Camera Rain Gauge Based on Artificial Intelligence

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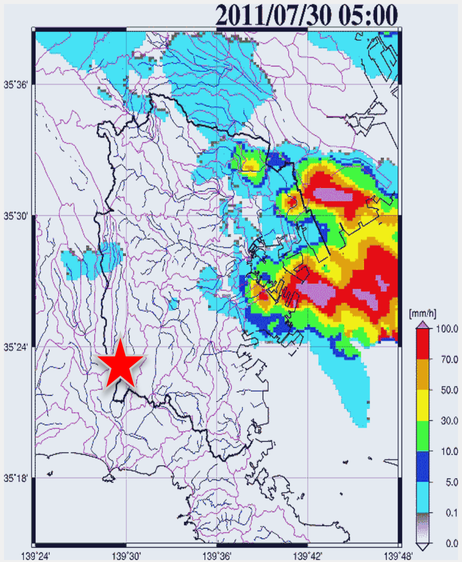
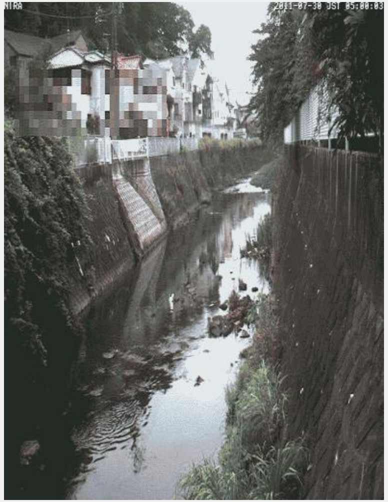
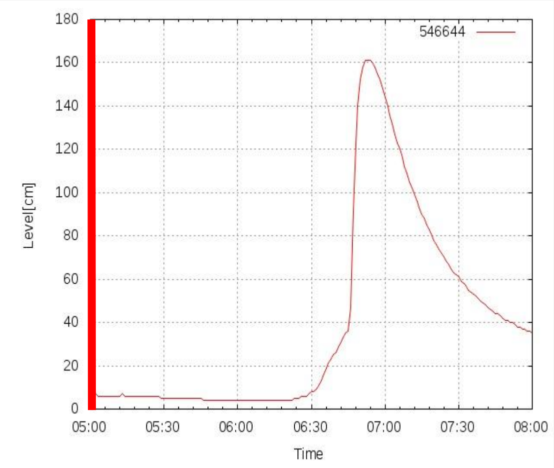
Goal: Improving quality, quantity, and access of rainfall observations

- Flood risk monitoring, alert and adaptation in urban areas require near-real-time fine-scale precipitation observations that may be challenging to obtain in some areas from currently available measurement networks.
- This study proposes an unprecedented system for rainfall monitoring based on artificial intelligence (using deep learning for computer vision) and not-specific, widespread, and accessible devices.







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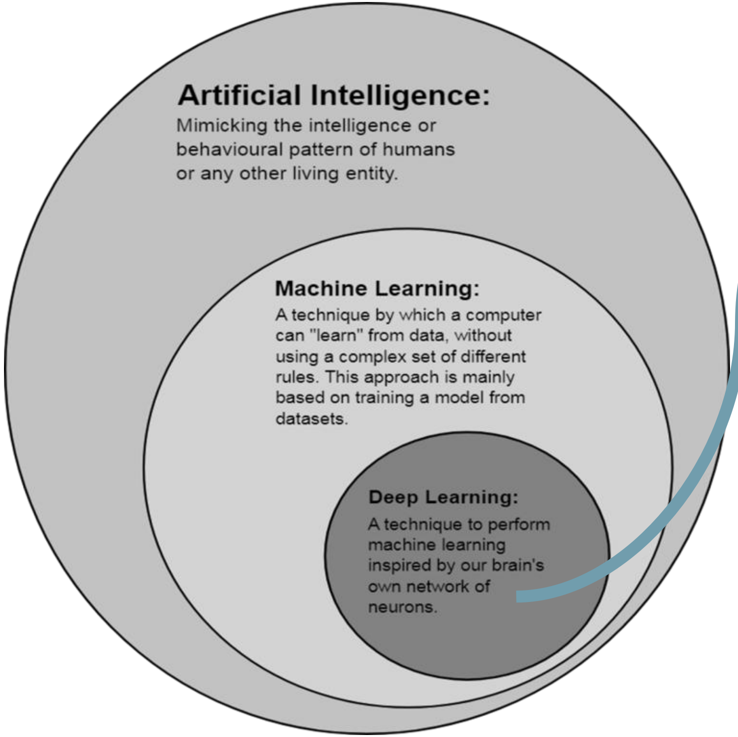
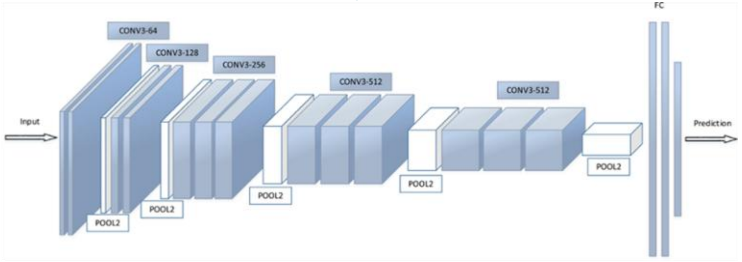
AI-based approach



