An Approach of Reliable Data Transmission with Random Redundancy for Wireless Sensors in Structural Health Monitoring

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Abstract: The main aim of the project to monitor the health parameters and transmits into the remote area using wireless technology. The existing system monitors the person's health status from remote area. Based on process some time the receiving end does not get exact data. So that in proposed system we can eliminate this problem and data can access from longer distance the proposed method includes a source coding stage to compress the natural redundant information inherent in SHM signals and a redundant coding stage to inject artificial redundancy into wireless transmission to enhance the transmission reliability. Methods with light memory and computational overheads are adopted in the coding process to meet the resource constraints of wireless sensor nodes. A wireless sensor node transmits the same payload of coded data instead of the original sensor data to the base station. Some data loss may occur during the transmission of the coded data. However, the complete original data can be reconstructed losslessly on the base station from the incomplete coded data given that the data loss ratio is reasonably low.

Keywords: Data Loss Recovery, Wireless Sensor Network, Structural Health Monitoring, Lossless Entropy Compression, Redundant Coding, Imote2.

I.INTRODUCTION

In Recent years, remote savvy sensor system (WSSN) has pulled in much consideration in the field of auxiliary wellbeing checking (SHM). Because of their conspicuous points of interest over customary wired checking frameworks, WSSN based SHM frameworks are increasing expanding prevalence for both industry what's more, exploratory applications. Specifically, for extension observing, WSSN not just gives a minimal effort and simple to-send elective for the customary wired sensors, it likewise empowers nearby preparing of the gained information to make the observing framework wise. In spite of the great characteristics of WSSN, the information transmission of remote SHM frameworks is especially helpless to bundle misfortune. The transmission unwavering quality very depends on the correspondence environment and receiving wire. Information misfortune amid

remote transmission disables the information quality and reductions the precision of consequent methods that work on the information. Such information misfortune has been accounted for by a few scientists for different applications, specifically, has broke down the impact of information misfortune on auxiliary and modular examination. It was found that the effect of 0.5 percent information misfortune is proportionate to that of 5 to 10 percent estimation commotion on the force ghostly thickness (PSD) estimation and modular recognizable proof results. As information misfortune expands, the nature of results in view of these estimations further corrupts.

In spite of the fact that a specific measure of information misfortune is middle of the road in numerous SHM applications, more dependable information transmission is dependably favored to give more exact examination in light of the information. Diverse methodologies have been proposed to improve the unwavering quality of remote transmission. For the most part, they can be characterized into two principle classes, i.e., receptive retransmission furthermore, excess coding. In receptive retransmission, the sender is told to retransmit lost information bundles until all information parcels are gotten at the destination. Such a methodology experiences correspondence delay and critical bidirectional activity (NACK/ACK messages). Then again, excess coding takes another way to deal with transmit excess coded bundles to the beneficiary rather than the first information parcels; the complete unique information can be recreated once an adequate number of coded bundles are gotten. In spite of the fact that such excess coding has points of interest over responsive retransmission regarding productivity and adaptability, few of the current strategies are all around custom fitted for the remote sensor hub with compelled locally available assets; even less are focused for information serious SHM applications.

To explicitly take care of the lossy transmission issue for remote SHM frameworks, has explored the likelihood of utilizing compressive detecting (CS) based strategies for

lost information recuperation. The possibility of the CS based II. BLOCK DIAGRAM transmission strategy additionally has a place with the excess coding class. In spite of the fact that the strategy indicates guarantee to expand information transmission dependability of remote SHM frameworks, it is basically a lossy recreation strategy whose execution intensely relies on upon the scanty attributes of the objective flag that is not generally ensured. Be that as it may, the arbitrary projection utilized by CS is in fact a motivation for the arbitrary coding proposed in this examination. In this article, another specialized technique is proposed to improve the information transmission unwavering quality of the WSSN based SHM frameworks, considering the application particular necessities of WSSN and SHM. The proposed strategy incorporates two coding stages, i.e., a source coding stage to pack the characteristic repetitive data innate in SHM signals and an excess coding stage to infuse fake repetition into remote transmission to improve the transmission dependability. A specific commitment of this exploration is the proposition of a straightforward arbitrary grid projection to accomplish repetitive coding of the compacted SHM bit-stream. For SHM signals including quickening, temperature, wind speed and so forth, the proposed technique empowers lossless reproduction of the first sensor information with high likelihood by just transmitting the same payload of coded information rather than the first information, given that the information misfortune proportion is low (ordinarily underneath 30%) amid the transmission process.

