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Development of Camera-Based Rainfall Intensity Measurement Tool with Fourier Transform Analysis

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Abstract. In this research, the development of a camera-based rainfall intensity measuring instrument with the Fourier Transform Analysis has been carried out. The ESP32 CAM Microcontroller was used to capture images and record rainfall videos. The research objective was to design a development model for measuring rainfall intensity, understanding the working principle of the tool, and knowing the histogram of the rainfall intensity video recording produced by the rainfall intensity detection tool. The research consisted of several stages, namely literature study, design of research tools and components, system design, assembly of tools, testing of all components, programs and screen record testing and image capture. The design model for the development of a measuring instrument for rainfall intensity that has been made is that when water flows through the shower there will be rainfall. The process of rainfall will be captured and recorded by the ESP32 CAM Microcontroller which is accessed via a computer device. Experiments were carried out ten times, with a time span of 60 seconds per experiment and an increase in rainfall every minute, then the data was processed using python software in the form of a histogram (grayscale), which would be analyzed using the Fourier Transform Analysis method. The results showed that the development of a camera-based rainfall intensity gauge has worked well.

Keyword: rainfall, video recording, ESP32 CAM Microcontroller, Python software, Fourier Transform Analysis

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1 Introduction

In everyday life rainwater has a very important role for the survival of living things on earth. Without water the processes of life will be disrupted and living things will not survive and the hydrological cycle will change resulting in the balance of the earth being disturbed. Rainfall that exceeds the capacity of nature is one of the factors causing flooding. Various ways have been used to overcome flooding but not enough to cope with the damage caused by high rainfall.

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Therefore, a tool is needed that is able to observe and show the phenomenon of rainfall that occurs in a region and automatically provide information on the ongoing rainfall.

Rainfall is a measure that represents the amount of rainwater in a particular region [1]. In agricultural activities, rainfall data becomes important because it is needed in terms of water management activities for crops [2-3]. In hydrological cycles, precipitation (rain) can be associated with evaporation data on plants. The amount of rain on a given day can cause evapotranspiration on plants to be slower or faster, so that the feeding of water to plants can be adjusted [4-5]. In addition, on dry land agriculture rainfall data becomes important because the determination of schedules and planting patterns is influenced by rainfall data in the region concerned [6].

Rainfall data can be obtained by measuring it using rainfall measuring instruments. Rainfall measuring instruments are generally cylindrical with a funnel on top [7-14]. Rainfall measuring instruments are placed in areas that are still natural as well as in un-titled field. Rainfall measurement using rainfall measuring instruments and calculated using Python and Arduino IDE software [15].

The rainfall measuring instrument used in this study is ESP32-CAM, which is equipped with a camera to take pictures or record video. The ESP32 CAM microcontroller is a chip that serves as a controller electronic circuit equipped with wifi and bluetooth devices. Using this device remotely in real time, needs to be tested first to get more accurate and efficient results [16]-[20]. The Indonesian Institute of Sciences is building a measuring instrument as well as an optical-based rainfall testing tool, which can help measure the speed of rainfall at any time. Both of these tools require smartphone or computer devices and internet networks that have been programmed as needed in the manufacture of tools and testing of rainfall measuring instruments. This rainfall measuring instrument will be used within a certain distance so that it requires a sufficient internet network in obtaining rainfall data. ESP-32 CAM microcontroller base instrumentation system consists of processors, Wireless connectivity, Memory, Peripheral input/output, Security. While the DC motor-based instrumentation system has three main component parts consisting of the field pole, current electromagnetic or dynamo and commutator.

2 Methods

This research was conducted from February to May 2020 at the Laboratory of Hydrometeor Instrumentation Optoelectronics Research Group Of Physics Research Center-Indonesian Institute of Sciences Building 442 PUSPIPTEK appeared Serpong District, South Tangerang City. Tools used in the development of Camera-Based Rainfall Intensity Measuring Instruments are computer devices, browser software, buckets, showers, pipe glue, shelter pipes, electric soldering, tin, hoses, straps, connecting cables, water faucets, screen recording software and

ESP32 cam cameras. While the materials used are microcontroller esp32 cam, Arduino IDE, Python software, jumper cable, USB module, USB Connector and water as a source of rainfall.

