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Hydreon-Rg-11 Rainfall Sensor

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ABSTRACT
Climate change contributed to extreme weather events including heavy rainfalls across the country. Scientists projected that climate change had increased the frequency of heavy rainstorms, putting many communities at risk for devastation. Approximately, 30 typhoons hit the Philippines annually, ignited soil erosions, and deadly raging floods that killed numerous people. The worst flood that hit the Philippines attributed to climate change took place all over the world. People were not warned of the rise of water in the locality because no device monitored the rainfall in real-time. To detect rainfall that produced flash-floods is determining the location, and time duration of most intense rainfall cores. A rain gauge is a tool used to detect heavy rainfall with floods. RG-11 rain-fall-sensor was a device that resolved the concern. It is optical, rugged, sensitive, and reliable. It was extremely sensitive and immune to false trips. No exposed conductors to corrode. So that the researcher can help the community to prepare for the said possible floods, the researcher, wanted to develop a digital rain gauge that monitors the amount of rainfall in real-time at Southwestern University, Cebu City. The accuracy of the digital rain gauge using Hydreon-RG-11 rainfall-sensor was verified to the standard rain gauge.

Keywords: Climate Change Flash Floods Rain Gauge Rainfall Hydreon RG-11 rain-fall sensor

1. INTRODUCTION

Rain-fall measurement of precipitation is also known as the way one calculates how much rain has fallen. There are various ways in which one can do this depending on many factors. One needs to ask why do we need to measure how much rain has fallen? For centuries, meteorologists have been measuring how much rain falls for centuries to observe how the climate is changing, and because the earth is warming up, our reservoirs are drying up, and thus our water shortages. Local weather stations can also keep a record of the data, to see how it affects our rivers and streams. Another important field where the amount of rain is measured is for agricultural needs. Any growing plant needs water to survive, so rainfall is crucial to its survival, but in another respect, too much rainfall can damage crops and other farming products. There are many ways in which we can measure how much rain we get. This is a container that holds the water so that we can measure it. The standard NOAA (National Oceanic Atmospheric Administration) rain gauge (see figure 1), developed around the start of the 20th century, consists of a funnel emptying into a graduated cylinder, 2 cm in diameter that fits inside a larger container which is 20 cm in diameter and 50 cm tall. If the rainwater overflows the graduated inner cylinder, the larger outer container will catch it. When measurements are taken, the height of the water in the small graduated cylinder is measured, and the excess overflow in the large container is carefully poured into another graduated cylinder and measured to give the total rainfall. In locations using the metric system, the cylinder is usually marked in mm and will measure up to 250 millimeters (9.8 in) of rainfall. Each horizontal line on the cylinder is 0.5 millimeters (0.02 in). In areas using Imperial units, each horizontal line represents 0.01 inches (Groisman, P.Y.1994). The RG-11 bounces beams of light within the lens (see figure 2). When drops hit the outside surface, it allows some of the beams to escape. The RG-11 detects the change in beam intensity and determines the size of the raindrops that caused the change. The sophisticated circuitry and Digital Signal Processing detect tiny raindrops and reject the effects of ambient light disturbances. The RG-11 detects the surface condition, caused by dirt, contaminants, aging, and other factors. It properly compensates the data, making the device virtually impervious to environmental factors. The sensor is optical - not mechanical, chemical, or conductive, it is far more rugged, sensitive, and reliable than any other technology.

Sophisticated software gathers data from individual raindrops and implements a proper control strategy for the selected mode. The system can detect individual drops of under half a millimeter. The tipping-bucket emulation algorithm can register accumulations of just one ten-thousands of an inch-- a hundred times more sensitive than a typical tipping bucket. The RG-11 borrows technology that was developed over many years for automotive rain-sensing windshield wiper controls. (Hydreon Corporation, 2011)

The Hydreon RG-11 Sensor (A) gathers and measures the amount of rain during rainfall over a pre-determined period (see figure 4). The data from the sensor cannot be directly attached or the data cannot be directly saved into the computer. It needs a device called Data Interface Controller (B) so that the data can be sent or saved to the computer.

