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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 Wi-Fi (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 deploybility, 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 word 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.

Keywords:*Hierarchical WSN, Structural Health Monitoring, Artificial Intelligence Structural Prediction, Multi Sleep Modes.*

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I. Introduction

As an alternative to current wired-based networks, wireless sensor networks (WSNs) are becoming an increasingly compelling platform for engineering structural health monitoring (SHM) due to relatively low-cost, easy installation, and so forth. However, there is still an unaddressed challenge: the application-specific dependability in terms of sensor fault detection and tolerance. The dependability is also affected by a reduction on the quality of monitoring when mitigating WSN constrains (e.g., limited energy, narrow bandwidth). We address these by designing a dependable distributed WSN framework for SHM (called DependSHM) and then examining its ability to cope with sensor faults and constraints. We find evidence that faulty sensors can corrupt results of a health event (e.g., damage) in a structural system without being detected. More specifically, we bring attention to an undiscovered yet interesting fact, i.e., the real measured signals introduced by one or more faulty sensors may cause an undamaged location to be identified as damaged (false positive) or a damaged location as undamaged (false negative) diagnosis. This can be caused by faults in sensor bonding, precision degradation, amplification gain, bias, drift, noise, and so forth. In Depend SHM, we present a distributed automated algorithm to detect such types of faults, and we offer an online signal reconstruction algorithm to recover from the wrong diagnosis. Through comprehensive simulations and a WSN prototype system implementation, we evaluate the effectiveness of Depend SHM.

Wireless sensor networks (WSNs) consist of a number of sensor nodes that can collaborate with each other to perform monitoring tasks. WSNs have been widely deployed on the ground, vehicles, structures, and the like for enabling various applications, e.g., target detection, safety-related, and traffic monitoring . Recent work has explored that WSNs can be a compelling platform for engineering structural health monitoring (SHM), due to relatively low-cost, easy installation, and so forth . In a typical SHM system, the interest is in monitoring possible changes (e.g., damage, crack, corrosion) on physical structures (e.g., aerospace vehicles, buildings, bridges, nuclear plants, etc.) and providing an “alert” at an early stage to reduce safety-risk. This prevails throughout the aerospace, civil, structural, or mechanical (ACSM) engineering communities. Both ACSM and computer science (CS) communities have already addressed numerous challenges/requirements, including data acquisition, compression, aggregation, damage detection, distributed computing.

II. LITERATURE REVIEW

In this paper, we proposed a dependable WSN-based SHM scheme, DependSHM, by making the best use of resource-constrained WSNs for SHM and incorporating requirements of both engineering and computer science domains. DependSHM 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 analyzed 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 analyzed 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 AmboBot to more exile 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. The identification methods have been automated and their reliability has been improved, so that the system can track small changes in the dynamic behavior of offshore wind turbines. The advanced modal analysis tools used in this application include the poly-reference least squares complex frequency-domain estimator, commercially known as PolyMAX, and the covariance-driven stochastic subspace identification method. The implemented processing strategy will be demonstrated on data continuously collected during 2 weeks, while the wind turbine was idling or parked. [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 Sigsbee modules, which are in the form of a single unit called a "Node" that combines all these sensors, an ARM processor, and a Sigsbee 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]

III. METHODOLOGY

3.1 System Block Diagram:

Here we have a microcontroller which has inbuilt analog to digital converters.

These analog to digital converters (ADC) is connected to the different types of sensors and microcontroller is directely connected to the battery. And the sensors and RF transmitter is connected to the a timer wakup. When timer is wake up then the sensors read data and this data send to the microcontroller and when we give command to the RF transmitter then it power on and send Data.