To keep the calculation and memory overheads moderate by the asset constrained remote sensor hubs, a straightforward lossless pressure technique called lossless entropy pressure (LEC) is received to firstly cut back the unique sensor information; in the mean time, an arbitrary lattice projection with meager network passages is consequently used to produce irregular excess and the coded information that is transmitted over the lossy remote connections. On the off chance that the recipient gets a adequate segment of the transmitted information, complete recuperation of the first information is ensured with overpowering likelihood through an opposite recreation process. This specialized technique is inserted into the Imote2 brilliant sensor stage, which depends on the middleware given by the Illinois Structural Health Monitoring Venture (ISHMP) Services Tool-suite. Information correspondence probes a link stayed extension are then completed to accept the pertinence of the inserted program. In the accompanying of this article, the LEC strategy is firstly inspected; its application for the source coding of the first SHM information is clarified. The proposed irregular projection based repetitive coding technique is then given scientific details. Cases of different investigation information are utilized finally to exhibit the viability of the specialized technique. It is demonstrated that the technique is capable to withstand information misfortune up to 30% and still gives lossless reproduction of the first sensor information with overpowering likelihood. This outcome speaks to a critical change of information transmission unwavering quality of remote SHM frameworks.

II. BLOCK DIAGRAM

Description: The project design consists of LPC2148Microcontroller, LCD, Heart beat sensor, dehydration sensor, Buzzer, x-bee transceiver and power supply unit. The power supply unit provides +3.3v to the xbee transceiver and microcontroller. Here we are implementing a wireless sensor network for monitoring health status for different types of persons structurally as shown in Figs.1 and 2. For this we are monitoring the dehydration status and heart beat status, sensors will gives analog data, it will be converted into the digital level that are read by microcontroller and display on the LCD and transmitted to remote unit, if the sensors can exceeds the given limit then the microcontroller alert the persons with an alarm sound. X-bee transceiver can provide the communication between sensor unit and monitoring unit.

Node1:

Fig.1.

Node2:

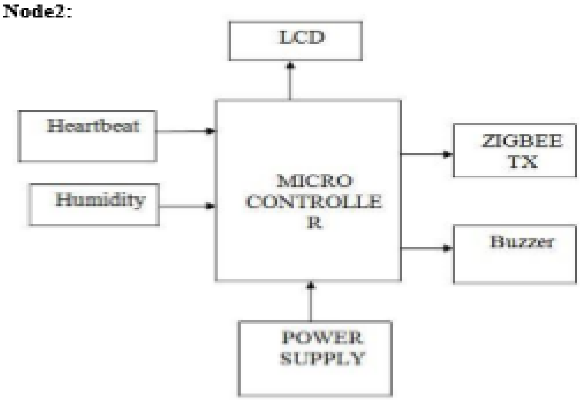


Fig.2.

A. Hardware Requirements

- Micro Controller (LPC 2148)
- LCD
- Heartbeat Sensor
- Humidity Sensor
- MAX 232
- Zigbee Modules
- Buzzer
- Power Supply

1. LPC2148 Microcontroller: LPC2148 microcontroller board is based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontrollers with embedded high-speed flash memory ranging from 32 KB to 512 KB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. The meaning of LPC is Low Power Low Cost microcontroller. This is 32 bit microcontroller manufactured by Philips semiconductors (NXP). Due to their tiny size and low power consumption, LPC2148 is ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale as shown in Fig.3.

Features of LPC2148 Microcontroller:

- 16-bit/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 8 KB to 40 KB of on-chip static RAM and 32 KB to 512 KB of on-chip flash memory; 128-bit wide interface/accelerator enables high-speed 60 MHz operation.
- USB 2.0 Full-speed compliant device controller with 2 KB of endpoint RAM. In addition, the LPC2148 provides 8 KB of on-chip RAM accessible to USB by DMA.