2.1 Design Criteria

The Camera-Based Rainfall Intensity Measuring Instrument is designed to record rainfall data in one minute. Data retrieval was carried out ten times. Data recorded by ESP32 cam will be processed through microcontroller which then the data is sent to the web. Users can view or access both stored and running data using the software.

2.2 Tool Creation

Install Arduino IDE (Integrated Development Environment) software to create programs on ESP32-CAM microcontrollers. Assemble the ESP32-CAM microcontroller and adjust it to the datasheet. Program creation on Arduino IDE software to capture or take water pictures or videos automatically through ESP32-CAM microcontroller. Phase Uploading program on ESP32-CAM microcontroller.

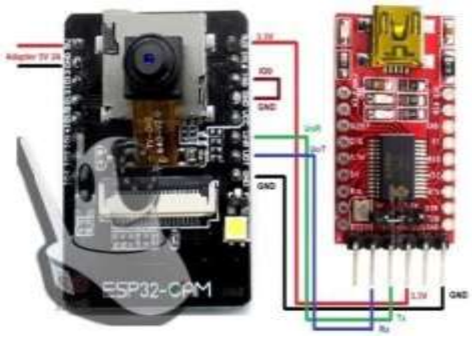


Figure 1. ESP32-CAM circuit with USB modulo

2.3 Principle of working tools

Experiments were carried out in the instrument laboratory of the Optoelectronics group to capture images and record camera-based rainfall video, to achieve this, then there are several ways of working the following tools:

1. Water flowing through the shower as rainfall.

2. Rainfall flowing will be captured and recorded by ESP32-CAM through a screen recording device that can be accessed via computer or mobile phone.

3. Rainfall captured and recorded by the screen recording device as many as ten times the experiment, with a span of 60 seconds per experiment and the increase in the volume of rainfall through the tap water every minute.

4. Data obtained in the form of videos and images will be processed through python software in the form of histograms.

5. The value of rainfall in mini rainfall simulation is calculated using the data that has been produced.

Figure 2. Hardware Work Diagram

Figure 2 shows the performance of the hardware used. The camera-equipped ESP32 CAM microcontroller gives a signal. Rainfall captured and recorded by the screen recording device will be processed through python software.

2.4 Flowchart

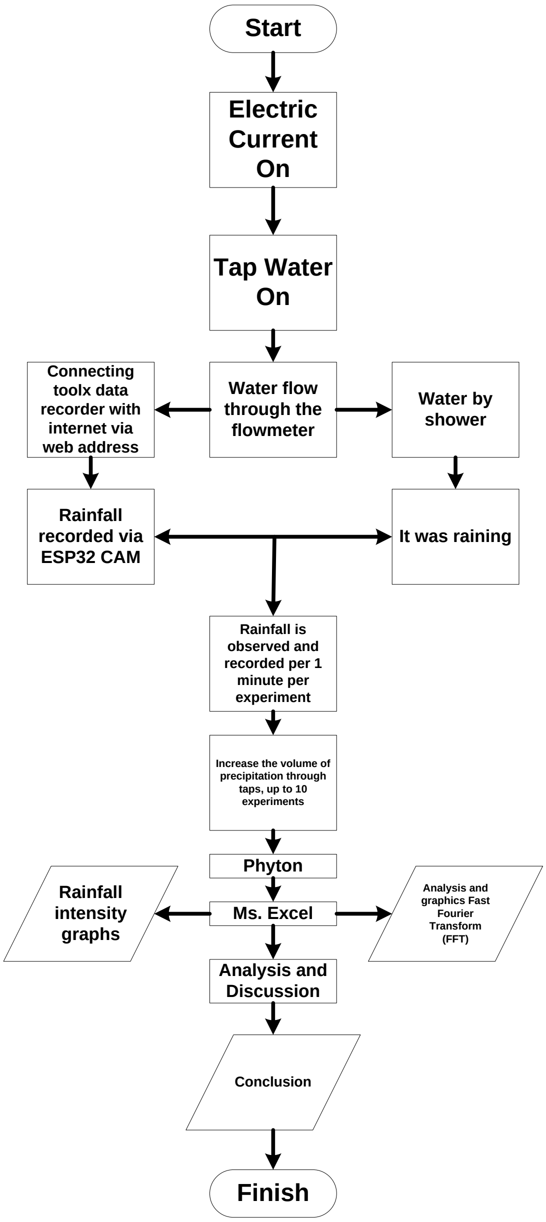


Figure 3. Research Flowchart

3 Result and Discussion

3.1 Histogram Value Images (Grayscale)

The under curve area value is calculated in real time (directly) and will display the histogram area value when the video is run. Figure 4.1 shows python coding, under curve area values, histograms (Grayscale) and data retrieval videos. The blue line indicates the area limit of the histogram value to be calculated the value that will appear in the output in the form of histogram and the value below the curve.

