

Design of Multiple Sensors Monitoring System using Small Flying Vehicle

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Abstract— Recently, as deteriorated buildings such as high-rise buildings, chemical plant structures have various social problems and heavy economic loss due to its cracking, fire and collapse, it leads to national loss eventually. In order to prevent these problems in advance, this study intends to suggest test data control and efficient information provision service in structural safety test system using small flying vehicles being mounted with multiple sensors. The goal of this study is to store and control multiple sensor data, image and thermal infrared image data transmitted from small flying vehicle through its synchronization and to design integrated control system for safety test that provides test result and historical data management.

Keywords— Multi-Sensor, Small Flying Vehicles, Sensor Fusion, Monitoring System

I. INTRODUCTION

Recently, as outdated high-rise buildings, bridge piers, wind power generators, petro-chemical plant structures are deteriorated, a lot of problems for the dangerous situation such as internal/external cracking, fire and disasters are taken place and create a social issue. In order to detect dangerous situations and cracking, there is a small flying vehicle that does the work that is hard to be inspected by the workers as a proxy. This small flying vehicle mounted with various sensors provides a function of integrated management services from structure monitoring to safety inspection. A process of developing small flying vehicle and verifying its performance for safety inspection of structures is continuity of complicated process from its design to test flight and a lot of cost and research time are required. In order to perform safety inspection for the structures, mounted various sensors are required to be measured and measured result is required to be transmitted. This study intends to suggest efficient wireless transmission, control technique for sensor data including sensing space of sensed data, data accumulation and its transmission.

This study intends to design integrated management system for safety test that stores and controls multiple sensor data, image, thermal infrared image, data being transmitted from small flying vehicle through its synchronization and provides test result and historical data information.

II. RELEVANT STUDY

Various sensors, imaging equipment and communication equipments are mounted on unmanned small flying vehicle. Data obtained from mounted various sensors and devices will be controlled and information provision service will be researched.

A. Type of sensor

Temperature sensor is a device used for recording or controlling temperature by detecting temperature of fluid such as air or water or wall. Detected temperature is converted to electric signal and transmitted [1].

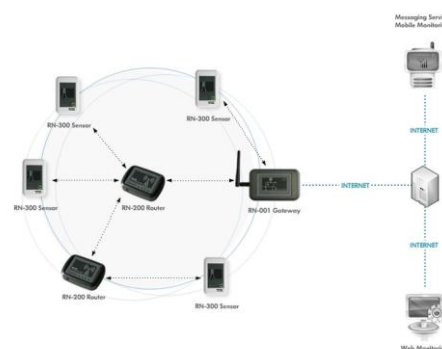


Figure 1. Wireless monitoring of wireless temperature/humidity sensor

Humidity sensor is a device that detects humidity and outputs such humidity as electric signal. This sensor uses a mechanism that electric resistance and its capacity of porous ceramics and polymer electrolyte are changed due to physical absorption of moisture.

CO sensor is a sensor used for detecting carbon monoxide. In our living environment, dangerous gases of numerous types exist and recently, gas-related accident in ordinary homes, business places and construction sites, explosion accident in petrochemical combinat, mines, chemical plants and pollution, contamination are taken place in a row. As it is almost impossible for human sensory system to quantify concentration of dangerous gas or discriminate its type, gas sensor that uses physical, chemical properties of substances is used for detecting gas leakage, measuring its concentration and warning dangerous situation.

CO₂ sensor is a device for measuring carbon dioxide. Most common principle of CO₂ sensor is NDIR and chemical gas sensor. Measuring carbon dioxide is important for monitoring indoor air quality and various industrial processes.

Ozone sensor is a device for measuring ozone concentration in atmosphere. Dust sensor is a device for detecting floating dust or number of condensation nucleus.

VOC sensor is a device for evaluating air quality based on the amount of volatile organic compounds –cigarette smoke, harmful smoke and odour being generated at the time of cooking, outside pollution source, pollution source of living organisms [2].