- One or two (LPC2141/42 Vs, LPC2144/46/48) 10-bit ADCs provide a total of 6/14 analog inputs, with conversion times as low as 2.44 ms per channel.
- Single 10-bit DAC provides variable analog output (LPC2148 only)
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
- Low power Real-Time Clock (RTC) with independent power and 32 kHz clock input

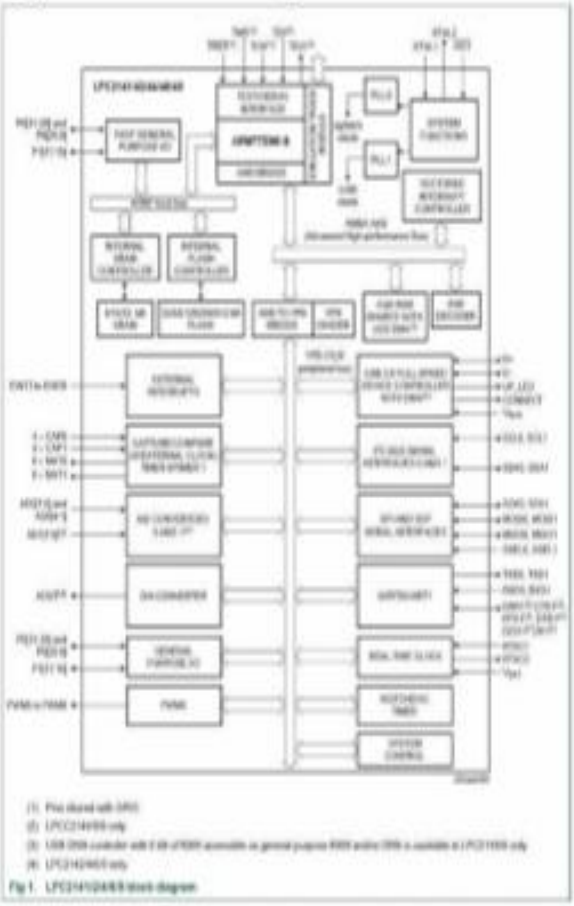


Fig.3. Block Diagram.

2. Liquid Crystal Display (LCD): LCD is a display module finding its application in many electronic devices and circuits. LCDs are preferred to LEDs since they are easily programmable and can display various special characters. We use JHD 162A LCD. A 16x2 LCD displays 16 characters per line with 2 lines in total. It has two registers Command and Data as shown in Fig.4. Key Features:

- High contrast display
- 16 Characters x 2 Lines
- Built-in HD44780 Equivalent LCD Controller with extension driver
- Works directly with ATMEGA, ARDUINO, PIC and many other microcontroller/kits.
- 4 or 8 bit data I/O interface (in our project 4 bits used) Low power consumption.
- Power supply of +5v or 3.3v or 2.7v
- Operating temperature of -20 to +70°C

- EA DIP 162-DNLED: Green color display with LED backlight
- EA B200-9 a 9-PIN socket is used to detach LCD fromkit.

Fig.4. LCD.

3. Heart Beat Sensor:

Fig.5. Heart Beat Sensor.

Heart beat sensor is designed to give digital output of heat beat when a finger is placed on it. When the heart beat detector is working, the beat LED flashes in unison with each heart beat as shown in Fig.5. This digital output can be connected to microcontroller directly to measure the Beats per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse. For further information please refer to its datasheet.
Features:

- Microcontroller based SMD design
- Heat beat indication by LED
- Instant output digital signal for directly connecting to microcontroller
- Compact Size
- Working Voltage +5V DC

Applications:

- Digital Heart Rate monitor
- Patient Monitoring System

4. Humidity Sensor:

Fig.6

Looking out for a sensor to measure humidity with ease? Here is the solution with accurate measurements from honey well. The HIH-5030 sensor delivers instrumentation-quality RH (Relative Humidity) sensing performance at small package. The sensor can operate down to 2.7 volt, which enables you to make your own battery powered equipments. The best part is, it provides analogue output, which enables you to directly interface to microcontroller.

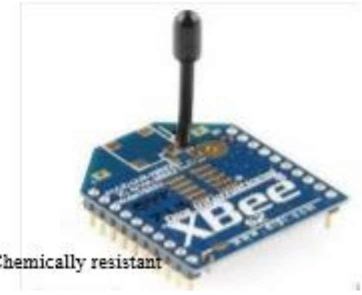
Features:

- Analog output can be directly fed into ADC port of microcontroller
- Works down to 2.7 volt
- Low current consumption, 200uA typical
- Small Package
- Near linear voltage output vs %RH Stable
- Enhanced accuracy and Fast response time
- Stable, low drift performance.

5. MAX232: The MAX232 is an IC, first created by Maxim Integrated Products, that converts signals from an RS- 232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approx. ± 7.5V) from a single + 5V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0V to + 5V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case. The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 VTTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresisof0.5 V.

Fig.7.

