EGU23-13072 : Precipitation Measurement from Raindrops' Sound and Touch Signals

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Introduction

- This study estimated rainfall intensity using raindrop sound and touch signals. Binary classification was used to detect rainfall based on these signals, and intensity was estimated from sound during rainfall periods. Signals were analyzed over 1-second, 10-second, and 1-minute intervals. Results were compared to observed rainfall intensity from PARSIVEL.
- Scan the QR code and listen to the sound of rain with different rainfall intensities. Did you notice the difference in sound according to the intensity of the rain?

No Rain

Weak Rain

Heavy Rain

Precipitation Measurement Device

- A device for measuring precipitation was created to gather sound and touch signals from raindrops. It consists of a Raspberry Pi, a condenser microphone (Actto MIC-24, sampling rate: 44100), and an accelerometer (MPU6050, sampling rate: 9).
- The accuracy of the rainfall intensity estimation model was assessed by utilizing rainfall intensity data obtained from PARSIVEL.

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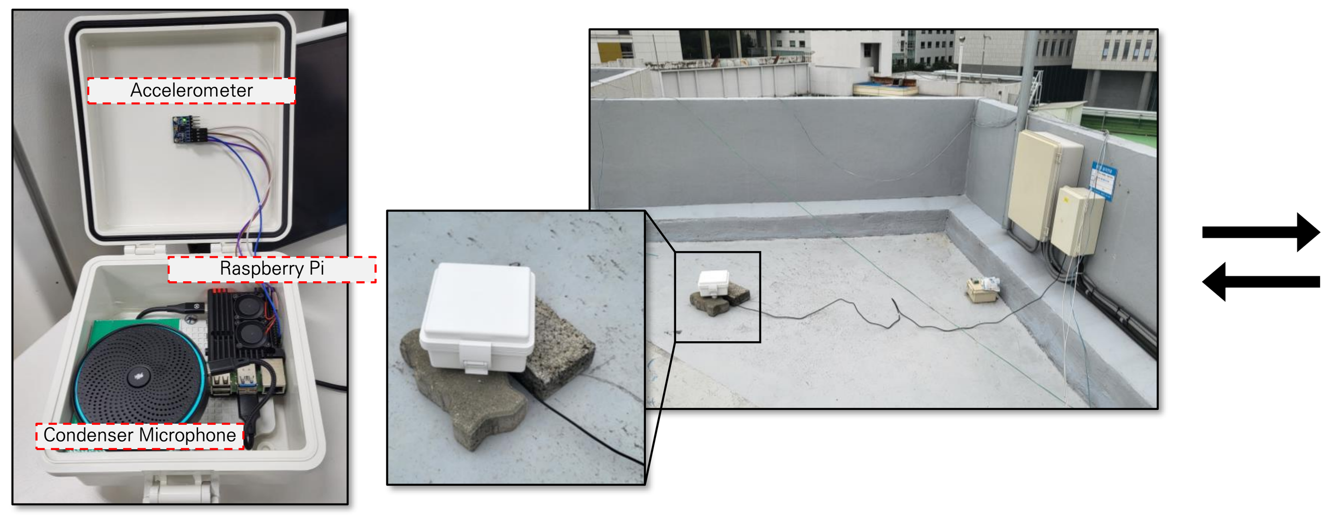

Fig. 1. Installation and components of the precipitation measurement device

Fig. 2. PARSIVEL

- The created device was installed on the roof of Chung-Ang University, Seoul, Republic of Korea (Lat: 37.5035°, Lon: 126.9575°). Data were collected in two times (2022.07.31. 15:28 ~ 2022.08.01. 13:28 / 2022.11.28. 16:59 ~ 2022.11.29. 11:17).