B. Structures that require safety test by small flying vehicle

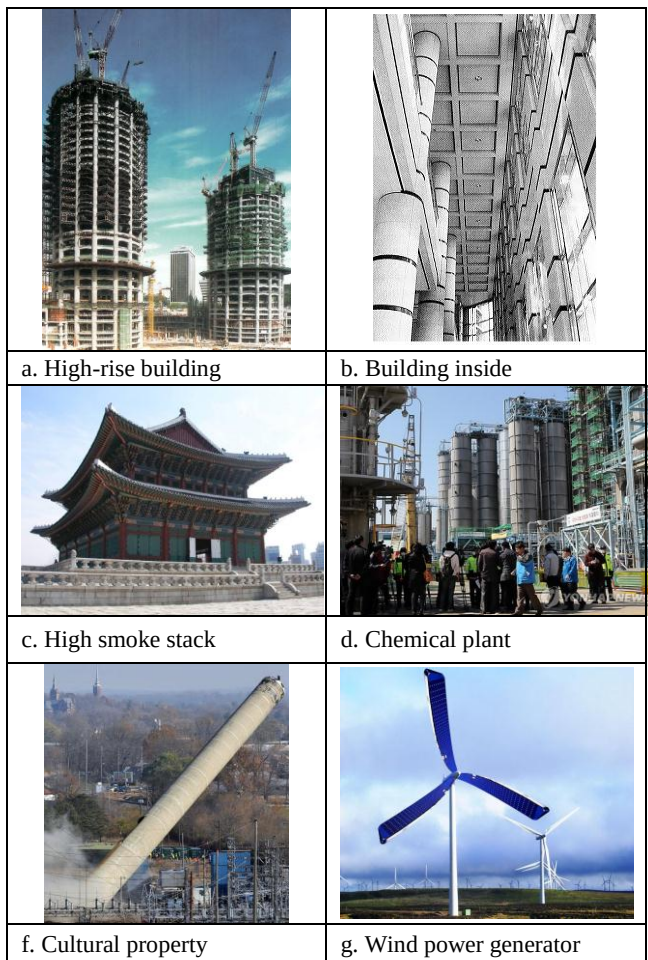


Figure 2. Diversified structures that require safety test[3]

Table 2 is an illustration of diversified structures. a. At the time of constructing high-rise building, safety problem is required to be inspected and for outdated high-rise buildings, efficiency of service life extension is provided by detecting cracking and abnormal temperature by its deterioration, b. By detecting cracks of building inside, building safety is increased, c. By monitoring cracking and dangerous elements of cultural property, national waste could be reduced. Recently, due to frequent fire in chemical plants, safety is required in reality, d. f. By analysing, investigating cracking

and emission gas in internal/external walls of plant smoke stack and chemical plants in real time, an advantage of being able to prevent an accident in advance is provided. In addition, site application for external cracks inspection through cinematography and internal cracks inspection through thermal infrared camera for the blades and tower of wind power generator that is popular as a renewable energy source will be performed and safety inspection manual for wind power generator is under the process of R & D.

C. Global Warming Potential (GWP)

GWP is a scale of evaluating how much heating effect of gas of 1kg is for a certain period of time after greenhouse gas is emitted in the atmosphere when comparing it with carbon dioxide of 1kg. In case of assuming CO₂ as 1 based on 100 years, CH₄ is 21, NO₂ 310, HFCs 1,300, PFCs 7,000 and SF₆ 23,900, respectively[4].

TABLE 1. GLOBAL WARMING POTENTIAL (GWP)

GREENHOUSE GAS	CHEMICAL FORMULA	GWP 1990	GWP 1995	GWP 2001
CARBON DIOXIDE	CO ₂	1	1	1
METHANE	CH ₄	22	21	23
CARBON SUBOXIDE	N ₂ O	270	310	296
HYDROFLUOROCARBON	HFCs	150-10,000	150-11,700	120-12,000
PFCs	PFCs	N/A	6,500-9,200	5,700-11,900
HFC	SF ₆	N/A	23,900	22,200

Abnormality could be confirmed by detecting concentration of carbon dioxide and harmful gases through information detected from each sensor based on GWP of above Table 1.

III. CONTENTS AND METHOD OF STUDY

A. Flying Vehicle Customizing for mounting multiple sensors

In order to perform safety inspection of structures that is unable to be confirmed by the workers, diversified kinds of sensors are mounted in flying vehicle. As sensors to be mounted, basically 7 sensors such as temperature sensor, humidity sensor, CO sensor, CO₂ sensor, Ozone sensor, dust sensor and VOC sensor (for detecting organic compounds) are included. ATMega 128 based universal sensor mounted module system that may receive signals of more than 7 sensors is under design and development.

