CLAUDIO PERSELLO, RONNY HÄNSCH, GEMINE VIVONE, KAIQIANG CHEN, ZHIYUAN YAN, DEKE TANG, HAI HUANG, MICHAEL SCHMITT, AND XIAN SUN

2023 IEEE GRSS Data Fusion Contest: Large-Scale Fine-Grained Building Classification for Semantic Urban Reconstruction

Buildings are essential components of urban areas. While research on the extraction and 3D reconstruction of buildings is widely conducted, information on the fine-grained roof types of buildings is usually ignored. This limits the potential of further analysis, e.g., in the context of urban planning applications. The fine-grained classification of building roof types from satellite images is a highly challenging task due to ambiguous visual features within the satellite imagery. The lack of corresponding fine-grained building classification datasets further increases the difficulty.

The 2023 IEEE Geoscience and Remote Sensing Society (GRSS) Data Fusion Contest (DFC23) (see Figure 1), organized by the Image Analysis and Data Fusion Technical Committee (IADF TC) of the GRSS, the Aerospace Information Research Institute under the Chinese Academy of Sciences, the Universität der Bundeswehr München, and GEOVIS Earth Technology Co., Ltd., aims to push current research on building extraction, classification, and 3D reconstruction toward urban reconstruction with fine-grained semantic information of roof types and height information.

To this aim, the DFC23 establishes a large-scale, fine-grained, and multimodal benchmark for the classification of building roof types. It consists of two challenging competition tracks investigating the fusion of optical and synthetic aperture radar (SAR) data while focusing on roof type classification and building height estimation, respectively. The data provided by the DFC23 includes several novel properties.

- *Globally distributed and large scale*: A novel large-scale urban building classification and reconstruction dataset is provided. Buildings are distributed across 17 cities on six continents to cover a wide range of different building styles. This allows capturing the heterogeneity of cities in different continents with various landforms.
- *Fine-grained roof type categories*: The buildings are labeled according to a detailed (fine-grained) categorization of roof types. The DFC23 provides nearly 300,000 instances with 12 different types of building roofs, rendering building classification significantly more challenging.
- *Multimodal data*: To facilitate multimodal data fusion, not only optical imagery but also SAR images are provided. The information captured by these different modalities can be jointly exploited, potentially resulting in the development of more accurate building extraction and classification models.

The contest is designed as a benchmark competition following the previous editions [1], [2], [3], [4], [5], [6], [7] and will consist of the following two parallel tracks:

1) "Track 1: Building Detection and Roof Type Classification"
2) "Track 2: Multi-Task Learning of Joint Building Extraction and Height Estimation."

Track 1: Building Detection and Roof Type Classification: This track focuses on the detection and classification of building roof types from high-resolution optical satellite imagery and SAR images. The SAR and optical modalities are expected to provide complementary information. The given dataset covers

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17 cities worldwide across six continents. The classification task consists of 12 fine-grained predefined roof types. Figure 2 shows an example.

Track 2: Multi-Task Learning of Joint Building Extraction and Height Estimation: This track defines the joint task of building extraction and height estimation. Both are two very fundamental and essential tasks for building reconstruction. As in Track 1, the input data are multimodal optical and SAR satellite imagery. Building extraction and height estimation from single-view satellite imagery depend on semantic features extracted from the imagery. Multi-task learning provides a potentially superior solution by reusing features and forming implicit constraints between multiple tasks in comparison to conventional separate implementations. Satellite images are provided with reference data, i.e., building annotations and normalized digital surface models (nDSMs). The participants are required to reconstruct building heights and extract building footprints. Figure 3 shows an example.

COMPETITION PHASES

The contest in both tracks will consist of the following two phases:

Phase 1: Participants are provided with training data and additional validation images (without corresponding reference data) to train and validate their algorithms. Participants can submit results for the validation set to the CodaLab competition website to get feedback on their performance. The performance of the best submission from each account will be displayed on the leaderboard. In parallel, participants submit a short description of the approach used to be eligible to enter Phase 2.

Phase 2: Participants receive the test dataset (without the corresponding reference data) and submit their results within seven days from the release of the test data set. After evaluation of the results, four winners for each track are announced. Following this, they will have one month to write their manuscript, which will be included in the IGARSS 2023 proceedings. Manuscripts are four-page IEEE-style formatted. Each manuscript describes the addressed problem, the proposed method, and the experimental results.

THE DATASET

Images of the DFC23 dataset are collected from the *SuperView-1* (or "*GaoJing*" in Chinese), *Gaofen-2*, and *Gaofen-3* satellites, with spatial resolutions of 0.5, 0.8, and 1 m, respectively. nDSMs provided for reference in Track 2 are produced from stereo images captured by *Gaofen-7* and *WorldView-1* and *-2* with a ground sampling distance of roughly 2 m. Data were collected from 17 cities on six continents to provide a large and representative dataset of high diversity regarding landforms, architecture, and building types. Roof type categories are organized according to 12 fine-grained roof type classes based on the geometry of the roof.