Convolutional base - VGG16 network
(Simonyan and Zisserman, 2014)

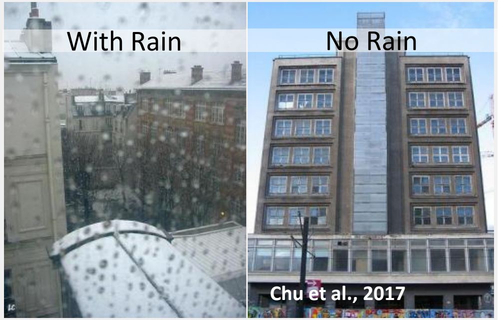


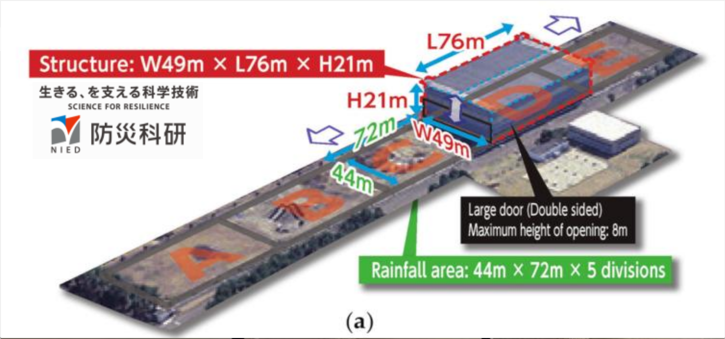
Rainfall is measured directly from single photographs through Deep Learning models based on **transfer learning with Convolutional Neural Networks**, using the VGG16 as the convolutional base.

A binary classification algorithm is developed to detect the presence of rain.

A multi-class classifier is used to estimate a quasi-instantaneous rainfall intensity range.

Dataset





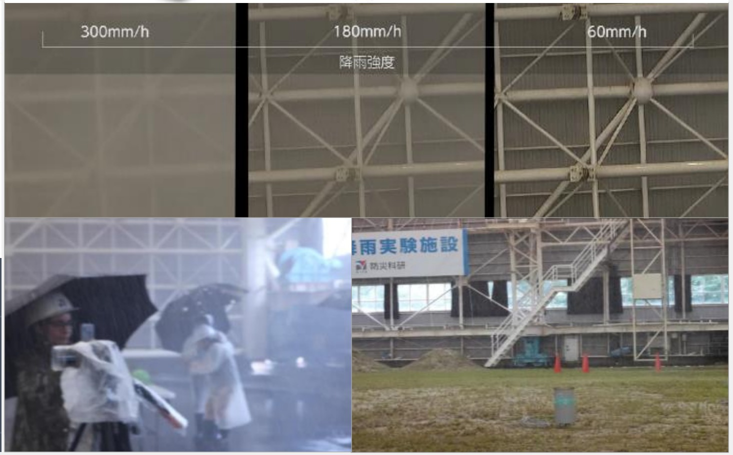


Image sources

- crowdsourced Image2 Weather (Chu et al., 2017)
- dashcams moving in Japan (©NIED)
- experiments in Large-scale Rainfall Simulator of the NIED (Tsukuba, Japan).

