Application Analysis of Artificial Environment Control System with Ultra-miniature UAV

Wenhong Yu\textsuperscript{1} and Xiaojie Niu\textsuperscript{1} and Kuan Wang\textsuperscript{2}

\textsuperscript{1}School of Civil Engineering, North China University of Technology, 100144, Beijing, China;
\textsuperscript{2}China Railway Construction Group Technology Center, 100041, Beijing, China.

Abstract. In recent years, with the continuous development of building energy-saving technology, people are more aware of adjusting the energy-saving situation of air-conditioning system or heating system from the aspects of indoor thermal comfort and human thermal sensation. The key problem is that the thermal comfort of human body is constantly changing in the process of moving building space. Therefore, this paper puts forward a kind of assembled artificial environment control system with ultra-micro Unmanned aerial vehicle (UAV). It can adjust the thermal comfort of human body locally, reduce the running energy consumption of heating/cooling equipment, and realize building energy saving under the condition that human body can obtain the same or even better thermal comfort environment.

1. Introduction
In recent years, the development of building energy-saving technology is more and more rapid. People's demand for indoor environmental comfort is also increasing. Comparing with the previous methods that only through air conditioning equipment and heating equipment for indoor overall cooling or heating, it has been unable to meet people's needs of comfort. This is because human fever has unsteady characteristics. It belongs to unsteady load in summer and unsteady heat source in winter. The solar radiation and the radiation load of dense crowd can not form the cold load of air-conditioned room immediately, but be absorbed, reflected, exothermic, re-absorbed, re-reflected and re-exothermic by the inner surface of the room and various furnishings. In the process of multiple heat exchanges, the radiation components in the heat are eliminated through the heat storage and exothermic effect of the room and the furnishings. Gradually converted into convective components (cold loads), this process takes a certain amount of time. However, the effect of this part of radiation heat on human thermal comfort is not delayed. It will immediately affect the human body's sensory temperature and make people feel uncomfortable. Moreover, as an independent demand individual, the comfort degree required by each individual is also very different. Then, it is necessary to use some method for local cooling or heating, so that everyone can get as much comfort as possible while reducing the energy consumption of the cooling or heating system. In this paper, a kind of assembled artificial environment control system with ultra-miniature UAV is proposed to simulate and realize this idea. The UAV is used as the collection equipment of air parameters.
2. Introduction of Artificial Environment Control System

The system includes temperature and humidity sensors, ultra-micro UAV, UAV lift platform, intelligent control center, remote jet nozzle, air supply port, radiation heating and cooling system, active cooling beam, moisture absorption equipment, air purifier, all-air system, fan coil system and fresh air system. Temperature and humidity sensors are indoors. Ultra-micro UAV is equipped with thermometer sensor, humidity sensor, infrared radiation thermometer sensor, wind speed sensor and air quality sensor, and is installed on the UAV lifting platform. The remote jet nozzle is arranged indoors and connected with the whole air system. The air supply outlet, radiant heating and cooling system and active cooling beam are located at the top of the room. The air supply outlet is connected with the whole air system, fan coil system and fresh air system respectively. The hygroscopic equipment and air purifier are installed indoors. The intelligent control center is connected with temperature and humidity sensors, ultra-micro UAV, UAV lifting platform, remote jet nozzle, radiation heating and cooling system, active cold beam, moisture absorption equipment, air purifier, all-air system, fan coil system and fresh air system.

The technical problem to be solved by this system is to provide a kind of high intelligence, wide applicability and good energy-saving effect. It can measure the local air parameters of the room with the help of the Ultra-micro UAV indoor temperature and humidity sensor, predict the indoor air quality distribution, and use the remote jet nozzle to eliminate indoor load directionally. It is an artificial environment control system with miniature UAV that can automatically and accurately control the coordinated operation of air conditioning systems such as all-air system, fan-coil system, fresh air system, radiation heating and cooling system. The control system can make the air conditioning system more intelligent and accurate, and can significantly improve the indoor thermal comfort of human body.

3. Intelligent Control Center

The intelligent control center can determine the distribution of indoor air parameters according to the indoor temperature and humidity sensor and the information of indoor air quality obtained by the Ultra-micro UAV which can fly at high speed, carry out CFD simulation in advance, and aim the remote jet nozzle in advance at the most disadvantageous position of indoor air parameters reflected by CFD simulation results. CFD simulation can obtain the air parameters of the whole room in advance and improve the reaction speed of the system. Ultra-micro UAV can detect indoor air temperature and humidity without dead angle. The system controller compares the parameters with CFD simulation results, and then corrects CFD simulation. Intelligent control center with image recognition chip can control the UAV lifting platform and support the landing, charging and downloading data of the Ultra-micro UAV.

There are two ways for Ultra-micro UAV to transmit data to the intelligent control center: one is through wireless transmission of the main temperature and humidity information, the other is through downloading to the UAV lifting platform and then transferring to the intelligent control center. It can be said that UAV and intelligent control center are the two core parts of this system.

4. Operation method of the system

The simulation of operation method of this system takes the large conference auditorium as an example in summer. Half an hour before the meeting begins, the flight parameters of each point in the auditorium are measured by the take-off Ultra-micro UAV. It is found that the areas with temperature and humidity exceeding the standard should be treated by opening air supply outlets, radiation heating and cooling systems, long-distance jet nozzles, active cold beams and moisture absorption equipment in the corresponding areas, so as to realize on-demand supply and save energy. If the air quality exceeds the standard, the air purifier at the corresponding position should be opened for treatment, so as to save the power consumption of the purifier and the life of the filter element. The flight trajectory of the take-off Ultra-mini UAV is carried out according to the sitting height of the conference room.
personnel. Among them, when measuring the height close to the conference table, the UAV can land at the position of the people on the conference table and close the propeller for measurement.

