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# Interlayer Noise Prevention System using IoT

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**Abstract:** Recently, interlayer noise has emerged as a social problem but there is not a method of accurately measuring interlayer noise. As Internet of Things (IoT) is applied homes, smart home systems that may make life in home more convenient have emerged and commercialized. Smart home systems may help the users who have difficulties for being unable to accurately measure interlayer noise. In the present study, a system that may measure interlayer noise was designed by using IoT which is the essence of smart home systems. The present study has realized a smart home system that measures interlayer noise at homes through a smart phone and enables users to control the system through using wireless communication.

**Key words:** Internet of things, smart home, Bluetooth, smart phone, Korea

## INTRODUCTION

As the problem of interlayer noise becomes severe recently it has emerged as a social issue. The Ministry of Environment and the Korea Environment Corporation established the ‘Community Center for Interlayer Noise’ to resolve the conflict caused by interlayer noise and the Ministry of Land, Infrastructure and Transport made a regulation to increase the floor thickness of buildings. Although, the Korean government and municipal governments are positively working to prepare various preventive measures, conflicts are still caused by interlayer noise (Kang *et al*., 2014). Means of measuring interlayer noise is not sufficient and different people sense interlayer noise differently. The Ministry of Environment has prepared a standard for interlayer noise and uses a certain noise level (dB) to define interlayer noise but measuring interlayer noise at homes is generally difficult. Internet of Things (IoT) may help to solve the problem to some degree. As the application of IoT is extending, homes may be also managed by means of IoT. This home management is called smart home which enables to efficiently manage what is inside homes in a real-time manner (Lee *et al*., 2014; Ko *et al*., 2015).

The interlayer noise measurement system using Arduino, proposed in the present study, measures real-time interlayer noise with attached sound detection sensor, vibration sensor and Bluetooth through Arduino that enables to easily realize the IoT described above, so that the interlayer noise caused inside a house may be measured and verified anytime and anywhere by using a smart phone. While conventional interlayer noise measurement systems has only the function of measuring noise, the interlayer noise measurement system developed and realized in the present study may display an alarm message when the measured interlayer noise is higher than the national standard.

### Literature review

**Arduino:** Arduino which is an open source-based, single board micro controller refers to the completed board and the development tool and environment. Arduino is usually prepared by using a board including AVR of Atmel. A micro controller may be easily operated through the provided Integrated Development Environment (IDE).

Arduino enables to easily upload a compiled firmware through USB without undergoing the inconvenient procedure of general AVR programming. Arduino is a product optimized to sensor-based IoT because it enables to fabricate various IT devices, electronic devices, lighting devices and robots by connecting various sensors and part in a space of the size of a palm (Ahn, 2016).

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**Internet of things:** Internet of Things (IoT) has been defined in various ways depending on the areas where the concept is applied. The definition of IoT made by the Ministry of Science, ICT and Future Planning in 2014 was "a super-connected internet where all things including people, things, spaces and data are connected with each other through the internet to create, collect, share and utilize information." The definition of IoT by the Korea Internet and Security Agency is "the environment of sharing through the internet information created by identifiable things; a next-stage internet advanced from the conventional wired communication-based internet and mobile internet" (Choi and Kim, 2016; Park and Kang, 2014).

**Bluetooth:** Bluetooth is a local wireless communication technology using a wireless frequency of 2.4 GHz. Bluetooth is highly reliable because it consumes little electric power and uses a high-speed frequency hopping method and includes an independent error correction technology. For low-power operation, the wireless modem has been produced in a small size. The small wireless mode is recently provided as a module and used to fabricate a cheaper local communication system (Je and Yang, 2012; Cho, 2015).The data transmission through Bluetooth is performed by polling to transmit data packets in a slot time of a specific period. Since, the data transmission is performed only in a regular slot period, the data transmission rate is constant (Kim *et al*., 2008).

## MATERIALS AND METHODS

### Interlayer noise prevention system

**System design:** In the present study, an interlayer noise measurement system was prepared by using Arduino, a sound sensor, a vibration sensor and Bluetooth. This article proposes a smart home system where the noise and vibration are measured by using an interlayer noise measurement device attached to the ceiling and the real-time noise level may be checked out through a smart phone. The architecture of the system is shown in Fig. 1.

The main module shown in the system architecture consists of two types of sensors and a Bluetooth module. A user may check out the noise level by using an application based on the communication between a smart phone and the Bluetooth module. The user may turn off the system through Bluetooth when the measurement is not necessary.

