Raspberry Pi Based Smart Humidifier with Model Prediction

Mengdong Xue [1, a], Hengyang Wu [1, *]

[1] School of Computer and Information Engineering, Institute for Artificial Intelligence,

Shanghai Polytechnic University, Shanghai 202309, China

[a] 2716727469@qq.com, [*] wuhy@sspu.edu.cn

Abstract. This work is based on Raspberry Pi and implements three main functions, namely temperature and humidity measurement, automatic switching on or off of the humidification module beyond the threshold, and anti-dry burning warning. The temperature and humidity sensor and pressure sensor receive the data and display it in real time on the serial port monitor. After the data is sent to the serial port, the WiFi module can transmit the data to the mobile phone application for remote real-time monitoring and surveillance. When the mobile phone detects insufficient water in the humidifier, it turns on the operation pump and pumps a fixed amount of water into the humidifier. At the same time, the data detected by the sensor is put into the deep learning model, and the predicted data is analysed to achieve the effect of pre-humidification and regulating the balance of environmental parameters.

Keywords: Raspberry Pi; Humidifier; Mobile App; Deep Learning.

1. Introduction

In life, air temperature and humidity always work together with other physical parameters to affect human comfort. When the ambient humidity is too low, human skin will become rough or even cracked due to water evaporation, and the body's immune system will be harmed, so that the resistance to diseases will be greatly reduced or even lost; when the indoor humidity is too high, the increase in relative humidity of the skin will enhance the friction between the skin and clothing, which will lead to damage to the skin barrier[1]. Indoor air humidification, although it can be done by sprinkling water or placing a water basin, but these methods are not effective in improving the surrounding temperature and humidity values, the most effective and convenient method is still to use a humidifier.

With the progress of society, the traditional humidifier has been backward, unable to meet the increasingly lazy lifestyle of contemporary young people. The study of intelligent humidifiers will surely become another great achievement in the use of science and technology in life.

This project is based on the design and implementation of Raspberry Pi intelligent humidifier, can be achieved through the temperature and humidity sensors and pressure sensors humidification operation of the humidifier and anti-dry burning function, through the WiFi send and receive signals to determine the indoor temperature and humidity and temperature and humidity control range of the transmission of information, the use of mobile phone applications to achieve the real-time display of the indoor temperature and humidity, when the temperature and humidity exceeds the threshold value set, the humidifier automatically[2]. When the temperature and humidity exceeds the set threshold, the humidifier will automatically carry out humidification operation, and through the pressure type water level sensor to achieve dry burning warning, below the water level line automatically add water, at the same time, the detected data will be transmitted to the database into the model for prediction, according to the prediction of the situation of humidity fine-tuning, this work to meet the user's humidification needs and safety and security, is conducive to improving the quality of life, comfort and sense of well-being.

2. System Design Options and General Framework

2.1 System design scheme

Smart humidifier is a new type of humidifier that makes full use of the interaction of sensors to perceive environmental changes, so as to adjust and control the humidifier's work [10]. The designed smart humidifier can work automatically according to the temperature and humidity set by the mobile phone application, which needs to meet the following four requirements:

1.Referring to the water dispenser, the humidifier is controlled to achieve the humidification operation by comparing the self-set relative humidity value with the actual humidity value. When the relative humidity value of the environment is lower than the set value, the humidifier will automatically humidify; when the relative humidity value of the environment is higher than the set value, the humidifier stops working[3].

2.Users can download the humidifier application on their mobile phones and set the humidity limit value by themselves through the application according to the environment where they are located, and the relative humidity value, temperature value and humidity limit value collected by the sensor can also be displayed on the mobile phone application.

3.The humidifier automatically adds water when it is below the water level line to prevent dry burning.

4.The model prediction takes the lead in fine-tuning the ambient humidity so as to avoid an uncomfortable situation when the environment suddenly changes too quickly. The overall system design is shown below.