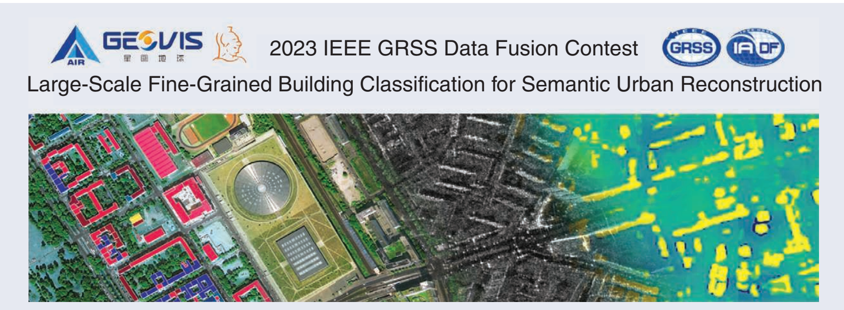

FIGURE 1. The banner image for the DFC23.

GET THE DATA, AND ENTER THE CONTEST

The training and validation datasets were made publicly available on 3 January 2023 on IEEE DataPort. The evaluation server with a public leaderboard opened on 4 January 2023 so that participants can submit prediction results for the validation set to the CodaLab competition to get feedback on the performance of their

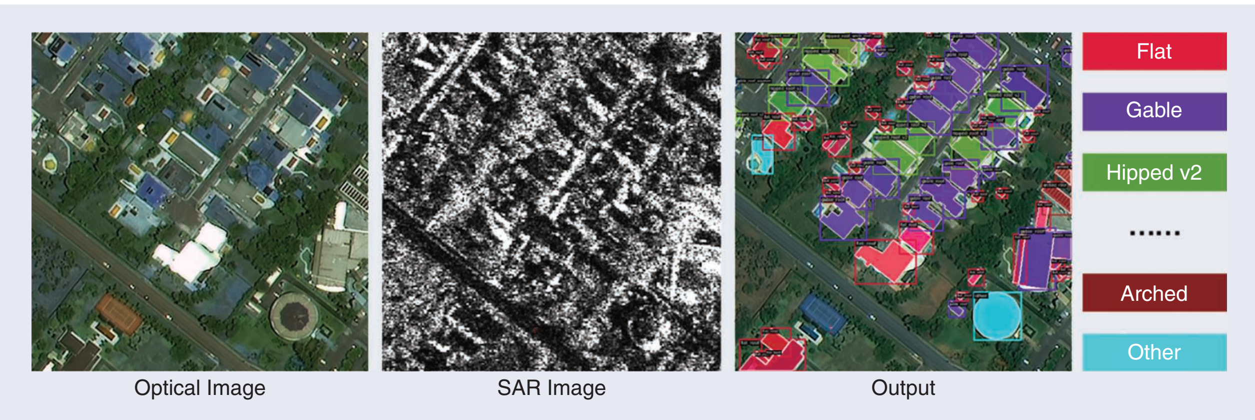

FIGURE 2. An example image tile of the provided multimodal data (optical and SAR) for building detection and roof type classification.

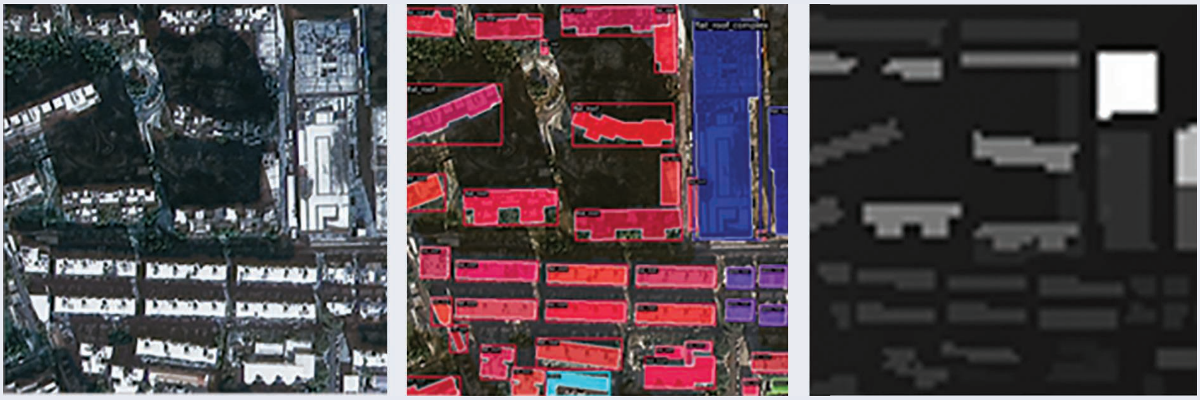

FIGURE 3. An example of joint building extraction and height estimation.

approaches. To enter the test phase, participants submit a short description of the used approach by 28 February 2023. The test phase is allocated during 7–13 March. The test phase is kept short to ensure an objective and fair comparison among methods. After the final check of the submitted classification and height maps, comparing them with the undisclosed ground truth for testing, winners are announced on 28 March 2023. The evaluation server will be reopened after the winners' announcement for further development in the field (see "Using the Data and Joining the Image Analysis and Data Fusion Technical Committee").

