, privacy issues, energy

consumption of sensor nodes and then analysed about the causes and effects of these major issues. This is not a complete list of challenges, but these do constitute some of the major challenges as wireless sensor networks become widespread and move into many other application domains such as agriculture, energy, and transportation. Our survey is about the increase of energy consumption and security among wireless sensor networks and it as a major consideration to implementing the wireless technology in medical field. Based on the disadvantages of existing system this paper planned to overcome those disadvantages especially energy consumption and privacy issues to fulfil the needs of the growing field. Security issues will also be considered in the future work. [4]

The availability of low-cost single-chip microcontrollers, and advances in wireless communication technology has encouraged engineers to design low-cost embedded systems for healthcare monitoring applications. Such systems have ability to process real-time signals generated from bio sensors and transmit the measured signals through the patient's phone to the medical center's server. In future we aim to improve the hardware of the Ambo Bot to more exible structure such as unidirectional. We also consider improve the system from robot to multiple robots for collaborative performance. We even consider equipping the current mobile robot, with a drone robot partner which can fly in collaboration with the current system for faster performance in addition for operation in higher elevations. [5]

The security is very important in monitoring of healthcare which may provide by wireless sensor network. Wireless sensor networks make patients' life more comfortable and provide viable solutions. So it is an emerging research topic and it is worth studying. This paper provides study of health WSNs. This paper presents the design& implementation of healthcare monitoring system using WSN with GSM modem. A test bed is constructed to test the performance of Health Care Monitoring where sensor node measures blood pressure, Electrocardiogram, heart rate, temperature & Respiration. [6]

The potential benefits by deployment of Wireless sensor networks in healthcare applications are easy access of updated patient data at any time and from anywhere. It is wearable, portable, web based, real time system. Immediate response to emergency situations, provision of high quality healthcare with low cost individual health monitoring system. The system offers great conveniences to both patients and health care providers. This demonstrates an intelligent system for mobile health monitoring. Smart sensors offer the promise of significant advances in medical treatment. Networking multiple smart sensors into an application-specific solution to combat disease is a promising approach, which will require research with a different perspective to resolve an array of novel and challenging problems. [7]

—In this paper, we aim to highlight on the latest technologies and developments in the field of Structural health monitoring (SHM) using Wireless sensor networks (WSNs) in bridge engineering. The need for SHM has become inevitable for broad engineering fields including civil engineering sector. Wireless sensor network technology has widely drawn research interests, which can significantly

improve the flexibility and versatility of SHM by implementing WSN as a vital tool for practical applications in bridge and building. The attention for WSNs has been greatly increased due to their accuracy, low-cost installation, low-cost sensing and capability to process data on-board and thus there is trend to apply the WSN technology to replace traditional wired monitoring systems. Even though, successful SHM applications have been done on some critical civil structures using the WSN technology at the Lab and the field, it is still very limited to be employed for practical implementation in full-scale structures. Therefore, ongoing WSNs applications on full-scale civil structures are still needed to be conducted beside the lab evaluation to finally achieve the desired objective which is the SHM. [8]

In this paper we take a closer look at the decision aggregation problem in distributed sensing systems. Though some efforts have been made towards this problem, the resulting approaches suffer from the limitation of only examining discrete decisions from individual sensor nodes as a way to avoid high energy cost potentially caused by excessive network transmission if raw data from sensor nodes were to be transmitted. Our proposed generalized decision aggregation (GDA) framework overcame this limitation by thoroughly accounting for and intelligently taking advantage of the decision confidence and reliability of each sensor, thus consistently achieving higher final decision accuracy over the state of the art approaches, as we extensively demonstrated through various experiments using both synthetic and

realistic data. We believe our GDA framework's superior generalizability and flexibility make it suitable for a broad spectrum of sensing scenarios. [9]

This paper will present and discuss the approach and the first results of a long-term dynamic monitoring campaign on an offshore wind turbine in the Belgian North Sea. It focuses on the vibration levels and modal parameters of the fundamental modes of the support structure. These parameters are crucial to minimize the operation and maintenance costs and to extend the lifetime of offshore wind turbine structure and mechanical systems. In order to perform a proper continuous monitoring during operation, a fast and reliable solution, applicable on an industrial scale, has been developed. It will be shown that the use of appropriate vibration measurement equipment together with state-of-the-art operational modal analysis techniques can provide accurate estimates of natural frequencies, damping ratios, and mode shapes of offshore wind turbines. [10]

