SMART WEATHER STATION

Non-Mechnical Rain guage

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Hardware Setup

VCC

GND

ANALOG SIGNAL

- SIG(Sound sensor) – A0
- NC – A1
- SIG(Loudness sensor) – A3
- SDA – A4
- SCL – A5

DIGITAL SIGNAL

- CS – D10
- SCK – D11
- MOSI – D12
- MISO – D13

Data Collection

Data Collection Setup(Lab setup)

Date :25-10-2022 Time Duration: 5 minutes data
Method: By using Mist Irrigation Nozzles

COLLECTION SETUP

Dataset Creation

Lab simulated data

Moderate Rain

Time	Sound	Loudness
12:07:07	659	260
12:08:07	20	271
12:09:08	620	273
12:10:08	486	238
12:11:08	521	258
12:12:08	200	254
12:13:09	491	91

Set up 1
Settings used for creating this condition:

Tap was almost closed.

Heavy Rain

Time	Sound	Loudness
12:15:09	447	277
12:16:09	280	255
12:17:10	308	224
12:18:10	472	260
12:19:10	383	287
12:20:10	12	139

Setup 2
Settings used for creating this condition:

Tap was more closed than the previous set

Light Rain

Time	Sound	Loudness
12:21:11	39	141
12:22:11	26	131
12:23:11	137	141
12:24:12	254	165
12:25:12	130	136
12:26:12	19	102

Setup 3
Settings used for creating this condition:

*Tap was more open than **setup 1***

Modified Nozzle (i)

Time	Sound	Loudness
12:32:14	90	172
12:33:14	447	275
12:34:14	665	240
12:35:15	563	251

Setup 4
Settings used for creating this condition:

The Mist Nozzle was cut.
Tap was partially open.

Modified Nozzle (ii)

Time	Sound	Loudness
12:37:15	848	383
12:38:16	676	373
12:39:16	377	378
12:40:16	362	328
12:41:17	469	372
12:42:17	56	120

Setup 5
Settings used for creating this condition:

The Mist Nozzle was cut.
Tap was more open than previous setup.

Fan jet Nozzle

Time	Sound	Loudness
12:43:17	79	139
12:44:18	615	338
12:45:18	79	126

Setup 6
Settings used for creating this condition:

The Fan Jet Nozzle was used
Tap was same as previous setup.

Labelled data

Sound	Loudness	Label
659	260	moderate
20	271	moderate
620	273	moderate
486	238	moderate
521	258	moderate
200	254	moderate
491	91	moderate
447	277	heavy
280	255	heavy
308	224	heavy
472	260	heavy
383	287	heavy
12	139	heavy
39	141	light
26	131	light
137	141	light
254	165	light
130	136	light
19	102	light

Classified Labelled Data

Model Creation

Lab simulated data

Training data

Classified Labeled data is cleaned by eliminating anomalies and kept as a time series in CSV format with a 60000-millisecond time interval.
Light rain, moderate rain, and heavy rain are indicated on weather labels.

Impulse design

Impulse was created using timeseries raw data, two input axes, a window size of 60000 ms, and a frequency of 0.16667 Hz, along with the features of sound and loudness.

Labels for the weather indicate whether it will rain lightly, moderately, or heavily.
and choose to classify using keras using input (sound, loudness) and output attributes (light,moderate and heavy)

Model Training

The model was trained during 30 training cycles with 20% of the validation training data and a learning rate of 0.0005 and got a 0.03 loss with 100% accuracy.

Performance Evaluation

Performance metrics found while performing classification predictions are

<u>Precision:TP/(TP+FP)</u>

Heavy rain:1
light rain:1
moderate rain:1

<u>Recall:TP/(TP+FN)</u>

Heavy rain:1
Light rain:1
Moderate rain:1

F1 score:2*(Precision*Recall/Precision+Recall)

Heavy rain:1

Light rain:1

Moderate rain:1

Accuracy:(TP+TN)/(TP+TN+FP+FN)

Heavy rain:100%(1/1)

Light rain:100%(1/1)

Moderate rain:0%(2/2)

Model Deployment

Live tested the model by deploying the model on Arduino nano ble sense with sensor fusion method. and got the desired output.

