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The application of wireless sensor technology in gymnasium temperature and humidity control system

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Abstract. The main objective of this study on temperature and humidity control in indoor sports halls is to provide an environment that is suitable for the people exercising in the halls and a way to minimize unnecessary sports injuries. The research methods used in this paper are both field monitoring of the environment and online data collection. The paper concludes with a temperature and humidity monitoring network based on a wireless sensor network to detect environmental temperature and humidity and thus achieve a system that can regulate it.

Keywords: Wireless Sensors, Gymnasium, Intelligent Regulation.

1. Introduction

The lack of attention to the environment of stadiums in China has led to the absence of such a system in most stadiums. After reading several papers on the subject, I was convinced of the above hypothesis. Most of them are used only for detection and not for the next step of regulation. Most of the methods based on wireless sensing technology for monitoring indoor environments are already relatively well established. In the earliest problems concerning the monitoring of components in the indoor environment, people were solving the problem of fast energy consumption and bad recharging of wireless sensors, and later on people solved the problem mainly for different building types and building internal structures requiring different deployment solutions. The above ideas at home and abroad are in fact similar, but abroad this technology has developed more time, the technology is relatively mature. The biggest difference between domestic and international methodologies is the research on deployment methods and the updating of wireless sensor charging problems.

2. Significance of the subject

2.1. Cost saving

Now the temperature and humidity control in major stadiums are controlled by separate air conditioners and dehumidifiers separately, if there is no temperature and humidity control system supported by wireless sensing technology now, then these separate air conditioners and dehumidifiers will continue to work and consume a lot more power than the temperature and humidity control system established based on wireless sensing technology, so one of the major advantages of this system is power saving and energy saving.

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2.2. Sports safety
Sports safety: In hot and humid climates, the cold air produced by the air conditioning in the gymnasium will form a layer of water on the floor when it meets the hot and humid air, increasing the risk of injury to the enthusiast.

3. Designing process

3.1. Research objectives
Making a wireless sensor-based temperature and humidity monitoring system for indoor stadiums. Using humidity and temperature sensors for site deployment, when humidity and temperature reach certain numerical thresholds, dehumidifiers and air conditioners work until both values monitored by the environment drop to the desired level, after which they enter a dormant state until the next operating interval is reached.

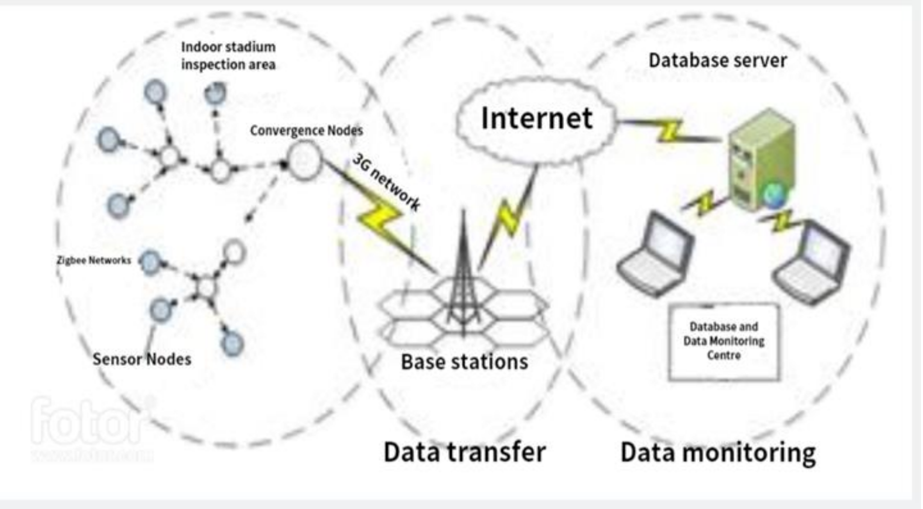

Figure 1. Relationships between inputs, outputs and control hubs.

3.2. Research content
The existing indoor environmental monitoring system is updated to enable subsequent regulation and on-demand functions, e.g. by connecting the terminal to the output and programming it to work or rest at a certain humidity and temperature.

3.3. Key issues to be addressed
The existing wireless sensing technology supported indoor environmental monitoring system is upgraded to achieve three important aspects of environmental self-monitoring, self-feedback and self-regulation. Among the key issues are:

- Deploying wireless nodes according to different building interior environments.
- Connecting the nodes that collect information to the intelligent terminals, which are then connected to the outputs (air conditioners and dehumidifiers).
- Programming to control the operating status of the air conditioners and dehumidifiers on the output side by analysing the data collected at the front end.

4. Data collection

4.1. Data acquisition node consolidation

The data collection nodes are mainly divided into convergence nodes, routing nodes and terminal nodes, where the most important temperature and humidity sensor is the DHT22 temperature and humidity sensor, which can detect a wide range of -40 ~ 80°C and the detection error is ±0.5°C (Humidity range: 0-100%RH Resolution 0.1%RH Error ±2%RH) [5].

4.2. Take some indoor temperature and humidity measurements on the hottest days of the summer (August to September)

Table 1. Short cut of some data.

Date and time	Temperature in stadium(degree)	Difference in temperature/humidity according to average optimum
8/2 13:00	29.2	4.2/
8/3 13:00	30.7	5.7/
8/5 13:00	29.0	4.0/
8/6 13:00	27.9	2.9/
8/10 13:00	27.8	2.8
8/14 13:00	28.2	3.2/
8/21 13:00	30.3	5.3/
8/22 13:00	28.2	3.2/
9/1 13:00	29.1	4.1/

5. Specific experimental procedures

5.1. Selection of monitoring sources

The ESP8266 NodeMCU and the DHT22 module are selected as the hardware for the indoor temperature and humidity monitoring system. The temperature and humidity data obtained by the DHT22 module is sent to the ESP8266 NodeMCU development board every second.

