Air conditioner Wind Direction Adjuster for JI Dormitories

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EXECUTIVE SUMMARY

The purpose of this report is to introduce our design in detail. It will firstly introduce the problem of direct air-con wind blow and explain our design solution in detail, including criteria, final prototype and tests. It will finally end with further recommendations and our conclusions on our final design.

Students at the UM-SJTU Joint Institute (JI) dorms face problems that the air conditioner may blow directly on students and do harm to their health. In other cases, air conditioner blade is broken or the remote control of the air conditioner is missing. In order to solve these problems, our team designed an air conditioner wind direction adjuster which enables students to adjust wind direction simply with hand gesture.

We formulated three criteria for our design: functionality, interference resistance and rustproof. Concerning functionality, it should change wind direction. Despite wind direction change, we also expected a detectable environment temperature change. Besides, it should not be interfered with other unexpected movements, such as passing through the balcony door, sleeping on bed, sitting or standing by study desk and taking clothes from the wardrobe. In addition, it should be rustproof as water vapor may condense on the wind blade.

To operate our design, the user firstly wave left and right to activate the servo. Meanwhile the user should keep his hand still and continue activating one of the two sensors. The wind deflector of our design, which is attached to outer frame, will then turn until the user lift his hand when it turns to the desired direction. The wind deflector has a default turning angle range so that it will turn back and forth until the user stopped it. All the inputs and outputs of our design are processed and controlled by the Arduino board.

From our test on final prototype, we found significant change in wind direction. We also tested the temperature before and after applying our wind adjuster and found a seeable change. We walked around the sensors and did some daily movement mentioned above which one may carry out in the dorm and the wind deflector will not turn, showing no interference with unexpected motion. As we used rustproof material, which will be covered in main part, our design is therefore rustproof.

Further recommendations include expanding the sensing zone, enabling turning on and off the air conditioner with hand gesture, more robust material for outer frame, and making the adjuster fit with various type of air conditioner.

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1 Introduction

Due to the hot weather in Shanghai, air conditioners are frequently used in the UM-SJTU Joint Institute (JI) dorms in summer semester and students tend to select a low temperature. As the JI's dorms are rather small, students near the air conditioner may suffer the cold wind from the air conditioner. However, many air conditioners are for years out of repair. Some of them have problems with their blades or they lose their remote controls. Students cannot change the wind direction, and the cold wind may harm students' health. To solve this problem, our team came up with an idea to design an air conditioner wind direction adjuster. Before we started, we studied existing products and made some surveys (Appendix B). We refined our idea and carried out the plan after it.

We created an air conditioner wind direction adjuster which can adjust the wind direction of the air conditioner simply by gesture. According to the survey results and existing products, we formulated some criteria as a standard for successful DIY project. To check if the design satisfied these criteria, we made a prototype and did several tests on it. With these tests, we hoped to find flaws of our design and methods to improve.

This report includes the background about the significance of our design, the details of our design, the tests we did, and further recommendations for development. The purpose of this report is to document the whole process of our design and let other people understand its working principle. Besides, people can use this report as a reference to improve our design.

2 Background

2.1 Use of air conditioners in Shanghai

Shanghai, enclosed on the east seaside of China, has East Asian Monsoon Climate which is warm and moist (Tang, Qian & Liang, 2006). However, the summer in Shanghai is extremely hot with average temperature approaching 30°C. For many days, the temperature is above 30°C and extreme weather can reach 40°C (Appendix J). Li Zhenghai (2005) indicated that the popularizing rate of air conditioner in Shanghai was 98%. The peak time of using the air conditioner was in July and August because of the hot weather. Hence we see the necessity to design a wind adjuster for those that cannot make wind direction adjust.

2.2 Problems when air conditioner is too cold

The comfort temperature in summer for an average human should be 24-27°C when the humidity is about 50% (ASHRAE Standard 55P, 2003). According to *The Harm and Prevention of Air-conditioning disease* (Zhong, 1997), long-time exposure to the cold temperature of the air conditioner, and cold wind is one of the causes of air-conditioning disease. Under cold air-conditioning atmosphere, human's ability to adapt to warm temperature weakens and symptoms like bloody nose, body aches, sore joints, and arthritis may happen (Pearson, 2010). To avoid such cases, changing the wind direction of the air conditioner so that it will not blow directly to people is an effective way according to Zhong Chen's report.

2.3 Use of air conditioners at the Joint Institute

We did some surveys on the use of air conditioner in summer at the Joint Institute. Results indicated that air conditioners were used frequently and widely at the Joint Institute. Since the weather in summer is extremely hot in Shanghai, nearly 85 percent of students used air conditioner more than five hours a day and many students in the dorm turn their air conditioner under 20°C. Due to limited space in JI dorms (Figure 2.4.1), not having remote control and broken wind deflector of the air-con, more than 60 percent of students report that they face the problem that the direct cold wind of air conditioner blow directly to them and felt uncomfortable (Appendix B) .

2.4 Existing products and patents

We searched on the Internet and found several products that aim to solve the wind direction problems.

Among them, the feature products are "Air Wings Rim" (Air conditioner related goods, 2012), which is a fixed wind deflector that can change the wind course in a designed way; "Wind Direction Adjusting Mechanism for Air conditioner" (Hayakawa & Sugiura, 1987), which requires the user to use hand to adjust the wind direction of the air conditioner whose outlet is within hand's reach; and "Apparatus for Deflecting the Direction of the Wind in an Air conditioner" (Himeno, Shimokawa & Fukuda, 1988), which is a built-in vertical wind direction deflector with a complicated automatic mechanism by which the user cannot adjust the wind direction according to their needs. Still others are for car air-cons. The details of these products and patents can be found in Appendix A.

However, in the existing designs, the wind deflector is either fixed, hand-helped, which is not possible for JI dorms as the air-con is high above, or automatic. They cannot provide an alternative way for JI students to adjust the air conditioner wind direction.

Figure 2.4.1 JI Dormitory with Air conditioner

3 Criteria

The following section contains the five criteria we set for an air conditioner wind direction adjuster (wind adjuster) used in a JI dormitory.

- Wind deflection

  A wind adjuster should have a mechanism that can deflect the air conditioner wind. This is a fundamental criterion as a wind adjuster basically changes the wind direction.

- Wind adjustment

  A wind adjuster should adjust the air conditioner wind as the user wants. A wind adjuster differs from the air conditioner build-in wind deflector in that it can change the wind direction according to the user's needs. We judge this aspect of our design based on the user's feedback. Since it is a DIY project with limited resource, we expect our design to be qualified if over 60% of the volunteer users give positive feedback on this criterion of our design.

- Intervention resistance

  A wind adjuster should be activated by a limited informational source of signal, i.e. sound, gesture, digital signal etc. Similar to our house appliance, the wind adjuster should only turn on and off when the user needs it, not interfered by other information input.

- User friendliness

  A wind adjuster for JI dorm use should be controllable when the student is sitting by his or her desk (the two desks near the air conditioner). For the arrangement of JI dorm, see Appendix L. As a wind adjuster is an alternative way of adjusting the air conditioner wind besides using remote control, it should be as easy to operate as using remote control. We expected our design can be controlled when the student, whose position is near the air conditioner, is sitting by his or her disk. This indicates that our design should have a sensing zone with a radius of approximately 3 meters and an angle of about 160 degrees.

- Rustproof

  A wind adjuster for air conditioner should be rustproof. As water vapor condenses when the temperature changes dramatically, air conditioner wind deflector always has water condensed on it. Our design therefore works in an environment which is constantly in contact with condensed water vapor. To guarantee its life expectancy, it should be rustproof.

- Accordance with SJTU Accommodation Regulation

  A wind adjuster for JI dorm use should obey SJTU Accommodation Regulation. As our wind adjuster is planned for JI student dormitory, we derived that it should not violate the rules stated in the Accommodation Regulation of Shanghai Jiao Tong University. In this case, we should not violate the line that we should not change the electrical circuit of the dorm building and should not use electrical devices that does not pass China Compulsory Certification (CCC) (SJTU Accommodation Regulations, 2012). For more details, please refer to Appendix K. Therefore our design should not change the electrical circuit of our dorm and the electrical devise we use should satisfy CCC standard.

4 Final Design

Our air conditioner wind direction adjuster changes the wind direction of the air conditioner with a wind deflector which is attached to frame that we designed for the air conditioner in our dorm. The user can control the direction of the wind deflector with specific waving pattern we designed, so that the user can choose a comfort wind direction according to his or her need.

Figure 4.1.1 Our Design in Context

4.1 Design overview

Our design (Figure 4.1.2) has a frame, which contains the wind deflector, attached to the air conditioner with Velcro stick on the top side. A servo is connected to the wind deflector and enables it to turn.

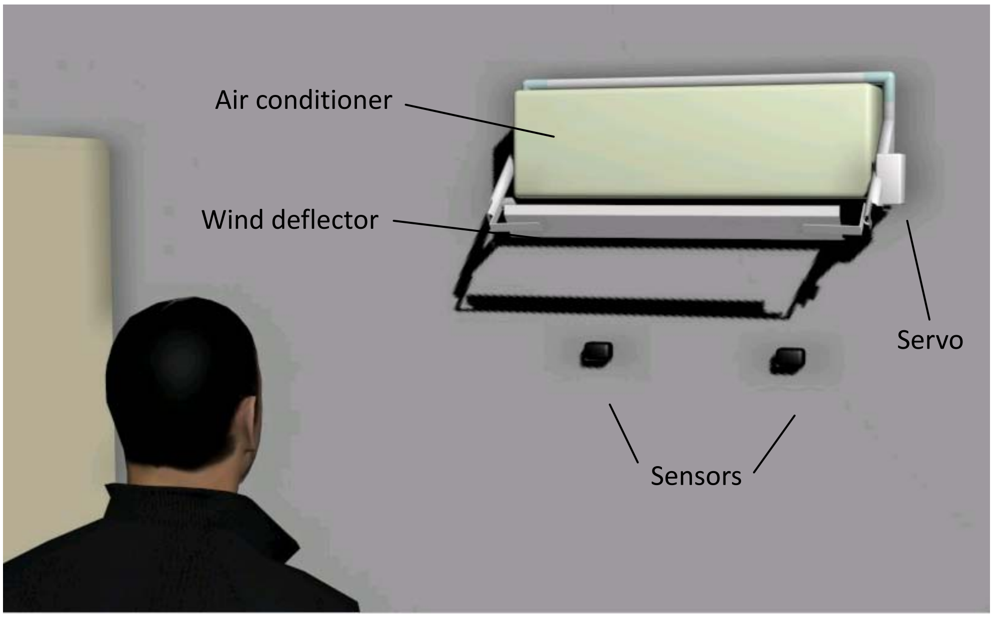

Figure 4.1.2 Our Design (Zoom In)

To operate this wind adjuster, user firstly wave one hand left and right, activating the two sensors, which is linked to the Arduino board, the main control, and the wind deflector turns. The user keep the hand activating one of the sensors while the wind deflector keeps turning with an angle range of 30° to 150°. The user can lift his or her hand when the desired angle is reached.

Figure 4.1.3 shows our final design. We used the materials the same as design to build the mechanical part. And the electrical part worked well as expected. The position of sensors in the figure is not the place in practical use as it was for demonstration.

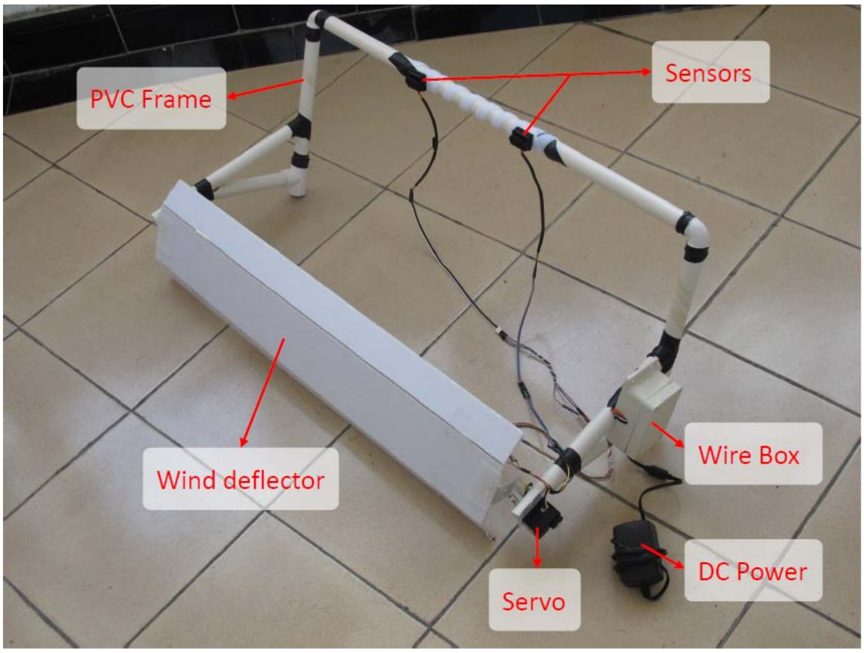

Figure 4.1.3 Final Design with Components Introduced

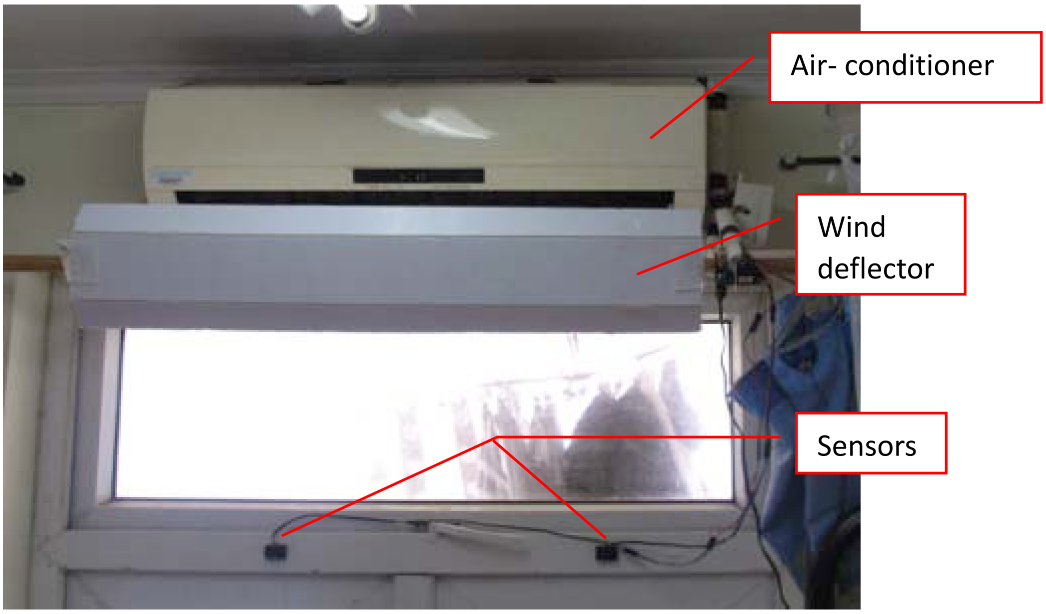

Figure 4.1.4 Final Design in Practical Context

With this prototype, we do tests to evaluate its functionality and flexibility and check if it satisfies our criteria. For more information about the design prototypes, please refer to Appendix H.

4.2 Mechanical Design

The mechanical part of our design consists of the frame, wind deflector, wire box and servo, as shown in Figure 4.2.1 and Figure 4.2.2.

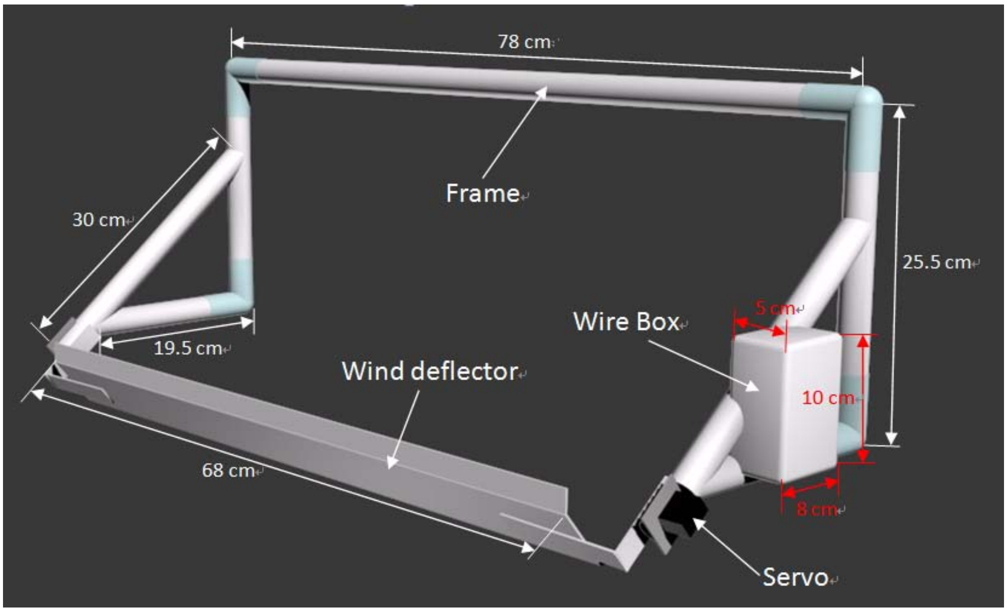

Figure 4.2.1 Whole View of Mechanical Design

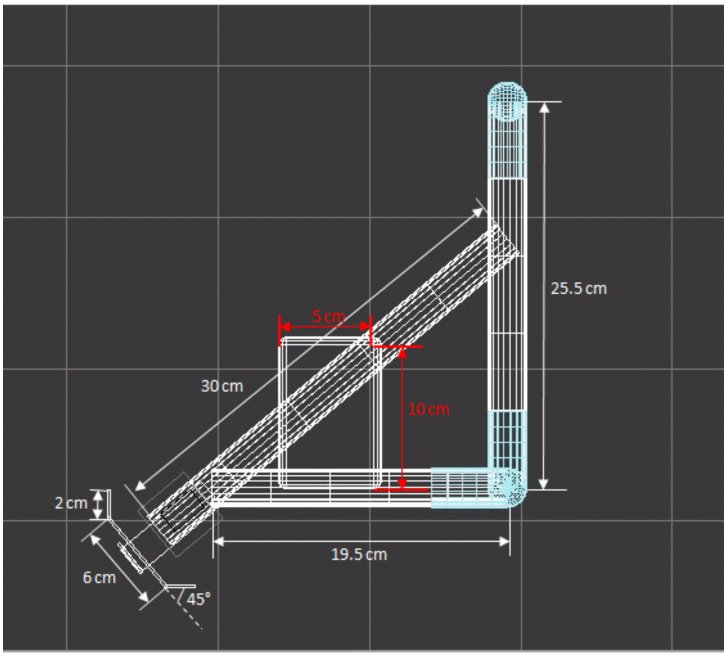

Figure 4.2.2 Side View of Mechanical Design

We planned to use PVC pipe to make the frame structure of our design. The frame structure is made in strict accordance with the size of the air conditioners in JI's dorm. The deflector is made of three pieces of foamed plastic boards. These boards formed a wind deflector with two wings so that it can perfectly deflect the wind direction. Considering our wind direction adjuster will work in a moist atmosphere, we choose rustproof materials to build the mechanical part so that it can have long working life.

4.3 Electrical Design

4.3.1 Overall concept

There are two sensors sensing the movements of human beings. We programmed a sketch so that a special hand gesture will activate the sensors. Waving hands back and forth to trigger two sensors successively will enable the servo motor to rotate. To be more specific, the special hand gesture is waving to trigger sensors in order of ABA or BAB, like shown in figure 4.3.1.1. Then the servo will start to work in control of Arduino board, during this process, the user should keep one hand activating one of the sensors.

1st Time	2nd Time	3rd Time	Out Put
A	B	A	True
B	A	B	True

Figure 4.3.1.1 Waving Gesture Pattern

Consequently the blade will rotate to adjust the wind direction until the user lifts his or her hand when the desired position is reached. The whole process can be found in Figure 4.3.1.2.

