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Prototype of Automated Vehicle Window Using the Detection of Raindrop Sensor

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Abstract: This project presents prototype of vehicle window using the detection of raindrop sensor in order to reduce heat trapped in the prototype. This project will investigate the effectiveness of heat dissipation at different opening gap of power window. The climate seasons are almost the same throughout all year. Temperature are uniformly high throughout the year, it can range up to 33℃ and drop as low as 23℃. Meanwhile, the mean annual rainfall of Malaysia is approximately 2540mm. Since high number of houses in Malaysia does not have garage to park their vehicle inside, the temperature of the car cabin can reach a high temperature when the weather is hot. The rise in temperature in the vehicle cabin is caused by the ultraviolet ray from the sun that passes through the window and windscreen of the vehicle. The amount of ultraviolet ray passing through can be reduced by tinting the window but it is not effective. The propose mechanism for the prototype of vehicle window to reduce the interior cabin temperature. Finally, evaluate the effectiveness of the prototype vehicle window mechanism in reducing the interior cabin temperature. Studies will be conducted to investigate the factors of increasing temperature inside the car cabin. A prototype of vehicle window will be built to propose the mechanism. To evaluate the effectiveness of the prototype vehicle window mechanism in reducing the interior temperature is done by conducting 2 experiments. By doing this project, the prototype has proven that the implementation of automated power window to dissipate heat is effective with the use of raindrop sensor.

Keywords: Cabin temperature, prototype of vehicle window

1. Introduction

This project presents automated vehicle window glass in order to reduce heat trapped in vehicle cabin. The purpose of this project is to reduce the heat trapped in the vehicle when the vehicle is stationary [1-5]. Considering the climate of Malaysia, both peninsular and insular Malaysia lie in the same tropical latitudes and are affected by the similar airstream. The climate seasons are almost the same throughout all year. Temperature are uniformly high throughout the year, it can range up to 33℃ and drop as low as 23℃. Meanwhile, the mean annual rainfall of Malaysia is approximately 2540mm [6-8]]. There are 31.2 million units of vehicle registered in Malaysia in the year 2020. From the past two and half years, around 1.2 million of average increase is recorded annually. This statistic shows that the annual vehicle users are growing exponentially as vehicle are getting more and more affordable to consumers [9-12].

Most of vehicles in Malaysia are parked at an outdoor parking. There are only few whom park their vehicle in an indoor under roof parking. Since high number of houses in Malaysia does not have garage to park their vehicle inside, the temperature of the car cabin can reach a high temperature when the weather is hot. Vehicle in Malaysia users usually

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wind down their vehicle window to disperse heat from the cabin. By doing this, the cabin temperature can be reduced unfortunately the user have to be alert for any rainfall [13-17].

The automated vehicle window glass works using two sensors. The temperature sensor senses the rise in the temperature in the cabin and sends signal to wind down the window glass to approximately 20%. The window glass will wind up when the raindrop sensor senses raindrop. The window glass will also wind up when the temperature of the cabin is low. The device will only work when the engine of the car is turned off. [18-20].

2. Materials and Methods

The prototype of vehicle window consists of two main sensors. The first sensor is a DHT11 temperature and humidity sensor. This sensor is used to detect the high rise of temperature in the prototype. Next is a raindrop sensor, this sensor will detect the rainfall and send an input to Arduino board to allow the window to close when rain is detected. A stepper motor is used to wind the window up and down. For the software of this project, Arduino IDE is used to code the C++ coding in order to upload to the Arduino board.

The C++ coding of the project uses the input of the raindrop sensor to wind the window up and down using the stepper motor. For the connection, the output of the DHT11 sensor and raindrop sensor is connected to digital pin 4 and pin 7 respectively to Arduino board. The Arduino board then sends output to motor driver through digital pin 8 to 11 and to LCD screen through analog pin A4 and A5.

The coding of the project starts with the define of the pin and include of the sensors. The stepper motor is set at an operation speed of 60 rpm. The coding uses the selection structure of “if/else” and “goto”. The “if/else” selection structure will control the direction of rotation for stepper motor. If the input of the raindrop sensor is 1 for dry, then the stepper motor will rotate anticlockwise. The “goto” selection structure with “stop” will enable the stepper motor to only rotate one resolution clockwise when the input is 0 for wet. Without the “goto” selection structure, the stepper motor will be continuously turning one revolution at a direction.

The prototype structure is built mainly using acrylic sheet with the thickness of 3mm. Other recycle materials are also used such as bamboo string, polystyrene and plastic sheet. The prototype for the project is shown in Figure 1.

