



# Research on the Design of Human Settlement System and Personal Air Purification System Under the Background of Internet of Things

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**Abstract.** This paper discusses my research on human settlement system and personal air purification system based on mobile internet, internet of things, cloud computing, and big data analysis technologies under the condition that air pollution in China seriously affects people's normal life. The design and development of personal air purification system is mainly designed by optimizing the principle of anion air purification. The design background, design principles, design innovations, and design results of the system are described in detail. The problems encountered in the R&D process and solutions are described in detail in conjunction with actual products. Since the product was introduced, this product has been widely recognized by the market and has achieved a lot of honor and research patent achievements.

**Keywords:** Haze · Air purifier · Human settlement system · Anion Internet of things · Big data · Wearable device

## 1 Research Background

### 1.1 The Perception of PM2.5 in Chinese Cities

Air pollution, water pollution, noise pollution and even light pollution have long been known and valued. The word “Haze” has gradually been recognized by us since 2011 because of the continuous release of PM2.5 readings by the US embassy.

Nowadays, people attach great importance to haze, and people will always pay attention to the numerical changes of PM2.5. The Chinese government has managed and improved the air quality index through various methods, but we cannot improve the over-all environment quickly. Recently, China's market for purifiers is booming because aforementioned problems. Air pollution can cause respiratory diseases and cardiovascular diseases, and some sensitive people may have obvious discomfort or complications in a short period of time. The simplest protection is to wear masks with anti-haze effects, so the local mask market can even be sold out when the severe smog comes, but people can't wear masks sustaining. Most people have a misconception that indoor air is better than outside, so it's safe indoors. In fact, according to the experiment, even if the doors and Windows are closed, indoor PM2.5 concentration is between 1/3 and 2/3 of the outdoor concentration. So people spend a lot of time indoors, and the amount of smog they breathe is higher than in outdoor activities.

### 1.2 Usage Scenario Analysis for Personal Air Purification System

Before designing the system, we need to analyze the user’s usage scenarios first. It is divided into three main scenarios: Home, Outdoor and Public Place. The main feature of the first scene “Home” is the space fixed, the environment is relatively stable, the activity range is small, high frequency of use at night. The second scene is mainly “Outdoor” and “Open Space”. Its characteristics are mainly in the outdoor, moving, the surrounding environment changes fast and so on. The third public place is mainly characterized by large indoor space, tremendous flow of passengers. In addition to public building space, it also includes public transportation such as buses, subways, high-speed trains and taxis. How to solve the multi-scene air purification problem at the same time and how to provide a healthy air environment to the user all-weather is the biggest challenge of the system. The wearable device is a good direction. After many attempts, we finally chose the anion technology to introduce a purifier that can be carried around. Its main features are wearable, low energy consumption, zero noise, zero pollution and excellent purification effect.

The personal air purifying system provides air purification and monitoring service for users in various usage scenarios through anion technology and Internet of things technology. There are already a lot of purifiers in the market, but there are few solutions for a full range of personal air purification systems. The architecture of personal air purification systems based on technology such as the Internet of things, cloud computing and big data analysis. (see Fig. 1).



Fig. 1. The framework of the personal air purification system

## 2 Innovation of Personal Air Purification System Under the Background of Internet of Things

What is about the personal air purification system? In simple terms, there are mainly air purification, air monitoring, data transmission, cloud analysis, remote control, automatic work and data analysis.

The development of new technology and product system should be based on the relevant infrastructure construction and the development of relevant technology. For example, the important reason for the rapid development of the “ofo” and “mobike” sharing bikes in the Chinese market is the improvement of the environment of mobile Internet technology and mobile payment system. The development of smart home is

also based on the huge development of Internet of Things and cloud-computing technology, so the data generated by these smart home products can be stored and analyzed.

The living environment system (see Figs. 2 and 3) can satisfy both managers and ordinary users to check the relevant data of air quality. The manager can log on to the management system and check the air quality of multiple rooms in real time. Ordinary users can check the air quality of the current room through mobile devices such as



Manager, display screen

**Fig. 2.** The living environment system

mobile phones.