Transmission protocol and sensor data monitoring system that may receive various signals based on embedded system by developing a module in which diversified kinds of sensors

including those sensors shown in Table 1 could be mounted is under R & D and at present, a monitoring system that transmits signal at the time when the amount and specific gravity of carbon dioxide are high by measuring carbon dioxide in the air using CO2 sensor is under R & D.[5],[6]

		
CO Sensor	VOC Sensor	Dust Sensor
		
Ozone Sensor	CO2 Sensor	Humidity sensor

Figure 3. Kinds of sensors

B. Multiple Sensor Module

In order to detect each information, control circuit design and mounting module board have been developed in order to drive and control each sensor by applying temperature sensor, humidity sensor, carbon monoxide sensor, carbon dioxide sensor, ozone sensor, dust sensor, VOC sensor (for detecting organic compounds).

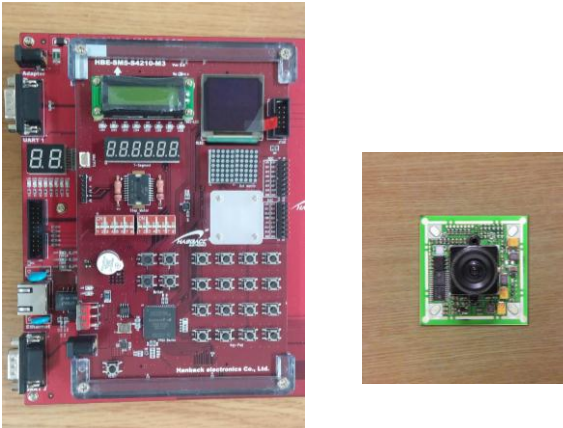


Figure 4. Multiple sensor modue and embedded system

In addition, a system that informs users through smart phone when various harmful gas concentration reaches a certain concentration level by sensing harmful gas concentration in multiple sensor module is under development. If harmful gas concentration should be higher than that of setting value in multiple sensor module by setting it arbitrarily, such result is informed to the user through smart phone and the user is able to inspect such dangerous situation.



Figure 5. Small flying vehicle based integrated control system for structural safety inspection

Figure. 5 is a research project that is currently required to be developed.



Figure 6. Multiple sensor mounted small flying vehicles

Fig. 6 is a small flying vehicle mounting multiple sensors and by mounting multiple sensors and image sensor, it inspects safety of internal/external structures.

C. Design of multiple monitoring system

Multiple sensor monitoring system is a system for preventing occurrence of cracking and various dangerous situations due to diversified causes including deterioration or defective work of structures in advance. In addition, this system inspects data in the air in real time using unmanned flying vehicle and by using obtained data, monitors subject structure in real time.

Multiple sensor monitoring system is mainly divided into small flying vehicle and embedded system. Small flying vehicle is an unmanned flight system that performs data detection and transmission in real time by using multiple sensor and embedded system receives data transmitted from small flying vehicle and processes received data in real time and at the time of risk occurrence, informs users of dangerous situation through smart phone.

As embedded system that is data processing system is required to process data collected by heterogeneous multiple sensors based on processing module that may process data in real time with high speed and perform a function of processing images in real time at the same time, it was

designed based on excellent performance. In addition, as sensors being used for multiple sensor monitoring system use diversified sensors including PTZ camera having a function of infrared ray, temperature, humidity sensors, it is required to use and provide diversified interfaces.

Embedded system provides a function of acquiring, processing and transmitting various sensor data and controlling sensors by analysing instructions after receiving it and provides monitoring information of sensors so that status information of each sensor could be observed remotely. At the same time, in order to synchronize data collected by each sensor, it provides a separate function and a process of storage, transmission processing of sensor data is required.

D. Structure of Multiple Sensor Monitoring System

The whole configuration diagram of the system proposed in this paper is shown on figure 7.