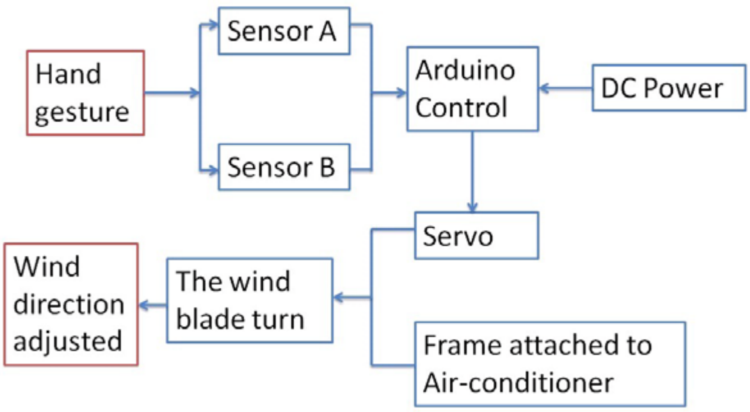

Figure 4.3.1.2 System Diagram

4.3.2 The Circuit

The electrical structure of our designs includes the following several parts: the microcontroller Arduino Uno, a 180° servo, two infrared proximity sensors, a power adapter, a bread board and some wires.

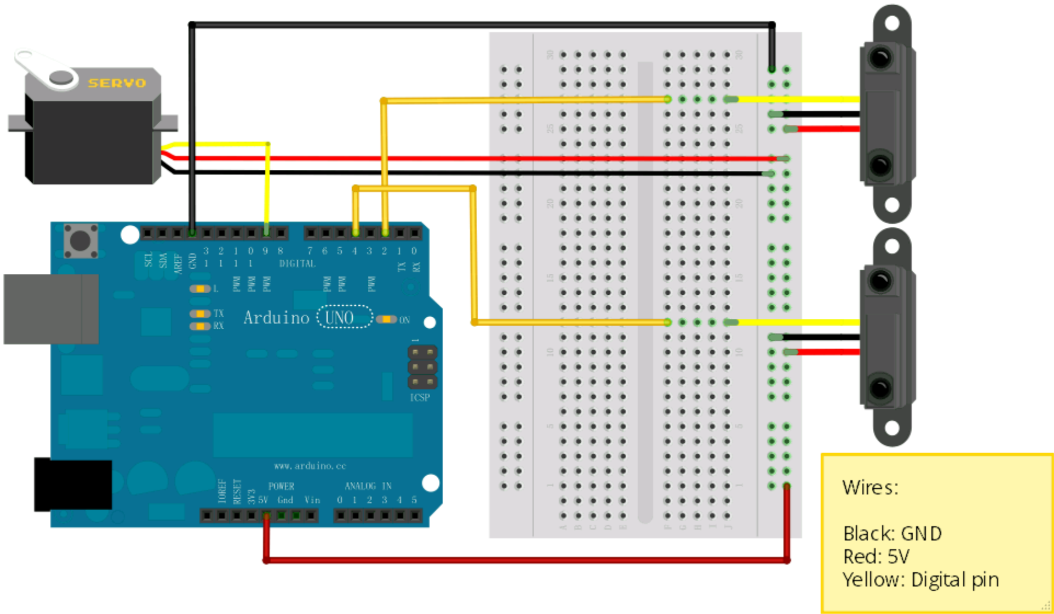

Figure 4.3.2.1 Electrical Circuit Design

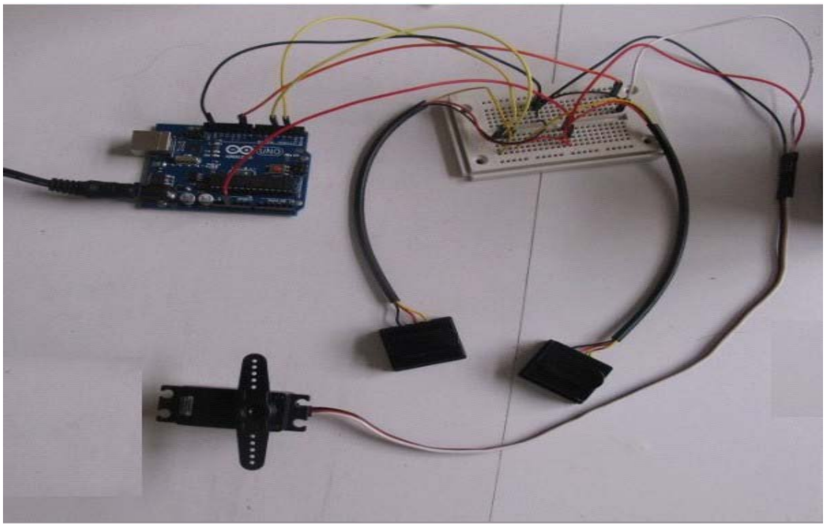

Figure 4.3.2.2 Electrical Part

4.3.3 Components

- Microcontroller Arduino Uno

  The Arduino Uno is an 8-bit microcontroller (Arduino Uno., n.d.). A user can easily link a USB cable to it while uploading the programming sketch

(Appendix G) edited through Arduino integrated development environment. After connecting other components to the Arduino Uno board (Appendix F), the design will work in the way that we expected.

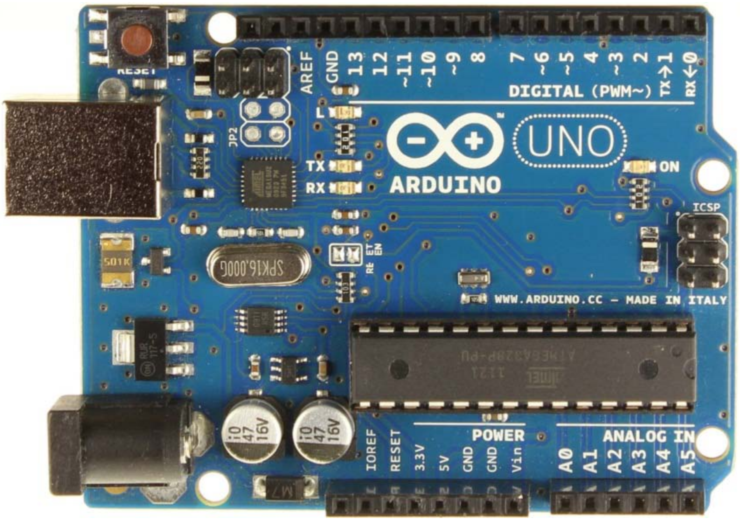

Figure 4.3.3.1 Arduino Uno
(Image retrieved from http://arduino.cc/en/uploads/Main/ArduinoUno_R3_Front.jpg)

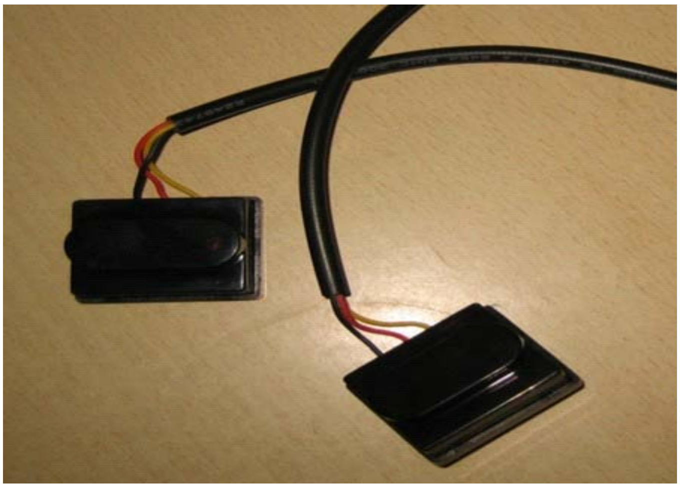

Figure 4.3.3.2 Infrared Proximity Sensor

- Servo
  The servo we used in this design is a 180° servo. It is SPRINGRC SR-403P servo produced by Spring Model Electronics Co., LTD. The reason why we chose this servo and more other details will be covered in the material analyze (Appendix F).

- Sensor
  The sensors we used in this design are two infrared proximity sensors, as shown in Figure 4.3.3.2. We choose this kind of sensor due to its high precision and more information will also be introduced in the material analyze (Appendix F).

We should here emphasize that they are not regarded as the most suitable sensors, and the fact that they failed to meet to our criteria on sensing zone. More details will be introduced in the test and evaluation section.

- Power Adapter
  The power adapter we used has an input voltage of 100 to 240V (AC) and an output voltage of 9V (DC). Its output current is 2A. This kind of capacity power is totally ideal for our design. That is to say, it provides enough but not too large power.

- Bread Board
  The bread board we used is SYB-46, which does not require too much room, since it is only 9.05cm long, 5.26cm wide and 0.86cm high (ElecFreaks., 2011a). The hole quantity of 290 is also more than enough to spare for our design.

- Wires
  We strongly recommend the users to use DuPont lines instead of common wires. The DuPont lines will provide us with great convenience while plugging them to the Arduino board, the bread board and the servo. The reason is that the hard contact pins of DuPont lines enable us not to weld the wires by ourselves. Since we do not need to care about welding thanks to the DuPont lines, we can focus more on assembling and setting up.

5 Test and Evaluation

This section includes the data we obtained from the tests we had done.

5.1 Wind deflection test

This test was carried out to ensure our design's primary function: changing the air-con wind direction. We decided that our design should be able to deflect the wind blowing directly to a point after the wind deflector turns to face that position tangentially. We compared the position of the plastic strips which we attached to a line before and after we apply the wind adjuster. We found our design worked well at changing the wind direction as the strips' direction changed greatly. This shows that our design is capable of changing the direction of the air-con wind. More details of the test will be shown in Appendix D.

5.2 Wind adjustment test

We aimed to find how effective our design seems to our target user, which means how our design meets with the expectation of the user on adjusting the wind direction. We asked 20 volunteers to test our design and recorded their reply on the effectiveness of our design. It turns out that 80% think our design changed the wind direction as they have expected, which is more than what we expected. Our design proved its ability in adjusting the wind direction. See Appendix E for more details.

5.3 Interference resistance test

We did this test to see if our design would be interfered by unwanted source of input. As the wind deflector of our design is activated with hand gesture, it is necessary that the design does not react to the unintentional movements a JI student usually carries out in dormitory. We had a team member simulate the usual movements, such as passing through the balcony door; walking in the dorm; taking cloths form the wardrobe; sitting or standing by the desk; or one's unintentional movements when in bed. We find that our design is not interfered with the usual movements a JI student may carry out, except from our designed gesture (Appendix D).

5.4 Sensing range test

The sensing range was measured to see if our design can be as comfort to use as a remote control, based on which we judge the user friendliness of our design. The result turns out not so satisfactory. The sensing range of our design is a restricted cone with a long edge of 22cm and a radius of 1.3 cm, which is much smaller than our expected range of sensing. This is mainly because we had chosen an infrared proximity sensor (Appendix F). We made this choice because our design requires high precision and should have no interference with gestures besides our intended gesture. Only this kind of sensor we have learnt can meet our requirement for precision. And if we change the aspect of view, such a sensing region has the advantage that the two sensors' sensing region will not form an intersection, so that one does not worry about activating two sensors at one time. See Appendix D for more detail on sensing region.

5.5 Rustproof evaluation

To ensure the endurance of our design, mainly the endurance in a wet environment, we evaluated the materials we choose and concluded that our design is rustproof. As we had chosen materials like PVC pipe, plastic board, nylon screw and angle Aluminum that do not rust, our design will not rust under wet conditions. For detailed information on the materials, please refer to servo and sensor selection in Appendix F.

5.6 SJTU Accommodation Regulation accordance evaluation

Our design should obey SJTU Accommodation Regulation as it is applied in JI dormitories. It was shown in Final Design section that our design has no interference with the electrical circuit design of the dorm building, as it is a closed system except requiring external electrical power. Therefore the DC power of our design, according to the SJTU Accommodation Regulation, should be CCC qualified. And indeed it does (Appendix D). Our design is fully qualified to be used in JI students' dormitories.

6 Recommendations

Due to pecuniary and technical limitations, our air conditioner wind direction adjuster gives a solution but a little far from perfect. According to the test and evaluation we have made, we find our design has some flaws in practical use. Here are some recommendations to improve our design.

- More suitable sensor
  According to the test on reaction zone, our sensor has a very limited sensing region. We strongly recommend choosing more accurate sensors with larger reaction zone if finances allow. A possible candidate is an ultra-sonic sensor, which we learnt recently (Appendix F). With a better sensor, our design may have better performance in receiving intended motion and resisting unexpected interference.

- More function
  Since our air conditioner wind direction adjuster can adjust the wind direction without the remote control, we can further improve our design to control the powering on and off of the air conditioner with gesture. We can make it by adding more sensors and writing a program code for new gesture.

- Power cut protection
  We can add power cut protection to our design so that it can still work if the power is down. Adding emergency power supply can be a solution. We also need a device to avoid leakage of electricity.

- New design for the frame
  Our current design only fit for the air conditioners in our dormitory, which are smaller in size, only 765 mm in length. In order to have our design adaptable for more air-con, for example, the air conditioner in the activity room of students' dorm, it is recommended that future design introduce a new design for the frame so that the frame can adjust its size according to the type of air conditioner.

7 Conclusions

To evaluate our design, we carried out several tests to see if our design satisfied all the criteria we formulated. According to the data and phenomenon in the tests, we found our design satisfied all the criteria. Our wind direction adjuster can change the temperature and humidity in the room and make them at ideal standard. Walking around the sensors or other daily movement cannot trigger the deflector of our design. It is made up of rustproof materials and can work well under moist condition. Our design is removable and easy to install and dismantle. Furthermore, it is user-friendly and healthy for users.

We also did cost analysis and market survey on similar products while evaluating our design. We found there are some similar products in markets and our design is no cheaper than them. However, our wind direction adjuster has the unique function of enabling changing wind direction with hand gesture and removing from one air conditioner to another. It is quite different from the existing product and has great room to improve. We believe our design have higher price quality than any other existing product.

All in all, our design is a unique design that can truly improve the dorm environment and enable healthier life. It meets all of our criteria we formulated and can detect hand gestures and deflect the air conditioner wind as expected. We believe it is capable of improving life quality of JI students and bring health to them.

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Appendix A: Existing Products and Patents

- Wind Direction Adjusting Mechanism for Air Conditioner

United States Patent [19]
Hayakawa et al.

[11] **Patent Number: 4,653,386**
[45] **Date of Patent: Mar. 31, 1987**

[54] **WIND DIRECTION ADJUSTING MECHANISM FOR AIR CONDITIONER**

[75] Inventors: **Toshihiro Hayakawa; Hiroshi Sugiura,** both of Toyota, Japan

[73] Assignee: **Toyota Jidosha Kabushiki Kaisha,** Aichi, Japan

[21] Appl. No.: **792,912**

[22] Filed: **Oct. 30, 1985**

[30] **Foreign Application Priority Data**

Nov. 20, 1984 [JP] Japan .... 59-176246[U]
Nov. 22, 1984 [JP] Japan .... 59-177535[U]

[51] **Int. Cl.**[4] **F24F 13/15**
[52] **U.S. Cl.** **98/40.28**; 98/2; 98/40.24
[58] **Field of Search** 98/2, 2.04, 40.24, 40.26, 98/40.27, 40.28, 40.3

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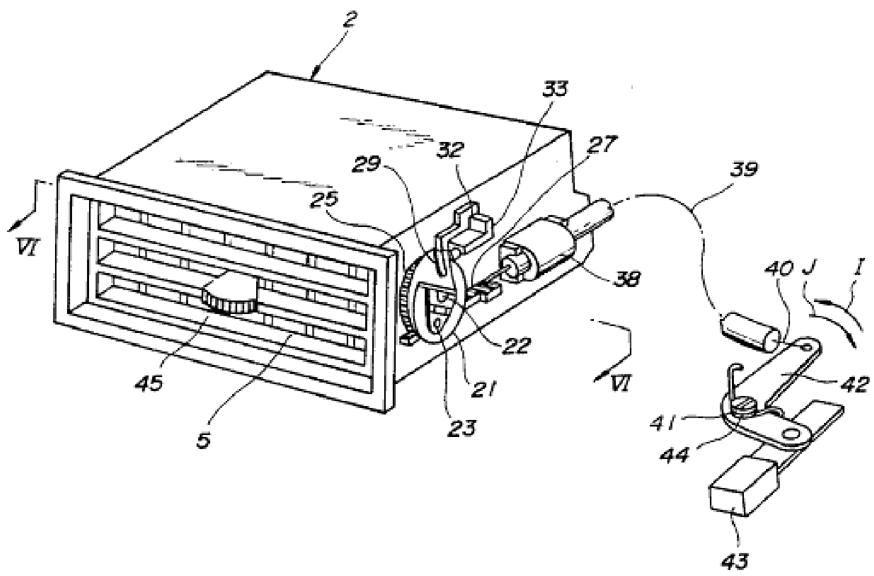
148132 9/1982 Japan 98/2
28943 2/1983 Japan 98/2

Primary Examiner—Harold Joyce
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] **ABSTRACT**

A wind direction adjusting mechanism for an air conditioner which has an air diffuser barrel supported to a rotational shaft to rotate in elevational or lateral directions in a bezel of a side ventilator, longitudinal or lateral blades pivotally secured in lateral or longitudinal directions in the barrel, a cam rotatably engaged with the rotational shaft, a rod engaged with the cam for operating to rotate the longitudinal or lateral blades, rotary drive means coupled with said cam, and a frictional clutch for producing a slip by a resistance of a predetermined value to couple the cam with the drive shaft. Thus, the adjusting mechanism can separately rotate the air diffusing barrel in a bezel of a side ventilator and the longitudinal or lateral blade in the barrel by a simple drive mechanism, protect the drive mechanism by the slip of the clutch when an unreasonable force is acted to the air diffuser barrel side, be associated in large degree of freedoms of designing in an instrument panel to improve the design in the compartment and provide the large defrosting function of the side window glass.

13 Claims, 9 Drawing Figures



- Apparatus For Deflecting The Direction Of The Wind In An Air Conditioner

United States Patent [19] | [11] **Patent Number: 4,738,116**

Himeno et al. | [45] **Date of Patent: Apr. 19, 1988**

[54] **APPARATUS FOR DEFLECTING THE DIRECTION OF THE WIND IN AN AIR CONDITIONER**

[75] Inventors: **Yasunori Himeno**, Otsu; **Naoki Shimokawa; Katsumi Fukuda**, both of Shiga; **Teruo Yamamoto**, Yamatokoriyama, all of Japan

[73] Assignee: **Matsushita Electric Industrial Co., Ltd.**, Osaka, Japan

[21] Appl. No.: **881,838**

[22] Filed: **Jul. 3, 1986**

[30] **Foreign Application Priority Data**

Jul. 8, 1985 [JP] Japan 60-149519
Jul. 8, 1985 [JP] Japan 60-149523
Jul. 8, 1985 [JP] Japan 60-149524

[51] **Int. Cl.**^{4} **F25D 17/04**
[52] **U.S. Cl.** **62/186**; 98/121.2; 236/49
[58] **Field of Search** .... 62/186; 98/42.09, 94.2, 98/40.27, 40.25, 40.3, 121.2; 236/49, 49 D

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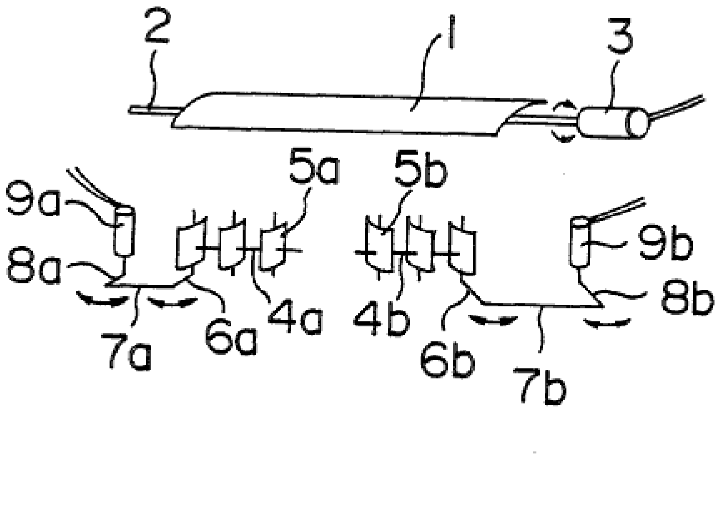
Primary Examiner—William E. Wayner
Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

The present invention provides an air conditioner comprising, at a blowout port, a vertically deflecting vane and a group of the laterally deflecting vanes for respectively vertically and laterally deflecting the wind blown out from the blowout port. The group of the laterally deflecting vanes is partitioned with respect to the center of the blowout port into at least one rightwardly deflecting vane and at least one leftwardly deflecting vane, so that the rightwardly deflecting vane and the leftwardly deflecting vane can be individually operated. A drive means is controllably provided for individually driving the vertically deflecting vane and the group of laterally deflecting vanes, so that the wind blown out from said blowout port is changed in accordance with a temperature value to a mode in which the blowout wind is laterally split in a horizontal or upward direction, a mode in which it is concentrated in the horizontal or upward direction, a mode in which it is laterally split in a downward direction, and a mode in which it is concentrated in the downward direction.