The RG-11 is a novel, futuristic, and relatively inexpensive optical rain sensor, pictured right. This sensor has particular appeal for hobbyists and experimentalists, including those who need a sensor to trigger some electromechanical action when it starts to rain, as well as for more traditional weather-monitoring applications. The sensor design consists of a clear hemispherical dome – about 7cm (2.75 inches) in diameter and with the whole assembly about 12cm (4.5″) long, to give some idea of scale – within which a set of four light beams are reflected and constantly monitored.

The dome also covers a circular circuit board (see below), both attached to a sturdy grey plastic mounting bracket. When rain or some other cause of water droplets (for example dew or condensation) start to form on the outside of the dome, the beam reflection pattern changes in a subtle yet detailed way which can be translated by onboard circuitry and firmware into a carefully-processed output signal. As the water droplets run off or evaporate or are replaced by fresh droplets so the reflection pattern changes and is continuously monitored, with outputs triggered accordingly – see below for a more detailed description. The sensor output is provided by a contact closure of a built-in miniature relay with contacts rated at 24v DC and 1A. The output can be connected to a low-voltage circuit such as a counter module for further processing or, used to control some external device directly. (Obviously to switch AC mains devices an intermediate heavy-duty relay or solid-state equivalent would need to be used.) Because of its optical basis– not mechanical, chemical, or conductive, the RG-11 sensor is far more rugged, sensitive, and reliable than other technologies. The sensor is extremely sensitive and virtually immune to false trips. Yet, it is completely unaffected by jostling and motion. There are no exposed conductors to corrode, and no openings for bugs to crawl into. Similarly, there is no place for leaves or other debris to collect. Therefore, once assembled and attached to a suitable mounting point by mounting holes provided in the bracket, the RG-11 sensor is fully weather-proof and can be left outside to continue operation for extended periods, needing no maintenance or other attention. (NB For maximum accuracy, it is recommended that the dome be given a fresh coat of Rain X once per year.)

A Data Interface Controller will be made that contains a microcontroller chip that runs embedded software (firmware) that converts data from the sensor into a digital format that a computer can understand so that data will be saved into the computer.

A computer program will be made and installed at the computer so that the computer will know what to do with the acquiring and saving of data. This is the part where the automation of the system takes place. It will now be called a Monitoring Program.

The Monitoring Program is computer software that is installed to the computer that provides a clear user interface to monitor, acquire, store and control data coming from the rain gauge sensor. It is somewhat a remote control of the device through the display on the screen of the computer.

Finally, the data from the Rain Gauge Monitoring System will be then compared to a standard rain gauge to validate its reliability.

The standard rain gauge and the Hydreon-RG-11 sensor will be placed near the math and physics department, 2nd-floor terrace of MBA III memorial building Southwestern University, Urgello Campus, Cebu City, Philippines.

2. METHODS

Research Design

The research used experimental and observation methods in gathering the data.

Data Collection Tools

Volume Test:

1. Using 10ml of distilled water in a syringe, the water was gradually dropped.
2. Repeated 10 times.
3. The monitoring program recorded the rainfall.

Rainfall Test:

1. The digital rain gauge and traditional rain gauge (5 graduated cylinders with funnel), were set up under the rain for many hours.
2. To get multiple trials, the 5 cylinders were not exposed at the same time. Then two were read earlier than the other.
3. The monitoring program recorded the rainfall.
4. The volume of rain in the cylinders was used to compute the height of rainfall.

Treatment of Data

The gathered data were analyzed and compared using the following computations:

1. Percent error was used to compare the result of the digital rain gauge reading to the traditional method.
2. t-test for paired samples was used to determine significant differences for volume and height between the digital rain gauge and the traditional method.

3. RESULTS

Table 1

Volume Of Water (Cm^3) Recorded Compared To The Measured Water Droplets

Trial	Digital Rain Gauge(cm^3)	Graduted Cylinder(cm^3)	Percent Error

1	9.996	10.0	0.04
2	11.995	10.0	20.0
3	10.623	10.0	6.2
4	10.623	10.0	6.2
5	9.839	10.0	1.6
6	8.742	10.0	12.6
7	10.231	10.0	2.3
8	9.643	10.0	3.6
9	11.368	10.0	13.7
10	8.075	10.0	19.2
Total	101.136	100.0	85.45
Average	10.114	10.0	8.5

The table above shows that the average volume of water drops recorded using the digital rain gauge is 10.114 cm^3 with a percent error of 8.5%. This result indicates that the digital rain gauge was able to detect the volume of water at a minimal error.