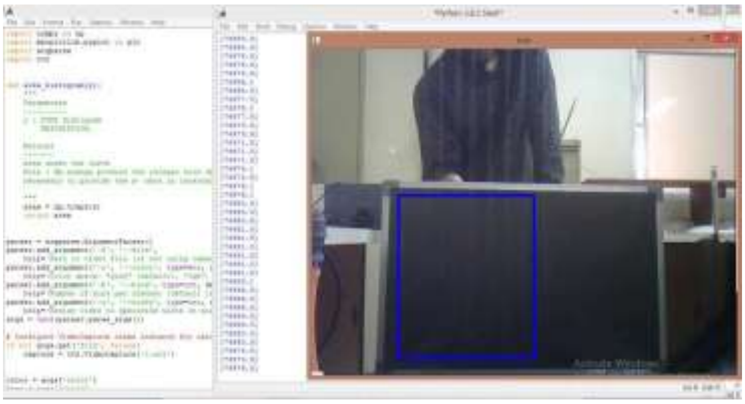
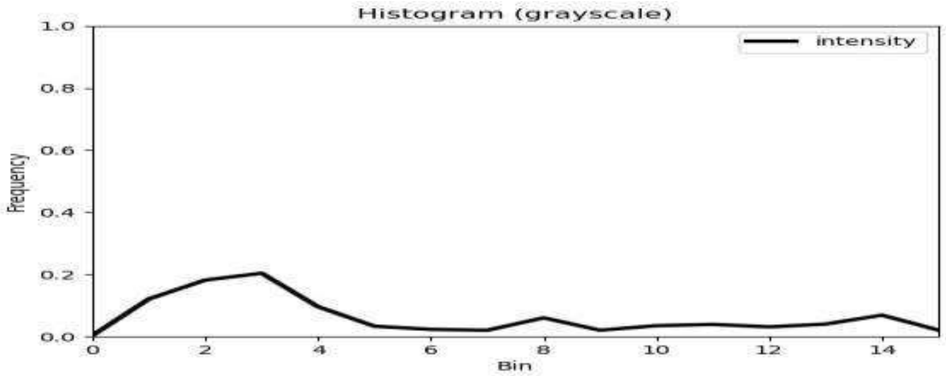