32 Claims, 12 Drawing Sheets



- Wind direction control apparatus and method for an air conditioner

US005788570A

United States Patent [19]

Cho

[11] **Patent Number:** **5,788,570**

[45] **Date of Patent:** **Aug. 4, 1998**

[54] **WIND DIRECTION CONTROL APPARATUS AND METHOD FOR AN AIR CONDITIONER**

[75] Inventor: **Jae-Seok Cho**, Seoul, Rep. of Korea

[73] Assignee: **Samsung Electronics Co., Ltd.**, Suwon, Rep. of Korea

[21] Appl. No.: **850,823**

[22] Filed: **May 2, 1997**

[30] **Foreign Application Priority Data**

Sep. 3, 1996 [KR] Rep. of Korea 96-38004

[51] **Int. Cl.**[6] **F24F 13/15**

[52] **U.S. Cl.** **454/233**; 454/315; 454/320; 454/324

[58] **Field of Search** 454/202, 233, 454/234, 313, 319, 320, 321, 324, 334

[56] **References Cited**

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63-286650 11/1988 Japan 454/233

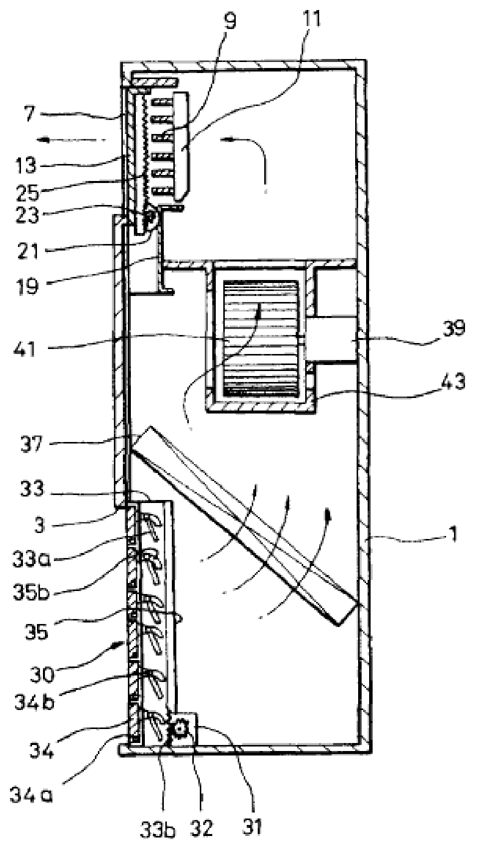
Primary Examiner—Harold Joyce

Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis, L.L.P.

[57] **ABSTRACT**

An air conditioner includes an air inlet, an air outlet, and a heat exchanger. The air outlet has adjustable air direction control blades extending thereacross enabling a direction of discharged air to be set by a user. The blades are adjusted by a motor. When the air conditioner is shut-off, a controller memory stores the position of the blades and then moves the blades to a closed state. Upon re-starting the air conditioner, the controller drives the motor to return the blades to their previous (memorized) position.

4 Claims, 11 Drawing Sheets



- Wind control apparatus for air conditioner

United States Patent [19] [11] **4,339,991**

Asano et al. [45] **Jul. 20, 1982**

[54] **WIND CONTROL APPARATUS FOR AIR CONDITIONER**

[75] Inventors: **Tetsumasa Asano; Mitsuhiro Fujimoto; Ryuichi Mizukawa,** all of Himeji, Japan

[73] Assignee: **Mitsubishi Denki Kabushiki Kaisha,** Tokyo, Japan

[21] Appl. No.: **184,170**

[22] Filed: **Sep. 4, 1980**

[30] **Foreign Application Priority Data**

Sep. 13, 1979 [JP] Japan 54-118584

[51] **Int. Cl.**[3] **F24F 13/10**

[52] **U.S. Cl.** .... **98/40 VM;** 98/2; 98/40 E; 98/40 V

[58] **Field of Search** .... 98/2, 40 E, 40 V, 40 VM, 98/94, 103, 108, 110, 111, 112, 113, 121 A; 415/125

[56] **References Cited**

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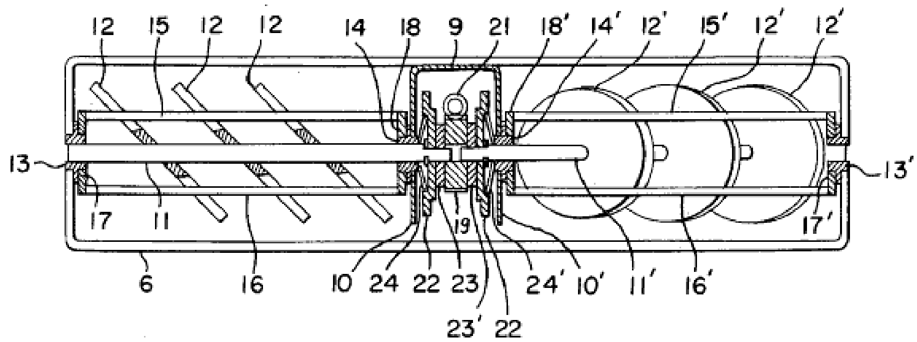
1452270 10/1976 United Kingdom .

Primary Examiner—Lloyd L. King
Assistant Examiner—Harold Joyce
Attorney, Agent, or Firm—Oblon, Fisher, Spivak, McClelland & Maier

[57] **ABSTRACT**

A wind control apparatus for an air conditioner comprises a pair of first wind-deflection plates for changing the direction of wind in a first axial direction by manual operation independent each other; a pair of second wind-deflection plates for changing the direction of wind periodically in a second axial direction with a driving means; and a phase adjusting means placed between the second wind-deflection plates and the driving means so as to change the phase of wind direction by manual operation.

1 Claim, 4 Drawing Figures



- Air Wings Rim

(Image retrieved from: http://thumbnail.image.rakuten.co.jp/@0_mall/tno/cabinet/ikou_20100125_002/img10283153094.jpg?_ex=350x350)

Appendix B: Survey Results

1. How old are you?

Age	Number	Percentage
< 18	2	3.13%
18 – 22	60	93.75%
> 22	2	3.13%
Sum total	**64**	

2. What's your gender?

Gender	Number	Percentage
Male	39	60.94%
Female	25	39.06%
Sum total	**64**	

3. How long will you use the air conditioner in summer if the average temperature approaches 30 ℃?

Time	Number	Percentage
24 hours	4	6.25%
18-10 hours	28	43.75%
10-5 hours	23	35.94%
Less than 5 hours	9	14.06%
Sum total	**64**	

4. Have you ever met the following circumstances?

Item	Number	Percentage
Cold wind blows directly to you	41	64.06%
No winds	33	51.56%
Neither of them	12	18.75%
Sum total	**64**	

5. What would you like to do if cold wind blows directly to you or there are no winds?

Item	Number	Percentage
Let it be	2	3.85%
Find the remote control to adjust	25	48.08%
Adjust wind direction with hand gesture	25	48.08%
Sum total	**52**	

6. Do you agree that winds from air conditioner do harm to health if they blow directly to human beings?

Item	Number	Percentage
Yes	60	93.75%
No	4	6.25%
Sum total	**64**	

7. Do you know that adjusting wind direction can help save energy?

Item	Number	Percentage
Yes	19	29.69%
No	45	70.31%
Sum total	**64**	

8. Would you like to try if wind direction can be adjusted by hand gesture?

Item	Number	Percentage
Yes	59	92.19%
No	5	7.81%
Sum total	**64**	

9. What is the acceptable reaction time?

Reaction time	Number	Percentage
0-2 s	27	42.19%
2-4 s	26	40.63%
4-6 s	6	9.38%
6-8 s	5	7.81%
Sum total	**64**	

10. How much would you like to pay for this function compared to the cost of an air conditioner?

Item	Number	Percentage
< 5%	28	43.75%
5% - 10%	26	40.63%
10% - 15%	9	14.06%
> 15%	1	1.56%
Sum total	**64**	

Appendix C: DIY Manual

Material List

Material Name	Quantity	Remark
Arduino board	1	
PVC pipe	4 meters	Decided by the size of the air conditioner.
Elbow PVC pipe	4	Decided by the size of the air conditioner.
Bread board	1	Do not use one bread board too big.
Infrared proximity sensor	2	More suitable sensors should be used.
Servo	1	A 180° servo is recommended.
Plastic board	120cm*15cm	Decided by the size of the air conditioner. The material can be replaced by thin wooden board or else.
Container	1	Should suit the size of bread board and the Arduino board.
DuPont Wires	20	Decided by the user and size of the air conditioner.
Velcro	3m	
Plastic tape	1 volume	
Double sided tape	1 volume	
Power Adjuster	1	Should coordinate with the rated voltage.
Plastic screw	10	

Table C-1 Material list

Step by Step Manual

Electrical Part (For details of program, see Appendix G.):

1. Edit the sketch through the Arduino integrated development environment.
2. Upload the sketch into the Arduino board.
3. Connect the Arduino board with the breadboard.
4. Connect the two sensors to the breadboard with wires.
5. Connect the steering engine to the breadboard.
6. Use the plastic tape to wrap the wires.

Mechanical Part:

1. Accurately measure the size of the air conditioner.

Figure C-1 Step by step user manual

2. Cut the pipe into segments according to the size of the air conditioner you have measured.

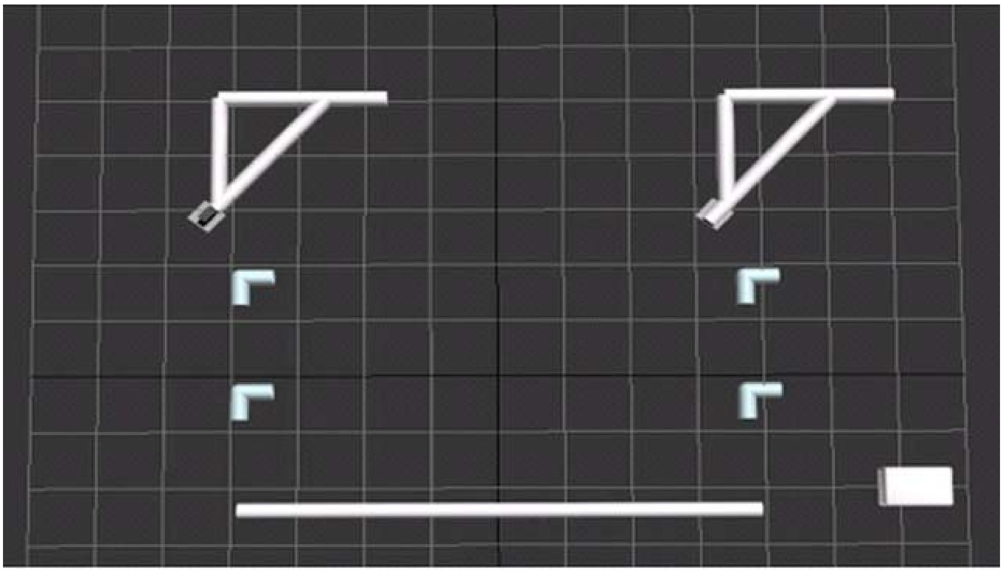


Figure C-2 Step by step user manual

3. Fix the pipes together with the elbow pipe.

Figure C-3 Step by step user manual

4. Use plastic tape to fix them tightly.

Figure C-4 Step by step user manual

Figure C-5 Step by step user manual

5. Reel the buckle on the top of the frame.

Figure C-6 Step by step user manual

6. Stick another half of the buckle on the top of the air conditioner with the double-sided tape.

7. Fix the Arduino board into the container

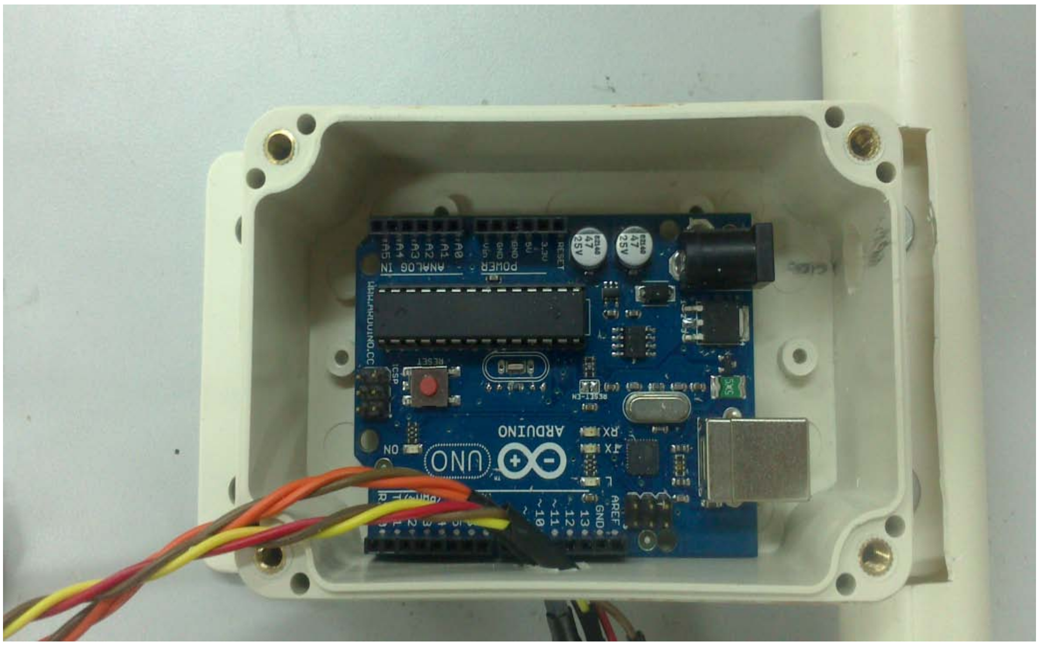


Figure C-7 Step by step user manual

8. Fix the servo on the foamed plastic board with plastic screws and angle aluminum

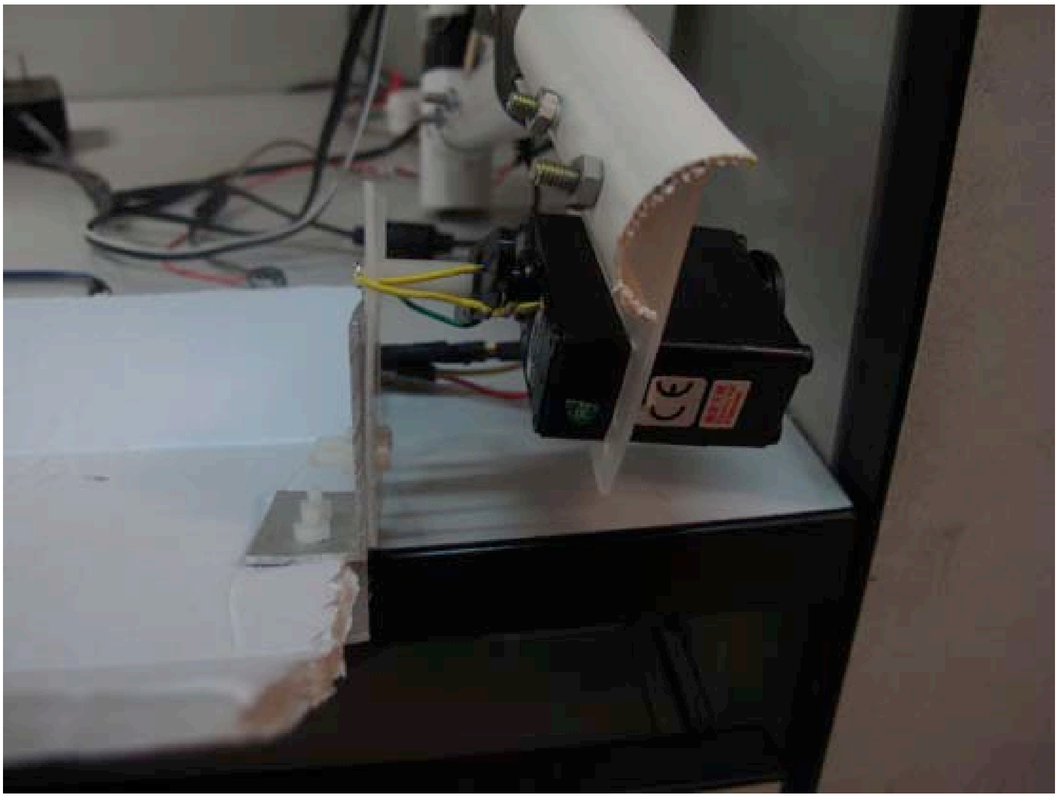
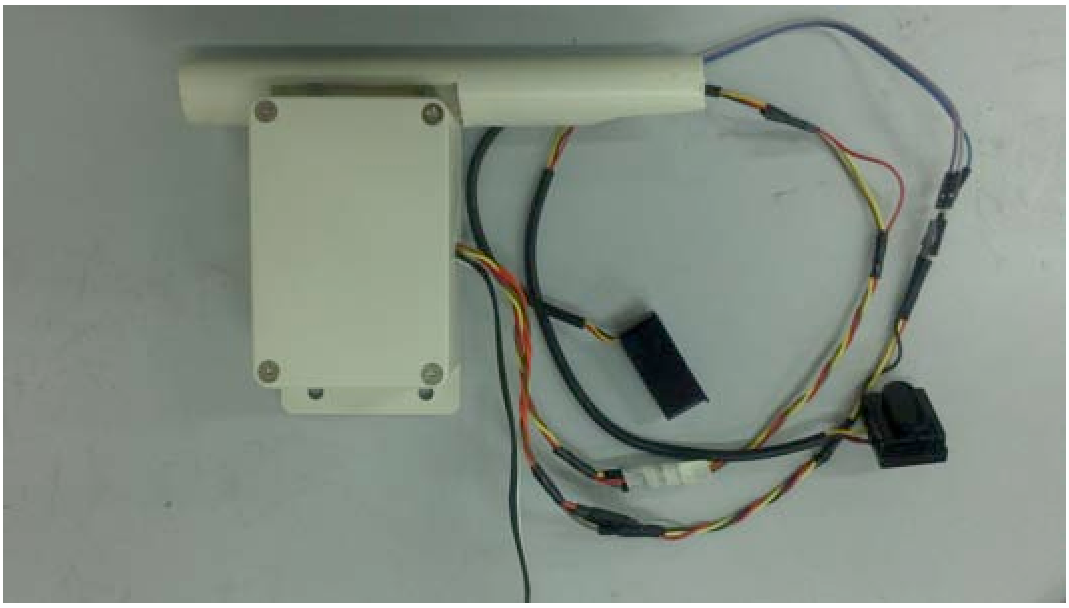