Table 2 Height of Rainfall Recorded Using the Digital Rain Gauge System and Traditional Method

Trial	Time	Digital Rain Gauge(mm)	Manual Rain Gauge(mm)	Percent Error
1	12:56-4:54	0.101	0.121	19.04
2	12:56-3:53	0.099	0.106	9.44
3	2:00-4:54	0.082	0.097	

		15.22	
4	2.45-3:50	0.079	0.088
		10.42	
5	3:29-4.54	0.077	0.085
		9.28	
		Average	
		12.68	

***Recorded Rain January 30, 2013**

The table above presents the height of rainfall in the unit of millimeter using the digital rain gauge and the manual rain gauge. The result of the digital rain gauge shows a 12.68% error compared to the manual rain gauge.

Table 3 **Test of Difference on Volume Between the Digital Rain Gauge and Measured Droplets**

t-Test for Hypothesis of the Mean	
Null Hypothesis	**□= 10**
Level of Significance	**0.05**
Sample Size	**10**
Sample Mean	**10.114**
Sample Standard Deviation	**1.154**
Degrees of Freedom	9
t -Test Statistic	0.311
Critical Value	**±2.262**
p-Value	**0.763**
Does not reject the null hypothesis	

The t-test result as presented in the table above shows a p-value of 0.763 is less than the 0.05 level of significance which means that the null hypothesis is accepted. There is no significant difference in the volume of water between the recorded in the digital rain gauge and the measured water droplets. This implies that the developed digital rain gauge is comparable to the traditional method which is based on PAG-ASA standards.

Table 4 Test of Difference on Height Between the Digital Rain Gauge and Traditional Method

t-Test for Differences in Two Means
Level of Significance
0.05
Digital Rain Gauge
Sample Size
10
Sample Mean
0.088
Sample Standard Deviation
0.011
Traditional Method
Sample Size
10
Sample Mean
0.101
Sample Standard Deviation
0.016
Total Degrees of Freedom
18
t-Test Statistic
2.073
Critical Value
±2.101
Does not reject the null hypothesis

The table above shows that the computed p-value is less than the 0.05 level of significance which indicates the acceptance of the null hypothesis. This signifies that there is no significant difference in the height of rainfall as recorded using the digital rain gauge and the computed height based on the traditional method of gathering rainfall. Based on the gathered data, the performance of the digital rain gauge is comparable to the traditional method or the manual rain gauge.

4. DISCUSSION AND CONCLUSION

4.1 DISCUSSION

The average volume of water drops recorded using the digital rain gauge is 10.114 cm^3 with a percent error of 8.5%. This result indicates that the digital rain gauge was able to detect the volume of water at a minimal error.

On the other hand, the height of rainfall with the millimeter unit using the digital rain gauge and the manual rain gauge. The result of the digital rain gauge shows a 12.68% error compared to the manual rain gauge.

The t-test result showed a p-value of 0.763 is less than the 0.05 level of significance which means that the null hypothesis is accepted. There is no significant difference in the volume of water between the recorded in the digital rain gauge and the measured water droplets. This implies that the developed digital rain gauge is comparable to the traditional method which is based on PAG-ASA standards.

Finally, the computed p-value was less than the 0.05 level of significance which indicated the acceptance of the null hypothesis. This signifies that there is no significant difference in the height of rainfall as recorded using the digital rain gauge and the computed height based on the traditional method of gathering rainfall. Based on the gathered data, the performance of the digital rain gauge is comparable to the traditional method or the manual rain gauge.

4.2 CONCLUSION

The researchers developed a digital rain gauge monitoring system that is not only capable of measuring the rainfall in real-time but also its volume. Rainfall monitoring using the digital rain gauge is far more convenient compared to the traditional method. The effectiveness of the digital rain gauge is also comparable to the traditional manual rain gauge though its reliability and accuracy remain to be seen due to the limited data gathered.

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