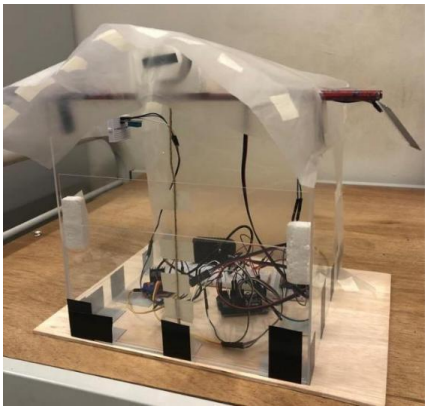

Fig. 1 - Project prototype

The experiment was conducted at a resident house at Taman Merdeka Jaya. The experiment was conducted in front of the house as it is a usual place of the resident to park their vehicles. The prototype was placed for a total of 8 days. The dates of the experiment were decided based on the weather forecast. The time duration for each day is 7 hours and the time is fixed from 10am to 5pm. Based on the weather forecast, 4 days were selected to be clear without rainfall and another 4 days with expected rainfall was selected. The selected dates are 15th to 20th, 22nd and 24th December 2021. The prototype was placed on a table with the power supply connected to a nearest electric socket in the house. The temperature and humidity reading will be taken for every one hour.

3. Results and Discussion

There are two parts for this experiment, the first experiment is experiment 1 and is conducted on a clear day without any rainfall. Day 1 to 4 in experiment 1 are 16th, 18th, 19th and 20th December 2021 respectively. For experiment 1, the prototype will wind down the window 2cm for day 1 and another additional 2cm until day 3. For day 4, the window will not open in any situation. The prototype will then close the window when rainfall is detected for day 1 to day 3.

Table 1 shows the result of the temperature obtained in the prototype during experiment 1.

Table 1 - Temperature obtained for experiment 1

Day	10am (℃)	11am (℃)	12pm (℃)	1pm (℃)	2pm (℃)	3pm (℃)	4pm (℃)	5pm (℃)
1(2cm)	32.90	34.51	33.66	34.51	35.00	34.47	32.80	33.50
2(4cm)	30.37	30.75	31.89	32.26	33.15	33.18	31.79	31.55
3(6cm)	29.59	30.24	30.58	30.58	32.95	33.13	31.40	31.32
4	27.95	30.65	31.51	33.52	33.87	33.62	33.49	34.48

Table 2 shows the results of the humidity obtained in the prototype during experiment 1.

Table 2 - Humidity obtained for experiment 1

Day	10am (%rh)	11am (%rh)	12pm (%rh)	1pm (%rh)	2pm (%rh)	3pm (%rh)	4pm (%rh)	5pm (%rh)
1(2cm)	70	62	66	62	63	66	62	70
2(4cm)	74	74	70	70	62	59	70	66
3(6cm)	84	74	74	70	66	62	66	62
4	79	74	70	62	59	59	59	59

Table 3 shows the operation of the prototype window for experiment 1. The symbol 1 defines the opening of the window while 0 defines the closing of the window. For day 4, the window remains close all time and there was no rainfall on that day.

Table 3 - Prototype window operation for experiment 1

Day	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm
1(2cm)	1	1	1	1	1	1	1	1
2(4cm)	1	1	1	1	1	1	1	1
3(6cm)	1	1	1	1	1	1	1	1
4	0	0	0	0	0	0	0	0

For experiment 2, the dates are selected to have expected rainfall. Day 1 to 4 in experiment 2 are 15th, 17th, 22nd and 24th December 2021 respectively. The prototype will wind down the window 2cm for day 1 and another additional 2cm until day 3. For day 4, the window will not open in any situation. The prototype will then close the window when rainfall is detected for day 1 to day 3.
Table 4 shows the result of the temperature obtained in the prototype during experiment 2.

Table 4 - Temperature obtained for experiment 2

Day	10am (℃)	11am (℃)	12pm (℃)	1pm (℃)	2pm (℃)	3pm (℃)	4pm (℃)	5pm (℃)
1(2cm)	28.61	29.59	31.15	31.00	30.25	29.63	28.30	27.45
2(4cm)	27.50	27.65	30.87	30.45	29.23	29.74	28.10	27.38
3(6cm)	27.00	28.19	29.56	31.65	30.95	31.61	32.40	31.20
4	29.45	31.96	32.67	34.12	32.43	30.32	29.18	28.00

Table 5 shows the results of the humidity obtained in the prototype during experiment 2

Table 5 - Humidity obtained for experiment 2

Day	10am (%rh)	11am (%rh)	12pm (%rh)	1pm (%rh)	2pm (%rh)	3pm (%rh)	4pm (%rh)	5pm (%rh)
1(2cm)	74	70	62	62	66	74	74	88
2(4cm)	89	84	75	70	74	79	89	79
3(6cm)	89	84	79	62	66	62	63	62
4	79	74	70	63	75	79	89	89

Table 6 shows the operation of the prototype window for experiment 2. The symbol 1 defines the opening of the window while 0 defines the closing of the window. For day 4, the window remains close all time and there was rainfall from 2pm to 5pm.

Table 6 - Prototype window operation for experiment 2

Day	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm
1(2cm)	1	1	1	1	0	0	0	0
2(4cm)	0	1	1	1	0	1	0	0
3(6cm)	0	1	1	1	1	1	1	0
4	0	0	0	0	0	0	0	0

Figure 2 shows the temperature vs time graph for day 1 to 4 in experiment 1.