After all the parameters are up to standard, the parameters measured by UAV are compared with those simulated by the CFD model of the room, and the CFD model of the room is modified.

Before the start of the meeting, people arrived one after another, the projection equipment was turned on and the lights were all turned on. At this time, the heat dissipating capacity of the human body, equipment and lighting in the conference room began soaring. The flight parameters of each point in the room were measured by the take-off ultra-micro UAV. At this time, if the flight measurement is carried out according to the sitting height of the conference room personnel, it will undoubtedly be dangerous and seriously affect the meeting. Other existing technologies can not automatically measure the temperature of each person's area. Therefore, the method adopted is: Ultra-miniature UAV flies close to the top air supply port, obtains all kinds of air parameters on the top of the room, and uses infrared radiation thermometer sensor to measure the infrared radiation temperature of each person's position from top to bottom, finds out the area where the temperature exceeds the standard, and opens the air supply port in the corresponding area. Radiant heating and cooling system, long-distance jet nozzle, active cold beam and moisture absorption equipment are processed to realize on-demand supply and save energy.

The air parameters from the roof of the room obtained by UAV are input into the existing CFD model of the room as the boundary condition. The intelligent control center can use the CFD model to simulate the humidity and air quality parameters of each location, and control the hygroscopic equipment and air purifier of each location according to these parameters.

Under the same temperature and humidity, people with different gender, age, region and health status will feel different degrees of warmth and cold. Considering the individual difference of cold and hot sensation and providing personalized and convenient interactive adjustment function for all users, the UAV has an image recognition camera in the present invention. The intelligent control center has image recognition chip. When the infrared radiation thermometer sensor is used to measure the infrared radiation temperature of each person's position from top to bottom, the image recognition camera starts at the same time. When the five fingers of the participants are separated on the top of the head, the image recognition camera and intelligent control are used. The heart recognizes this signal (or other signals) to indicate that the person feels overheated. At this time, he adjusts the air supply outlet, radiation heating and cooling system, long-distance jet nozzle and active cold beam in his position to reduce the temperature of his position. When the participants clenched their fists and put their fists on the top of their heads, the image recognition camera and the intelligent control center. Recognize this signal (or other signals) to indicate that he feels too cold. At this time, adjust the location of the person's air outlet, radiation heating and cooling system, long-distance jet nozzle and active cold beam, targeted to increase the temperature of his location.

After the meeting, the UAV returned to the UAV lifting platform, closed the air conditioning terminal equipment, and finished operation. In this way, the energy consumption of air conditioning system can be greatly reduced, so that it can supply cooling efficiently and shut down the system in time when there is no need for personnel to achieve the purpose of energy saving. The specific simulation drawings are as follows:
Figure 1. The schematic diagram of a simulation case of the artificial environment control system of an ultra-micro UAV.

Figure 2. Top view of the simulated case shown

Figure 3. Sectional view of the simulated case shown

In the Figure 1-3: 1. Temperature and humidity sensors; 2. Ultra-micro UAV; 3. UAV lifting platform; 4. Intelligent control center; 5. Long-distance jet nozzle; 6. Air supply outlet; 7. Radiation heating and cooling system; 8. Active cold beam; 9. Hygroscopic equipment; 10. Air purifier; 11. Glass curtain wall.
Figure 4. Structural schematic diagram of the super-miniature UAV shown in the simulation case.

In the Figure 4: 2-1. Thermometer sensor; 2-2. Humidity sensor; 2-3. Infrared radiation thermometer sensor; 2-4. Wind speed sensor; 2-5. Air quality sensor.

5. Summary
This paper puts forward a kind of assembled artificial environment control system with ultra-micro UAV. Then it discusses the characteristics and application analysis of the assembling artificial environment control system with ultra-miniature UAV, as well as its effect on building energy saving. This system takes advantage of UAV’s three-dimensional controllable operation, and uses UAV with sensors to realize three-dimensional dead angle parameter monitoring of indoor artificial environment parameters (temperature, humidity, infrared radiation temperature, wind speed, air quality). Compared with the existing wall sensors which can only measure fixed points, desktop mobile sensors which need manual movement or ground robot sensors which can only measure the height below the robot height, UAV can extend the monitoring range of indoor artificial environment parameters to the whole room space and obtain indoor artificial rings. It can control the indoor environment more accurately, improve the thermal comfort of human body, check the possible faults of indoor terminal equipment and realize energy saving.

Reference
[1] Li Zhengtong, Ming Tingzhen, Gong Tingrui, Tian Ying, Wen Yuanhao. The Impact of Human Mobility on Thermal Comfort of Indoor Environment[J]. Architectural Technology Development, 2016 (06).
[2] Yuan Hao. Study on the influence of human movement on indoor environment[D]. Changsha: Hunan University, 2005.
[3] Du Qiang. Indoor environment control analysis based on thermal comfort[J]. Journal of Hebei Energy Vocational and Technical College, 2008 (01).
[4] Li Chengwei. Air temperature, humidity, enthalpy and thermal comfort[J]. China Construction Daily, 2013 (06).
[5] Xu Xiaolin, Li Baizhan. Effects of indoor thermal environment on human thermal comfort[J]. Journal of Chongqing University (Natural Science Edition), 2005 (04).
[6] Zheng Wei, Chen Yifei, Liu Chang. Research on Indoor Environment Intelligent Control System Based on PMV Index[J]. China Agricultural University, October 2011.