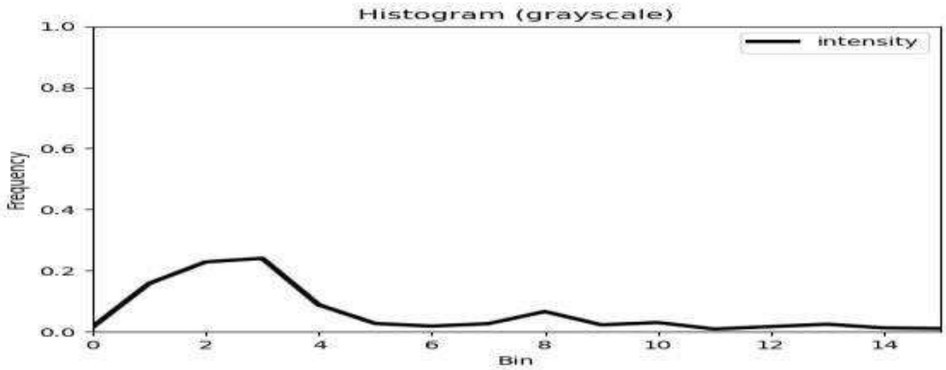
Figure 4. Under Curve Area Values

3.2 Histogram (Grayscale)

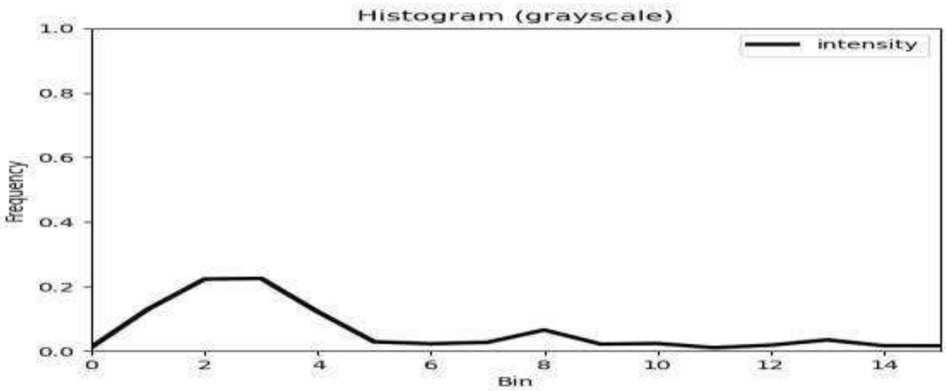
Experiment I



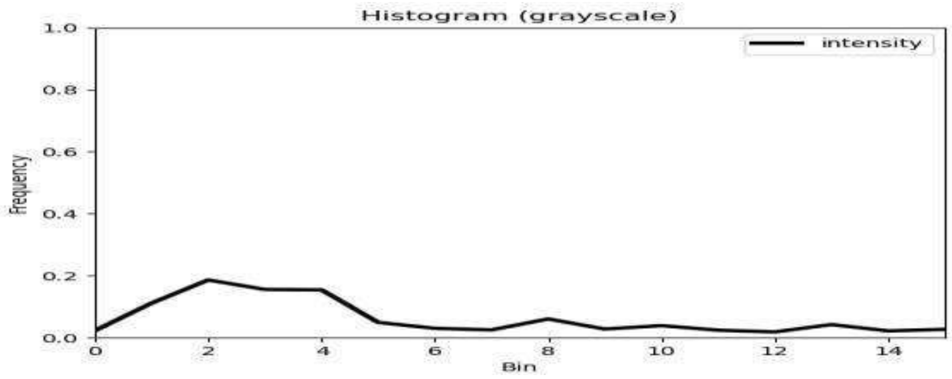
Experiment II



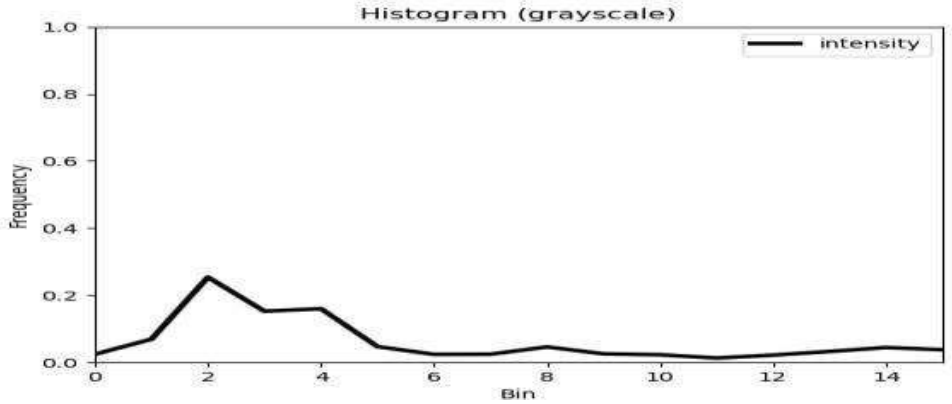
Experiment III



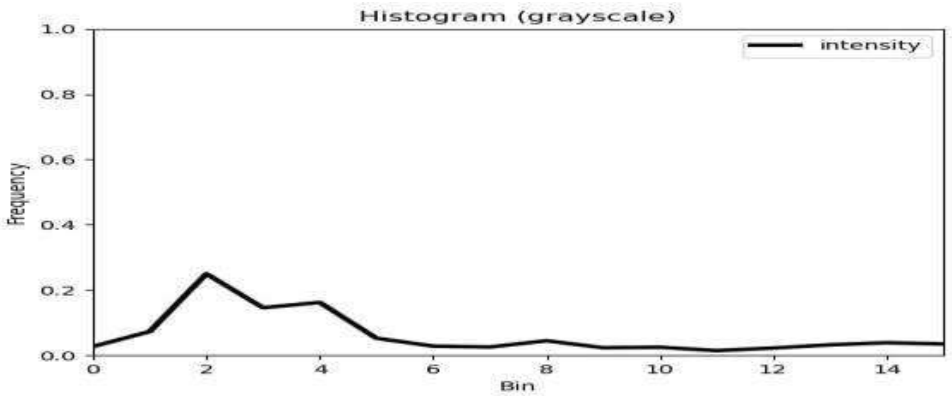
Experiment IV



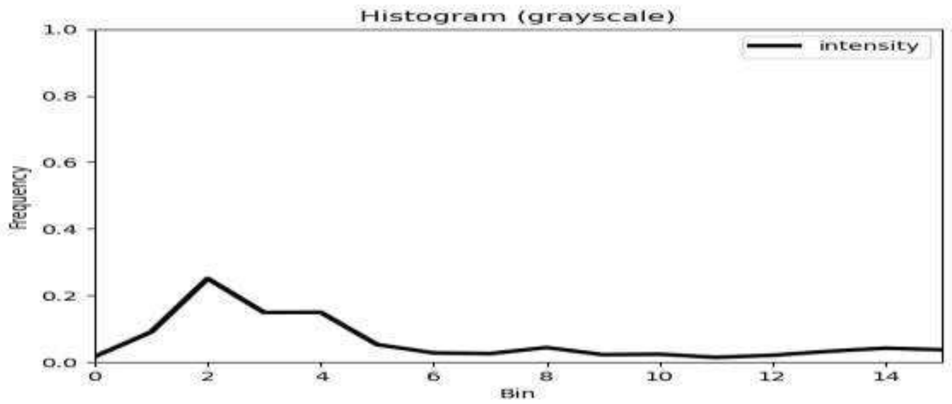
Experiment V



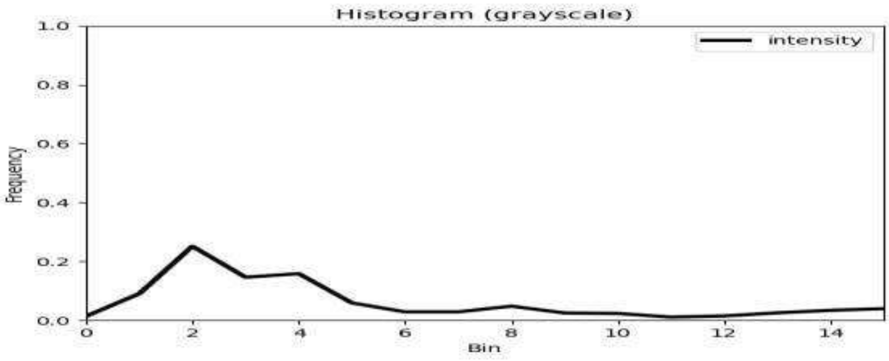
Experiment VI



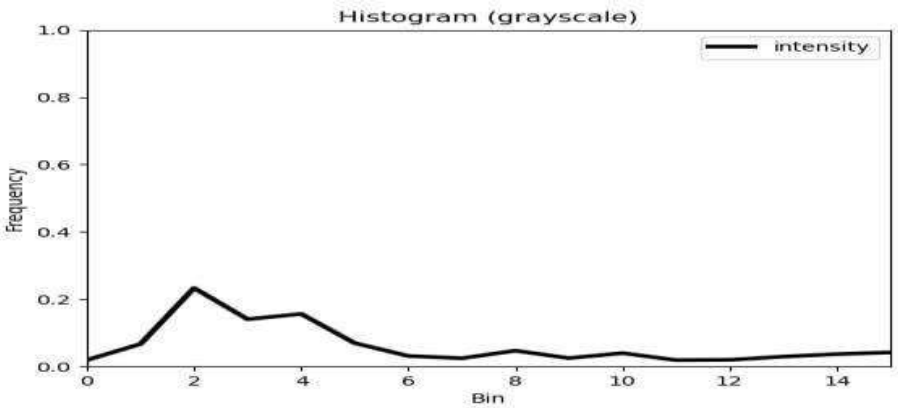
Experiment VII



Experiment VIII



Experiment IX



Experiment X

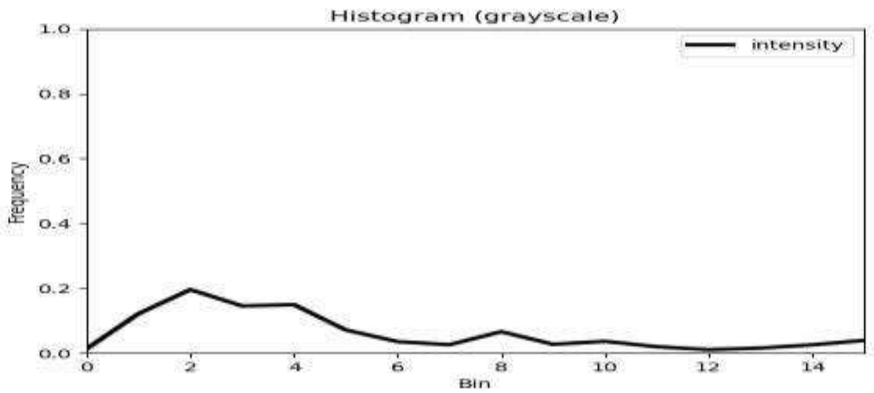


Figure 5. Histograms for 10 Experiments

Histogram is a visual representation of the frequency of numerical data based on a group formed from a range of sequential values (bins). Histogram understanding in image processing is a graphical representation for the distribution of colors of digital imagery or to describe the spread of pixel intensity values of an image or a particular part of an image. From a histogram it can be known the relative frequency of appearance of the intensity of the image, brightness, and contrast of an image.

Figure 5 is a histogram formed from pixel intensity values of the video derived from the source ESP32 CA. It shows the number of darker pixels for the pixel value 0 and the right region indicates the number of lighter pixels for the pixel value of 255. The histogram in Figure 5 shows the intensity value is not constant or stable. The x-axis value represents the pixel value while the y-axis indicates the amount of pixel data in each pixel value (0-255).

3.3 Rainfall Intensity Value

The result of analysis of rainfall intensity by comparing intensity value physicly, obtained rainfall intensity value as in Table 1.