Figure C-8 Step by step user manual

9. Fix the container onto the frame.



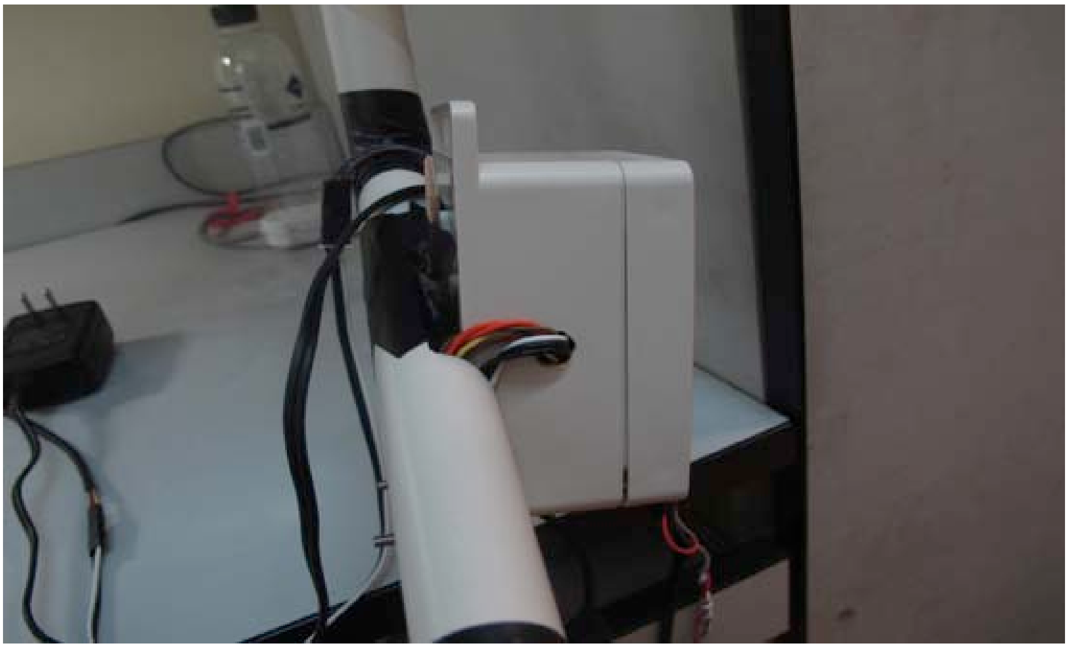


Figure C-9 Step by step user manual

10. Fix the foamed plastic board to the frame with screws.

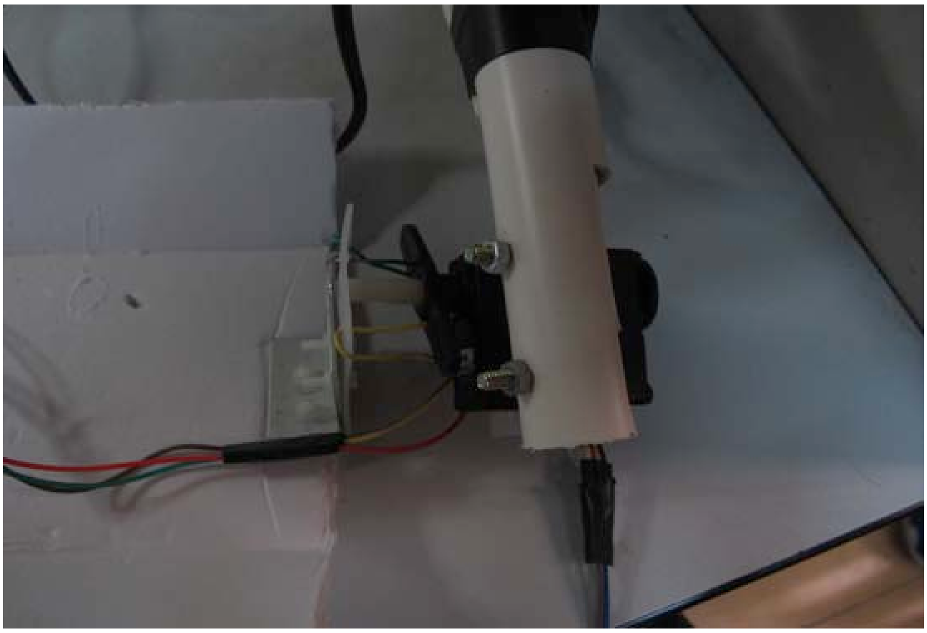


Figure C-10 Step by step user manual

11. Place the frame on the air conditioner and buckle up. Position the sensors at desired height.

Figure C-11 Step by step user manual

12. Try it out!

Appendix D: Tests and Evaluations

- Wind deflection test

This test was done to see if our design can deflect the wind with the current design of the wind deflector.

In this test we made a line with several strips of plastic bags stuck on it. We set the line directly in front of the air outlet of the air conditioner, where was blown at directly, and compared the position of the plastic strips to see how our design deflected the air conditioner wind.

From Figure D-1, we can see that the wind is blowing directly at it as the strips showed great deflection.

Figure D-1 Wind Direction without Wind Adjuster

Figure D-2 Wind Direction with Wind Adjuster

When we turn the wind deflector up and face the line, the wind was totally blocked and deflected to other directions, as we can see from Figure D-2. This result showed our deflector is totally capable of deflecting the air conditioner wind.

- Interference resistance test

The purpose of this test is to see of our design will be affected by unintentional movements of a JI students in the dormitory.

We tested the usual movements a JI student may do in the dormitory; the movements include passing through the balcony door; walking in the dorm; taking cloths form the wardrobe; sitting or standing by the desk; or one's unintentional movements when in bed. We videoed the whole process, three scenes shown in Figure D-3 to D-6, and found our design not interfered by any of these movements, which meet with our criteria on no interference.

Figure D-3 Passing through the Door

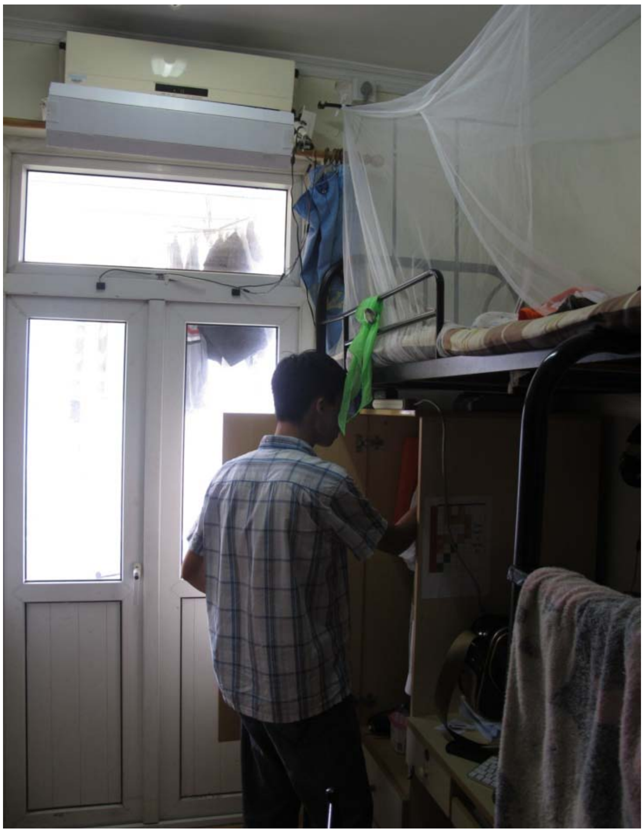


Figure D-4 Opening the Closet

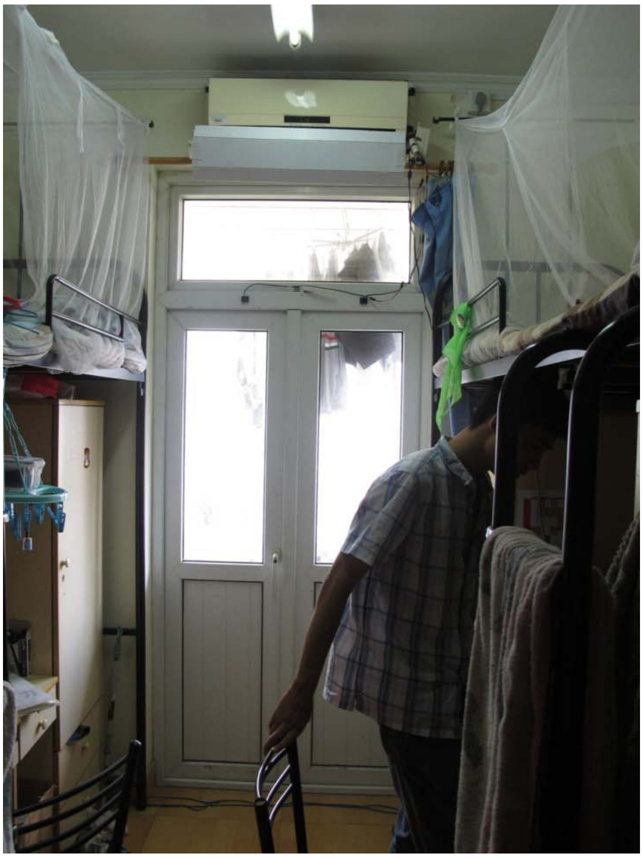


Figure D-5 Standing by the Desk

● Sensing Region Test

In this test, we tested and measured the sensing zone of our design in order to evaluate the sensing region of our design.

We first measured the distance between the upper, lower, left, and right boundary of the sensing zone on a plane that is parallel to the sensor's surface, and we measured the distance from the sensor to this plane. Then we measured the farthest vertical point from the sensor that can activate the sensor. Lastly we measured the distance between the two sensors.

After recording the data and geometric calculation based on Pythagoras theorem, we draw the sensing region shown in Figure D-6 and D-7.

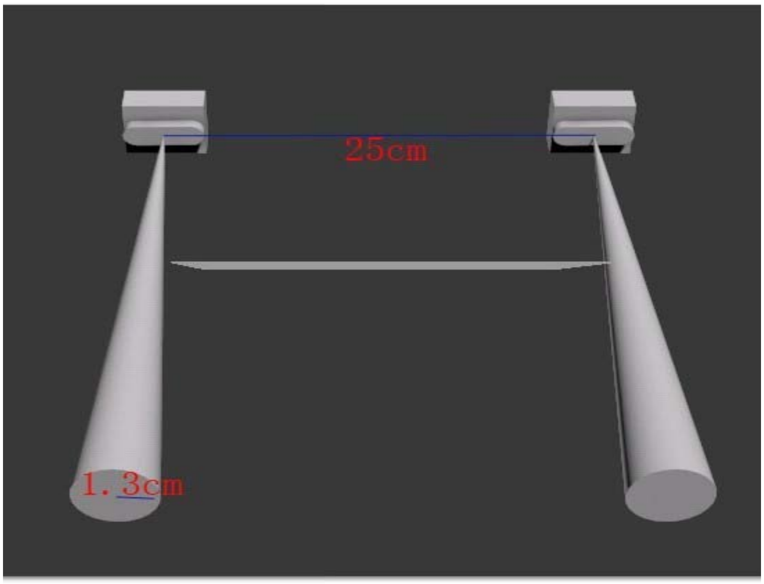


Figure D-6 Sensing Zone (front)

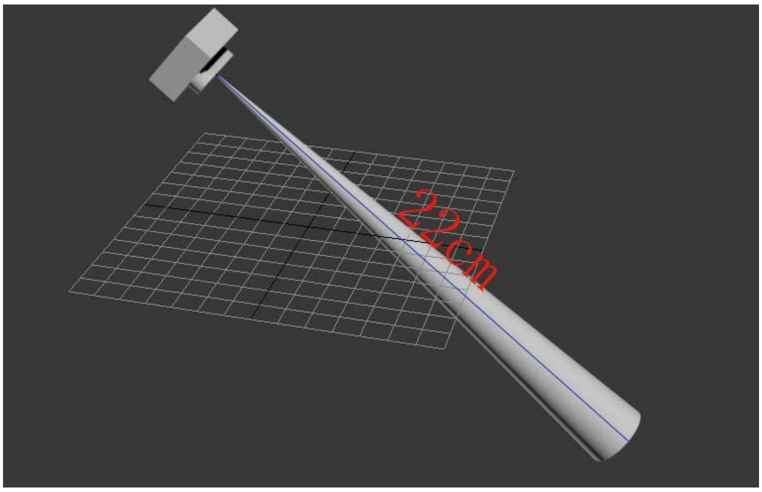


Figure D-7 Sensing Zone (side)

We can see the sensing region is formed of two identical almost parallel cones with their radius 1.3 cm and the long edge 22 cm, which are much smaller than our expectancy. This is mainly due to the infrared sensor we choose features in its precision as it is a proximity sensor which requires the user to be close enough to activate it. For more details, see Appendix E.

- Evaluation on rustproof

We evaluate the material we use for the wind deflector in this part.

As shown in Figure D-11, we used PVC pipe, foamed plastic board, nylon screws and angle aluminum to make our wind deflector. As these materials are either plastic or metals that don't rust when exposed to water. "When oxygen is present (in the air, soil, or water), aluminum instantly reacts to form aluminum oxide. This aluminum oxide layer is chemically bound to the surface, and it seals the core aluminum from any further reaction (Brown, 2007). " In *Chemistry the central science,* it is also mentioned that aluminum undergoes oxidation in the air that "can form an insulating protective oxide layer, however, that prevents further reaction of the underlying metal (Brown, LeMay, Bursten, & Murphy, 2009)." We conclude that our design is rust proof.

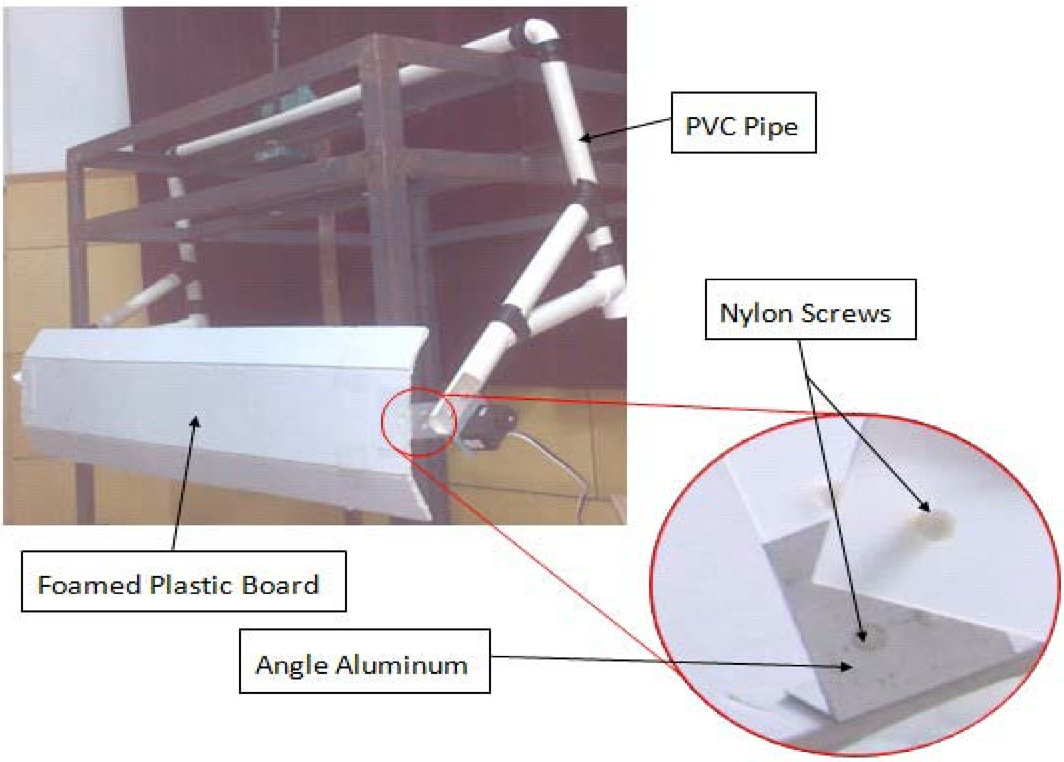


Figure D-11 Rustproof Materials

- Evaluation on the no violation of SJTU Dorm Regulation

This evaluation verifies that our design is qualified to be used in JI dormitories. As mentioned in the criteria part, our design made no change to the electrical structure of the dormitory building and used electrical devices that satisfied CCC standard. See Figure D-12.

Figure D-12 Qualified DC Power Adapter

Appendix E: Efficiency Test with User Study

The purpose for this user study is to test the user experience of our design. So, we proposed three questions for those students who have already tried using our design. For each question, there are four choices: “A” for “very”, “B” for “yes”, “C” for “not so much” and “D” for “not at all”. The three questions are: “do you feel it convenient to operate this adjuster”, “do you think the wind adjuster effective in changing the wind direction” and “do you think the device easy to attach”.

For every volunteer, we first showed him or her how to attach the design to the air conditioner. Next, we asked this volunteer to repeat the same procedure without help from any other people. If the volunteer is not tall enough, our team member, Wang Qian, could attach it instead. Then, we showed how to use this wind adjuster for the volunteer. After he or she tried the same operation personally and felt the effectiveness, the volunteer will answer the three questions above.

The data and results of these three questions are shown below. Also, for each question, we could draw some certain conclusions. We will analyze these conclusions, too.

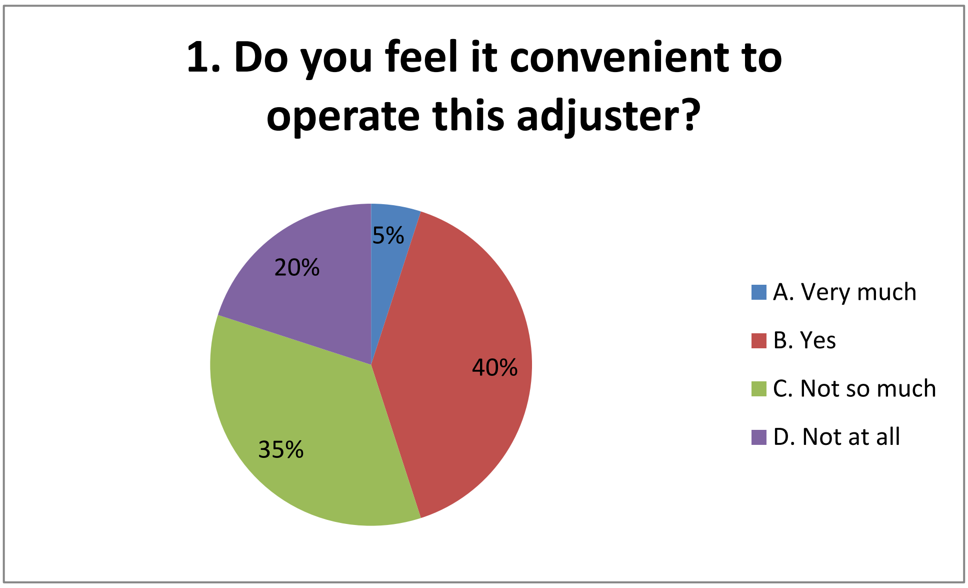


Figure E-1 Question 1

For the first question, nine of the twenty users thought that our design is convenient while eleven of the twenty users thought that our design is not convenient. The reason for this difference is that the users have different understandings of “convenience”. Some of them thought that our final design is convenient enough for them, while the other claimed that they would like to control the wind adjuster just at the desk. This result emphasized again that we should find a more suitable sensor to reach the criteria about the sensing range so that the users may find our design more convenient.

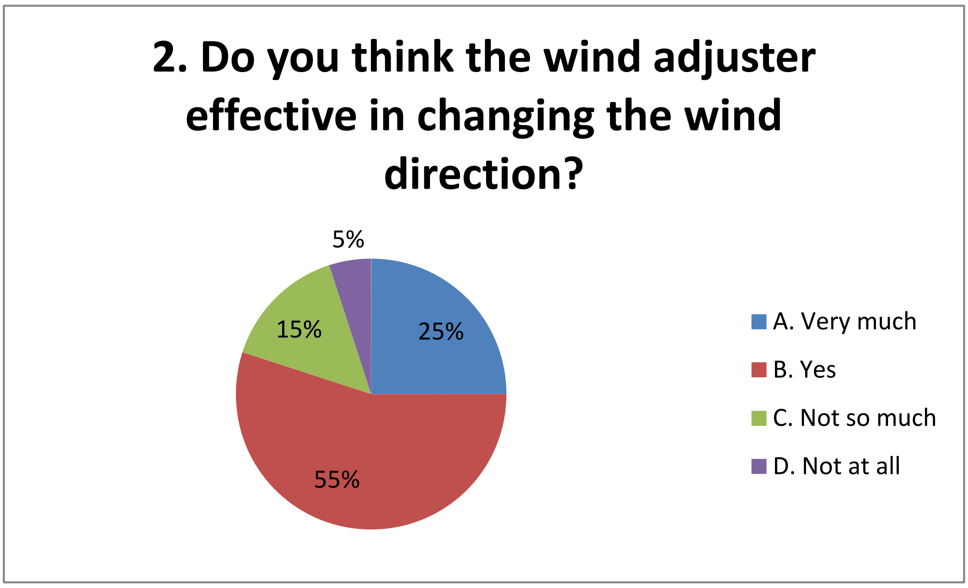


Figure E-2 Question 2

For the second question, most of the twenty users thought that out design can change the wind direction effectively. But some of the other users said that when they were lying on the bed, they can still felt the wind slightly, though it was not as strong as before. We think that this small defect can be overcome through changing the value of the variables representing the rotating angle while the user is programming the sketch, according to the requirement (Appendix G).