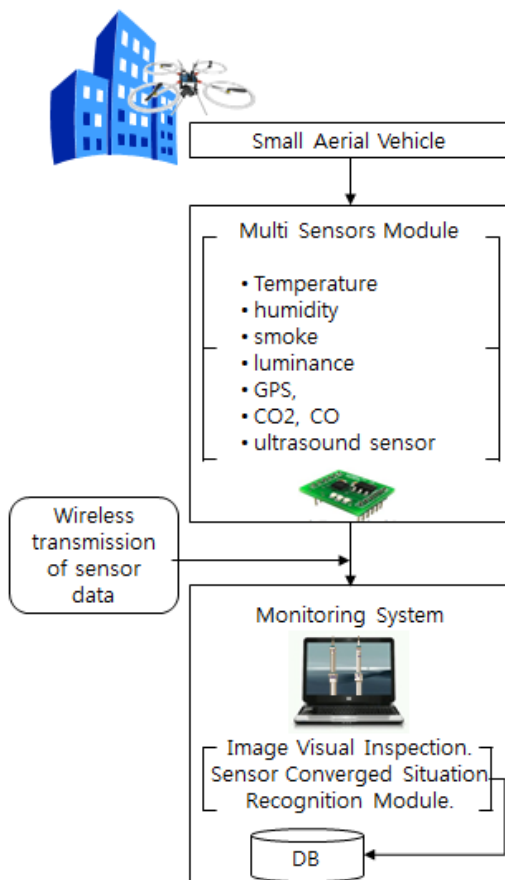


Figure 7. System Configuration Diagram

As main function of multiple sensor monitoring system is that the functions such as high speed input/output processing of various sensors, real time synchronization of sensing data, transmission of processed data are required to be performed at the same time, real time monitoring is required. By flight of small flying vehicle, each sensor starts to be operated and at this time, storage of sensing data and its transmission module are required. In addition, this system was designed to transmit

and store collected data in big data storage device and process stored data after the flight is finished.

Each module of multiple sensor monitoring system was designed to perform each function that is required to be provided by data processing system. In order to process image data of PTZ camera, compression module is provided and for data synchronization of various sensors, synchronized module and transmission module for transmitting data in real time are provided. In addition, in order to process input/output of diversified sensors being connected through each interface, temporary storage space was provided. These modules provide informing and monitoring system function through smart phone by it being implemented in parallel.

IV. SENSOR CONTROL AND DATA PROCESSING

A. Sensor Control

Multiple sensor monitoring system provides real time control function to multiple sensors. As this system uses operating small flying vehicle and commanding embedded system, multiple sensor monitoring system provides control function to diversified sensors. This system controls sensors by transmitting instructions to sensor that is desired to be controlled and using data processing system that analyses transmitted instructions.

B. Data Processing

In multiple sensors monitoring system, sensing data collected by each sensor is processed in real time and transmitted to embedded system. However, as transmission rate of transmission route being used at the time of transmission by embedded system is limited, in order to transmit big data, a process of compressing sensing data is required. In particular, as image data being collected by camera is big data, its compression process is essential and as compressed image data is also unable to be transmitted at one time, it is required to be transmitted to embedded system by dividing it into transmissible packet by using a separate transmission format. In addition, as data of each sensor is required to be transmitted by division at the time of transmitting sensing data, transmission format is required to be indicated with tag matching with each sensor. At the same time, tag of sensing data based on time synchronization is required to be included.

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V. CONCLUSION AND FUTURE TASK

At present, a lot of small flying vehicles are applied, researched and developed in various fields including shooting site of TV program such as entertainment and documentary, patrol purpose for safety control, exploration purpose for roving Mars and other purpose of diversified specificities.

This study is being progressed by using small flying vehicle for safety inspection of structures. By using small flying vehicle for safety inspection of structures, development process that may collect, store, transmit and process multiple sensor data of multiple sensor monitoring system was explained. In multiple sensors monitoring system, modules for high speed input/output processing, real time sensor data synchronization, compression, and transmission of data were designed.

This study is a part of a project for developing safety inspection system of structures based on augmented reality by using small flying vehicle. A module for controlling sensors by mounting diversified sensors that are key elements of this system study contents in small flying vehicle was designed and this module could be applied not only to small flying vehicle but also to other systems.

In the future study, a system that may increase utilization accuracy of various sensors through diversified direct tests by using various sensors and prevent structural cracking and dangerous situations in advance through analysis of image data being transmitted from PTZ and thermal infrared camera is scheduled to be researched.

It is expected that based on this system, various structures would be free from the danger of fire, disaster and deterioration and its high-levelled safety would be maintained with reasonable coast.



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