Why isn't the smart home market moving faster than sharing a bike? Because of the connection cost of Internet of Things, network security, user demand, business model etc., the Internet of Things technology is implemented slowly. Without complete infrastructure construction and mature technology application scale, it is difficult to make household products really intelligent. There is no guarantee that users' data and privacy security is the biggest threat. If the home intelligence security camera was hacked, then personal privacy and property security will be seriously threatened.

### 3 Design Principle of Air Purification System

First of all, we will compare and analyze the technical principle of existing air purification. At present, the widely used purification technology in the market is mainly three kinds: fiber filtration, electrostatic adsorption and anion. According to the new technology trend and market environment, it is easy to figure out which technology is best suited for the intelligent air purification system according to the following comparative analysis.



### Mobile Users

**Fig. 3.** The App of the living environment system

### 3.1 Fiber Filtration

This technology is the most widely used and the least technically difficult technology in the market. We call it air purification 1.0 technology. Its principle is in air to the machine, through internal filters and filter physics will air dirty things such as separate layers of filtration, finally, the clean air out of the machine outside so reciprocating cycle. The disadvantage of this technique is that it is noisy in use, and it is necessary to replace the filter and filter element frequently. If the filter element is not replaced in time, it will cause secondary pollution, leading to the high maintenance cost.

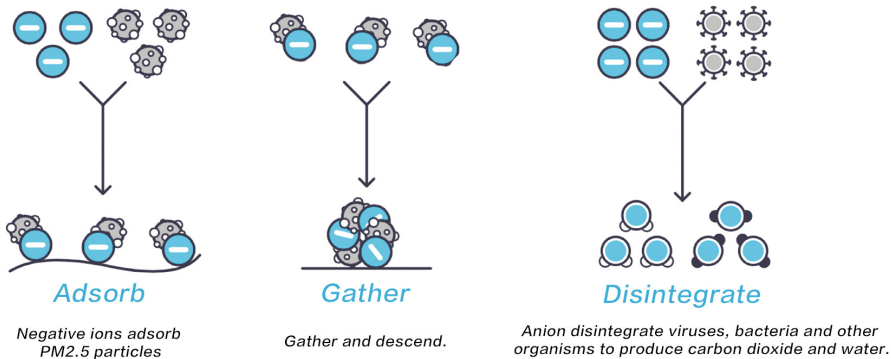
### 3.2 Electrostatic Adsorption

The purification principle of this technology is different from fiber filtration purification. We call it air purification 2.0 technology. The principle is to inhale the air through a fan, and the dust in air positively charged by the positive wire. Then it goes into the anion- charged multi-layer metal dust collector. Thus, the positively charged particles will rapidly adsorb on the dust-collecting device with negative power to achieve the purpose of dust removal and purification. Its advantage is that it does not need to consume material, purify efficiency is high, the disadvantage is if control was not good discharge voltage and so on condition can produce ozone, and this kind of principle air purifier general price is high.

This kind of electrostatic adsorption purification technology is mostly applied to the new wind system. Although the new wind system has been widely used, the main problem of the new wind system is that the installation is very complicated. Moreover, the fresh air system can cause secondary pollution of the air if the ventilation ducts and improper use are not regularly cleaned.

### 3.3 Anion

This air purification technology is the latest and most effective new technology that we call air purification 3.0. Its technical principle is to release negatively charged ions into the air through an anion generator, which binds the negatively charged ions to the airborne particles that are less than PM2.5. The small particles accumulate and form large particles and are eventually settled by gravity, thus achieving the effect of air purification (see Fig. 4), its advantages are that there are no consumables, no radiation, no noise, low energy consumption, sterilization, and sleep improvement. The disadvantage is that it is difficult to control the release of ozone. But through our purification system to the whole optimization design, adopted new booster module to the traditional technology upgrading, ensure air purification with excellent results at the same time avoid the secondary pollution of ozone. The interpretation of its working principle is also in the previous period of time in the column of CCTV channel 10 *Approaching Science* to be invited to show, made more people understand and believe that the reliability and practicability of this technology.