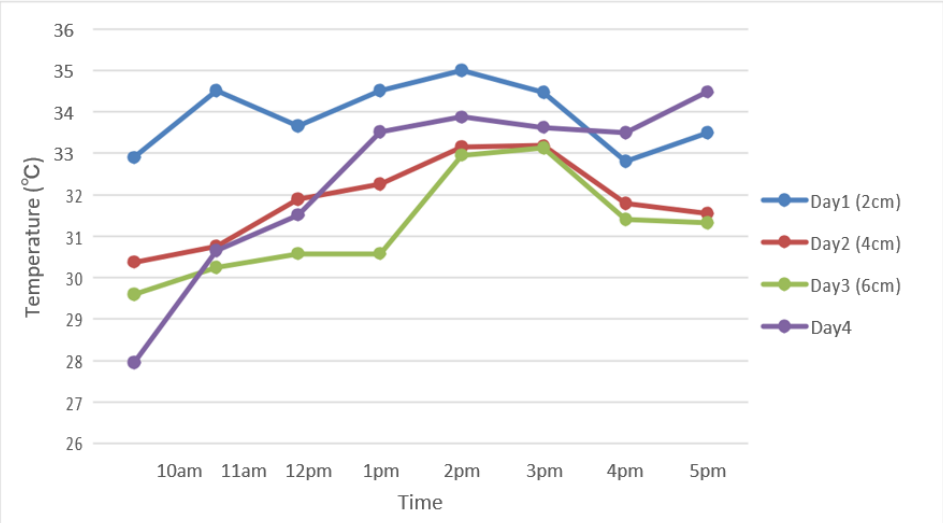

Fig. 2 - Temperature vs time graph for day 1 to 4 in experiment 1

For experiment 1, there was no rainfall experienced by the prototype. Thus, the window was open all time for day 1 to day 3. By looking at the graph, the temperature for day 1 rank the highest while day 3 rank the lowest. From this part of experiment 1 we are able to conclude that the increase in the opening of the window will decrease the temperature in the prototype. The increase in the opening of the window will increase the rate of heat to dissipate from the prototype. For day 4, the temperature increases gradually without any decrease in the temperature. We are able to conclude that the temperature will not decrease if the window is not open to allow heat to dissipate but in contrast the temperature will increase exponentially.

Figure 3 shows the temperature vs time graph for day 1 to 4 in experiment 2.

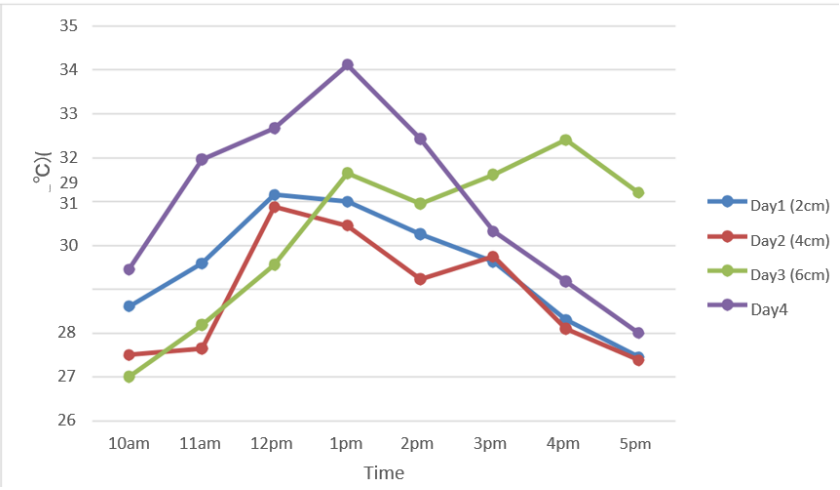

Fig. 3 - Temperature vs time graph for day 1 to 4 in experiment 2

For experiment 2, there was rainfall as predicted and was experienced by the prototype. Thus, the window of the prototype was operating the opening and closing of the window for day 1 to day 3. By looking at the graph, day 2 rank the lowest followed by day 1. This is due to heavy rainfall in this two days that lasted a total of 4 hours during the experiment 2 period. Temperature in day 3 was increasing due to high temperature and less rainfall that only lasted 2 hours in total. The window for day 4 was closed for the entire day and the temperature was increasing gradually until 1pm. The temperature then decreases due to heavy rainfall from 2pm until 5pm. From this experiment 2 we can conclude that rainfall is able to reduce the temperature inside the prototype even without opening the window for experiment 2 in day 4. However, with the opening the window to dissipate heat when there is no rainfall can reduce the temperature even further as shown in the graph for day 1 and day 2.

4. Conclusion

The prototype of vehicle window using the detection of raindrop sensor objectives had successfully accomplished. The project scope also achieves the target and the effectiveness of the sensors and stepper motor are tested in individually to eliminate any potential problems. The prototype structure of the power window has proved that the heat dissipation is effective without any inputs from a person. By doing this project, the prototype has proven that the implementation of automated power window to dissipate heat is effective with the use of raindrop sensor. This implementation in production vehicle can benefit vehicle users in Malaysia and also can be a marketing strategy for vehicle manufacturers.

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