5.2. Development of code

Code content that could be improved: The ESP8266 NodeMCU development board then sends the temperature and humidity data to the cloud server via the HTTP protocol, and then the changes of the indoor temperature and humidity can be observed through the website page.
The original code is shown below:

```
#include <dht.h>

dht DHT;
#define DHT22_PIN 7

void setup()
{
  Serial.begin(115200);
  Serial.println("DHT TEST PROGRAM ");
  Serial.print("LIBRARY VERSION: ");
  Serial.println(DHT_LIB_VERSION);
  Serial.println();
  Serial.println("Type,\tstatus,\tHumidity (%),\tTemperature (C)");
}

```

```
void loop()
{
  Serial.print("DHT22, \t");
  int chk = DHT.read22(DHT22_PIN);  //read data
  switch (chk)
  {
    case DHTLIB_OK:
                Serial.print("OK,\t");
                break;
    case DHTLIB_ERROR_CHECKSUM:
                Serial.print("Checksum error,\t");
                break;
    case DHTLIB_ERROR_TIMEOUT:
                Serial.print("Time out error,\t");
                break;
    default:
                Serial.print("Unknown error,\t");
                break;
  }
  // display data
  Serial.print(DHT.humidity, 1);
  Serial.print(",\t");
  Serial.println(DHT.temperature, 1);

  delay(1000);
}
```

The dht library is the official library provided by Arduino. To implement the subsequent feedback and self-adjustment functions (detecting the ambient temperature and humidity and then adjusting it to the appropriate indicator for the movement), it is necessary to introduce the http protocol and the data management service of the cloud server.

5.3. The development of code snippets

Based on the address of the web server for uploading temperature and humidity data, and at the same time creating http objects, the NodeMCU module can effectively upload the sensor monitoring data to the cloud after connecting to the local WIFI, part of the important code is as follows.

```
Serial.print("[HTTP] begin...\n");
  //Start a connection and send HTTP headers and messages
  httpClient.addHeader("Content-Type", "application/json");
  int httpCode = httpClient.POST(requestBody);
  Serial.print("[HTTP] POST...\n");
  if (httpCode > 0) {
    Serial.printf("[HTTP] POST... code: %d\n", httpCode);
    if (httpCode == HTTP_CODE_OK) {
      const String& payload = httpClient.getString();
      Serial.println("received payload:\n<<");
      Serial.println(payload);
      Serial.println(">>");
    }
  } else {
    Serial.printf("[HTTP] POST... failed, error: %s\n", httpClient.errorToString(httpCode).c_str());
  }
}
```

5.4. Adaptive regulation of air conditioners and dehumidifiers based on ESP8266 NodeMCU development board

The last and most critical step is to connect this system to the dehumidifier and air conditioner. When the humidity is lower than the lowest comfortable humidity (generally around 40%~70%), the

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development board controls the relay to turn off the dehumidifier, and when it is higher than the comfortable humidity, the development board controls the relay to turn on the dehumidifier; when the temperature is lower than the lowest comfortable temperature (generally around 18℃~25℃), the development board controls the infrared emitting module to turn on the air conditioner for heating, and when the temperature is higher than the highest comfortable temperature, the development board controls the infrared emitting module to turn on the air conditioner for cooling.

After collecting data from the temperature and humidity sensors, uploading the data and comparing the data laterally, the air conditioner and dehumidifier connected to the development board were responsible for the temperature and humidity control respectively. The air conditioner, however, works steadily within the set temperature range. The source code is attached in the appendix.

6. Conclusion

The whole process was complete and most of the steps went as expected, but some of the experimental processes had equipment problems that prevented the best results from being achieved. In many sports stadiums today, most staff only use dehumidifiers and air conditioners for long periods of time as separate devices for convenience. Especially in the hot and humid south of the country in summer, the lack of precise control of the temperature and humidity in the indoor arena has caused considerable problems for the people playing sports in the arena, not only in terms of sports safety but also in terms of energy saving and emission reduction. If the intelligent control system used in this experiment is applied to major sports venues, it will bring unimaginable benefits to the people who play in the venues.

Appendix

```
#include "AirConditionerAutoControl.h"


AirControl::AirControl(char* ssid, char* pwd)
{
    dht.begin();
    irsend.begin();
}

void AirControl::listen()
{
    int temp = this->getSensorData();
    Serial.print(temp);
    if (temp > TEMP_COLD_MODE_LIMIT)
    {
        if (lastCommand == "shut")
        {
            this->sendIRcommand(irCold28);
            lastCommand = "cold";
        }
    }
    else if (-50 < temp < TEMP_HOT_MODE_LIMIT)
    {
        if (lastCommand == "shut")
        {
            this->sendIRcommand(irHot24);
            lastCommand = "hot";
        }
    }
    else if (TEMP_HOT_MODE_SET < temp < TEMP_COLD_MODE_SET)
    {
        if (lastCommand != "shut")
        {
            this->sendIRcommand(irShut);
            lastCommand = "shut";
```

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```
        }
    }
}

int AirControl::getSensorData()
{
    //get temp data
    // float humi = dht.readHumidity();
    float temp = dht.readTemperature();
    // int h = (int)humi;
    int t = (int)temp;
    if (isnan(t)) {
      return -500;
    }
    if (t > 75)
    {
        return -500;
    }
    return t;
}

void AirControl::sendIRcommand(uint16_t command[])
{
    //send air conditioner ir signal
    irsend.sendRaw(command, 147, 38);
}
```

References

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