Classes

- rainfall rates retrieved from multiparameter radar XRAIN (©NIED, Hirano et al. 2014; Hirano and Maki 2018) by capture time and GPS
- Nominal simulator rain rates (20-150 mm/h) and rain gauges

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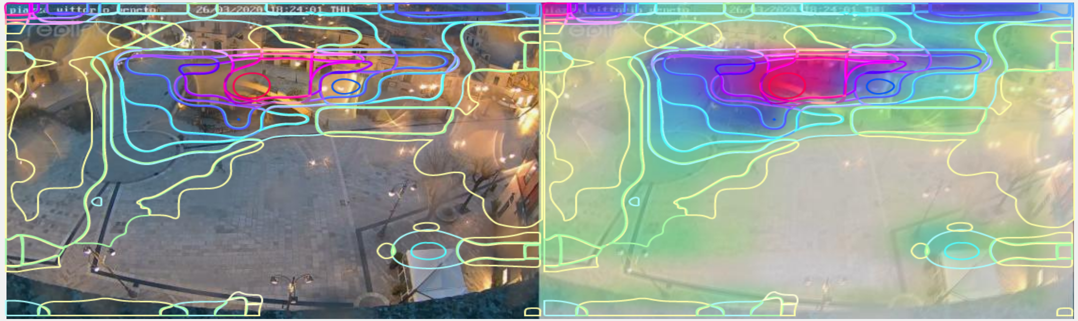
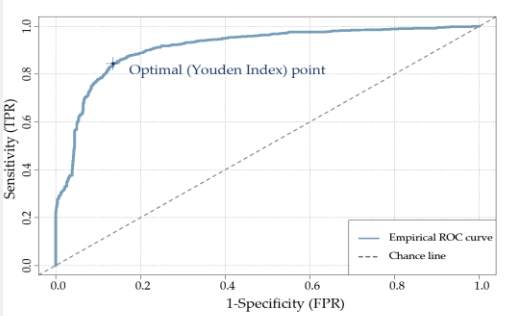
Results - deployment





Notarangelo et al., 2021

Metric	Value test set	Value TIM set	Reference Values*
Overall accuracy	85.28%	85.13%	worst=0% best=100%
Cross Entropy Loss	0.3400635	0.3960878	perfect ≈ 0
Sensitivity - Recall	90.44%	83.14%	worst=0% best=100%
Specificity	80.13 %	87.12%	worst=0% best=100%
Precision	81.98%	86.58%	worst=0% best=100%
F_1	0.8600	0.8482	worst=0 best=1
Matthews correlation coefficient MCC	0.7094	0.7031	worst=-1 best=+1

reference values (Goodfellow et al. 2016; Zheng 2015; Murphy 2012; Chicco and Jurman 2020).

- The prototype was deployed in a real-world operational environment using a pre-existent 5G surveillance camera.
- The results of the binary classifier showed great robustness and portability, whereas the literature algorithms suffer from drastic accuracy drops changing the image source (e.g. from 91.92% to 18.82%. Notarangelo et al., 2021).
- The 6-way classifier results reached test average accuracy and macro-averaged F1 values of 77.71% and 0.73, presenting the best performances with no-rain and heavy rainfall, which represents critical condition for flood risk.

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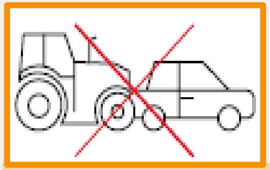
Integration in Early Warning System using 5G connectivity

PLUVIOMETRIC FORCING

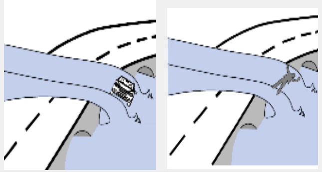
SMART NEAR REAL TIME CAMERA RAIN GAUGES

RISK AND EVENT SCENARIOS

HISTORICAL DATA
GIS LAYERS
HYDROLOCIAL AND HYDRODYNAMIC MODELS



Don’t try to rescue your car or other vehicle. Flowing water can knock over you and the debris can block you.



EARLY WARNING

LEVELS OF CRITICALITY - LEVELS OF ALERT INDICATIONS – WARNINGS

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Conclusions and future directions

- ❑ The results of the tests and the use-case demonstrate the model's ability to detect a significant meteorological state for early warning systems.
- ❑ The classification can be performed on single pictures taken in disparate lighting conditions by common acquisition devices without adjusted parameters.
- ❑ This system does not suit scenes that are also misleading for human visual perception.
- ❑ The method features readiness level, cost-effectiveness, and limited operational requirements.
- ❑ Altogether, this study corroborates the potential of non-traditional and opportunistic sensing networks for the development of hydrometeorological monitoring systems in urban areas and in data-scarce contexts.

- These promising results are part of a work in progress
- Further experiments and crowdsourcing will be used to validate models against real events
- Incremental learning may be implemented to improve and fine-tune the model
- A mobile app and API are planned for release

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Thank you for your interest

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