**Fig. 4.** Principle of anion purification

After the above analysis, the anionic air purification principle is finally selected. After technical improvement and optimization, professionals and authorities have also detected the purification effect. As is shown in the Fig. 5, various agencies also provide authoritative inspection reports. Because the anion generator module we developed is small enough to design as a wearable device. With this portable air purifier as the starting point, a whole set of personal respiratory purification systems has been developed to improve our living environment.

After using the new purification system, the indoor air environment can be improved obviously and the purification effect can be viewed remotely and in real time. As is shown in the Fig. 6, there is a huge difference in air between inside and outside the classroom and the data is updated in real time.

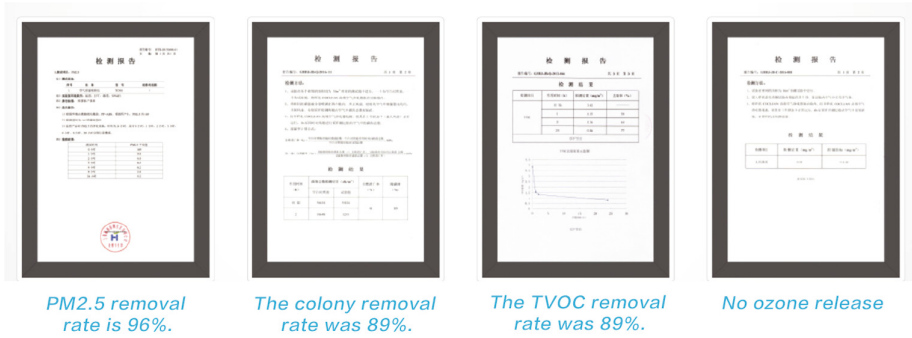


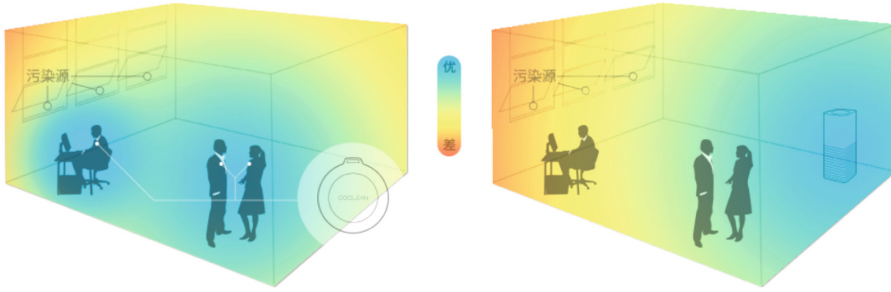
Fig. 5. The authoritative inspection reports



Beijing renmin university affiliated primary school

Fig. 6. Indoor and outdoor air quality comparison.

In addition to the technical breakthrough, in the air purification form has also been reconsidered. The core of this personal air purification system is to purify and monitor the air in people’s breathing areas. Other air purifiers clean up all the air in the space in order to complete the purification (see Fig. 7). The process is about 30 to 40 min or more, so it’s less efficient. Such purifying duration may be acceptable to the user, but the noise caused by its high power is unacceptable to most part of users. And if the work is not sustained, indoor PM2.5 levels will rise slowly. Noise can greatly affect people’s sleep quality. So the air that directly purifies the breathing area reflects the idea of efficient purification. After all, the air we care about most is the air that is inhaled into our bodies. Of course, we also developed a large anion air purification system to improve the indoor air quality. The product has high precision environmental monitoring function and can monitor the temperature, humidity and PM2.5 changes. Through the real-time air condition, the device will automatically open the purification or enter the sleep state. At the same time, the data will be feedback to the background environment of service system, so you can learn the same place of indoor and outdoor air condition, to make the building of the whole environment improvement plan has accumulated a large amount of data. When enough indoor and outdoor air data are collected, professional analysis results and recommendations for habitat improvement can be provided.



**Wearable air purifier**

Focus on purifying 1 cubic meter of portable air purifier.