Power Consumption Analysis

Theoretical Analysis

By using Component datasheet,
The maximum and minimum values of power consumption were calculated.

1.RTC Module

Operating Voltage= 3.63 V - 5.5 V
Current Requirement= 200 µA - 300 µA
Power = V*I
Minimum Power= 3.63*200*10^-6
= 0.000726 W

Maximum Power= 5.5*300*10^-6
= 0.00165 W

2.Micro SD Adapter

Operating Voltage= 4.5 V - 5.5 V
Current Requirement= 0.2 mA - 200 mA
Minimum Power=4.5*0.2*10^-3
= 0.0009 W

Maximum Power= 5.5*200*10^-3
= 1.1W

3.Sound Sensor

Operating Voltage= 5 V
Current Requirement= 4 mA ~ 5 mA
Minimum Power=5*4*10^-3
= 0.02W

Maximum Power= 5*5*10^-3
= 0.025W

4.Loudness Sensor

Operating Voltage=3.5 V ~ 10 V

Power Rating Minimum= 0.0009+0.000726+0.020
= 0.021626 Watts

Power Rating Maximum= 1.1+0.00165+0.025
=1.12665 Watts

Average Power Rating is 0.5 Watts

Practical Analysis

Setup

Voltage = 9V
Current = 0.045 A
Power = V*I
= 9*0.045
= 0.405W

Overall power consumption of Arduino Nano BLE ,Sound sensor,Loudness sensor,7805 voltage regulator

Voltage = 9V
$Current_{min}$ = 0.024 A
$Power_{min}$ = V*I
= 9*0.024
= 0.216W

Voltage = 9V
$Current_{max}$ = 0.026 A
$Power_{max}$ = V*I
= 9*0.026
= 0.234W

Average current=0.025A
Power =V*I
=9*0.025
=0.225 W

Overall power consumption for Data Collection setup (Arduino Nano BLE,Sound sensor,Loudness sensor,7805 voltage regulator)= 0.225 Watts

Overall power consumption for Data Collection setup (Arduino Nano BLE,Sound sensor,Loudness sensor,7805 voltage regulator,microSD adapter, RTC)= 0.405 Watts

Capacity

- **for 500 mAh=11 Hr 6 min**
- **for 800 mAh=17 Hr 46 min**

Overall power consumption for Edge device (Arduino Nano BLE sense,Sound sensor,Loudness sensor,7805 voltage regulator)= 0.225 Watts

Capacity

- **for 500 mAh=20 Hr**
- **for 800 mAh=32 Hr**

In a practical analysis, an 800mAh battery has a 7-hour capacity.

Trail-Test with real rain

Data collection(Real rain analysis)

Data is gathered using a configuration similar to that of a mechanical (tipping bucket) rain gauge following which the data are correlated with respect to a time stamp of 1 minute, or 60000 milliseconds.

A 2 hr data from 4th nov 2022 8PM-10PM IST is considered.

labelling of rain is based on the constrain over a period of 1 hour

lightrain <2.5mm
moderate rain 2.5mm-7.6mm
heavy rain>7.6mm

By comparing the data of mechanical(tipping bucket)rain guage we have values of 0,0.4,9.6,4,1.2,0.2
these are categorized under

no rain:0
light rain:0.2,0.4,1.2
moderate rain:4
heavy rain:9.6

Dataset(Real rain analysis)

no_rain.csv - LibreOffice Calc

	A	B	C
1	timestamp	sound	loudness
2	0	197	136
3	60000	197	123
4	120000	283	131
5	180000	302	127
6	240000	371	132
7	300000	343	126
8	360000	362	117
9	420000	397	120
10	480000	375	126
11	540000	475	121
12	600000	428	119
13	660000	446	132
14	720000	471	131
15	780000	430	121
16	840000	449	126
17	900000	417	137
18	960000	488	118
19	1020000	451	123
20	1080000	503	125
21	1140000	506	125
22	1200000	499	130
23	1260000	549	119
24	1320000	525	143
25	1380000	469	121
26	1440000	523	123
27	1500000	513	112
28	1560000	491	124