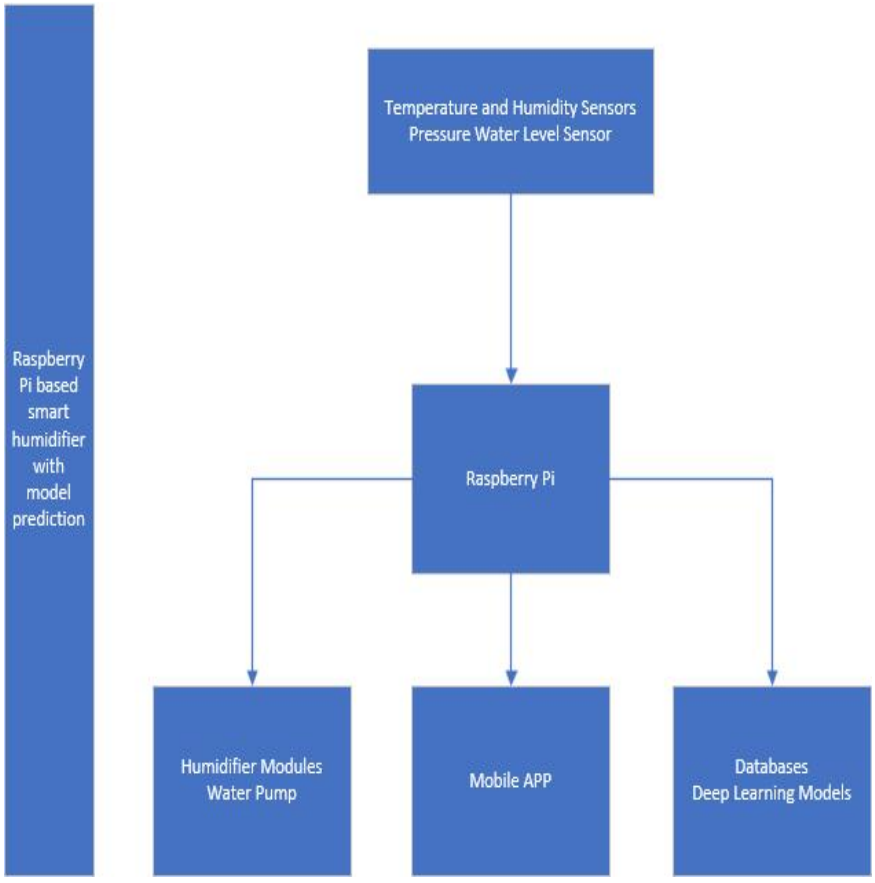

Fig. 1 Overall system design diagram

2.2 System flow chart

The main programme flow chart clearly reflects the humidifier humidification workflow. After the power supply is connected, the DHT11 temperature and humidity sensor immediately

carries out its work and sends it to the Raspberry Pi in real time, which parses the real-time data and sends it to the application on the mobile phone, and the Raspberry Pi determines whether it needs to carry out humidification after receiving the temperature and humidity thresholds sent by the application on the mobile phone[4]. As shown in Figure 1.