**Traditional air purifiers**

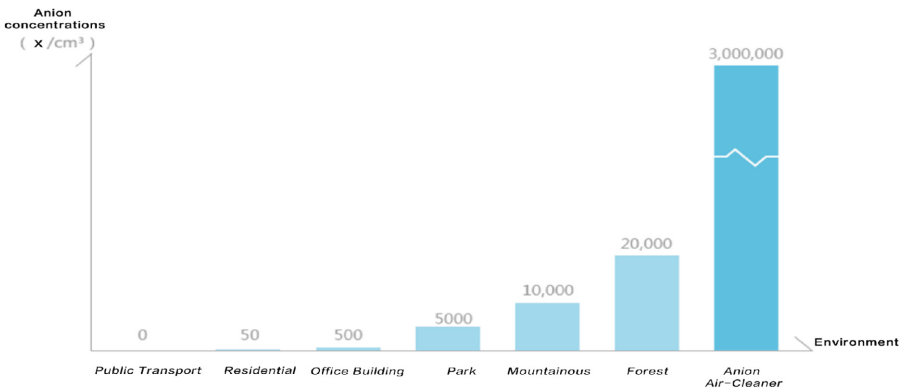
The air in the breathing zone is difficult to purify effectively.

**Fig. 7.** Comparison of purification methods

## 4 Analysis of the Effect of Personal Air Purification System

### 4.1 Anion Concentration Contrast in Everyday Situations

By optimizing the anion generator, the high active negative oxygen ions can be released under the condition that no ozone is produced. Anion can cause the particles in the air to be charged with particles (PM2.5), smoke, pollen and other particles and then settle down with other uncharged particles around them. Anion can also cause the hydrogen bond of bacteria, viruses and other organisms to break down to the effect of sterilization. The concentration of negative oxygen ions in the 20 cm range is 3–8 million/cm<sup>3</sup>. The concept of this number and the anion concentration in the natural environment will be very intuitive (see Fig. 8). Wearing such an air purifier can guarantee the air safety of 1 m<sup>3</sup> in the respiratory area. And it would be better to work with large anion purifiers, because large anion purifiers can release 60 million/cm<sup>3</sup> of highly reactive oxygen ions into the chamber every second.



**Fig. 8.** Anion concentration contrast in everyday situations

## 4.2 The Advantage of Anion Purification Technology

The advantage of anion purification technology is that it does not produce radiation, noise and consumables. Compared with the noise and consumables produced by traditional air purifiers, we have caused other pollution to our environment. Because there is no noise, we can use it in sleep, work, meetings and study without affecting other people. Also, the portable purification module USES very low energy consumption, and the built-in lithium battery can be fully charged for half an hour and work continuously for 10 h. 10 h can basically meet the need to go out for a day. The appearance of the product is shown in Fig. 9.



Fig. 9. The product renderings

## 4.3 The Smart Center Base

The purification system also designed the smart center base of the personal health respiratory system (hereinafter referred to as the base). The base part is the brain of a person's health respiratory system, which can monitor PM2.5 levels, temperature and humidity in the surrounding environment. These data would be uploaded to mobile phones in real time by bounding to WeChat, so that people can master the air quality of the places they care about. Now that the product has been purchased by many cities across the country, we can also learn about the indoor and outdoor environmental data using the product at the same time through the sharing of data. These data are analyzed through our cloud data, which is of great significance for the scientific improvement of human living environment.

The base part not only can monitor and share data, but also can charge the mobile purification module and enhance the purification effect. We use the special five-pin charging interface to achieve the functions of charging, data transmission and positive power export. Since the charging port of the base and the mobile purification module is the same, the charging of two devices can be combined separately. When two modules combine to work together, they can also enhance the purification effect of charging (as shown in Fig. 10) during sleep, if placed near the head of the bed, it can actually create a better sleep environment for users.





**Fig. 10.** The user maps

## 5 Analysis of the Wearing Forms of Personal Air Purifiers

At the beginning of product design, we also studied product positioning and target users. The background of the design is also fully introduced, so what kind of purification products can be made to stand out among the many air purifiers in this context? First of all, we have a patented technology to purify module is small, the core of the first generation product purification module size only 24 mm \* 14 mm \* 10 mm. The size like a pen is suitable design as a portable product, but the main question is how to wear it and whether to consider multiple ways of wearing it. We did a lot of experimentation and analysis. The core idea after this analyst is that design the purifier wearable to distinguish between traditional large air purifiers.