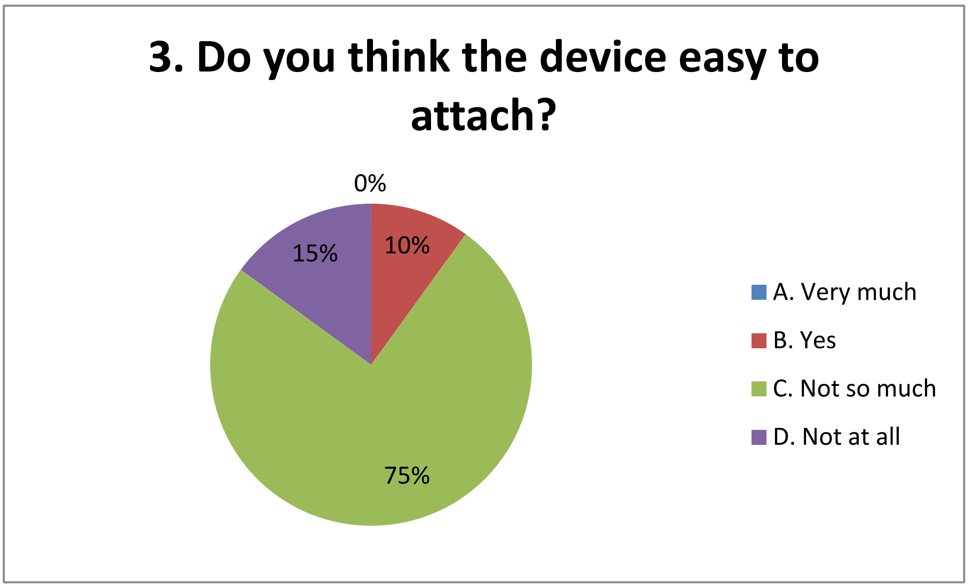


Figure E-10 Question 3

For the third question, early all the twenty users thought that setting up out design is not very easy. The biggest problem is that the air conditioner in the dorm is too high, so it is not easy or even impossible for a single person to reach. Moreover, fixing it on the air conditioner took them a lot of time, too. Also, because of the structure of our dorm, the users must use an outlet in order to power out design. Therefore, most of the users said that it is too complicated to set up our design. From the result of this question, we may conclude that the structure of our design needs to be optimized so that it can fit out dorm more.

Based on these results, we can find that though our design may be regarded as an effective design, which meet with our criteria, there are still some details for us to improve. We wish that the future improvement for our design can increase the user experience more and more.

Appendix F: Servo and Sensor Selection

In this appendix, the reason why we chose the certain servo and sensor in our design will be illustrated in detail. Due to the time limit, the servo and sensor being used now may not be the most suitable, but we have already tried our best to choose a relatively suitable one for our design.

In order to rotate the blade, we should first choose a suitable motor. There are mainly three kinds of motors (Zong & Zhang, 2003/2004). They are DC-motor, stepping motor and servo. According to the book *Building Robot Drive Trains* translated by Zong and Zhang, the speed of a DC-motor is too high and the volume of a stepping motor is too large. What is more, they all require large current. So, if we use these kinds of motors, we may violate the accommodation regulations. In the same book, it said that the advantages of a servo are low price, low speed and simple installation. Therefore, we decided to use a servo to rotate the blade.

When we were setting up our prototype, we tried two different servos. The first one we used was SPRINGRC SM-S4315R, and the second one we used was SPRINGRC SR-403P.

Figure F-1 SPRINGRC SM-S4315R

This is a 360° servo with a torque of 13.4 kg*cm (SPRINGRC MODEL ELECTRONICS CO., LTD., n.d.), which is completely strong enough for our project. At first, we thought that a 360° servo might prevent us from damaging the servo easily, since it can rotate freely. However, during the programming, we found that it was too difficult to get the current angle, if we insisted in using a 360° servo. Because inconvenience in controlling the angle of the wind adjustor would affect the user experience, we decided to use another servo.

From the failure above, we knew that we had better choose a 180° servo. Due to the restriction of the rotating angle of this kind of servo, we should pay a lot of attention when programming. But it was important to increase the user experience, so we finally used a 180° servo instead of the one above.

Figure F-2 SPRINGRC SR-403P

This is a 180° servo with a torque of 13.2 kg*cm (SPRINGRC MODEL ELECTRONICS CO., LTD., n.d.), which is still strong enough for our project. It was much easier to control the rotating range of the wind adjustor when using this servo. More details about controlling the servo with the help of microcontroller will be covered in Appendix G.

We also took a lot of time in finding a satisfying sensor. However, due to the limit of time and cost, we failed to find a sensor suitable enough to meet out criteria. As illustrated in recommendation, we wish that a more suitable sensor could be found.

We tried two different kinds of sensors and finally chose a relatively suitable one. The two sensors we tried were HC-SR501 and TDL-5001. They are all infrared proximity sensors, but their parameters are completely different. In the end, we chose to use TDL-5001.

The parameter we cared most was sensing range. In the criteria, it has been illustrated that the sensing range should be less that 160° and more than 3 meters.

HC-SR501 has a sensing range of less than 100° and more than 3 meters (ElecFreaks., 2011b). However, since this kind of sensor is a passive infrared sensor, it is too easy to activate it. That is to say, the user cannot control the sensor smoothly. So, we have to choose another kind of sensor.

TDL-5001 should have had a sensing range of 35° and about 1.5 meters (SHENZHEN TUODI ELECTRONICS CO., LTD., n.d.), which did not meet our criteria. However, in fact, its sensing range is very restricted, see Test and Evaluation. But still, compared with the former one, the wind-adjustor could eventually be controlled smoothly. The only problem was that the sensing range is smaller than what we expected too much, so we recommend finding a more suitable sensor in the future.

Figure F-3 HC-SR501 Body Pyro-electric Infrared Sensor

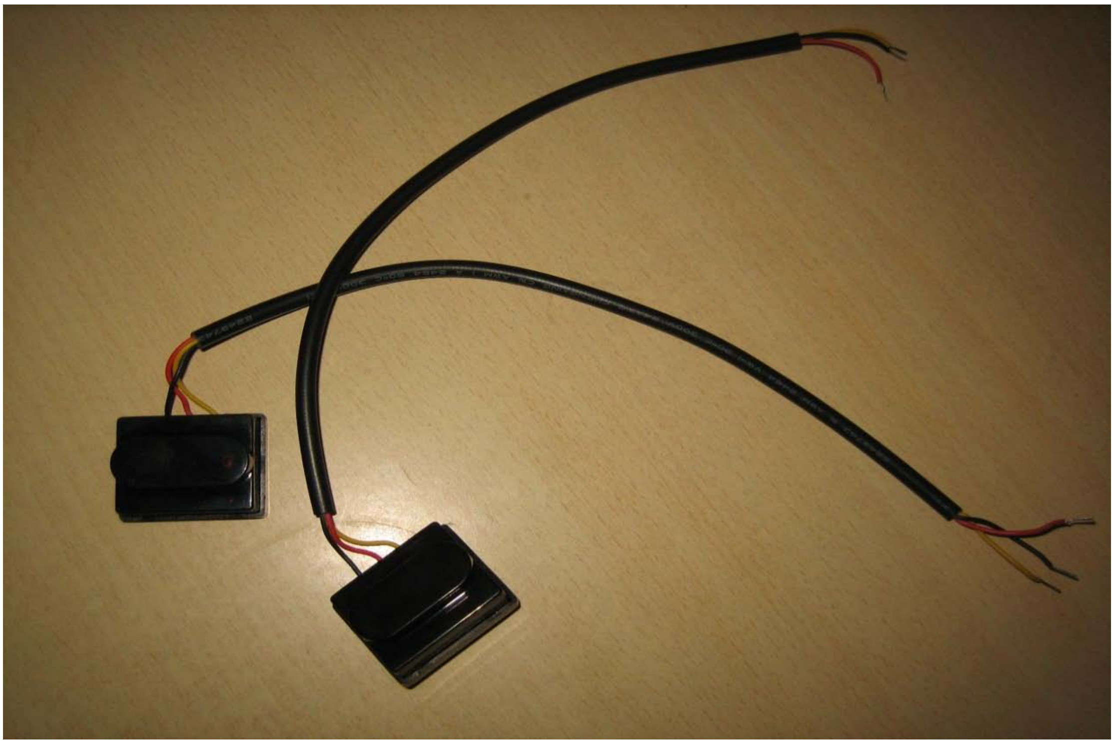


Figure F-4 TDL-5001 Active Infrared Sensor

Just as we have illustrated in the recommendation, an ultrasonic sensor may also be an alternative choice. An ultrasonic sensor has a transmitter and a receiver (Wu, 2012). The transmitter can first generate ultrasonic. Then the receiver can accept the reflected ultrasonic and convert its mechanical vibration into electric signal. Also, according to Wu, this kind of sensor can be used in automatic doors, counters, reversing sonar or other proximity switches. Therefore, here comes an assumption about the possibility to use an ultrasonic sensor in our design. Though we did not try it, we recommend that this trying can be made in the future improvement.

Appendix G: Programming Sketch

To make our design working, we used the microcontroller, Arduino Uno. The integrated development environment which we used was Arduino 1.0.1 in Windows 7.

The following programs have two functions: detecting the motion from the user through the sensors for three times and controlling the servo. Though the functions seem the same, they are a little bit different from each other in some details.

For the first version of the sketch, we used the following data structure.

```
const int servoPin = 9;
const int inputPinA = 2;
const int inputPinB = 4;
int valA,valB,valC;
```

Figure G-1 Data Structure for Version 1

The variables in this version had the following meanings.

servoPin	the digital pin to which the servo was connected
inputPinA	the digital pin to which the sensor A was connected
inputPinB	the digital pin to which the sensor B was connected
valA	the first input value from any sensor
valB	the second input value from the other sensor
valC	the third input value form the sensor the same as the first one

Figure G-2 Data Structure Explanation for Version 1

We then use the following sketch to declare the sensors as input and the servo as output.

```
void setup()
{
  pinMode(inputPinA,INPUT);
  pinMode(inputPinB,INPUT);
  pinMode(servoPin,OUTPUT);
}
```

Figure G-3 Setup Function for Version 1

The version 1 was for the servo SPRINGRC SM-S4351R. As illustrated in Appendix E, it is a 360° servo, so we had a great difficulty in determining the current angle. Because of this, we enabled the user to control the direction by waving his or hand starting from different sides.

The main loop contained two similar parts. If sensor A detected the motion first, the servo would rotate in a clockwise direction. If sensor B detected the motion first, the servo would rotate in a counterclockwise direction.

```
void loop()
{
  valA = digitalRead(inputPinA);
  if (valA == HIGH)
  {
    ...
  }

  valA = digitalRead(inputPinB);
  if (valA == HIGH)
  {
    ...
  }
}
```

Figure G-4 Main Loop Function for Version 1

Now, the first part of the main loop function will be used as an example to illustrate how to enable the servo to move in the direction as required.

```
for (int i = 0; i < 2000; i++)
{
  valB = digitalRead(inputPinB);
  if (valB == HIGH)
  {
    for (int i = 0; i < 2000; i++)
    {
      valC = digitalRead(inputPinA);
      if (valC == HIGH)
      {
        while (valC == HIGH)
        {
          digitalWrite(servoPin,HIGH);
          delayMicroseconds(1350);
          digitalWrite(servoPin,LOW);
```

Figure G-5 Clockwise Controlling Part for Version 1

```
            delayMicroseconds(20150);
            valC = digitalRead(inputPinA);
          }
          break;
        }
        delay(1);
      }
      break;
    }
    delay(1);
  }
```

Figure G-6 Clockwise Controlling Part for Version 1 (cont.)

This enabled one sensor to detect the motion from the user for two seconds at most. If the user kept the hand stilling in front of the last sensor activated, the servo would keep moving in the clockwise direction. As shown in the sketch, in this version we modulated the pulse width to control the servo angle and direction.

```
  for (int i = 0; i < 2000; i++)
  {
    valB = digitalRead(inputPinA);
    if (valB == HIGH)
    {
      for (int i = 0; i < 2000; i++)
      {
        valC = digitalRead(inputPinB);
        if (valC == HIGH)
        {
          while (valC == HIGH)
          {
            digitalWrite(servoPin,HIGH);
            delayMicroseconds(1500);
            digitalWrite(servoPin,LOW);
            delayMicroseconds(20000);
            valC = digitalRead(inputPinB);
          }
          break;
        }
```

Figure G-7 counterclockwise controlling part for version 1

```
            delay(1);
        }
        break;
    }
    delay(1);
}
```

Figure G-8 counterclockwise controlling part for version 1 (cont.)

The counterclockwise controlling part for version 1 was similar to the clockwise part. The two differences were the order in which the sensor were activated and the pulse width modulated.

Because of the inconvenience made by the 360° servo, we used a 180° servo, SPRINGRC SR-403P, to replace it. Therefore, we also modified the sketch.

For the second version of the sketch, we used the following data structure.

```
#include <Servo.h>
const int servoPin = 9;
const int inputPinA = 2;
const int inputPinB = 4;

Servo myservo;
int angle;
int dir;
int valA,valB,valC;
```

Figure G-9 Data Structure for Version 2

Here, we used the Servo Library to control the servo in a more convenient way. The variables had the following meanings in this version.

servoPin	the digital pin to which the servo was connected
inputPinA	the digital pin to which the sensor A was connected
inputPinB	the digital pin to which the sensor B was connected
myservo	the servo object
angle	the current angle of the servo
dir	the direction of the servo (1 for clockwise; 0 for counterclockwise)
valA	the first input value from any sensor
valB	the second input value from the other sensor
valC	the third input value form the sensor the same as the first one

Figure G-10 Data Structure Explanation for Version 2

We then used the following sketch to declare the sensors as input and attach the servo to the digital pin. We read the current angle before we really activate the sensors, too.

```
void setup()
{
  pinMode(inputPinA,INPUT);
  pinMode(inputPinB,INPUT);
  myservo.attach(servoPin);
  angle = myservo.read();
}
```

Figure G-11 Setup Function for Version 2

Since we changed the servo, it became easier to determine the current angle. So, we not only enabled the user to control the direction by waving his or hand starting from different sides, but also made it possible for the servo to rotate in a certain range from 30° to 150° continuously.

The same as in version 1, the main loop contained two similar parts, too. If sensor A detected the motion first, the servo would rotate in a clockwise direction. If sensor B detected the motion first, the servo would rotate in a counterclockwise direction.

```
void loop()
{
  valA = digitalRead(inputPinA);
  if (valA == HIGH)
  {
    ...
  }

  valA = digitalRead(inputPinB);
  if (valA == HIGH)
  {
    ...
  }
}
```

Figure G-12 Main Loop Function for Version 2

The frame of main loop function for this version was totally the same as that in the first version. However, the controlling part in this version was different from that in the one. One difference was that we used a variable to represent the direction. The other difference was that we used the function in Servo Library, which made us easier to get the current angle of the servo.

```
dir = 1;
for (int i = 0; i < 2000; i++)
{
  valB = digitalRead(inputPinB);     if (valB == HIGH)
  {
    for (int i = 0; i < 2000; i++)
    {
      valC = digitalRead(inputPinA);
      if (valC == HIGH)
      {
        while (valC == HIGH)
        {
          if (dir)
          {
            angle++;
            if (angle >= 150)
              dir = 0;
            myservo.write(angle);
            delay(20);
          }
          else
          {
            angle--;
            if (angle <= 30)
              dir = 1;
            myservo.write(angle);
            delay(20);
          }
          valC = digitalRead(inputPinA);
        }
        break;
      }
      delay(1);
    }
    break;
  }
  delay(1);
}
```

Figure G-13 Clockwise Controlling Part for Version 2

This also enabled one sensor to detect the motion from the user for two seconds at most. If the user kept the hand stilling in front of the last sensor activated, the servo would move in the clockwise direction at first, change the direction automatically if needed and keep moving in the range from 30° to 150° continuously.

```
dir = 0;
for (int i = 0; i < 2000; i++)
{
  valB = digitalRead(inputPinA);
  if (valB == HIGH)
  {
    for (int i = 0; i < 2000; i++)
    {
      valC = digitalRead(inputPinB);
      if (valC == HIGH)
      {
        while (valC == HIGH)
        {
          if (dir)
          {
            angle++;
            if (angle >= 150)
              dir = 0;
            myservo.write(angle);
            delay(20);
          }
          else
          {
            angle--;
            if (angle <= 30)
              dir = 1;
            myservo.write(angle);
            delay(20);
          }
          valC = digitalRead(inputPinB);
        }
        break;
      }
      delay(1);
    }
    break;
  }
  delay(1);
}
```

Figure G-14 Counterclockwise Controlling Part for Version 2

The counterclockwise controlling part for version 2 was similar to the clockwise part. The only difference was the direction in which the servo rotated at first.

But we found that though different starting directions might make it quicker for the user to get the wind direction needed, sometimes it was easy to confuse the user, too. So, we decided to cancel this function by setting a fixed starting direction. Also, in the final version of our sketch, we optimized the data structure so that we could change the waiting time for a sensor to stop detecting the motion from the user, the minimized rotating angle and the maximized rotating angle more easily.

For the third version of the sketch, we used the following data structure.

```
#include <Servo.h>
const int servoPin = 9;
const int inputPinA = 2;
const int inputPinB = 4;
const int waitMicro = 2000;
const int strAng = 30;
const int endAng = 150;

Servo myservo;
int angle;
int dir = 1;
int valA,valB,valC;
```

Figure G-15 Data Structure for Version 3

As shown above, we added three constants. These three constants have the following meanings.

waitMicro	the waiting time for a sensor to stop detecting the motion from the user
strAng	the minimized rotating angle
endAng	the maximized rotating angle

Figure G-16 Data Structure Explanation for Version 3

The remaining part of this version was very similar to that in version 2. But this version was easier for the user to modify as he or she wanted. The following is the completed sketch of version 3, which is the final version.

```
void setup()
{
  pinMode(inputPinA,INPUT);
```

Figure G-17 Setup Function for Version 3

```
  pinMode(inputPinB,INPUT);
  myservo.attach(servoPin);
  angle = myservo.read();
}
```

Figure G-18 Setup Function for Version 3 (cont.)

```
void loop()
{
  valA = digitalRead(inputPinA);
  if (valA == HIGH)
  {
    for (int i = 0; i < waitMicro; i++)
    {
      valB = digitalRead(inputPinB);
      if (valB == HIGH)
      {
        for (int i = 0; i < waitMicro; i++)
        {
          valC = digitalRead(inputPinA);
          if (valC == HIGH)
          {
            while (valC == HIGH)
            {
              if (dir)
              {
                angle++;
                if (angle >= endAng)
                  dir = 0;
                myservo.write(angle);
                delay(20);
              }
              else
              {
                angle--;
                if (angle <= strAng)
                  dir = 1;
                myservo.write(angle);
                delay(20);
              }
```

Figure G-19 Main Loop Function for Version 3

```
            valC = digitalRead(inputPinA);
          }
          break;
        }
        delay(1);
      }
      break;
    }
    delay(1);
  }
}

valA = digitalRead(inputPinB);
if (valA == HIGH)
{
  for (int i = 0; i < waitMicro; i++)
  {
    valB = digitalRead(inputPinA);
    if (valB == HIGH)
    {
      for (int i = 0; i < waitMicro; i++)
      {
        valC = digitalRead(inputPinB);
        if (valC == HIGH)
        {
          while (valC == HIGH)
          {
            if (dir)
            {
              angle++;
              if (angle >= endAng)
                dir = 0;
              myservo.write(angle);
              delay(20);
            }
            else
            {
              angle--;
              if (angle <= strAng)
                dir = 1;
```

Figure G-20 Main Loop Function for Version 3 (cont.)

```
          delay(1);
        }
        break;
      }
      delay(1);
    }
  }
}
```

Figure G-21 Main Loop Function for Version 3 (cont.)