Methodology

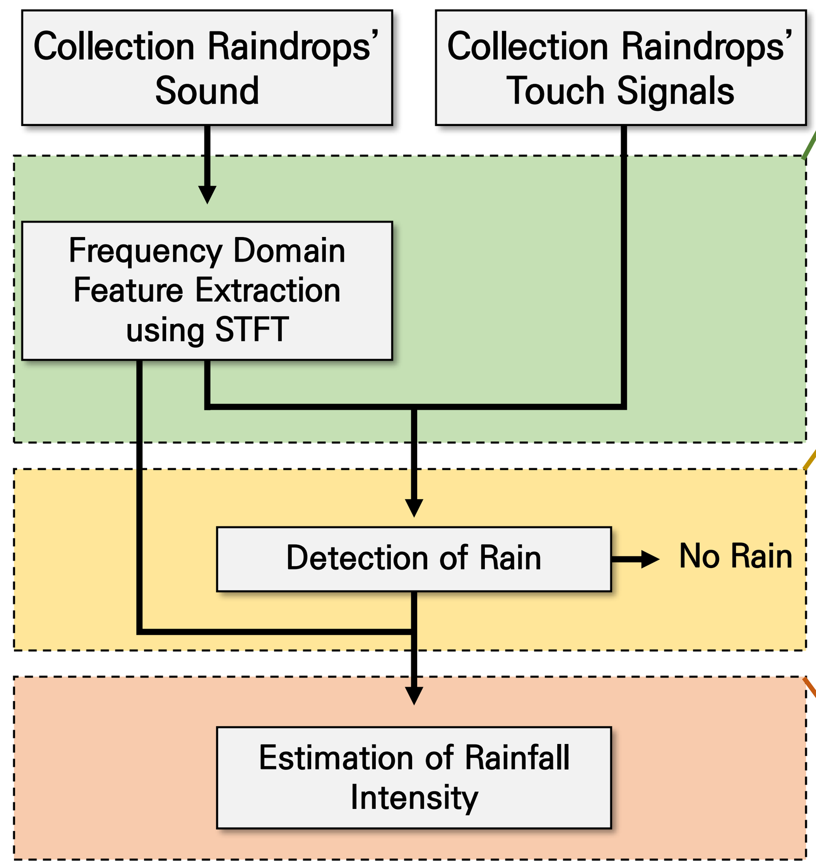

Fig. 3. Flowchart of the model for estimating rainfall intensity

- ✓ Through the utilization of STFT(Short-Time Fourier Transform) on raindrops' sound, four distinct feature values are extracted from the frequency domain:
  - Mean of magnitude
  - Frequency weighted mean of magnitude
  - Standard deviation of magnitude
  - Max frequency

Description of four features

- ✓ Four feature values of raindrops' sound and raindrops' touch signals were used to determine the presence or absence of rain.
- ✓ A binary classification model using the XGBoost algorithm, which is an ensemble-based machine learning approach, has been developed.
- ✓ The background noise in the sound can degrade the rain detection performance. As a solution to this problem, touch signals are also considered.

- ✓ Based on the four feature values of the sound, rainfall intensity is estimated for the period during which rainfall was determined to have occurred according to the results of rainfall detection using the XGBoost.

Results & Discussion

- Results indicate that the 1-minute signal demonstrated the highest performance for estimating rainfall intensity, when compared to signals of 1 second and 10 seconds.
- This is likely due to increased variability when signals are divided into shorter periods, which can result in more outliers and less smoothing.
- However, it is noteworthy that signals of 1 second and 10 seconds showed comparable performance to the 1-minute signal, and were able to produce accurate rainfall intensity data with very short observation periods.