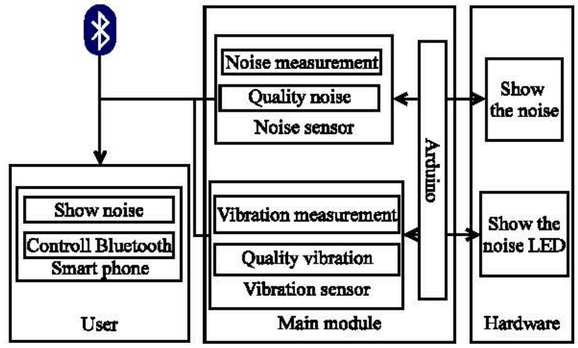


Fig. 1: System architecture

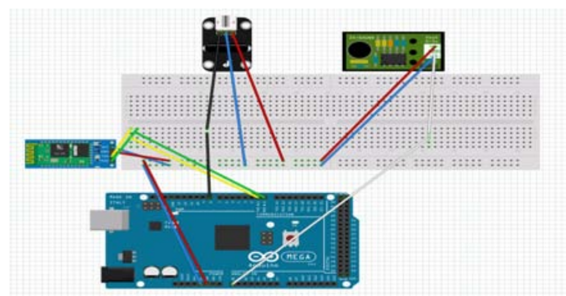

Fig. 2: Arduino architecture

The sound sensor and the vibration sensor included in the main module are connected with arduino to measure the noise generated by the upper layer. The measured noise level is shown to the smart phone of the user connected through Bluetooth. The application has a display that enables the user to view the noise level and the user may easily check out the interlayer noise. The LED sensor at the outlet of the main module emits light when the interlayer noise level is 40 dB or higher. The light enables the user that interlayer noise has been generated. When the smart phone device is not available, the command to the LED sensor is sent to the application through the Bluetooth module. The user may notice through the smart phone that the interlayer noise is over 40 dB.

Figure 2 shows the interlayer noise measurement Arduino and the sensor architecture. The sensors are a sound sensor and a vibration sensor. The devices attached to the ceiling are controlled through the Bluetooth module.

**System implementation:** The system of the present study were realized in the Microsoft Windows 8 Home Premium K 64 bit operating system. The Android Minimum Required SDK was realized by using API 14: Android 4.0 (Ice Cream Sandwich) and the Target SDK by using API 18: Android 4.4.2 (Kit Kat). Algorithm 1 shows the algorithm to execute the command to measure the noise by using a sound sensor in the main module consisting of Arduino, sensors and the Bluetooth module.

**Algorithm 1 (Sound sensor outlet):**

```
int state = 0;
void setup() {
pinMode(A0,INPUT);
pinMode(A1,OUTPUT);
}
void loop() {
 if(digitalRead(A0) == 1) {
  state = 1 - state;
digitalWrite(A1,state);
 delay(50);
 }}
```

As shown in algorithm 1, the sound sensor receives noise input through pinMode A0 and sends noise signal output through pinMode A1. In the algorithm, the noise signal output is released every 5 sec. The outlet algorithm of the vibration sensor of algorithm 2 is shown below. The ledPin is connected through '13' and the communication rate is set to be 9600.

When the measured noise level is 40 dB or higher, the LED gives a warning light output. When the measured noise level below 40 dB, the LED does not give a warning light output. The state of vibration is measured every 5 sec and the measurement value is returned every second.

**Algorithm 2 (Vibration sensor outlet):**

```
intledPin =13;
intvib =2;
void setup() {
pinMode(ledPin, OUTPUT);
pinMode(vib, INPUT);
Serial.begin(9600);
void loop() {
long measurement =TP_init();
delay(50);
Serial.print("measurment = ");
Serial.println(measurement);
if (measurement >40) {
digitalWrite(ledPin, HIGH);
}
else {
digitalWrite(ledPin, LOW);
}}
long TP_init() {
delay(10);
long measurement = pulseIn (vib, HIGH);
return measurement;
}
```

## RESULTS AND DISCUSSION

**Implementation results:** Figure 3 shows the device of the interlayer noise measurement system developed in the present study as it is attached to the ceiling. As shown in Fig. 5, two sensors and one Bluetooth module are

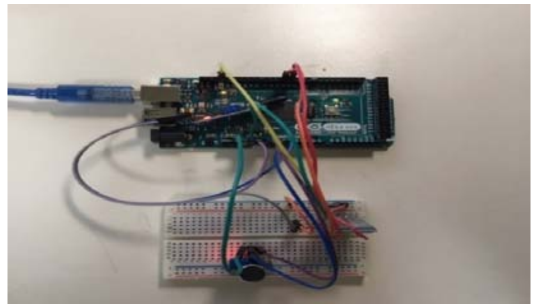

Fig. 3: System devices to be installed on the ceiling


Fig. 4: Main screen

installed on the ceiling to measure the interlayer noise. The sound sensor measure the sound in the living environment of the upper layer such as sound from a piano or sound caused by yelling. The vibration measures various vibration including the vibration caused by hopping in the upper layer. The outer package of the system device will be produced by using a 3D printer, enabling the system to be attached to or detached from the ceiling. Figure 4 and 5 show the main screens of the interlayer noise prevention system developed in the present study.

Figure 4 shows the main screen of the system which appears firstly when the application is run. The main screen shows the measurement values from the sound sensor and the vibration sensor. The main screen well shows the real-time measurements of sound and vibration. The measurements do not disappear: rather, the accumulated measurement values are continuously shown to the user.