light_rain.csv - LibreOffice Calc

	A	B	C
1	timestamp	sound	loudness
2	0	43	255
3	60000	40	207
4	120000	220	188
5	180000	237	173
6	240000	614	286
7	300000	161	137
8	360000	63	132
9	420000	269	180
10	480000	601	255
11	540000	217	215
12	600000	170	248
13	660000	62	185
14	720000	21	131
15	780000	115	127
16	840000	228	159
17	900000	226	158
18	960000	483	146
19	1020000	486	121
20	1080000	530	118
21	1140000	601	130
22	1200000	659	111
23	1260000	287	133
24	1320000	114	129
25	1380000	33	130
26	1440000	111	143
27	1500000	140	129
28	1560000	117	118

moderate_rain.csv - LibreOffice Calc

	A	B	C
1	timestamp	sound	loudness
2	0	321	163
3	60000	131	312
4	120000	76	117
5	180000	2	122
6	240000	18	143
7	300000	10	153
8	360000	126	141
9	420000	90	145
10	480000	179	159
11	540000	95	119
12	600000	175	134
13	660000	88	130
14	720000	200	118
15	780000	138	139
16	840000	116	118

heavy_rain.csv - LibreOffice Calc

	A	B	C
1	timestamp	sound	loudness
2	0	5	226
3	60000	67	165
4	120000	67	266
5	180000	506	306
6	240000	15	117
7	300000	21	95
8	360000	243	196
9	420000	64	131
10	480000	82	139
11	540000	101	119
12	600000	51	141
13	660000	92	145
14	720000	72	113
15	780000	43	113
16	840000	21	150

The real value of sound and loudness from the data logg is mapped with the mechanical rain guage (tipping bucket)

Time stamp of these datas are correlated with the non mechanical rainguage sensor sound and loudness data thus the Dataset is created with 4 labels No Rain, Lightrain, Moderate rain, Heavy rain

Model creation and Deployment(Real rain Analysis)

Training data

Classified Labeled data is kept as a time series in CSV format with a 60000-millisecond time interval.
Light rain, moderate rain, and heavy rain are indicated on weather labels.

Impulse design

Impulse was created using timeseries raw data without cleaning the datas, two input axes, a window size of 60000 ms, and a frequency of 0.16667 Hz, along with the features of sound and loudness.

Labels for the weather indicate whether it will rain lightly, moderately, or heavily.
and choose to classify using keras using input (sound, loudness) and output attributes (Norain,light,moderate and heavy)

Model Training

The model was trained with 80 percent of the data with 30 training cycles/epochs with 20% of the validation training data and a learning rate of 0.0005 and got a 1.79 loss with 68% accuracy.

Performance Evaluation

Performance metrics found while performing classification predictions are

Precision:TP/(TP+FP)

Heavy rain:0.38
light rain:0
moderate rain:0
no rain:0.79

Recall:TP/(TP+FN)

Heavy rain:1
Light rain:0
Moderate rain:0
No rain:1

F1 score:2*(Precision*Recall/Precision+Recall)

Heavy rain:0.55
Light rain:0
Moderate rain:0
No rain:0.88

Accuracy:(TP+TN)/(TP+TN+FP+FN)

Heavy rain:100%(3/3)
Light rain:0%(0/7)
Moderate rain:0%(0/3)
No rain:100%(19/19)

Deployment

Live tested the model by deploying the model on Arduino nano ble sense with sensor fusion method and got the desired output.

Conclusion

In the rain classification with the samples labelled of 4 classes such as heavy rain, moderate rain, light rain and no rain result in an accuracy about 100 percent for lab deployment and for real rain analysis without eliminating anomalies and random values with an accuracy of 68 percentage for real rain analysis.

Extensions planned for the non-mechanical rain gauge includes

- Solar powered system-for long term data collection.
- Planned Testing with different gauged aluminum sheet for hardware set up sound detection.
- Data collection with rain simulator setup inside lab for more data set similar to real rain by adjusting the real rain parameters such as intensity of rain, duration of rain , frequency of rain, amount of precipitation is the current ongoing work

References

- https://www.google.com/search?channel=fs&client=ubuntu&q=edge+impulse+documentation
- https://www.seeedstudio.com/