Table 1. Rainfall intensity value for 10 experiments

Exp. I (mm/sec)	Exp. II (mm/sec)	Exp. III (mm/sec)	Exp. IV (mm/sec)	Exp. V (mm/sec)	Exp. VI (mm/sec)	Exp. VII (mm/sec)	Exp. VIII (mm/sec)	Exp. IX (mm/sec)	Exp. X (mm/sec)
13.53629843	11.94177361	14.4724192	19.37173732	16.37848322	16.5795963	18.14209376	18.94052778	19.7678361	21.8739512
9.045872488	9.617188807	12.9414723	9.938487031	13.05703701	17.9771588	17.11703199	20.5855918	19.7935466	19.2871705
8.255633009	9.139484113	8.64618369	7.407577567	12.87708041	17.9760703	17.13123868	17.85700667	19.8092444	20.3333761
10.39439151	10.59379175	11.1645927	10.21925413	13.9398677	17.9641414	15.95839253	1.720971095	17.0923161	20.337677
8.691490211	11.47991274	9.94438081	8.475578562	14.38122948	16.6180759	17.13089948	18.91330572	19.7939325	20.3266398
8.328521542	10.7295046	8.309702	9.421162633	12.51495976	17.9886261	17.15536833	20.39314015	19.7815826	20.3262332
6.924287827	12.01844608	11.2350854	8.593786947	14.14820578	17.9621817	17.1347935	18.9287415	18.7051696	20.3189673
8.262763745	9.383202979	8.24332962	8.353957422	11.76293988	17.9381292	15.97240153	18.96055141	19.7831433	17.356387
8.945391066	11.90906889	7.8987649	10.36059816	12.48680152	17.9449901	17.11461304	19.07783703	19.7777586	21.0549475
8.99956954	8.93798268	8.55014725	9.871347251	11.72041073	17.9434654	15.97021138	18.94369441	18.6916752	23.9775718
8.496069629	9.020312635	8.6008495	7.148217219	14.62455547	17.9603297	17.07574505	18.79407878	19.7764952	2.04223314
7.51653897	9.97816118	8.12022644	9.70670353	13.19329381	17.9776647	15.97813343	18.91762123	19.7750375	20.6270507
9.592993196	11.95520764	87.1454203	7.758862711	13.55920727	19.5965856	17.08160498	18.98174957	18.6827524	20.6579844
7.984530797	7.675418615	9.17024574	9.899788576	12.82458647	18.1609883	15.96193376	14.69625902	19.7564345	21.7986954
7.58909879	10.12407423	10.9027743	10.23886581	12.56297449	18.1529742	17.12476333	18.8844255	19.7484321	21.8175574
10.31556894	9.772530981	8.75197201	9.447807693	13.20578214	17.9477544	15.9672897	18.99333827	18.6576737	21.8268405
10.09358058	10.86709574	9.8929318	10.80886805	11.19329865	18.2995539	17.09391082	16.18378063	19.7678844	218.584437
8.264832659	11.44864209	9.65525288	8.73919939	12.40300145	18.8320127	15.95562039	18.95523433	19.7409689	21.8249895
6.890770939	11.50374859	7.87489247	8.014506411	14.71360832	18.4744979	17.10750731	18.97028026	19.7454644	21.8412081
7.859467444	9.23753784	9.86190498	9.448495946	13.3160832	18.1045951	15.93827206	18.9376476	19.7339278	23.1758777
11.31000712	10.26166616	8.98815178	8.980723411	10.86098773	19.1903181	17.08431965	17.81135268	19.7335029	21.7977062
8.746309416	9.122194487	8.1060296	8.06376738	13.10627911	19.382095	15.93141364	18.98474211	19.7259082	21.8320097
8.655484126	11.70796549	8.35947795	8.439430727	13.55101227	16.7403887	17.08058	18.91122794	19.7216861	21.810167
8.242012246	9.704339379	8.27719405	9.683259005	13.44350991	18.6711847	15.94993281	17.84327065	19.7184543	23.1839666
7.552832676	8.170087746	9.29384365	4.095285812	12.48680152	18.473108	17.07697899	18.98493855	19.7157751	21.7910416
8.264883053	9.572954027	10.50147	9.02991547	13.39490463	18.1206977	15.94603714	18.94807687	19.7202442	22.082331
7.930577292	9.089531828	11.1765521	24.04910427	12.7963432	17.9252812	17.08728059	18.97365782	18.621426	23.1519202
10.26066701	9.686263132	10.8392792	7.861302631	15.07821837	21.2928286	15.94617921	18.88160637	19.7028224	21.665428
8.442575258	9.927586032	9.83698513	8.265415236	13.55920727	19.0001615	17.09293123	18.89095608	19.702315	23.1684015
11.24915008	9.810851033	9.96810443	6.909054036	12.82458647	187.283055	15.96854484	18.98891658	19.6894551	21.7841674
7.549319855	7.806193428	11.3330412	6.424962258	13.50273631	19.0746034	17.08513345	18.93603786	19.6840146	23.1507867
8.305818719	11.40481933	10.482938	8.671757599	11.79866778	18.2895992	15.9076036	18.98162152	19.6840294	21.7788947
10.24676116	11.3364097	9.36581788	9.375945116	15.23668572	18.9374042	17.09414559	18.92948569	18.5799246	21.5979577
7.139996646	10.143834	9.81705743	9.22944598	13.30565536	18.8446139	17.07774217	18.92783968	19.6679345	18.5591765

7.18661988	7.694538822	10.0989854	7.958562421	14.65505095	18.9836101	15.92409996	18.95405585	19.661588	22.9319036
6.992838632	9.770234933	8.42947695	9.170803265	13.20578214	18.8853698	17.10762828	18.99096909	21.1600254	21.5699374
7.604893143	11.74935614	34.1243892	8.148326922	11.19329865	18.9282995	15.95037584	18.9032668	18.6880574	22.9449702

4 Conclusion

Based on the research that has been done, it can be concluded that the development of rainfall measuring instruments has worked well and the model of designing the development of rainfall intensity measuring instruments that have been made in this study is water flowing through showers as rainfall. The lowest rainfall intensity value was in experiment 1 with a value of 6.890770939 mm/s while the highest rainfall value was in experiment 4 with a value of 24.04910427 mm/s.

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