Detecting urban fires after the 2024 Noto Peninsula Earthquake using satellite data

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Introduction

On 1 January 2024, the 2024 Noto Peninsula Earthquake occurred in the Noto region of Ishikawa Prefecture, Japan.
The most notable fire occurred in Wajima City, Ishikawa Prefecture, where an area of 49000 m^2 was destroyed and 240 buildings were damaged. The earthquake damaged the road network leading to the Noto region, greatly limiting the ability to grasp the full extent of the damage. In such situations, remote sensing using artificial satellites is one of the few options available for understanding the situation.
This poster presents the results of fire detection using infrared (IR) satellite data and a trial of detection using Synthetic Aperture Radar (SAR) satellite data.

IR Satellite Data Analysis

Four satellite datasets were analysed, and as a result, three spreading fires were detected (**Figure 1**).
The detection results were useful as reference information for our field survey on 3 and 4 January. However, there are the following limitations to IR satellite observations.

- ✓ It is not possible to observe fires under cloud cover.
- ✓ It is not possible to observe fires during twilight hours.
- ✓ The resolution is insufficient for accurate estimation of the location and size of fires.

SAR Satellite Data Analysis

In satellite SAR observation, radar is actively irradiated towards the Earth's surface from orbit, and the backscatter that returns to the satellite (passing through the clouds) is received in orbit. This allows it to complement IR observations.
The SAR data used in the analysis were GeoTIFF images with a ground resolution of 2.5 m/pixel obtained by ALOS-2 satellite. After the earthquake, five emergency observations were conducted by Japan Aerospace Exploration Agency (JAXA) covering the fire area of Wajima City (**Table 1**). We applied deep learning method using these data.

Image Analysis by Deep Learning

The procedure for creating the dataset for deep learning is shown in **Figure 2.** The ground-truth of the burnt area was obtained from the results of our field survey.
We applied the Mask R-CNN model and trained it for 3000 epochs. An example of inference results from the validation data is shown in **Figure 3**, where the fire area could be detected almost accurately in all 25 validation images.
The training progress is shown in **Figure 4**.

Conclusions

Fire detection using IR and SAR satellite data was conducted for a large-scale urban fire in Wajima City caused by the 2024 Noto Peninsula Earthquake.
Analysis of IR data detected three fires, which was useful for the on-site survey.
The deep learning method was applied to five pairs of pre- and post-earthquake SAR observation data, and it was shown that the burned areas could be detected with high accuracy.
Satellite remote sensing can be an important source of information for understanding the situation during large-scale disasters. Since fire detection by SAR was studied with limited data, it is necessary to accumulate data on fires in urban areas and verify the accuracy of fire detection in the future.

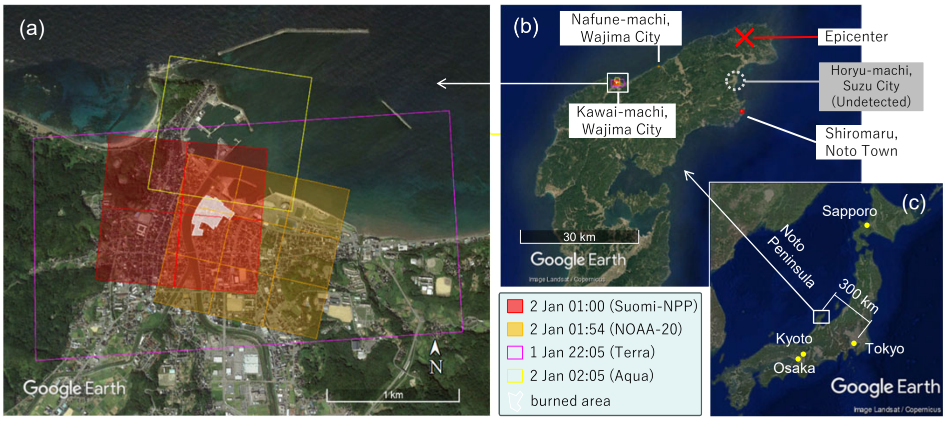

Figure 1. Fire detection results after the Noto Peninsula earthquake by IR satellite of Kawai-machi, Wajima City (a), and the location of detected area (b, c).