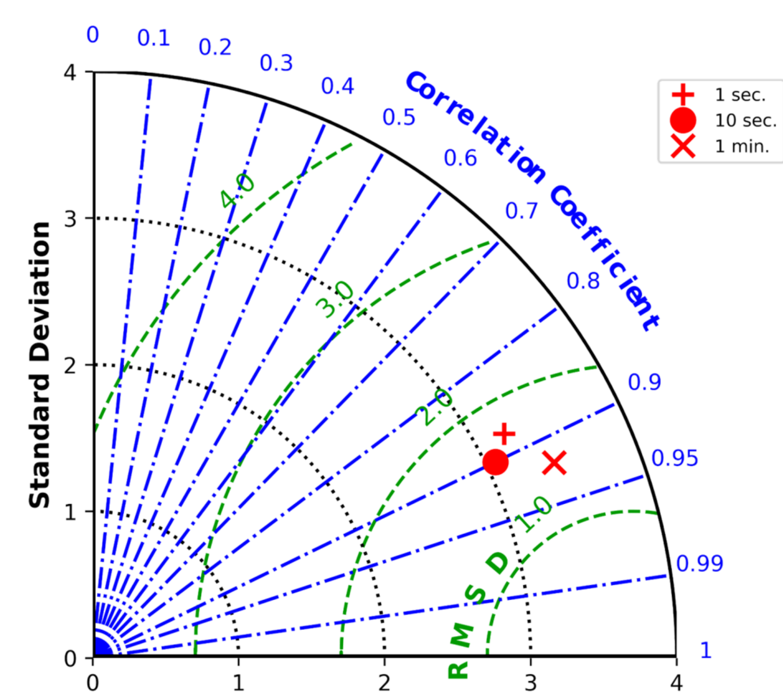

Fig. 4. Taylor diagram for different lengths of signals

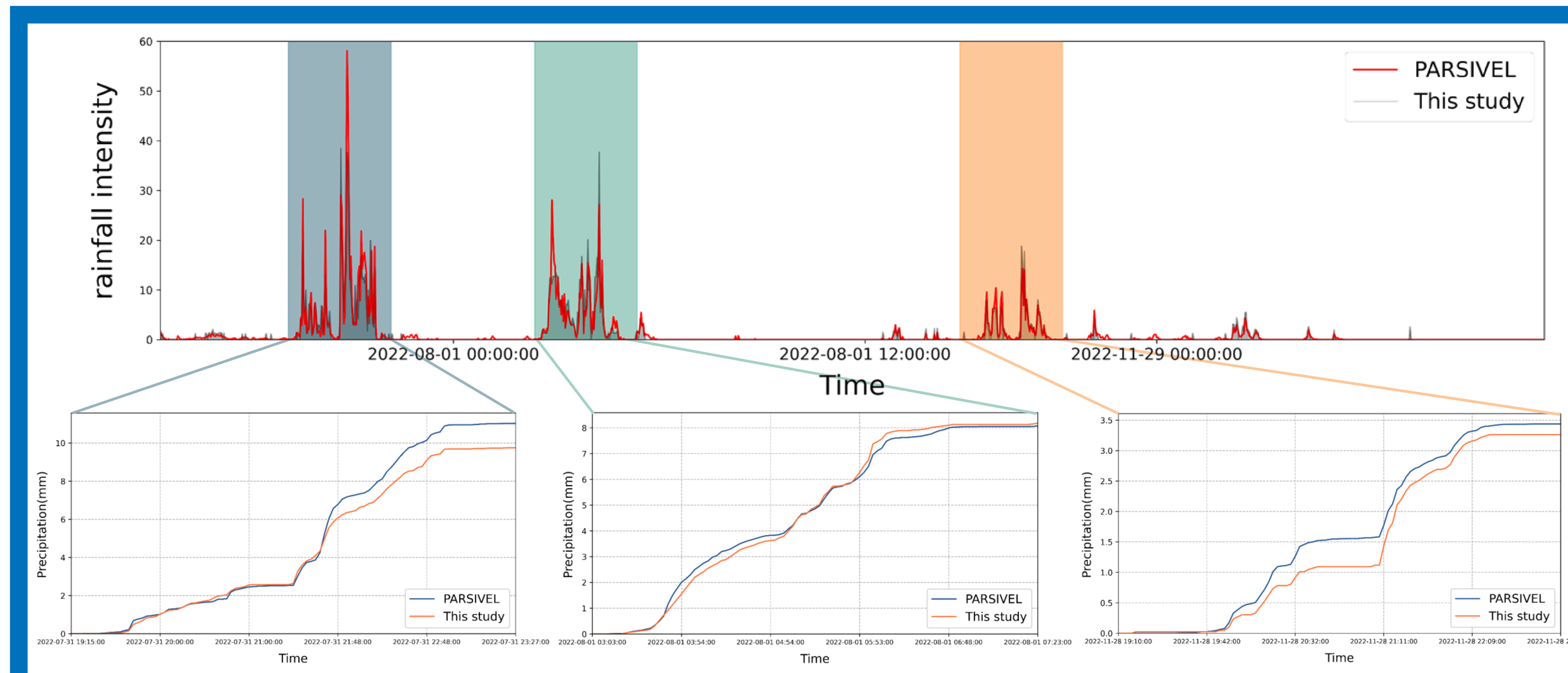

Fig. 5. Comparison of predicted (i.e., this study) and observed (i.e., PARSIVEL) cumulative precipitation for three rainstorm events (1−minute signal)

Conclusion

- In this study, we utilized the XGBoost to estimate rainfall intensity based on raindrop sound and touch signals. Signal lengths of 1 second, 10 seconds, and 1 minute were evaluated, with the 1-minute signal demonstrating the highest performance.
- While the touch signal had a low sampling rate and was unable to detect all touch signals from raindrops, it proved to be an effective solution for improving the accuracy of rain detection in the presence of background noise. Future studies may benefit from increased sampling rates to further enhance the utility of touch signals.
- This novel approach utilizing low-cost sensors for rainfall intensity estimation from acoustic and vibration data presents a promising solution for achieving high-resolution and accurate precipitation measurements in various settings with easy installation and maintenance.

Acknowledgement

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