Machine learning-assisted remotely sensed crisis information for rapid situational awareness during the floods in Western Germany 2021

Marc Wieland[1], Konstanze Lechner[1], Uwe Kippnich[2], Nina Merkle[3], Veronika Gstaiger[3], Corentin Henry[3]

[1] German Aerospace Center (DLR), German Remote Sensing Data Center (DFD), Oberpfaffenhofen, Germany

[2] Bavarian Red Cross (BRK), Headquarters, Munich, Germany

[3] German Aerospace Center (DLR), Remote Sensing Technology Institute (IMF), Oberpfaffenhofen, Germany

Abstract

Remote sensing data, such as satellite, aerial or drone imagery are frequently requested during large-scale natural disasters to support emergency response and relief efforts with rapid situational awareness. Operational rapid mapping procedures are largely based on manual image analysis and increasingly struggle to cope with the ever-growing data volume and complexity, and the inherent spatio-temporal dynamics of disaster situations. In this work we provide insights into the rapid mapping activities carried out by the German Aerospace Center (DLR) in cooperation with the Bavarian Red Cross (BRK) to support the Search and Rescue operations to the floods in Western Germany 2021. We discuss aspects of data acquisition and present results of machine learning methods that were used during the activation. On the basis of the acquired data, we further show experimental results of ongoing research activities that are conducted within the AIFER (artificial intelligence for analysis and fusion of earth observation and internet data to support situational awareness in emergency response) and the Data4Human (demand-driven data services for humanitarian aid) projects.

North Rhine-Westphalia and Rhineland-Palatinate and in particular the Ahr valley were severely affected by the floods as a result of prolonged rainfall on 14 and 15 July, 2021. The Center for Satellite-based Crisis Information (ZKI) of the DLR supported the emergency and rescue teams with satellite data and DLR aerial images that have been acquired, processed and analyzed within hours after notification. The products were used by the commanders in the field and the operation rooms for the mission planning. Flight campaigns were carried out on 15, 16 and 20 July, 2021 with different in-house camera systems from helicopter and plane platforms. Sentinel-1 Synthetic Aperture Radar (SAR) images were acquired daily between 14 and 20 July, 2021. A pre-trained convolutional neural network (CNN) for semantic segmentation has been used to automatically delineate flood water in the SAR images. Similarly, a CNN has been deployed to segment roads in the aerial images. The road extraction network has been trained and tested on several areas world-wide as part of the Data4Human project. By comparison with a pre-disaster reference road network, this can support the detection of road blockages and up-

to-date routing or identify isolated settlements. Automated image processing routines together with pre-trained machine learning methods could reduce the time between image acquisition and final product generation from several hours / days to just a few minutes. It therefore allowed not only faster product delivery but also higher analysis frequency and thus a more continuous monitoring of the situation. Good generalization ability of the deployed learning machines is, however, crucial to cope with the highly varying data availability in disaster situations.

Beyond the semantic segmentation methods that were successfully deployed during the flood activation, current research efforts focus on further image analysis tasks, namely object (e.g., exposed buildings) and change (e.g., damage) detection. In this context, the AIFER project (funded by the German Federal Ministry of Education and Research and the Austrian Federal Ministry of Agriculture, Regions and Tourism) develops artificial intelligence methods to extract and fuse information from remote sensing and geo-social media in order to provide targeted, dynamic decision support to authorities and organizations with security tasks. Besides the technical research, comprehensive consideration of ethical, legal and sociological aspects of the use of artificial intelligence in emergency response is highly relevant to the project. Validation and integrability into existing operational processes are tested in a practical way together with Public Protection Disaster Relief (PPDR) as could successfully be demonstrated during the floods in Western Germany 2021.