More information regarding data download and registration to the evaluation server can be found at the IADF TC website (https://www.grss-ieee.org/technical-committees/image-analysis-and-data-fusion/?tab=data-fusion-contest). Questions and comments on the data and the contest can be submitted to the IADF TC LinkedIn group (https://www.linkedin.com/groups/3678437/). Updates about the contest will also be published via the IADF Twitter channel (https://twitter.com/GrssIadf).

Using the Data and Joining the Image Analysis and Data Fusion Technical Committee

The data of DFC23 will remain available to the GRSS community for benchmarking algorithms and publishing research works. The data are usable free of charge for scientific purposes, but the Contest Terms and Conditions on the contest webpage remain applicable. Please read them carefully at https://www.grss-ieee.org/technical-committees/image-analysis-and-data-fusion/?tab=data-fusion-contest.

You can contact the IADF TC chairs at iadf_chairs@grss-ieee.org. If you are interested in joining the IADF TC, please fill in the form on our website at https://www.grss-ieee.org/technical-committees/image-analysis-and-data-fusion. Members receive information regarding research and applications on image analysis and data fusion topics as well as updates on the annual DFC and on all other activities of the IADF TC. Membership in the IADF TC is free! Also, you can join the LinkedIn IEEE GRSS Data Fusion Discussion Forum (https://www.linkedin.com/groups/3678437/) and Twitter channel (https://twitter.com/GrssIadf).

AWARDEES, AWARDS, AND PRIZES

The first- to fourth-ranked teams in each track will be declared as winners. The authors of the winning submissions will: 1) present their approach in an invited session dedicated to the DFC23 at IGARSS 2023; 2) publish their manuscripts in the proceedings of IGARSS 2023; and 3) be awarded IEEE Certificates of Recognition. The first-, second-, and third-ranked teams of each track will receive US$5,000, US$2,000, and US$1,000, respectively, as cash prizes. The authors of the first- and second-ranked teams of each track will coauthor a journal article that will summarize the outcome of the DFC23 and will be submitted with open access to the *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* (*JSTARS*). Top-ranked teams will be awarded during IGARSS 2023, Pasadena, CA, USA, in July 2023. The costs for open-access publication in *JSTARS* will be supported by the GRSS. The winning team prize is kindly sponsored by the organizing partners.

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IRENA HAJNSEK

2022 Earth Observation and Sustainable Development Goals Contest Winners

The Technical Committee Remote Sensing Environment, Analysis, and Climate Technologies (REACT) of the IEEE Geoscience and Remote Sensing Society (GRSS) is proud to announce the winners of the 2022 Earth Observation and Sustainable Development Goals (EO4SDG) contest. The miniprojects for the Sustainable Development Goals competition are an initiative of the Technical Committee REACT to support science and to motivate local students to work together on a specific topic related to EO4SDG. The focus is on local regional problems and how remote sensing can help to identify and quantify environmental/societal impacts of a changing Earth. More details can be found at www.grss-ieee.org/resources/news/new-react-eo4sdg-competition/.

The winning team this year is a group from the Remote Sensing and Spatial Analytics Lab of the Information Technology University in Lahore, Pakistan, with a miniproject entitled: "Deep Learning for Mapping Glacial Lakes in Hindu Kush & Himalayas using Sentinel-2 Multi-Spectral Data" from Abdul Basit, research associate, Ehtasham Naseer, Ph.D. fellow, and Nida Qayyum, research associate (Figure 1).

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FIGURE 1. The winning team of the EO4SDG contest: Abdul Basit, research associate, Ehtasham Naseer, Ph.D. fellow, and Nida Qayyum, research associate.

The abstract of their miniproject is that glacial lake outburst floods (GLOFs) are recurrent phenomena in high mountain regions around the globe. They are caused by rapid discharge of millions of cubic meters of melt water and ice debris in a short interval of time. They are one of the major environmental threats for local communities residing downstream. Recent decades have witnessed a rapid increase in the number of glacial lakes and subsequent GLOFs, which requires continuous monitoring of expansion of existing glacial lakes and formation of new ones (Figure 2). With the availability of open-source remote sensing data, it is now possible to monitor potentially dangerous zones at a large scale. Moreover, deep