Table 1. Observation data by ALOS-2 used in the analysis.

Emergency (Post-Fire) Observation date and time (Local)		Archive (Pre-Fire) Observation date and time (Local)		Uses of data when applying deep learning
1 January 2024	23:10:50	26 September 2022	23:10:49	For Training
2 January 2024	12:37:39	6 June 2023	12:37:37	For Training
3 January 2024	23:52:02	6 December 2023	23:52:02	For Training
8 January 2024	23:59:00	12 June 2023	23:58:57	For Training
9 January 2024	11:49:29	19 October 2021	11:49:27	For Validation

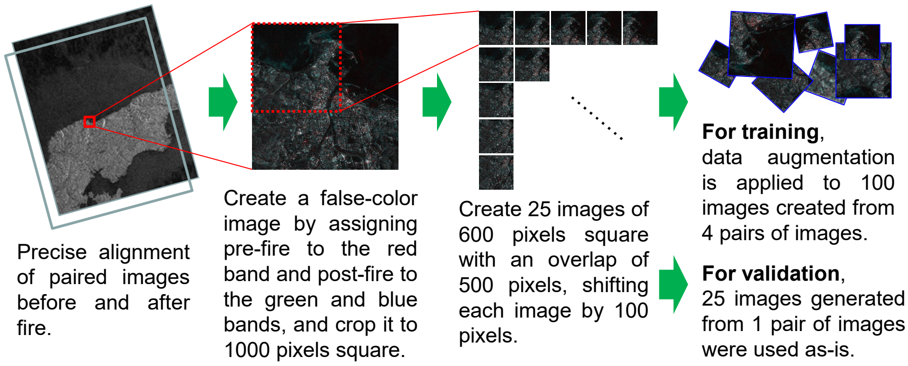

Figure 2. Flow of creating training and validation data using SAR data.

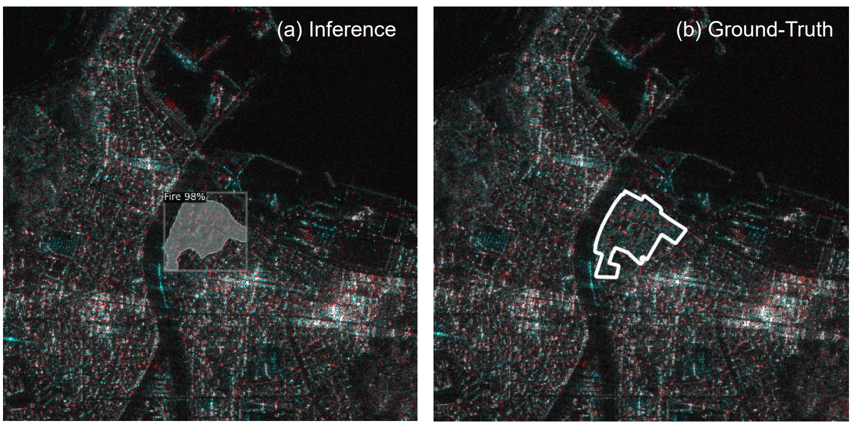

Figure 3. Example of inference results (a) comparison with the ground-truth (b).
(Background is a false-color image created from ALOS-2 data observed on 9 Jan 2024 and 19 Oct 2021.)

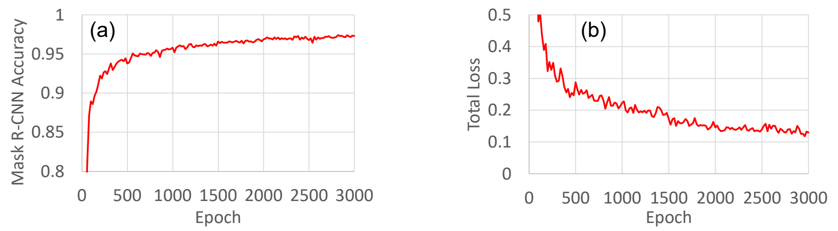

Figure 4. Training Progress of Mask R-CNN accuracy (a) and total loss (b).