6. Zigbee Technology: Overview or tutorial of the Zigbee standard and Zigbee technology used for remote sensor, data collecting applications. Zigbee is a wireless networking standard that is aimed at remote control and sensor applications which is suitable for operation in harsh radio environments and in isolated locations as shown in Fig.8. Zigbee technology builds on IEEE standard 802.15.4 which defines the physical and MAC layers. Above this, Zigbee defines the application and security layer specifications enabling interoperability between products from different manufacturers. In this way Zigbee is a superset of the 802.15.4 specification. With the applications for remote wireless sensing and control growing rapidly it is estimated that the market size could reach hundreds of millions of dollars as early as 2007. This makes Zigbee technology a very attractive proposition for many applications.



- Chemically resistant

7. Buzzer: A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke as shown in Fig.9.

Fig.9. Buzzer.

Applications:

• Microwave ovens and House hold appliances
• Annunciate panels
• Electronic metronomes

8. Power Supply: All electronic circuits works only in low DC voltage, so we need a power supply unit to provide the appropriate voltage supply for their proper functioning .This unit consists of transformer, rectifier, filter & regulator. AC voltage of typically 230volts rms is connected to a transformer voltage down to the level to the desired ac voltage. A diode rectifier that provides the full wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation . A regulator circuit can use this dc input to provide dc voltage that not only has much less ripple voltage but also remains the same dc value even the dc voltage varies somewhat, or the load connected to the output dc voltages changes as shown in Fig.10.

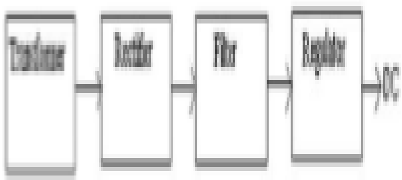


Fig.10. General Block of Power Supply Unit.

Transformer: A transformer is a static piece of which electric power in one circuit is transformed into electric power of same frequency in another circuit. It can raise or lower the voltage in the circuit, but with a corresponding decrease or increase in current. It works with the principle of mutual induction. In our project we are using a step down transformer to providing a necessary supply for the electronic circuits. Here we step down a 230volts ac into 12volts ac.

Rectifier: A dc level obtained from a sinusoidal input can be improved 100% using a process called full wave rectification. Here in our project for full wave rectification we use bridge rectifier. From the basic bridge configuration we see that two diodes(say D2 & D3) are conducting while the other two diodes (D1 & D4) are in off state during the period t = 0 to T/2.Accordingly for the negative cycle of the input the conducting diodes are D1 & D4 .Thus the polarity across the load is the same.

In the bridge rectifier the diodes may be of variable types like 1N4001, 1N4003, 1N4004, 1N4005, IN4007 etc… can be used. But here we use 1N4007, because it can withstand up to 1000v.

Filters: In order to obtain a dc voltage of 0 Hz, we have to use a low pass filter. So that a capacitive filter circuit is used where a capacitor is connected at the rectifier output& a dc is obtained across it. The filtered waveform is essentially a dc voltage with negligible ripples & it is ultimately fed to the load.

Regulators: The output voltage from the capacitor is more filtered & finally regulated. The voltage regulator is a device, which maintains the output voltage constant irrespective of the change in supply variations, load variations & temperature changes. Here we use fixed voltage regulator namely LM7805.The IC LM7805 is a +5v regulator which is used for microcontroller.

III. EXPERIMENTAL VALIDATION OF THE EMBEDDED DATA TRANSMISSION METHOD A. Description To demonstrate the performance of the embedded program, a series of sensing and communication experiments has been performed on the Songpu Bridge in Harbin. The Songpu Bridge is a single-tower cable-stayed bridge with a main span of 268 meters. It has eight lanes and two sidewalks, with a total width of 39.5 meters. Imote2s are used to measure both the acceleration of the bridge deck and a stay cable. The antennas are attached on top of the fence so that a direct communication path is assured for all tests. Fig.11 shows the setup of the experiments. An antenna with a gain of 6 dBi is used at both ends, i.e., sensing node and base station. The default maximum transmission power of Imote2, i.e., 0 dBm, is assumed for the data transmission. Two fixed sensor nodes are used as leaf-nodes to sense (at 100Hz), code and send acceleration signals, whereas a base station node connected to a laptop computer is placed at 140 meters from the leafnodes to test the communication performance. Multiple communication tests are conducted. The received data is then put through a statistical analysis of data loss and reconstruction. It should be mentioned that Imote2 is a powerful wireless sensor platform for SHM applications with sound data transmission ability, see reference [9]. ISHMP tool-suite also has an integrated reliable transmission protocol that is based on reactive retransmission [11]. However, for the purpose to demonstrate the efficacy of the proposed data communication method, the radio transmission of Imote2 is used unreliably without packets acknowledgement and retransmission to generate the desired communication data loss.