In this project a model of the wireless-sensor based bridge health monitoring system is developed. Sensors and wireless communication protocols have been used to create a Node and data transmissions. ARM7 does the Analog-digital conversion between sensors and ZigBee modules, which are in the form of a single unit called a "Node" that combines all these sensors, an ARM processor, and a ZigBee module. The maximum number of sensors was selected to allow wireless communication stability to be tested. In this study, wireless network was achieved, with low consumption of power. [11]

IV. METHODOLOGY

System Block Diagram:

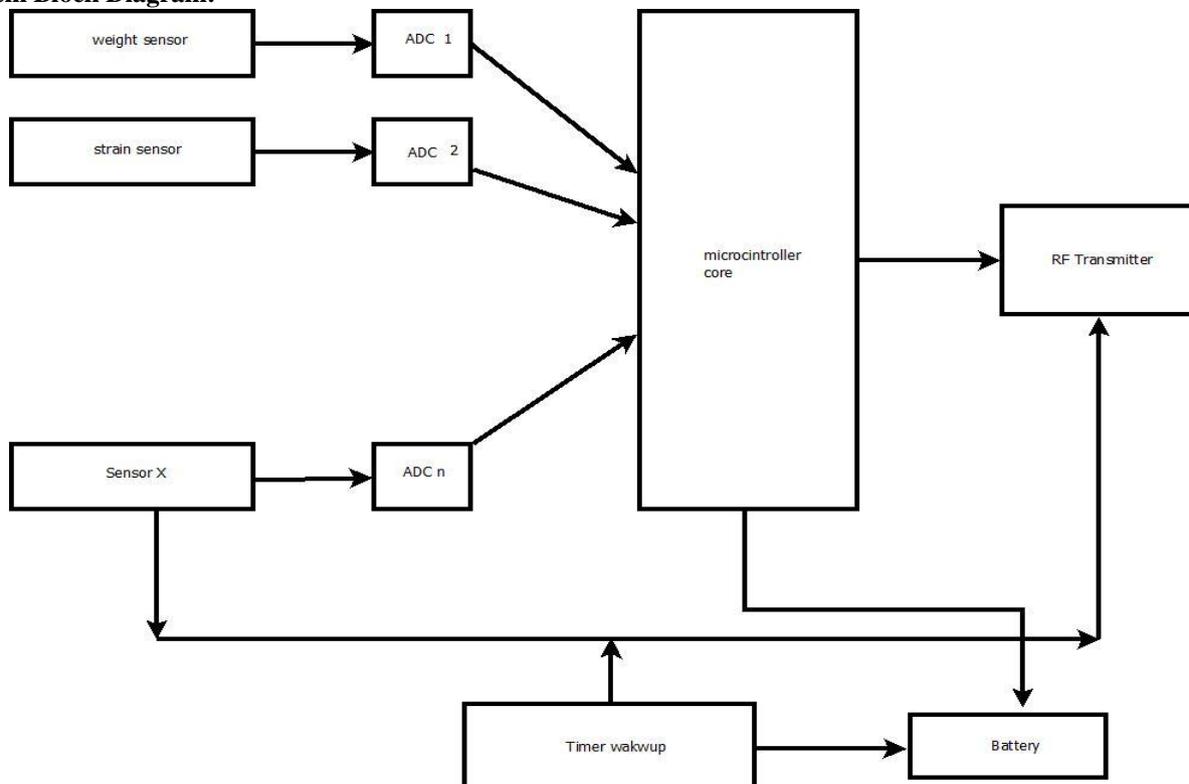


Fig 1 System Block Diagram

Table 1: Sensor Data and ANN Prediction Value

| S. No. | Sensor Data | ANN health Prediction Value |
|--------|------------------|-----------------------------|
| 1 | 1111111111111111 | 8 |
| 2 | 1111111111115555 | 13 |
| 3 | 1111111155551111 | 10 |
| 4 | 1111111155555555 | 16 |
| 5 | 1111555511111111 | 65 |
| 6 | 1111555511115555 | 70 |
| 7 | 1111555555551111 | 75 |
| 8 | 1111555555555555 | 80 |
| 9 | 5555111111111111 | 60 |
| 10 | 5555111111115555 | 63 |
| 11 | 5555111155551111 | 69 |
| 12 | 5555111155555555 | 67 |
| 13 | 5555555511111111 | 26 |
| 14 | 5555555511115555 | 26 |
| 15 | 5555555555551111 | 20 |
| 16 | 5555555555555555 | 18 |