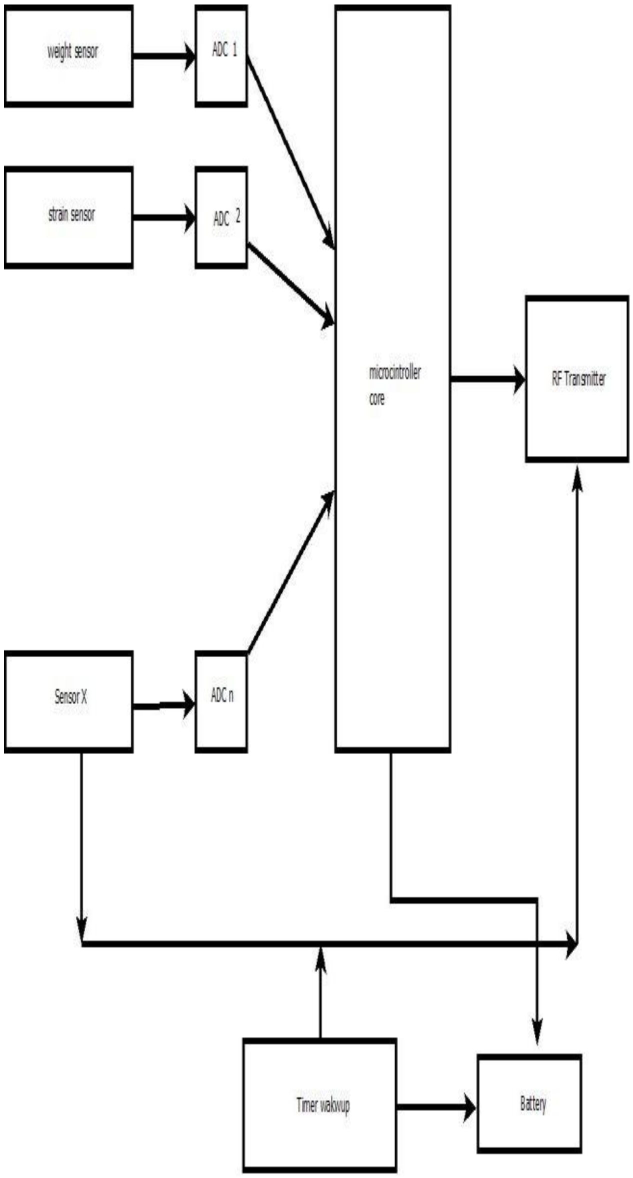


Fig 3.1 System Block Diagram

3.2 (A)

Here we have three sensors. These sensors data send to the pre trained artificial neural network. And by using these sensors data pre trained Artificial neural network predict Instantaneous structural health ANN.

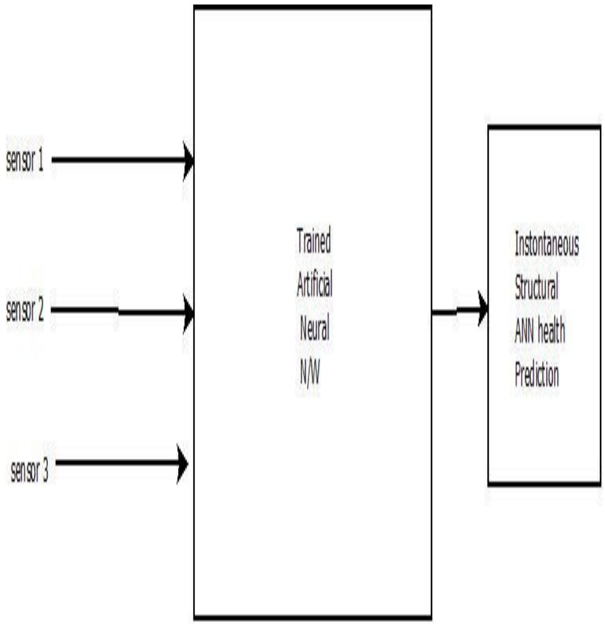


Fig 3.2 Instantaneous health prediction

(B)
When Impact health prediction value or threshold is grater then 80% then here a immediate threat is generated.