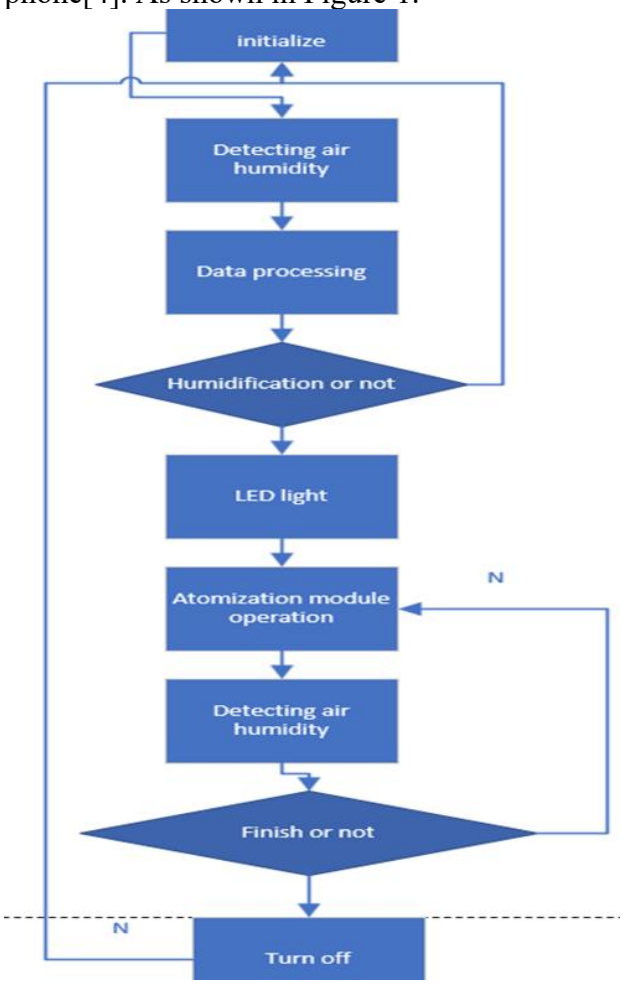

Fig. 2 System flow chart

3. System Module Introduction

3.1 Hardware Module

3.1.1 Raspberry Pi

Raspberry Pi is an ARM-based microcomputer motherboard with an SD card as the memory hard drive. The model used in this system is 4B, which is mainly used as an intelligent gateway with two duties[5]. The first duty is to receive the data from the mobile phone app and send the corresponding commands to control the humidifier module to react according to the data. The second duty is to send the data from the temperature and humidity sensors to the mobile app for the user to view.

3.1.2 Temperature and humidity sensor

The DHT11 digital temperature and humidity sensor is a temperature and humidity composite sensor containing a calibrated digital signal output. It applies special digital module acquisition technology and temperature and humidity sensing technology, making it highly reliable and long-term stability, and ultra-fast response, strong anti-interference ability, cost-effective[6]. DHT11 digital temperature and humidity sensor range humidity 20-90% RH, temperature 0 ~ 50℃, accuracy humidity +-5% RH, temperature +-2℃. DHT11's single-bus communication mode, taking

up the MCU's I/O ports less, the communication protocol is simple and affordable, and the measurement time is short, simple and fast. DHT11's single bus communication method, occupying less I/O ports of MCU, simple communication protocol, moderate price, and short measurement time, simple and fast[7].

3.1.3 Water Pump

The function of the water pump in this system is to pump water into the humidifier from the outside by power-driven work when the water level of the humidifier is insufficient to achieve the function of anti-dry burning.

3.1.4 Humidifier Module

The function of humidifier module in this system is to drive the humidifier module to work for humidification through Raspberry Pi when the temperature and humidity sensor senses that the air humidity is insufficient to achieve the humidification function[8].

3.2 APP design and database

Design a mobile phone application. The mobile application is connected to the Raspberry Pi via WiFi and receives the information from the Raspberry Pi, displays the real time indoor temperature and humidity on the application and sets the temperature and humidity range and sends it to the Raspberry Pi[9].

The database used is mysql database for storing the data, the data measured by the sensor will be stored in this data so that it can be used for subsequent data processing.

4. System Testing and Model Prediction

4.1 Overall structure diagram

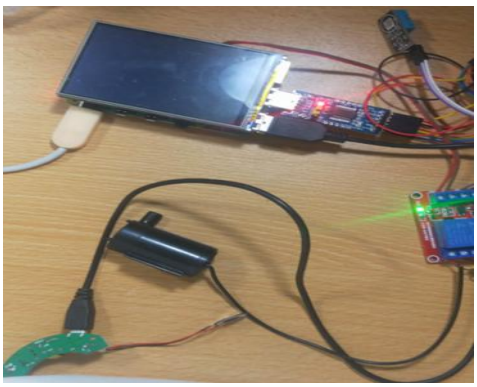

Fig. 3 System Appearance Diagram

4.2 Raspberry Pi connection and mobile app to set thresholds

Connect the humidifier and mobile phone in the same LAN.

Put the Raspberry Pi programme into operation. Figure 4 shows the Raspberry Pi running operation diagram. Figure 5 shows the Raspberry Pi running success diagram.