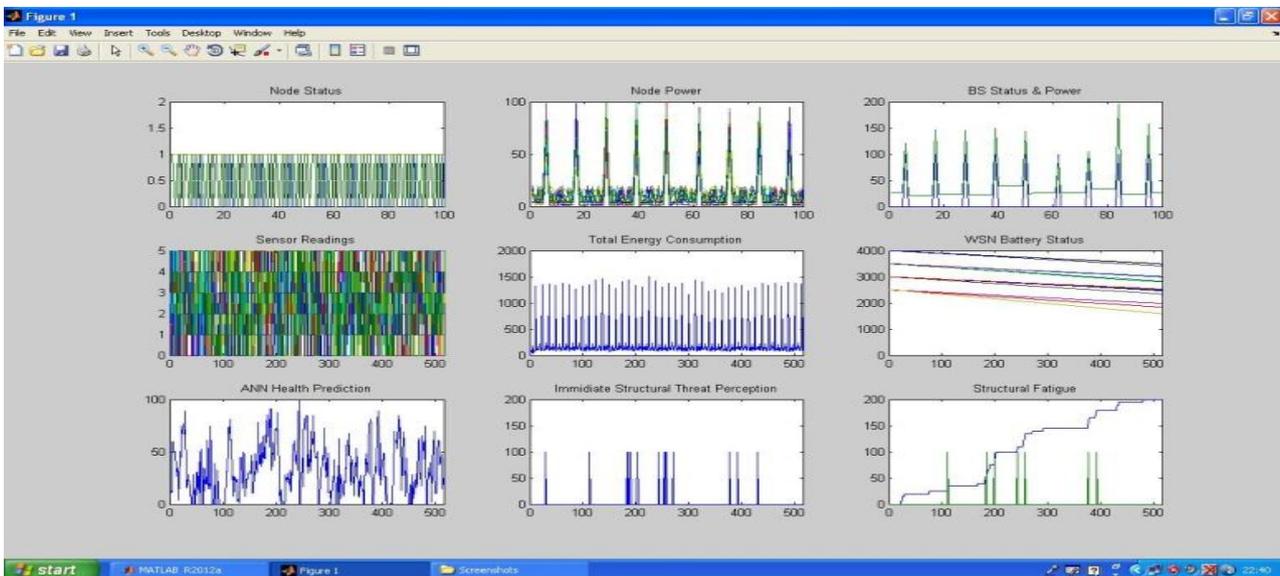


Fig:5 Different Data Graphs

This window show the results till 500 Seconds. In this window we can see the resultant graph of battery status, Power status, Node status, node power, Sensors readings, power consumption, Ann health prediction, Immediate Structural Threat Value and Structural fatigue.

Table 2 Time With ANN Prediction Value and Immediate Structure Threat Value

| S. No. | Time | ANN Health Prediction Value | Immediate Structural Threat Value |
|--------|------|-----------------------------|-----------------------------------|
| 1 | 0 | 60 | 100 |
| 2 | 100 | 90 | 100 |
| 3 | 200 | 95 | 100 |
| 4 | 300 | 100 | 100 |
| 5 | 400 | 95 | 100 |
| 6 | 500 | 80 | 100 |

VI. CONCLUSIONS

This work present a highly energy efficient, hierarchical intelligent wireless sensor network employed for structural health monitoring. Unique method of multiple sleep modes with timers as well as RF wake up & capacity to individually

control peripherals emerging out of power saving state gives this design higher energy efficiency & prolongs the battery life. Also the hierarchical deployment of the proposed WSN allows for reduction of transmission power required , as data collected is shifted upwards in the hierarchy towards the base station thus the node only need, small amount of RF power radiated , to communicate to the next upper/parent node in

hierarchy. By employing this method, energy saving is obtained by reducing the time of activity of RF power transceiver, elongating the sleep time of RF transmission & reduction of RF Power transmission employed.

Also the wake presents an intelligent wireless sensor network using artificial intelligence which automatically process multisensory data & predicts structural fatigue using neural network faster of data. Also on innovative method of computing immediate structural threat & cumulative structural fatigue from integration of predicted structural threat over time.

VII. FUTURE SCOPES

This work has depicted implementation of an energy efficient hierarchical of an energy efficient hierarchical wireless sensor network, which conserves wireless sensor network, which conserves energy using multiple sleep modes & AS well as built in intelligence to integrate sensor data into repeatable results. The proposed system has been implemented on matlab, & the results above describe successful implementation & validation of objectives however, as the technology is rapidly emerging & new challenges emerging advancement of this technique with current trends is essential is incorporation of energy harvesting systems reduce the dependability on batteries.

Also to counter the security threat of highly secure cryptographic system & hardware based security regimes is proposed.

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