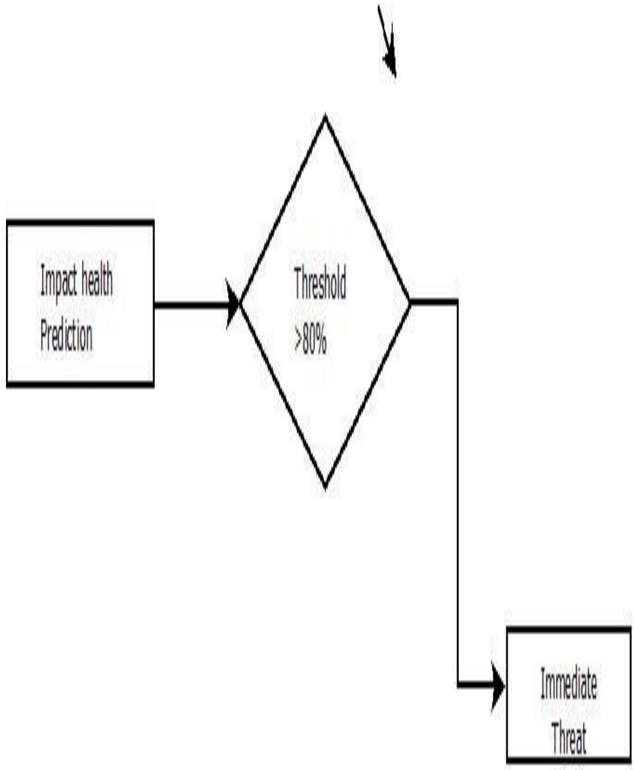
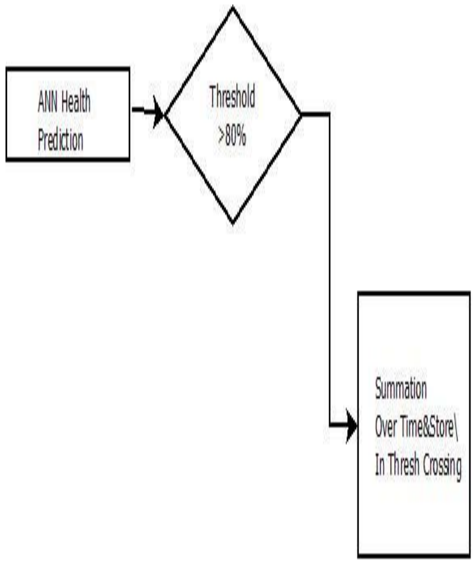


Fig 3.3 Immediate Threat Generate

(B)
Here ANN predict health then if threshold is grater then 80% then summation of over time will be stored in thresh crossing and structural thresh crossing data goes to structural threshold .

Then structural threshold value added by 5 and structural is fatigue.



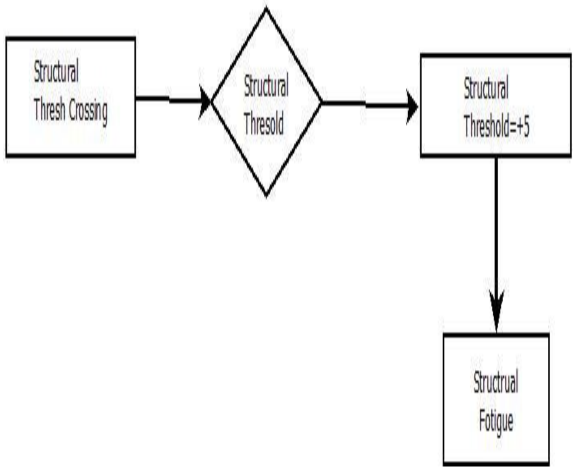


Fig 3.4Structural fatigue

IV. Result

This window open by using the open ANN code and run it by using the run code with help right click of mouse and click on run option. Then command window show the ANN Input and Target Values. In this window we can see the command history.