TABLE I: Examples

	Inflated K	Received M
Example 1	191	411
Example 2	290	369

Fig.11. Experimental verification on the Songpu Bridge.

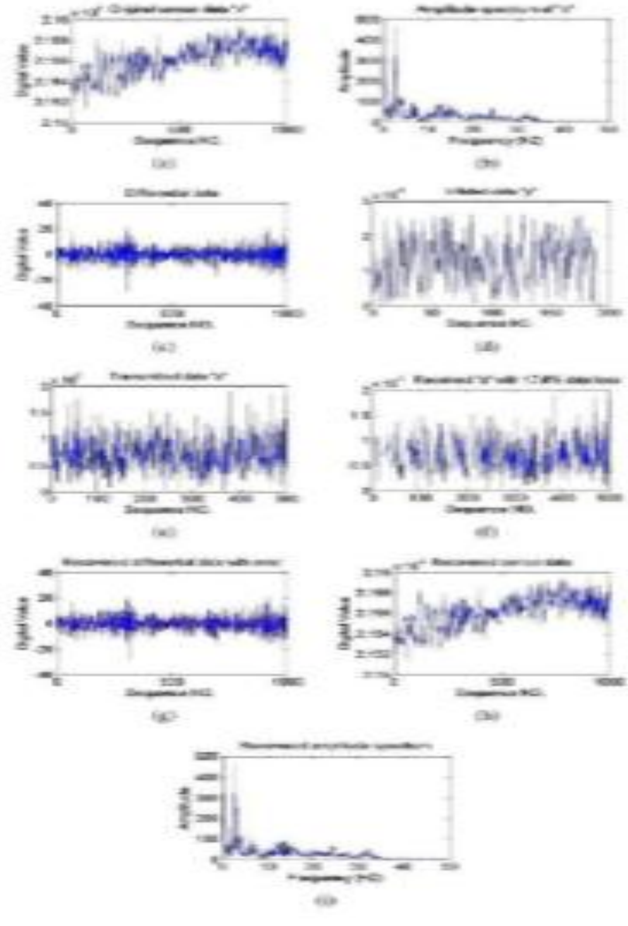


Fig.12. Data transmission example 1: typical deck acceleration (a) original sensor data, (b) frequency content of the detrended data, (c) differential data, (d) sliced data from LEC bit-stream, (e) data to be transmitted over wireless link, (f) received data on the base station, (g) recovered differential data with reconstruction error, (h)

recovered original sensor data, and (i) frequency content of the recovered data.

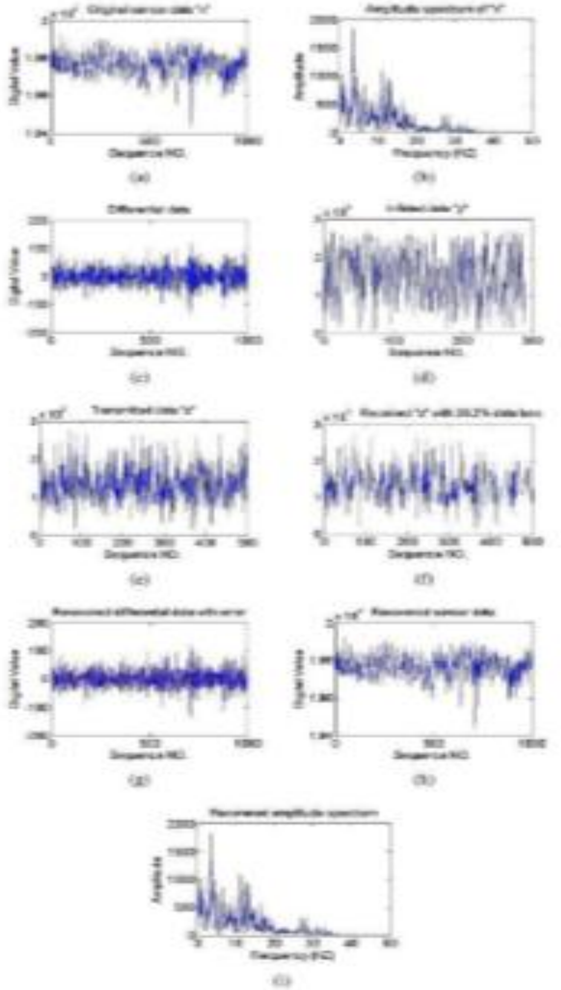


Fig.13. Data transmission example 2: typical cable acceleration (a) original sensor data, (b) frequency content of the detrended data, (c) differential data, (d) sliced data from LEC bit-stream, (e) data to be transmitted over wireless link, (f) received data on the base station, (g) recovered differential data with reconstruction error, (h) recovered original sensor data, and (i) frequency content of the recovered data.