Appendix H: Design Prototypes

- Conceptual Prototype

To test whether our design can work in the way we want, we made a prototype to which has a simplified version of our design. We used this prototype to test whether it can fit the features we want. We installed the servo on the frame, and then we activate the sensors. We found that the servo can drive the blocking board. However, the blocking board rotated in 360 degrees, and this will not happen in reality. After this test, we decided to change the previous servo to one can rotate in a certain range. Later, we tested the feature of size scalability of the frame.

We made many adjustments in the final design after we made this prototype, which confirmed our idea.

Figure H-1 Conceptual Design

Figure H-2 Conceptual Design in Operation

● First mechanical design

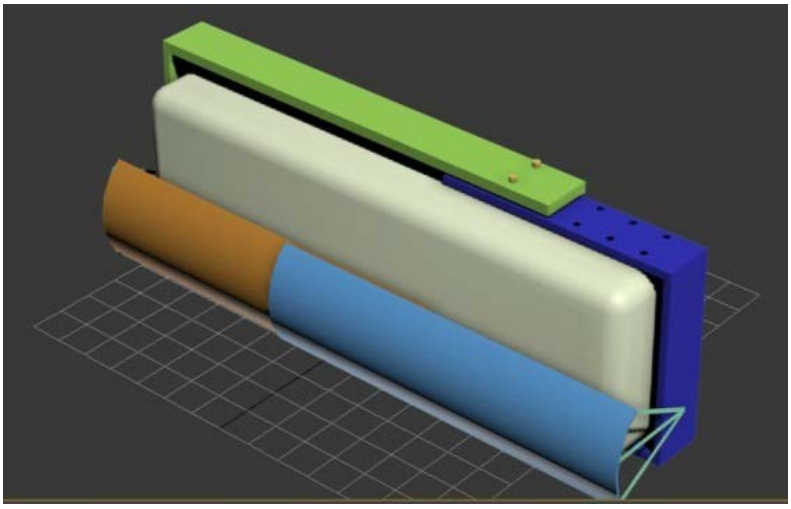


Figure H-3 First Mechanical Design

In our first design, we planned to make the frame telescopic, which is composed of metal boards and can adjust its size according to different types of air conditioner. When we were making that prototype, we found that it is too complicated to accomplish, as metal board are hard to acquire for us, and cannot fit our expectation of easy adjustment as it is rather heavy. Besides, the material cannot meet with the criteria of rustproof.

● Final mechanical design

For this final design, we changed the design and use PVC pipes to build up the frame. As one can cut pipes into different length, the user can change the length of the pipe when they install the frame. This is somehow a compromise to the limitation of material. But this design fits perfectly with our rustproof criteria.

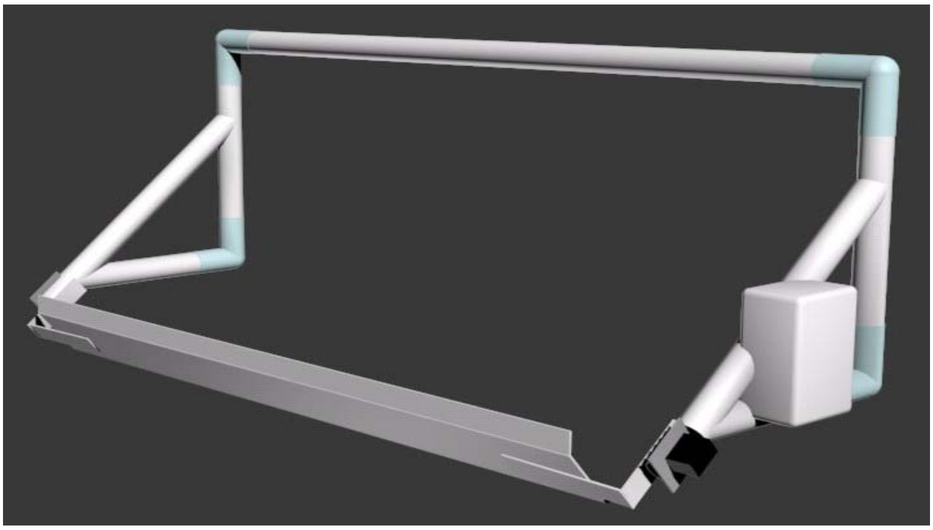


Figure H-4 Final Mechanical Design

Appendix I: Cost List

Though cost analysis is not a critical factor to judge a DIY project, we still would like to provide the cost list.

Arduino Board	80 RMB	PVC Pipe	10 RMB
Servo	65 RMB	Bread Board	5 RMB
Sensors	50 RMB	Power Adjuster	5 RMB
PVC Board	4 RMB	DuPont Wires	3 RMB
Plastic board	5 RMB	Container	10 RMB
Plastic screw	1 RMB	Velcro	3 RMB

Figure I-1 Cost List for Final Project (RMB)

However, if the project is improved, the cost will be changed. For example, as having been illustrated in the recommendation, more suitable sensors should be used. What is more, the servo seems a little bit expensive. The servo we use now has a torque of 13.2 kg*cm (SPRINGRC MODEL ELECTRONICS CO., LTD., n.d.), which is far beyond required. That is to say, we can, actually, choose a cheaper servo.

Appendix J: Summer in Shanghai

上海基本气候情况（据1971-2000年资料统计）

	1月	2月	3月	4月	5月	6月	7月	8月	9月	10月	11月	12月
平均温度(℃)	4.7	6.0	9.2	14.7	20.3	23.8	28.0	27.8	24.4	19.2	13.5	7.8
极端最高温度(℃)	19.2	26.4	26.1	32.2	34.9	36.8	37.7	37.8	36.7	32.2	26.5	20.3
极端最低温度(℃)	-5.5	-4.5	-0.7	2.4	9.4	16.0	20.0	19.9	13.9	6.5	-1.9	-7.7
平均降水量(毫米)	75.3	43.7	117.6	63.2	85.2	211.6	141.8	230.1	76.1	63.5	42.6	33.7
降水天数(日)	10.5	7.4	14.6	11.7	10.4	13.7	10.8	12.5	8.4	7.6	7.6	7.0
平均风速(米/秒)	3.0	3.1	3.3	3.2	3.3	3.2	3.2	3.4	3.3	2.9	3.0	2.9

Figure J-1 Information about the Weather in Shanghai
(Image retrieved from: http:/www.weather.com.cn/cityintro/101020100.shtml)

Appendix K: SJTU Accommodation Regulation

上海交通大学本科生宿舍管理规定（闵行校区）

第一章、总则

本条例适用于闵行校区学生生活园区除留学生宿舍之外的所有本科学生宿舍（以下简称本科生宿舍）。

校学生处下属生活园区管理中心具体负责本科生宿舍的日常服务、管理、教育工作；学校在各宿舍楼派驻生活指导教师，进行学习、生活辅导，开展思想政治教育；校学生工作党委、校团委在生活园区设立党、团工作分支机构，指导生活园区学生党、团建设及各类文化活动。

第二章、宿舍入住、变更、退宿管理

第一条 入住

1. 在本校正式注册接受学历教育，并根据学校教务处安排在闵行校区就读的的全日制本科学生，在规定学制年限内可以在学生宿舍住宿；未能在规定学制年限内毕业的，按规定办理延期手续后，在其最长学制规定的年限内，可以在学生宿舍另行安排住宿。
2. 不符合前款所述条件的其他各类在校就读人员，必须在学生宿舍住宿的，经学校教务处同意，生活园区管理中心在宿舍条件允许的前提下，与其签订相关协议后，在学生宿舍安排住宿，但此部分人员不享受本校学生待遇。
3. 新生入校时，生活园区管理中心根据学校教务处提供的在闵行校区就读的新生名单，向各院系提供相应数量的宿舍床位，由各院系具体分配学生宿舍及床位。
4. 住宿分布以“男女分楼（层），年级按楼集中，院系按楼层、相邻寝室、寝室集中，朝向、楼层好坏搭配并随机安排，按院系总体均衡”为原则。
5. 新生前往各楼办理入往手续时必须缴纳一张本人报名照。
6. 入住学生必须根据规定按时缴纳住宿费。住宿费在每学年注册时按当年学校规定的标准以学年为单位收取。
7. 学生住宿期间必须缴纳水电费。水电费由学校定额补贴，超额部分使用人平摊自理，由校水电中心代为收缴。学生可登录 mypower.sjtu.edu.cn 进一步查询水电费相关内容。
8. 学生处生活园区管理中心依照宿舍条件差异规定每个寝室入住人数标准并满员安排，宿舍楼内因故暂时空出的寝室、床位由生活园区管理中心统一管理。
9. 入住学生必须按指定寝室、床位入住，未经批准**严禁**擅自变更、出让、出租、占用。

第二条 变更

1. 规定学制年限内所住宿的宿舍一般不变更，但因个人学籍变动、整体教学科研布局变化、延期毕业、宿舍维修等不可预见的因素导致必须相应变更的，所涉及的学生应当予以配合，有关部门应当尽可能照顾学生利益，予以必要的帮助。

2. 因教学、科研需要个别申请跨校区调整住宿的，必须经学校教务处核实，个人申请并填写《跨校区住宿申请表》，由所去校区宿舍管理部门在宿舍条件允许的前提下予以安排。
3. 学生因其它个人或环境因素需要调换寝室的，应首先向学院方面反映情况，经协调无效后可向生活园区申请调换寝室。

第三条 退宿

1. 学生毕业时，应当办理退宿手续按时退出宿舍。因特殊原因办理毕业离校手续但需短期延住的，在符合规定的情况下，必须办理相关手续，由生活园区管理中心酌情另行安排，延住期间不再享受在校学生待遇。
2. 因休学、出国、退学、跨校区调整以及其它原因需退出宿舍的，应当办理退宿手续。
3. 下列学生应当退宿：身体、心理原因极不适宜集体生活的；个人生活习惯严重影响他人正常生活，经协调无法解决的；违反学校宿舍管理规定，屡教不改或情节严重的。
4. 学生退宿时必须在办理退宿手续后的两个工作日内搬迁出寝室，迁出时必须将房间清理妥当，搬离室内所有个人财物，并将所有宿舍钥匙交还本楼宿舍管理员。应当退出宿舍而未退出的，或应当办理退宿手续而未办理的，学校有关部门有权采取措施进行相应处置，所引起的损失由当事人本人自负。
5. 因退学、提前结束学业、学校教学科研活动安排等原因须要在学年中途退宿，并且当学年不再申请学校任一校区学生宿舍住宿的，由学校教务处出具证明，在搬离宿舍并办理退宿手续后，学校根据实际住宿时间，按月计退剩余的住宿费。因其它原因在学年中途退宿的，已缴纳的住宿费不予退还。

第四条 校外住宿

1. 因故在校外住宿的学生，应当填写《上海交通大学学生校外住宿（含租房）登记备案表》，进行备案登记，并办理退宿手续。
2. 学生必须承诺在校外住宿期间遵守相应的法律、法规及学校规章制度，对自己的行为负责，同时加强个人人身及财产安全的自我保护。
3. 校外住宿的学生，应当主动加强与学校的联系。学校相关老师应当掌握有效的通讯联络方式，及时了解校外住宿学生的情况。
4. 未满 18 周岁的学生一般不得申请校外住宿。

第三章、住宿规则

第一条 安全管理

1. 各宿舍楼大门设门卫，有权查验出入人员身份及所携带出楼的物品。
2. 基于安全考虑，学生宿舍 0：00~6：00 宿舍楼大门关闭，如有意外情况需在此期间出入，必须联系楼内值班人员。
3. 寒暑假期间楼内住宿学生少于一定人数时，将迁出另择楼安排集中住宿，并关闭宿舍楼。
4. 宿舍内个人财物由学生各自妥善保管，如有遗失，自行负责。

5. 学生应当增强安全意识和法制观念，重视管理部门给予的各类安全警示，提高自我保护和管理能力。学生应当自觉主动维护宿舍安全，有权劝阻、制止、报告有损宿舍安全和正常秩序的不良行为。
6. 学生宿舍不同于一般私人居住场所，为维护学校及宿舍正常秩序，相关宿舍管理、保安、维修人员每日均会对本楼学生宿舍进行安全、内务、维修等巡检，住宿学生应当予以配合，不得以侵犯隐私为由予以阻扰。但相关人员进入宿舍时应当遵从必要的规范和礼仪。
7. 学生应当主动学习并知晓楼内各种消防安全设施的位置、使用方法，并参加有关部门组织的消防演习；住宿在配有电梯宿舍楼的学生还应当知晓电梯故障时的正确处置方式。
8. 同寝室或相邻寝室成员应当相互照应，发现异常情况或遇自然灾害、紧急事故时应当首先避险自救、互救，并尽快向宿舍管理人员或救援机构寻求帮助。
9. 基于消防考虑，宿舍楼通道、寝室阳台、以及楼内除寝室以外所有的公共场所均应保持通畅，不可堆放杂物。
10. 基于学校电力设施的局限性以及宿舍环境的特殊性，为公共安全需要，部分可能引发安全隐患的电器非经特别许可，学生不得在宿舍中自备（见三（五）4）。学生可以自备的家用电器、电线电缆、插头插座组件等，应当符合国家强制性产品认证标准（具备“CCC”标识），并以正确方式妥善使用。
11. 基于安全用电考虑，寝室无人时应当关闭室内用电设备，管理人员巡查时发现未关闭的可以以切断电源的方式予以协助。
12. 宿舍钥匙不得随意转借他人，严禁私门换锁或另加门锁。严禁将公寓门禁卡转借他人，严禁带领陌生人进入公寓。

第二条 公共设施、设备管理

1. 寝室和宿舍楼内统一配置的各类设施、设备均为公共财产，应当妥善使用和保管，不得私自拆装、移动、改动，如有损坏应当及时登记报修，人为损坏或遗失按合理分担责任的原则由责任人赔偿。
2. 寝室和宿舍楼内统一配置的各类设施、设备，如网络、有线电视、电话、煤气表具等，依据管理权属分工，分别由不同的校内外机构具体管理、维护，并制定相应的使用规定，由生活园区管理中心代为管理或协调，予以协助。
3. 非经特别许可，寝室和宿舍楼内不得加放大型家具、家电，不得私自调换、加装寝室门锁，私配或外借宿舍钥匙。

第三条 公共环境及内务管理

1. 宿舍集体生活中学生应当自觉养成并维护文明健康的生活方式，语言、行为、衣着应当得体，互相尊重生活习惯，和睦相处。
2. 寝室内应保持整洁、卫生，每周自行进行一次卫生大扫除，各楼宿舍管理人员每周例行卫生评比，并开展各类评优活动。评比结果定期报送院系，作为院系评优评奖的依据。
3. 宿舍楼除寝室以外的公共部位卫生保洁工作由生活园区管理中心负责，住宿学生应当予以配合，共同维护良好的生活环境。
4. 为保证学生正常作息，学校规定学生寝室内网络、用电实行定时切送制度。
5. 学校鼓励入住学生积极参与园区组织的党团、文化建设活动，对园区的日常服务、管理提出合理意见和建议。

6. 因装修、公共设施改善等工程实施而需要对相应宿舍及楼栋进行改造的，学生应予以配合。

第四条 宿舍会客管理

1. 凡非本宿舍住宿的人员通称为访客。
2. 访客必须遵守宿舍所有的规章制度。
3. 学生宿舍会客时间为 8：00~23：00。女生宿舍只限在宿舍楼大厅接待异性访客，非工作之需，男访客进入女生宿舍仅限于搬运重物及紧急必要的协助等情况。
4. 凡访客进入宿舍楼，校外访客须凭交大会客单及本人证件，校内访客凭本人证件在门卫处登记进入。访客如携带贵重或大件物品出入，应当主动在宿舍门卫处登记说明，管理人员亦有权进行主动查验，遇异常情况时管理人员有权报学校保卫部门派员检查。
5. 访客未经宿舍管理部门同意，一律不得留宿，一经发现，管理人员有权予以制止；访客身份不明或有其他异常情况，管理人员有权报校保卫部门处理。
6. 访客和被访人应当举止得体，不影响同楼、同室其他成员的正常生活。
7. 访客和被访人应当尊重、配合管理人员工作，共同维护宿舍安全。
8. 一旦访客对宿舍内住宿人员造成人身财产威胁及伤害，或对毁坏公共设施财产的，园区将依法对该访客及相关引进人追究法律责任。

第五条 宿舍楼内禁止下列不当行为

一经发现管理人员有权制止或要求改正，并视改正情况或情节轻重报学校有关管理机构处置。

1. 高空抛物。
2. 饲养宠物。
3. 滋扰他人正常学习、生活（在楼内溜冰、玩球、跳舞、高声喧哗、高声播放音响、摔瓶子、放鞭炮等）。
4. 使用违规电器（电冰箱、洗衣机、电炉、热得快、电热壶、电吹风、电热杯、电热毯、取暖器、电磁炉等）。
5. 违章用电或以不安全方式用电（以非正常方式接电、接拉床头灯、擅自更改变动电路及装置、使用不符合安全标准的家用电器、电线电缆、插头插座组件、在潮湿或易燃环境下接拉临时电源等）。
6. 未经审核张贴；在规定区域之外张贴；在宿舍内外墙壁上刻划、涂鸦；以不当方式（使用铁钉、油漆、刀具、涂改液、双面胶纸等）布置宿舍墙壁、家具。
7. 楼内停放自行车或在楼内公共场所、通道堆放私人物品。
8. 非会客时间让访客逗留于宿舍楼内。
9. 未经批准在宿舍区内从事商业行为（租赁、修理、代售、代销、直销、上门派发推销等）。
10. 使用明火（使用酒精炉、烧烤炉、点蜡烛、焚烧废纸杂物等）。
11. 擅自将宿舍楼供公用的书籍、报刊杂志、设备设施等携离原处。
12. 在宿舍楼内烧煮食物。
13. 私自变更、出让、出租、占用宿舍床位。
14. 私自另配宿舍钥匙或将宿舍钥匙外借本寝室以外人员。
15. 在宿舍内从事生产、制造、实验等影响他人生活、安全的行为。
16. 进行商业宣传，悬挂条幅打广告

第六条 宿舍楼内严禁下列行为

一经发现将视情节轻重，报送学校有关管理机构或公安部门处置。

1. 违法行为。
2. 藏有法定违禁物品或危险物品（易燃、易爆、易腐蚀、剧毒、放射性物品、细菌和病毒标本等）。
3. 赌博或藏有赌具。
4. 酗酒闹事。
5. 从事各类宗教活动、迷信活动。
6. 有伤风化的行为。
7. 第三（五）项不当行为引发严重后果的。

第四章、附则

（一）本条例解释权归学生处生活园区管理中心。

（二）密西根联合学院参照本条例对其学生宿舍另作补充规定。

（三）学生处生活园区管理中心根据本条例另行制定各类具体实施细则。

（四）本条例自 2011 年 9 月 1 日起实施。

Appendix L: JI Dormitory Set-up

We can see from this picture that we have three beds in a JI dormitory and only two are near to the air conditioner. The room has the depth of merely two beds lined up and the width between two opposite beds is only 110cm. When the temperature of the air conditioner is relatively low, such a limited space increased the students' risk of being directly blown at.

