

Module 3

Lecture 3: Smart sensing for SHM

What are smart sensors?

Sensors, with embedded microprocessors and wireless communication links

Smart sensors

- Very useful in wireless sensor networks (WSNs)
- updated system is SHM scheme

Advantages of smart sensors

- (1) Ability to continuously monitor the integrity of the structure is real-time & can provide improved safety to public, particularly in case of aging structures (bridges)
- (2) Ability to detect damage @ an early stage, which can reduce the cost of repairs & also reduce the shut-down time of the structure

(3) It is helpful in predicting/observing initiation of damage

(a) any other undesirable behavior of the structure (settling of supports, fatigue fracture etc)

- They can be helpful to generate advance warning of removal of the structure (as making it inoperational due to safety regulations)

- It can prevent tendon disavow, structural damage

Smart sensors — wireless

- In conventional wired sensors
 - many # of wires
 - fibre optic cables as physical transmission medium
 - may become a serious issue for long-span bridges as tall buildings
- wireless sensors
 - have low cost and densely distributed network

Rapid advances - Wireless sensors

- Wireless communication
- Micro-Electro Mechanical System (MEMS)
- Advanced information Technology to enhance STM quality.
- Sensors are also available with
 - self-calibration
 - self-diagnosis capabilities

Sensors have ③ components

(1) Sensing element : resistors, capacitors, piezo-electric module, photo diode etc

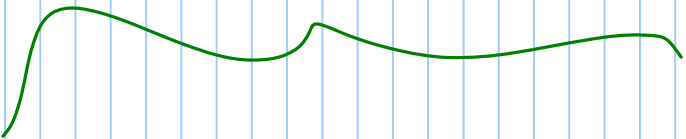
(2) Signal condition processing : amplifiers, linearization, compensation & filtering

(3) Sensor interface : wires, plugs, sockets to communicate with other electronic components

Essential difference b/w

Smart sensor and the conventional sensor

- Smart sensors have micro-processor on board
 - which makes them intelligent
- Microprocessors can perform the following functions
 - digital processing
 - analog to digital converter (ADC) or frequency-to-code converter

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- calculate and interface functions, which can facilitate
 - rdy - diagnose
 - rdy - identify
 - rdy - adaptability (decision-making)
 - It can also enable to control storage & data/dumping the data
 - It can decide when to remain in operation, & when to go in sleep mode
 - save power to a large extent

MEMS sensors

- manufactured using Very Large Scale Integration technology (VLSI)

- loads to manufacturing sensors is large
Qty, reduces cost & sensing

MEMS - 50 US\$

- These sensors perform integration of mechanical functions

- Sensing operation requires a physical or chemical phenomenon to be converted into a electric signal

- for display, processing, transmission or recording.

- These signals can also be used as actuators (control output)

Actuators reverse the flow

- converts electric signal into a physical action (eg a chemical change in the system)

- Size of MEMS are very small (10^{-6} m) microns

Mass production of MEMS may bring down the cost of these sensors

- enable their use in STM, widely

All smart-sensors are essentially wireless

They also possess capacity with data transmission, based on Radio-Frequency (RF) communication

Smart sensors have 4 features

- (1) On-board Control Processing Unit (CPU)
- (2) Small in size (compact to use)
- (3) Wireless (no connection due to wiring)
- (4) Low cost, if mass production is enabled

Since STM, using smart-phones are mostly automatic system,

Primary requirement of the STM should be

- enable preventive maintenance, when there is a likelihood of the repair, exceeding the threshold value

STHM, using smart sensors involve a (5) level classification (Ryder, 1993; Keira et al. 2003)

- It will first assess the response and determine whether the structure is damaged or not
- If damaged, it further shall try to locate the damage
 - damage localization
- Based on the data monitored, it will (shall) quantify the damage (extent of the damage)
- It shall also predict further progress of damage and remaining service life of the structure

- It should recommend appropriate remedial/repair measures to rectify

lost strength and
functionality of the structural

system - using smart sensors

- offers a complete solution for safety and
healthiness functionality of the
structure

Summary

- Smart tuning
 - requirements of smart tensors
 - adv of smart-tensors is STM
 - wireless is comparison to wired tensor
 - STM - smart-tensors, (S) spike process
STM should address-