C. Statistics In the communication experiments, multiple acceleration data segments are obtained for the bridge deck and stay cable; and multiple data communication trials were performed for each data segment. Fig.14 shows the mean and standard deviation of the inflated K using 10 data segments each for both deck and cable. Clearly, the LEC method achieves high compression for all segments in the experiments. It can be further seen that the LEC compression ratio (500) is smaller for deck accelerations than for the cable accelerations. This fact is attributed to the lower vibration level of the deck that makes its differential signal more clustered to small values (see Figs 12(c), 13(c)). In Fig.15, twelve data segments, six from the deck and six from the cable each, are associated with their observed data loss patterns in the experiments. The black squares indicate the inflated K for each of the segments, whereas the circles indicate the received M in each communication trials.

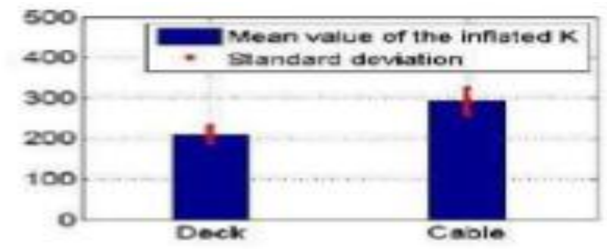


Fig.14. Mean and standard deviation of the inflated K for the acceleration data segments of the deck and cable.

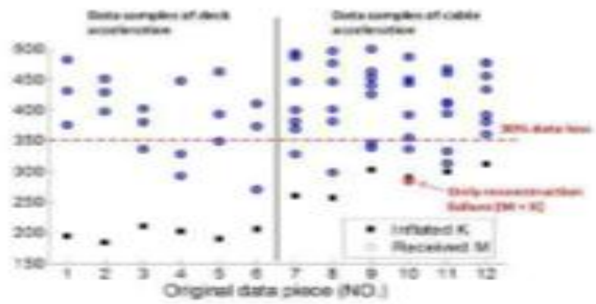


Fig.15. Statistics of communication experiments. The first six data pieces are samples of the deck acceleration whereas the latter six data pieces are samples of the cable acceleration.

The only reconstruction failure is marked in red, which is clearly attributed to the excessive data loss that causes M to drop below K. All other cases yield lossless recovery of the original sensor data. The communication experiments demonstrate the efficacy of the proposed data communication method in terms of its robustness against data loss. By transmitting the same payload of coded data instead of the original sensor data, the proposed method is able to withstand data loss up to 30% and still provides lossless reconstruction of the original sensor data with overwhelming probability. This result represents a significant improvement of data transmission reliability of wireless SHM systems. The tradeoff made is using slightly more computations in exchange for enhanced reliability of subsequent data transmission. It has a great potential to overcome the data loss problems for wireless SHM systems.

IV. CONCLUSION

This article handles the information misfortune issue of remote basic wellbeing checking (SHM) frameworks by another arbitrary excess coding technique. After sensor information is gained on the sensor hub, the inserted lossless entropy pressure (LEC) strategy is firstly actuated to decrease the information size, which is then trailed by an arbitrary projection to swell the compacted information back to the first information size utilizing simulated excess. The whole methodology adds up to a size safeguarding change on the first sensor information, the yield from which is transmitted over the lossy remote connections rather than the first information. The technique is executed on the Imote2 shrewd sensor stage. Both hypothetical improvements and test approvals are utilized to legitimize the viability of the information transmission technique. It has been appeared in this article, for legitimately conveyed remote SHM frameworks, the strategy can fundamentally build the information transmission dependability without expanding the transmission payload. Information misfortune beneath 30% amid the remote transmission can be effectively endured without giving up the complete recuperation of the first sensor information by any means. It is a basic yet down to earth strategy to overcome the information misfortune issues for remote SHM framework.

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