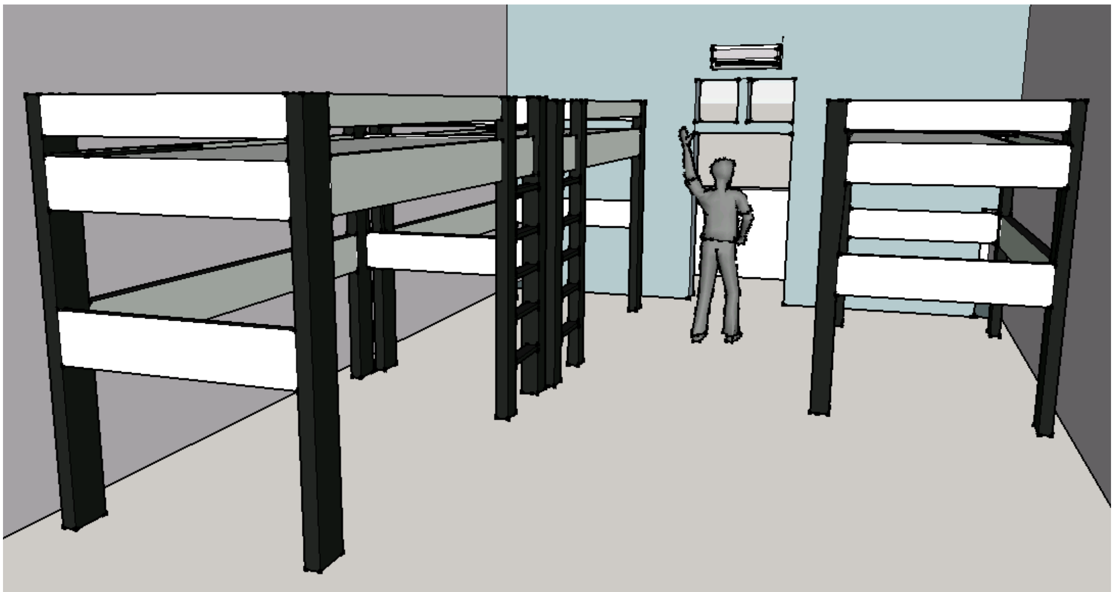


Figure L-1 Overview

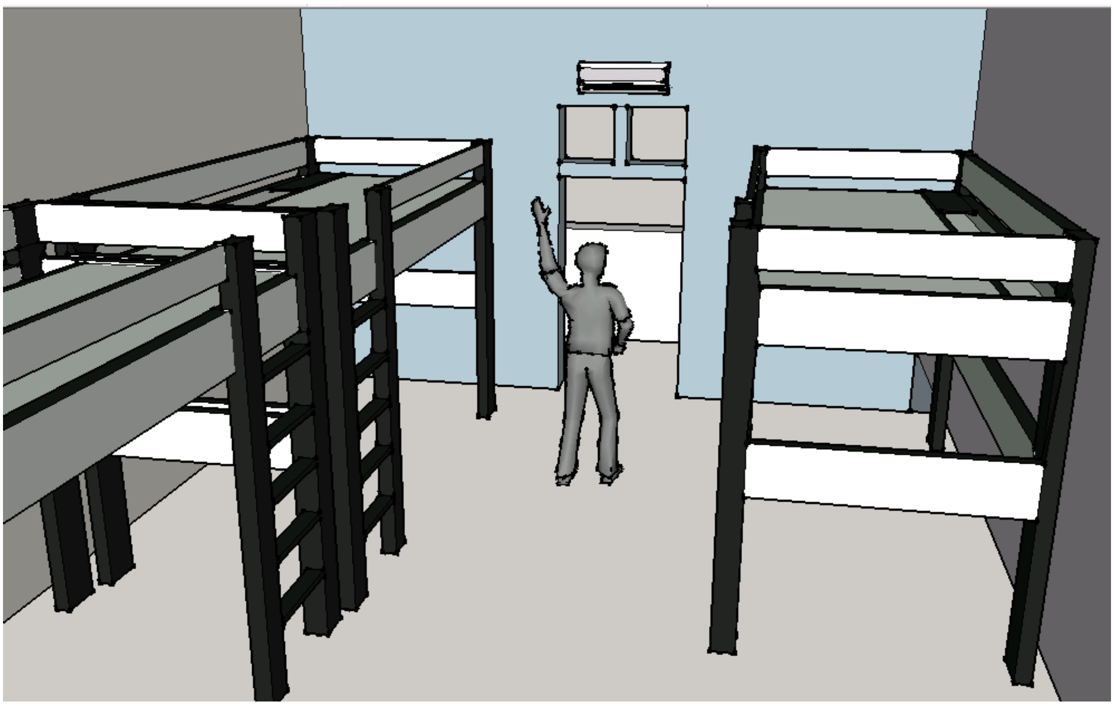
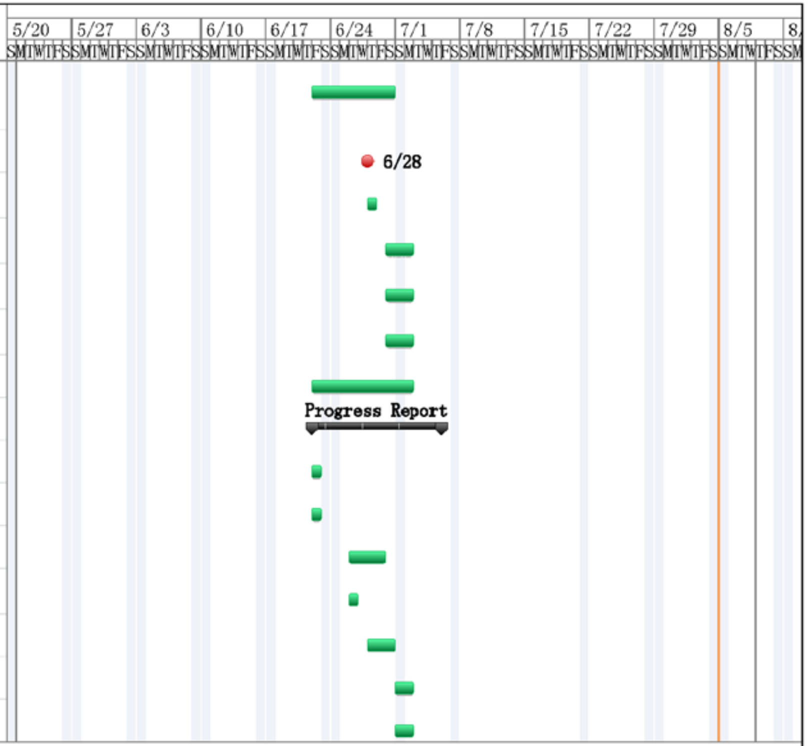


Figure L-2 Zoom In (standing)

Figure L-3 Zoom In (sitting)

Appendix M: Gantt Chart

ID	Task Name	People in charge	Start	Finish
16	Consult TA in charge on details of the design	Zhou	'12 Jun 22	'12 Jun 30
17	1st TA consultation	Team	'12 Jun 28	'12 Jun 28
18	Refine the early design	Team	'12 Jun 28	'12 Jun 28
19	Design the programme code	Wang	'12 Jun 30	'12 Jul 2
20	Design the electrical circuit	W;L	'12 Jun 30	'12 Jul 2
21	Design the mechanism	Shi	'12 Jun 30	'12 Jul 2
22	Draw the CAD graph	Yu	'12 Jun 22	'12 Jul 2
23	Progress Report	Team	'12 Jun 22	'12 Jul 5
24	Divide tasks	Zhou	'12 Jun 22	'12 Jun 22
25	Assign tasks	Zhou	'12 Jun 22	'12 Jun 22
26	Discuss Gantt chart	Team	'12 Jun 26	'12 Jun 29
27	Clarify current project content	Team	'12 Jun 26	'12 Jun 26
28	Gantt chart	Zhou	'12 Jun 28	'12 Jun 30
29	Task completed	Liu	'12 Jul 1	'12 Jul 2
30	Task remained	Yu	'12 Jul 1	'12 Jul 2

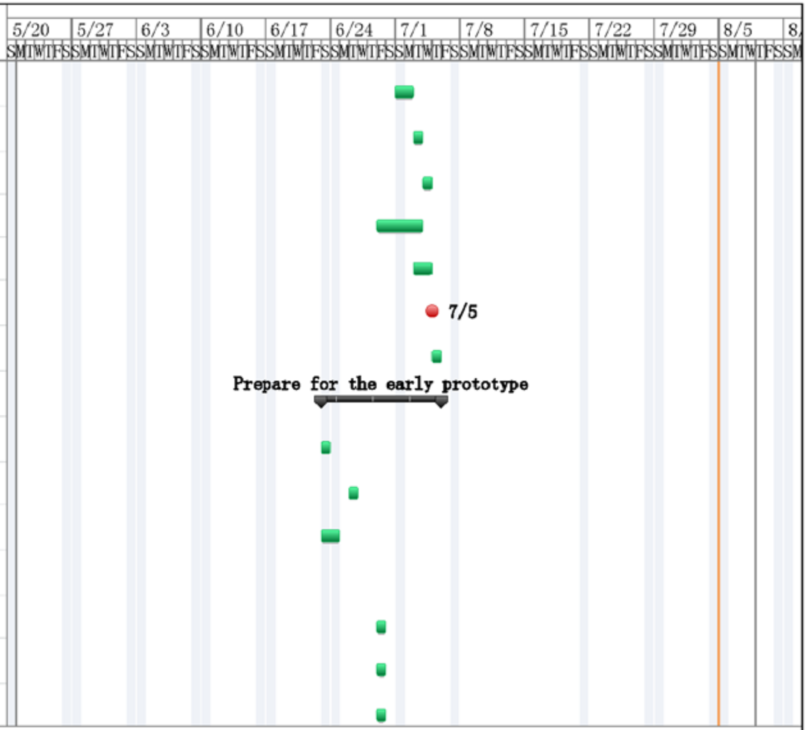


Project: Vg100 Final Projec
Date: '12 Aug 5

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress

Page 2

ID	Task Name	People in charge	Start	Finish
31	Cover & short version	Wang	'12 Jul 1	'12 Jul 2
32	Introduction & conclusion	Shi	'12 Jul 3	'12 Jul 3
33	Consult TA	Team	'12 Jul 4	'12 Jul 4
34	Refine Report	Team	'12 Jun 29	'12 Jul 3
35	Do synthesis	Zhou	'12 Jul 3	'12 Jul 4
36	Submit the soft copy	Team	'12 Jul 5	'12 Jul 5
37	Submit the hard copy	Team	'12 Jul 5	'12 Jul 5
38	**Prepare for the early prototype**	**Team**	**'12 Jun 23**	**'12 Jul 5**
39	Order the SCM board from TA	Wang	'12 Jun 23	'12 Jun 23
40	Get the SCM board	Team	'12 Jun 26	'12 Jun 26
41	Material info research	Zhou	'12 Jun 23	'12 Jun 24
42	Learn about materials	Zhou	'12 Jun 25	'12 Jun 29
43	Determine purchase	Team	'12 Jun 29	'12 Jun 29
44	Order the infared sensor	Zhou	'12 Jun 29	'12 Jun 29
45	Order the motor	Zhou	'12 Jun 29	'12 Jun 29

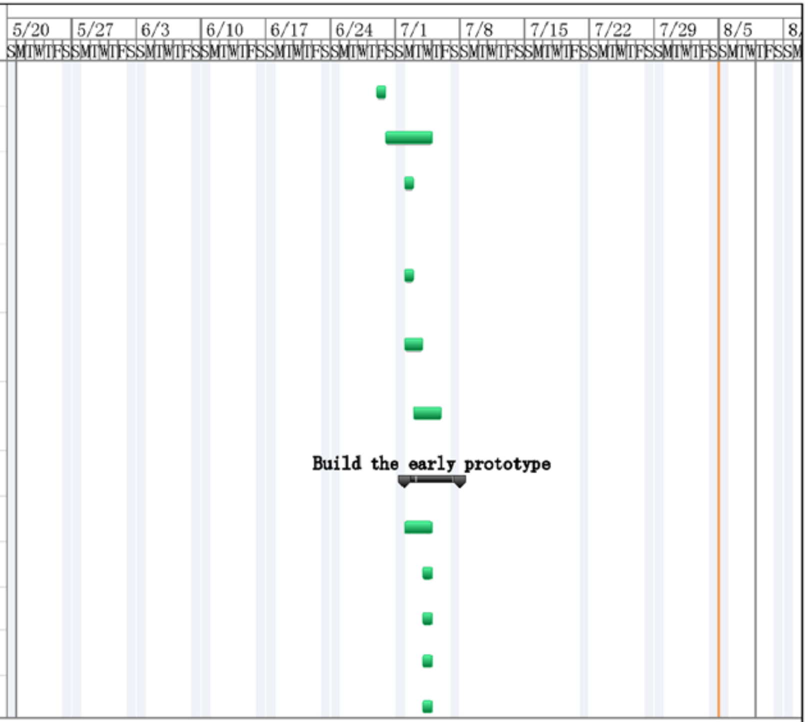


Project: Vg100 Final Projec
Date: '12 Aug 5

Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress

Page 3

ID	Task Name	People in charge	Start	Finish
46	Order other primary materials	Zhou	'12 Jun 29	'12 Jun 29
47	Receive ordered materials	Zhou	'12 Jun 30	'12 Jul 4
48	Further consult Daida on the category of the design	Team	'12 Jul 2	'12 Jul 2
49	Measure the height & width of the air-conitioner	Zhou	'12 Jul 2	'12 Jul 2
50	Determine the position of the sensor	Zhou	'12 Jul 2	'12 Jul 3
51	Draw the illustration for the position	Yu	'12 Jul 3	'12 Jul 5
52	**Build the early prototype**	**Team**	**'12 Jul 2**	**'12 Jul 7**
53	Write the programme code	Wang	'12 Jul 2	'12 Jul 4
54	Build the electrical circuit	W;L	'12 Jul 4	'12 Jul 4
55	Apply the SCM board	Wang	'12 Jul 4	'12 Jul 4
56	Apply the infared sensor	Zhou	'12 Jul 4	'12 Jul 4
57	Apply the servos	Shi	'12 Jul 4	'12 Jul 4

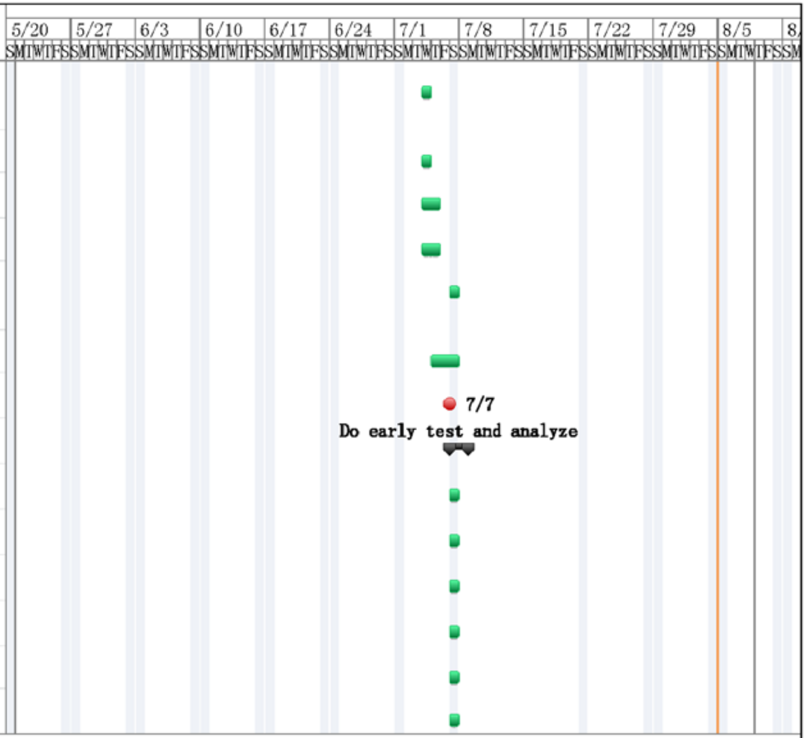


Project: Vg100 Final Projec
Date: '12 Aug 5

Task	External Milestone	Manual Summary Rollup
Split	Inactive Task	Manual Summary
Milestone	Inactive Milestone	Start-only
Summary	Inactive Summary	Finish-only
Project Summary	Manual Task	Deadline
External Tasks	Duration-only	Progress

Page 4

ID	Task Name	People in charge	Start	Finish
58	Make the early structure with paperboard	Team	'12 Jul 4	'12 Jul 4
59	Photo the design	Shi	'12 Jul 4	'12 Jul 4
60	Test the mechanical function	Team	'12 Jul 4	'12 Jul 5
61	Test the programme	Team	'12 Jul 4	'12 Jul 5
62	Consult TA about the realization of functions	W;Z	'12 Jul 7	'12 Jul 7
63	Refine the code	Wang	'12 Jul 5	'12 Jul 7
64	Complete the first protype	Team	'12 Jul 7	'12 Jul 7
65	**Do early test and analyze**	**Team**	**'12 Jul 7**	**'12 Jul 8**
66	Test the position of the sensors	Team	'12 Jul 7	'12 Jul 7
67	Adjust the positon of the sensors	Team	'12 Jul 7	'12 Jul 7
68	List the relating fators	Zhou	'12 Jul 7	'12 Jul 7
69	Test the functionality	Team	'12 Jul 7	'12 Jul 7
70	Test the rubustness	Team	'12 Jul 7	'12 Jul 7
71	Photo the test process	Shi	'12 Jul 7	'12 Jul 7

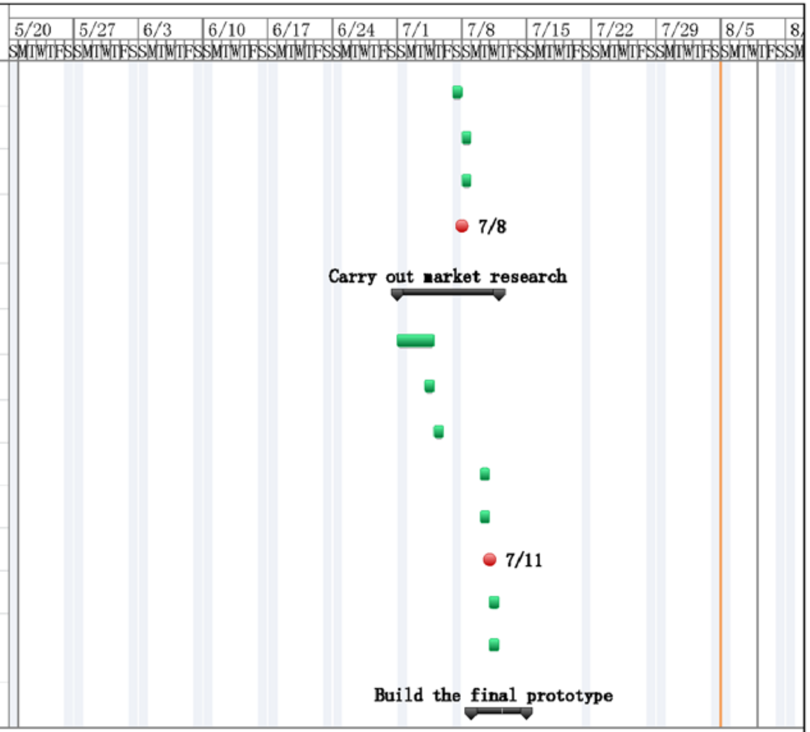


Project: Vg100 Final Projec
Date: '12 Aug 5

Task	External Milestone	Manual Summary Rollup
Split	Inactive Task	Manual Summary
Milestone	Inactive Milestone	Start-only
Summary	Inactive Summary	Finish-only
Project Summary	Manual Task	Deadline
External Tasks	Duration-only	Progress

Page 5

ID	Task Name	People in charge	Start	Finish
72	Record the early test results	Zhou	'12 Jul 7	'12 Jul 7
73	Analyze data	Wang	'12 Jul 8	'12 Jul 8
74	Form the table for data analysis	Wang	'12 Jul 8	'12 Jul 8
75	Conclude quantitative criteria	Team	'12 Jul 8	'12 Jul 8
76	**Carry out market research**	**Yu**	**'12 Jul 1**	**'12 Jul 11**
77	List the questions for the survey	W;Z	'12 Jul 1	'12 Jul 4
78	Discuss & Refine the questions	Team	'12 Jul 4	'12 Jul 4
79	Post it online	Yu	'12 Jul 5	'12 Jul 5
80	Collect the replys	Yu	'12 Jul 10	'12 Jul 10
81	Analyze the data	Yu	'12 Jul 10	'12 Jul 10
82	Draw conclusion	Team	'12 Jul 11	'12 Jul 11
83	Refine the design	Team	'12 Jul 11	'12 Jul 11
84	Generate general criteria for the design	Team	'12 Jul 11	'12 Jul 11
85	**Build the final prototype**	**Team**	**'12 Jul 9**	**'12 Jul 14**