### 5.1 The Form of Wristbands and Watches

The most popular wearable device at the time was the sports bracelet, but after research, our products were not suitable for wearing on the wrist. And lead us to give up the main reason is because of the concept of purification module is the most effective purification area is 1 cubic meters, if wear on your wrist will move away from breathing to greatly weaken the purification efficiency.

### 5.2 Head Wear

This mainly form of product is VR equipment and hat products will be worn by people. Because these products are not suitable for long wear, they do not meet the purpose of clean air at any time.

### 5.3 The Form of a Brooch or a Badge

The placement of the brooch and the breastplate is very appropriate, but they are very small and very thin products. It is difficult to make air purifiers so thin, so this form is not appropriate.

### 5.4 In the Form of Arms Package

This type of product is mostly used in the fitness process, with a mobile phone or purse strings attached to the big arm. This form is more suitable for exercise, wearing the scene is still limited.

### 5.5 In the Form like Necklace Pendant

This form is the way we finally consider how to wear the product (see Fig. 11). First of all, the form is the simplest and most suitable for various scenarios. Second, the product needs to be exposed to human skin for technical reasons. So it's easy to use the form of a necklace. One of the most important reasons is to wear the product's position so that the anions released by the core purification module are close to the human respiratory area. The necklace form can be the most efficient and simple way to solve all the problems; it is the best choice for wearable.



Fig. 11. In the form like necklace pendant

## 6 The Other Application of Anion Purification System

In order to solve the overall human living environment, we have also made the car version and the high power version after making the portable air purifier.

### 6.1 Car Version

At the beginning of the design, to facilitate product expansion, the power connector of the product was made into a universal interface. So by using a custom car charger, you

can easy to turn a common version of a purifier into a car version. Traditional car purifier in engine condition will not be able to work long and even immediately shut down, and the use of anions produced by the principle of car purifier because of very low energy consumption, the built-in lithium battery sustainable work more than 10 h. Every time the user enters the car, it is already a clean car environment. We call it parking purification. The average driving time of the customer is about 45 min, but the cleaning time is 20 min. If you start cleaning up, half of your driving time is not breathing fresh air. The effect comparison is shown in Fig. 12.