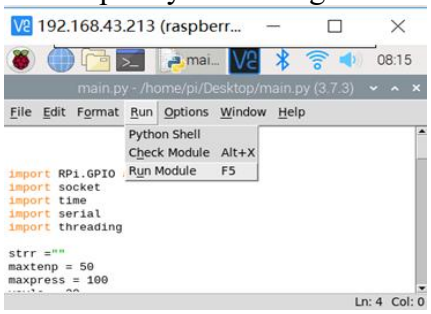

Fig. 4 Raspberry Pi Operation

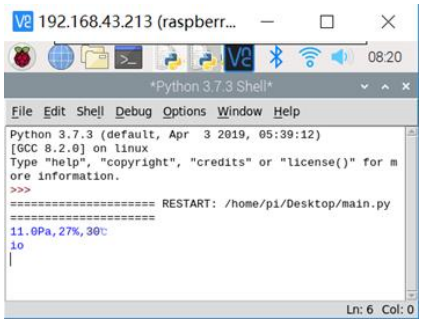

Fig. 5 Raspberry Pi Operation Successful Diagram

The Raspberry Pi can display the real-time temperature and humidity after successfully connecting with the mobile phone application and can set the threshold value on the mobile phone application, and the successful setting will show "Save Successfully!".

4.3 Model prediction and analysis

In this project, the extracted data is put into CNNLSTM hybrid model with Transformer

CNN-LSTM is a model that combines Convolutional Neural Networks and Long Short Term Memory Networks for processing time series data. The idea of this combined model is to use CNN for extracting spatial features in time series data, and then input the extracted feature sequences into LSTM for temporal modelling and prediction.Transformer is a neural network architecture based on the mechanism of self-attention, which is widely used in natural language processing tasks, such as machine translation, text summarisation, and language generation. The predicted data are as follows (in units of seven days):

Table 1. Forecast data table (seven days)

CNNLSTM(temp)	CNNLSTM(humi)	Transformer(temp)	Transformer(humi)
14.527142	43.04635	19.856725	41.254755
17.925055	41.3718	19.957896	41.453975
19.474205	41.093124	19.546355	41.39479
22.078205	42.683388	19.485262	44.125638
22.350403	43.326614	19.986321	44.478262
22.798237	41.47664	20.754126	43.456235
20.51659	41.27491	19.978145	41.551578

The accuracy of the prediction is shown below:

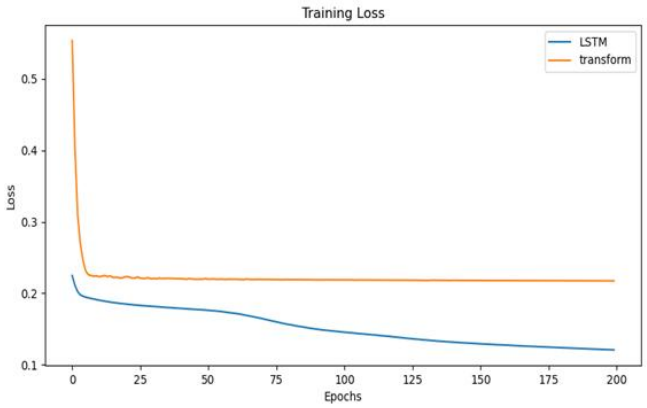

Fig. 8 Loss Function

After that we fine-tune the humidifier operation according to the predicted data, when the predicted data is biased towards lower humidity, we will give instructions to the humidifier to

slightly increase the humidity in the air to avoid the discomfort caused by the sudden change of humidity when in the environment, and vice versa.

5. Summary

Intelligent humidifier through the Raspberry Pi 4B that can be used as a microcomputer as a microprocessor and data core unit, through the DHT11 temperature and humidity sensors and the core code to control the humidifier in the set range of reasonable humidification, real-time temperature and humidity will be displayed on the mobile phone app, at the same time, through the pressure sensor and Android language to achieve the humidifier's anti-dry burning warning function. The humidifier can automatically detect the temperature and humidity value through the temperature and humidity sensor when it is working, and compare it with the threshold value set on the mobile phone app, so as to complete the intelligent humidification, obtain the information in the way of multi-sensor fusion, and provide the mobile phone and the intelligent terminal to carry on the data communication, so as to achieve the human-computer interaction and the remote monitoring, and the user can check the current indoor temperature and humidity and control the humidity range by using the mobile phone app, and the use of it is more convenient and has the promotion value[10]. The App terminal developed by Android can communicate with Raspberry Pi through WiFi in both directions, which can receive the environment temperature and humidity as well as control the range of humidifier to meet the needs of people's life convenience and comfort. Again, the data stored in the database will be put into the model for prediction in order to have a preventive effect. In terms of functionality, compared to more similar products on the market have certain advantages, more convenient and intelligent to use.

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