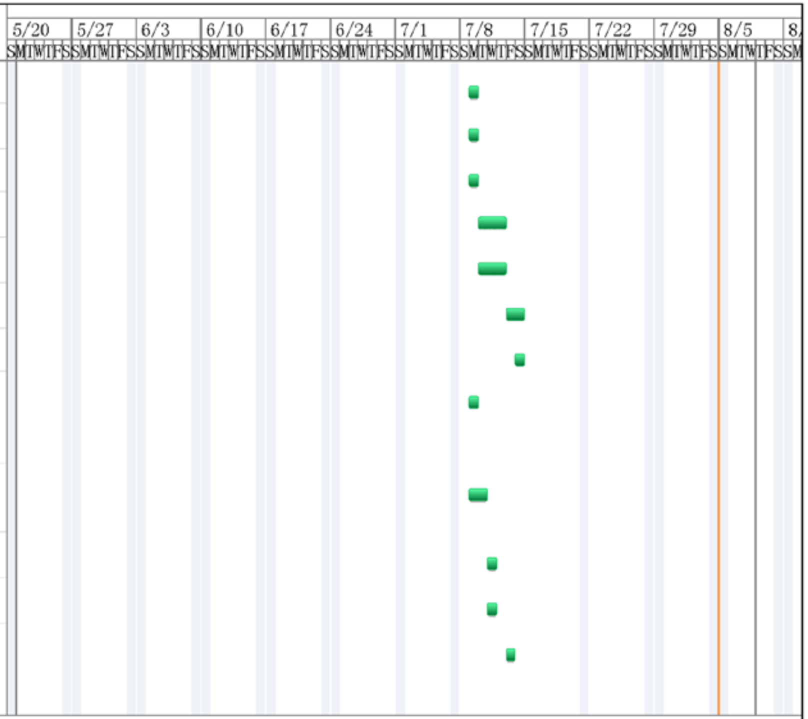


Project: Vg100 Final Projec
Date: '12 Aug 5

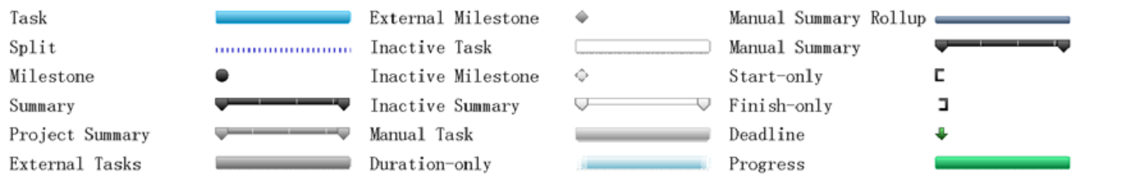
Task, Split, Milestone, Summary, Project Summary, External Tasks, External Milestone, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, Deadline, Progress

Page 6

ID	Task Name	People in charge	Start	Finish
86	Refine the design	Team	'12 Jul 9	'12 Jul 9
87	Determine new materials	Team	'12 Jul 9	'12 Jul 9
88	Order new materials	Zhou	'12 Jul 9	'12 Jul 9
89	Receive new materials	Zhou	'12 Jul 10	'12 Jul 12
90	Programme for the refined design	Wang	'12 Jul 10	'12 Jul 12
91	Test revision of the programme	Team	'12 Jul 13	'12 Jul 14
92	Optimize the code	Wang	'12 Jul 14	'12 Jul 14
93	Determine the material for the mechanical structure	Team	'12 Jul 9	'12 Jul 9
94	Get the material for the mechanical structure	Team	'12 Jul 9	'12 Jul 10
95	Make the mechanical structure	Team	'12 Jul 11	'12 Jul 11
96	Consider the way of attachment	Team	'12 Jul 11	'12 Jul 11
97	Apply the mechanical sturcture on the air-conditioner	Team	'12 Jul 13	'12 Jul 13

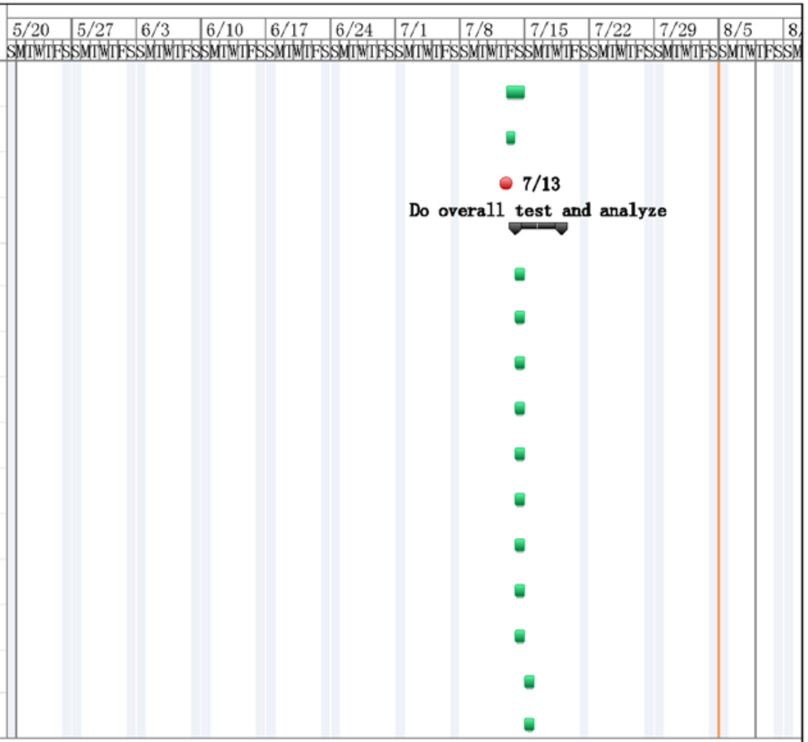


Project: Vg100 Final Projec
Date: '12 Aug 5



Page 7

ID	Task Name	People in charge	Start	Finish
98	Refine the attachment	Team	'12 Jul 13	'12 Jul 14
99	Photo the final design	Shi	'12 Jul 13	'12 Jul 13
100	Complete the final design	Team	'12 Jul 13	'12 Jul 13
101	**Do overall test and analyze**	**Team**	**'12 Jul 14**	**'12 Jul 18**
102	Test the sensors	Team	'12 Jul 14	'12 Jul 14
103	Test the function of the design	Team	'12 Jul 14	'12 Jul 14
104	Test the reaction time	Team	'12 Jul 14	'12 Jul 14
105	Test the reaction zone	Team	'12 Jul 14	'12 Jul 14
106	Test waterproof of the design	Team	'12 Jul 14	'12 Jul 14
107	Test temperature resistance	Team	'12 Jul 14	'12 Jul 14
108	Test the robustness of the design	Team	'12 Jul 14	'12 Jul 14
109	Photo the test process	Shi	'12 Jul 14	'12 Jul 14
110	Record the test results	Wang	'12 Jul 14	'12 Jul 14
111	Analyze data	Wang	'12 Jul 15	'12 Jul 15
112	Generate table and graph of the test	Wang	'12 Jul 15	'12 Jul 15



Project: Vg100 Final Projec
Date: '12 Aug 5

Task	External Milestone	Manual Summary Rollup
Split	Inactive Task	Manual Summary
Milestone	Inactive Milestone	Start-only
Summary	Inactive Summary	Finish-only
Project Summary	Manual Task	Deadline
External Tasks	Duration-only	Progress

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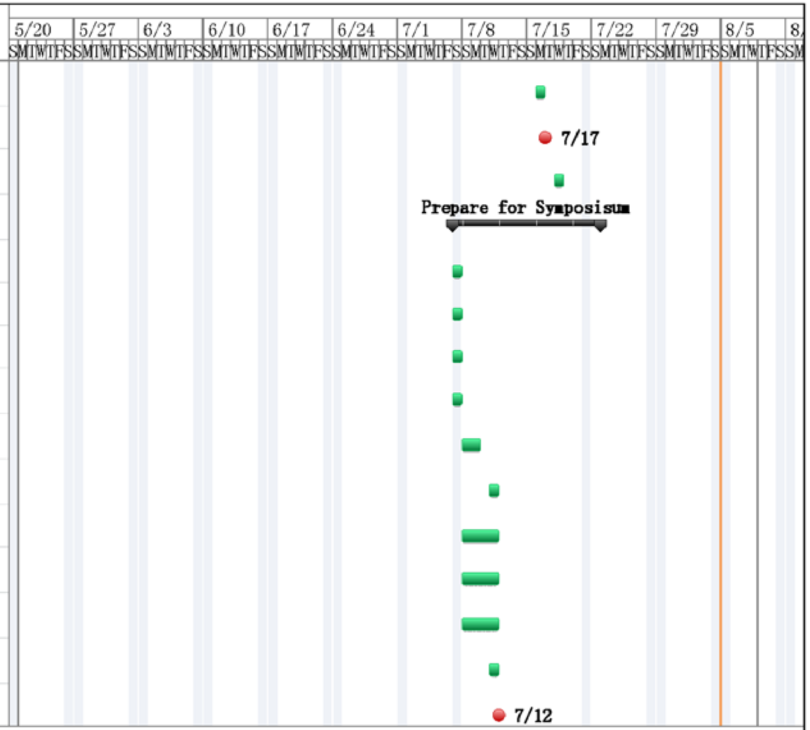
ID	Task Name	People in charge	Start	Finish
113	Generate a graph of the reactive zone	Zhou	'12 Jul 16	'12 Jul 16
114	Consult TA	Team	'12 Jul 17	'12 Jul 17
115	Find where to improve	Team	'12 Jul 18	'12 Jul 18
116	**Prepare for Symposisum**	**Team**	**'12 Jul 7**	**'12 Jul 22**
117	Discuss the content	Team	'12 Jul 7	'12 Jul 7
118	Divide sections	Zhou	'12 Jul 7	'12 Jul 7
119	Assign tasks	Zhou	'12 Jul 7	'12 Jul 7
120	Make an outline of presentation	Team	'12 Jul 7	'12 Jul 7
121	Search for materials	L;S	'12 Jul 8	'12 Jul 9
122	Shot the usage of the design	Shi	'12 Jul 11	'12 Jul 11
123	Prepare the slides	W;Y	'12 Jul 8	'12 Jul 11
124	Write the draft of the speech	Z;L	'12 Jul 8	'12 Jul 11
125	Prepare the photos and graph	Shi	'12 Jul 8	'12 Jul 11
126	Joint the slides and video	Team	'12 Jul 11	'12 Jul 11
127	Consult Prof. Daida	W;Z	'12 Jul 12	'12 Jul 12



Project: Vg100 Final Projec
Date: '12 Aug 5

Task
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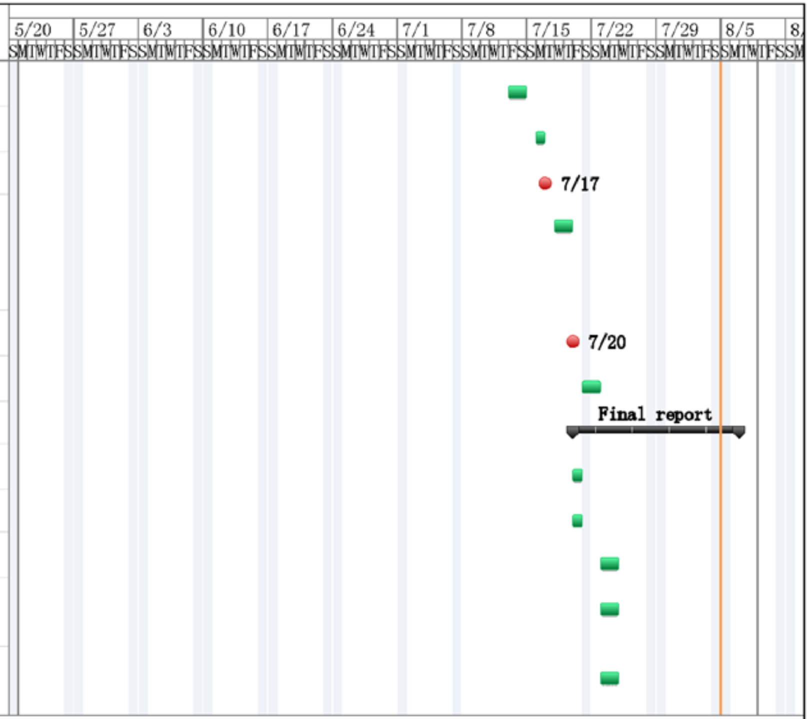
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress

Page 9

ID	Task Name	People in charge	Start	Finish
128	Refine the contents of the presentation	Team	'12 Jul 13	'12 Jul 14
129	Do the 1st rehearsal	Team	'12 Jul 16	'12 Jul 16
130	Consult Ms. Iwamoto	Team	'12 Jul 17	'12 Jul 17
131	Revise the technical communication aspect of the presentation	Team	'12 Jul 18	'12 Jul 19
132	Do the 2nd rehearsal	Team	'12 Jul 20	'12 Jul 20
133	Make symposisum presentation	Team	'12 Jul 21	'12 Jul 22
134	**Final report**	**Team**	**'12 Jul 20**	**'12 Aug 6**
135	Divide and distribute the task	Zhou	'12 Jul 20	'12 Jul 20
136	Discuss the content	Team	'12 Jul 20	'12 Jul 20
137	Complete final design part	Yu	'12 Jul 23	'12 Jul 24
138	Complete the introduction and background parts	Shi	'12 Jul 23	'12 Jul 24
139	Complete the criteria and tests & evaluations parts	Zhou	'12 Jul 23	'12 Jul 24



Project: Vg100 Final Projec
Date: '12 Aug 5

Task	External Milestone	Manual Summary Rollup
Split	Inactive Task	Manual Summary
Milestone	Inactive Milestone	Start-only
Summary	Inactive Summary	Finish-only
Project Summary	Manual Task	Deadline
External Tasks	Duration-only	Progress

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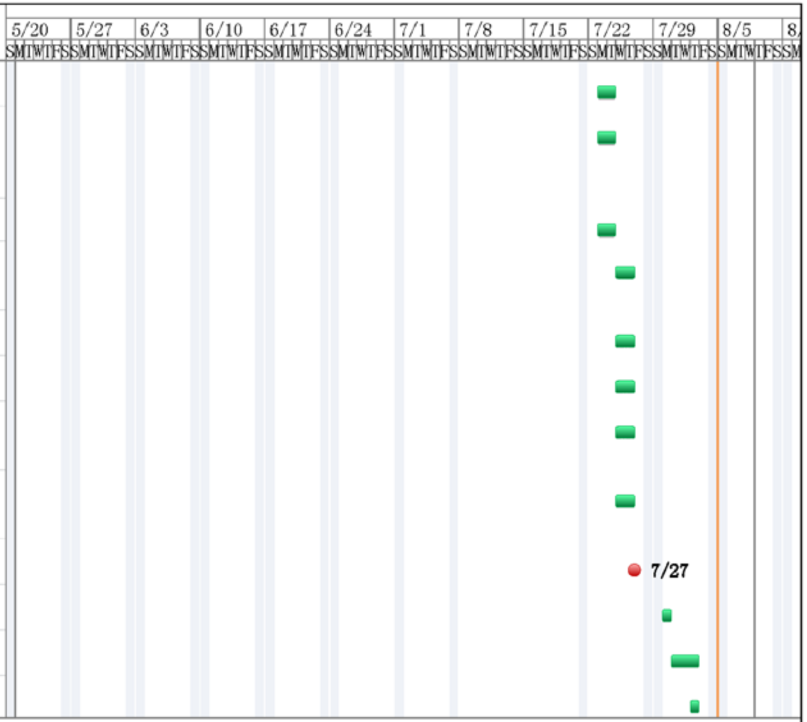
ID	Task Name	People in charge	Start	Finish
140	Write the executive summary	Liu	'12 Jul 23	'12 Jul 24
141	Complete the conclusion and recommendation parts	Wang	'12 Jul 23	'12 Jul 24
142	List References	Team	'12 Jul 23	'12 Jul 24
143	Write the manual for building the design	W;S	'12 Jul 25	'12 Jul 26
144	Write the appendices left	Z;L	'12 Jul 25	'12 Jul 26
145	Select the photos for the report	Shi	'12 Jul 25	'12 Jul 26
146	Refine the CAD graph for final prototype	Yu	'12 Jul 25	'12 Jul 26
147	Prepare the analysis table and graphs	Wang	'12 Jul 25	'12 Jul 26
148	Assemble different parts	Team	'12 Jul 27	'12 Jul 27
149	Consult TA on final report	Team	'12 Jul 30	'12 Jul 30
150	Refine the final report	Team	'12 Jul 31	'12 Aug 2
151	Further consult TA	W;Z	'12 Aug 2	'12 Aug 2



Project: Vg100 Final Projec
Date: '12 Aug 5

Task	External Milestone	Manual Summary Rollup
Split	Inactive Task	Manual Summary
Milestone	Inactive Milestone	Start-only
Summary	Inactive Summary	Finish-only
Project Summary	Manual Task	Deadline
External Tasks	Duration-only	Progress

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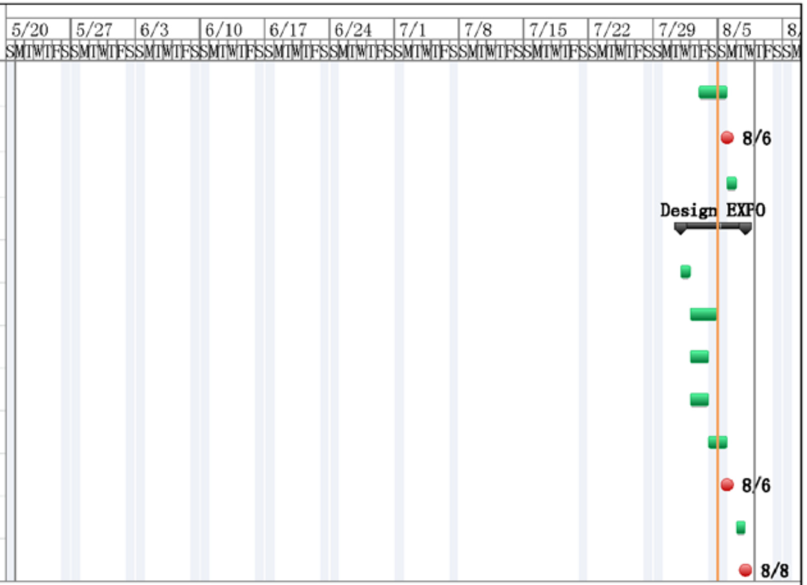
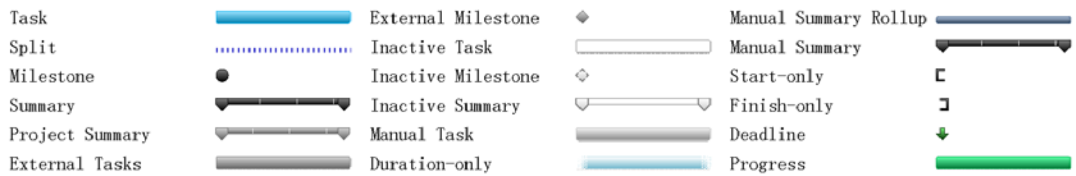
ID	Task Name	People in charge	Start	Finish
152	Refine the second time	Team	'12 Aug 3	'12 Aug 5
153	Turn in the soft copy	Team	'12 Aug 6	'12 Aug 6
154	Turn in the hard copy	Team	'12 Aug 6	'12 Aug 6
155	Design EXPO	Team	'12 Aug 1	'12 Aug 8
156	Discuss the content	Team	'12 Aug 1	'12 Aug 1
157	Write the content	Z;L	'12 Aug 2	'12 Aug 4
158	Prepare the graph	Yu	'12 Aug 2	'12 Aug 3
159	Prepare the photos	Shi	'12 Aug 2	'12 Aug 3
160	Make the poster	Wang	'12 Aug 4	'12 Aug 5
161	Consult TA	Team	'12 Aug 6	'12 Aug 6
162	Refine the poster	Team	'12 Aug 7	'12 Aug 7
163	Present on the expo	Team	'12 Aug 8	'12 Aug 8



Project: Vg100 Final Projec
Date: '12 Aug 5



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