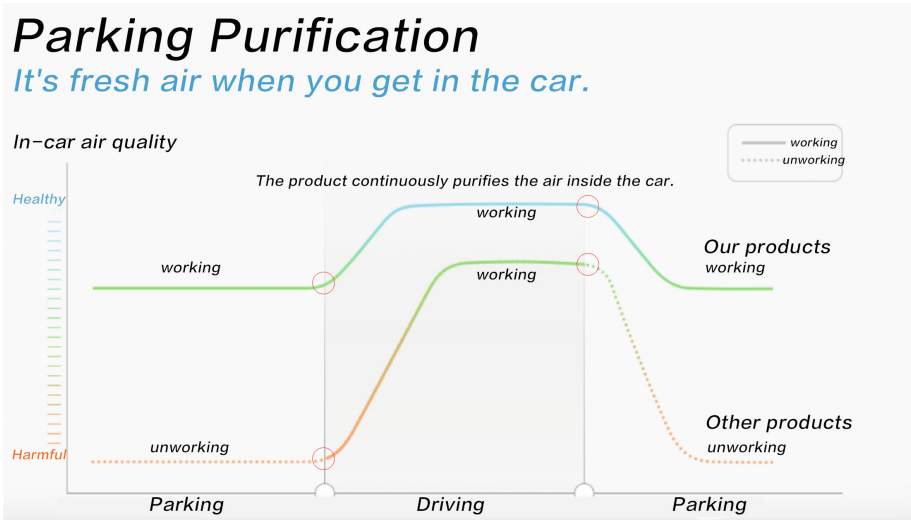


Fig. 12. Parking purification

## 6.2 High Power Version

With the same technology, we developed a high power version of the indoor anion air purifier. The high power version of the anion purifier has been widely used in families, schools, hospitals, hotels and factories across the country. Product installation and construction is also very simple. The ceiling version is mounted like a chandelier, while the landing version is more like a floor lamp. Therefore, the product does not need to punch holes in the wall or replace the filter element. Compared to the traditional large air purifier and the new air system anion purifier has a great advantage. The anion release concentration of high power purifier is 60 million/cm<sup>3</sup>. And the energy consumption is only 3w, and the electricity cost is only 15 Yuan per year. This product has no consumables, noiseless, low energy consumption, convenient construction, intelligent monitoring, etc., which has a strong market competitiveness compared with other products. As shown in the Fig. 13, we collect users' indoor air quality statistics, which can be used to analyze data to obtain users' usage habits and rules of life, so as to make accumulation for intelligent settlement of human settlement environment.

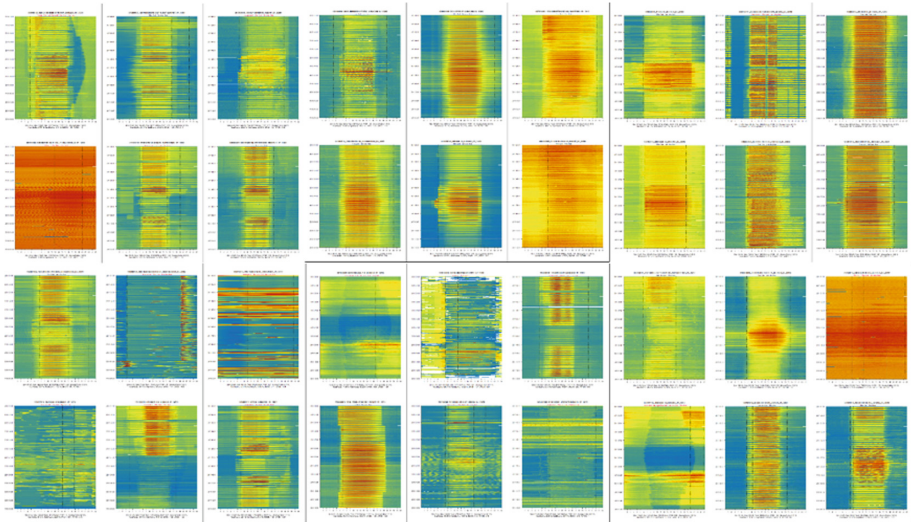


Fig. 13. User's indoor air quality detection data

## 7 Design Impact and Results

The personal air purification system has achieved mass production, has been enjoyed by a wide range of consumers and has received many honors and patents. Through the wide acceptance of the product by the market, the company is also rated as national high-tech enterprise. A lot of experience and achievements have been accumulated in focusing on human settlements environment and multi-parameter solutions to the Internet of Things. Through some air sensitive actual user's feedback, the personal air purification system improves their living conditions and reduces the discomfort caused by air quality and pollen. And users who insist on wearing products daily report that they have not had a cold or fever for nearly one year, because the industry also has the function of sterilization and disinfection. Large anion air purifier has been widely applied to classrooms, universities, primary and secondary schools, kindergartens and public spaces, and effectively improve the air quality of public space and to reduce the cross infection of bacteria. Users and managers can also check the indoor air quality at any time through smart phones, so that the purification effect can be visualized and monitored.

## 8 Conclusion

Through the design of personal air purification system, it is found that the solution proposed by combining the Internet of Things can solve the problem of air purification more intelligently and comprehensively. Although the whole system is still imperfect, but it provides a complete solution for the personal air purification system compared with the air purification products in the market. Its convenient and efficient purifying

concept is also designed to fully consider the living environment and habits of urban people. After a period of market testing, most of the feedback is good. Some of the return users are sensitive to the air, and feedback that the product has really changed the quality of their lives. Some of the users bought the product specifically to put it on the bedside of the babies, which moved us a lot. We hope that our products can help more people to improve the living environment around us.

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