Figure 5 shows the system control screen where the system device attached to the ceiling may be turned on or

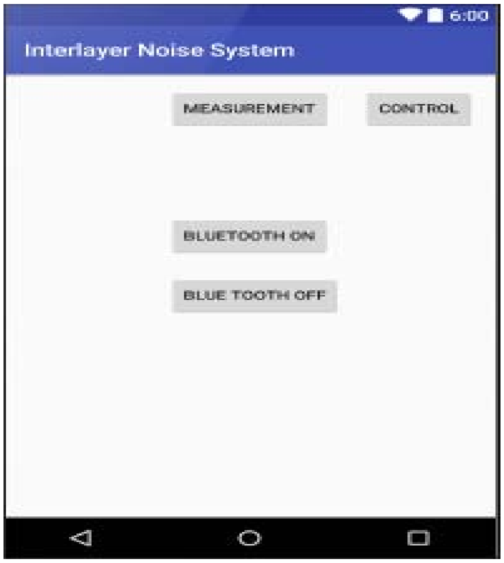


Fig. 5: System control screen

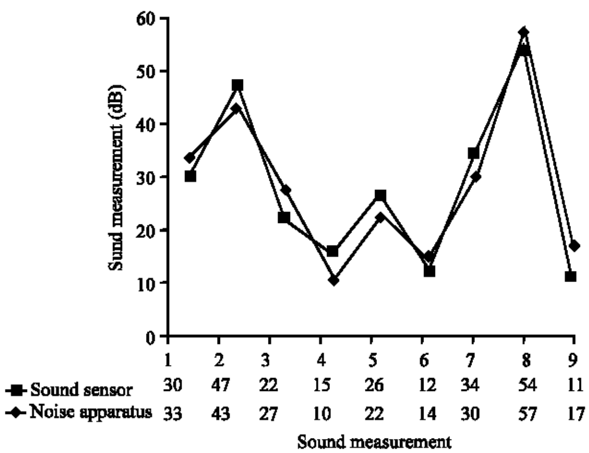


Fig. 6: Sound sensor simulation result 1

off through Bluetooth. The system control screen enables the user to turn off the system device if the user does not want the measurement. When the user wants the measurement, the user may turn on the system.

**Performance evaluation:** Figure 6 and 7 show the performance evaluation results of the interlayer noise measurement system. The simulation condition was to generate unspecified sound and vibration 9 times. The values measured by the sensors and received by the smart phone were compared with the values measured by using a commercially available noise measuring apparatus. As shown in Fig. 6, the simulation results showed that the values measured by the sound sensor and received by the

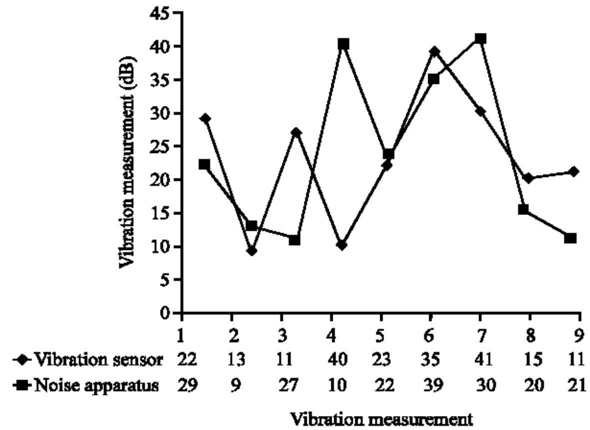


Fig. 7: Vibration sensor simulation result 2

smart phone were not significantly different from the values measured by the noise measuring apparatus.

The maximum error was just 5 dB. Therefore, the results verified that the noise level measured by the sound sensor was not very different from the noise level measured by the noise measuring apparatus.

Figure 7 shows the values measured by the vibration sensor. The values measured by the vibration sensor and received by the smart phone were different from the values measured by the sound sensor at certain time points. With regard to the fourth unspecified vibration in Fig. 7 the value measured by the sound sensor was 40 dB while the value measured by the vibration sensor was 10 dB. The difference was 30 dB. Except that time point, the difference was within 10 dB indicating that the system does not have a significant problem.

## CONCLUSION

In the present study, an Arduino-based interlayer noise measurement system was prepared by using a sound sensor, a vibration sensor and Bluetooth. A smart home system was also proposed to use the interlayer noise measurement system that enables to easily measure the interlayer noise at homes and to check out the real-time interlayer noise in the home through a smart phone. The system was realized without an additional installation cost by attaching the device to the ceiling so that the system may be easily controlled by using a smart phone through Bluetooth. The operation of the system was tested and demonstrated. The current system was realized to enable a user to check the real-time interlayer noise by using a smart phone. However, future studies will be conducted to establish a server that can produce database of the measured noise level and to develop a database system that enables to verify the interlayer noise level of specific dates.

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