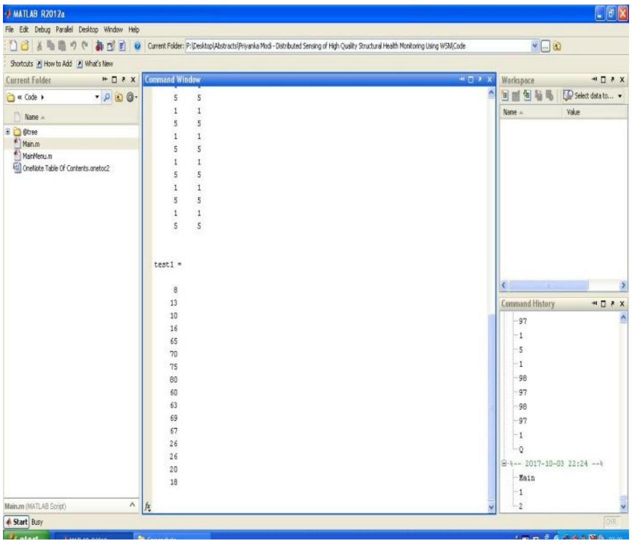


Fig:4.1

Table4.1

S.No.	Sensor Data	ANN health Prediction Value
1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	8
2	1 1 1 1 1 1 1 1 1 1 1 1 5 5 5 5	13
3	1 1 1 1 1 1 1 1 5 5 5 5 1 1 1 1	10
4	1 1 1 1 1 1 1 1 5 5 5 5 5 5 5 5	16
5	1 1 1 1 5 5 5 5 1 1 1 1 1 1 1 1	65
6	1 1 1 1 5 5 5 5 1 1 1 1 5 5 5 5	70
7	1 1 1 1 5 5 5 5 5 5 5 5 1 1 1 1	75
8	1 1 1 1 5 5 5 5 5 5 5 5 5 5 5 5	80
9	5 5 5 5 1 1 1 1 1 1 1 1 1 1 1 1	60
10	5 5 5 5 1 1 1 1 1 1 1 1 5 5 5 5	63
11	5 5 5 5 1 1 1 1 5 5 5 5 1 1 1 1	69
12	5 5 5 5 1 1 1 1 5 5 5 5 5 5 5 5	67
13	5 5 5 5 5 5 5 5 1 1 1 1 1 1 1 1	26
14	5 5 5 5 5 5 5 5 1 1 1 1 5 5 5 5	26
15	5 5 5 5 5 5 5 5 5 5 5 5 1 1 1 1	20
16	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	18

Table 4.1

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.

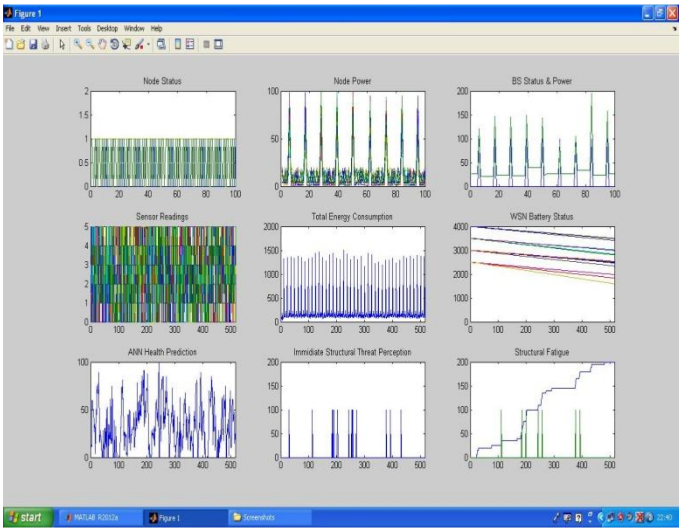


Fig:4.2

Table 4.2

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

Table 4.2

V. Conclusion AND FUTURE SCOPE

Conclusion

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 transreciver, enlongating 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 foctigue using neural network faster of data.

Also on innovative method of computing immediate structural threat & commulative structural fatigue from integration of predicted structural threat over time.

Future Scope

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 repetable 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 emerfing advancement of this technique with current trends is essential is incorporation of energy harvesting systems reduce the dependability on batteries.

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

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