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High resolution image processing and land cover classification for hydro-geomorphological high-risk area monitoring

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High-resolution images processing for land-surface monitoring is fundamental to analyse the impact of different geomorphological processes on earth surface for different climate change scenarios. In this context, photogrammetry is one of the most reliable techniques to generate high-resolution topographic data, being key to territorial mapping and change detection analysis of landforms in hydro-geomorphological high-risk areas.

An important issue arises as soon as the main goal is to conduct analyses over extended areas of the Earth surface (such as fluvial systems) in short times, since the need to capture large datasets to develop detailed topographic models may limit the photogrammetric process, due to the high demand of high-performance hardware.

In order to investigate the best set up of computing resources for these very peculiar tasks, a study of the performance of a photogrammetric workflow based on a FOSS (Free Open-Source Software) SfM (Structure from Motion) algorithm using different cluster configurations was performed leveraging the computing power of ReCaS-Bari data center infrastructure, which hosts several services such as HTC, HPC, IaaS, PaaS.

The selected research areas are located along the hilly plain of the Basento river near Ferrandina (MT), in the Basilicata region of southeastern Italy. The aerial images were acquired as sequences of shots collected by low altitude ($\sim$ 50 m above ground level of the take-off location) UAV flight missions. Two datasets made of 1139 and 2190 images respectively were used for our investigation. Each image has a very high resolution ($\sim$ 1.09 cm/pixel, $\sim$ 10 MB) resulting in quite demanding computing tasks to generate the orthophotomosaic, the dense point cloud and DEM (Digital Elevation Model) of the detected area in the shortest lapse of time.

In the case of this study, the resulting output is key to recognize the flooding hazard (through the monitoring of the river conditions, the identification of the channel alterations and morphological changes) and to timely plan the management activities of the emergency after a catastrophic event, with significant time and cost savings.

The high performance computing automated photogrammetric workflow fits the scope of direct intervention to safeguard the environment and people's safety, assessing the future scenarios of environmental damage as a function of sudden climate changes.

In our study the photogrammetric workflow was deployed on a HTC cluster composed of 128 servers for a total of about 8000 CPU core, with 4GB of RAM per core, and 4PB of parallel disk space. Each computing server, containing up to 64 slots, can access all ReCaS-Bari disk space, at a speed of 10 Gbps. The GPFS distributed file system is used for storage management. The operating system used is CentOS 7, and the queues are managed by the HTCondor batch system. A parallel study was also run using the new GPU ReCaS-Bari cluster exploiting one single server that hosts 4 GPUs, 96 CPU cores, 750GB of RAM and 5.9 TB of SSD.

Leveraging the high-computing resources available at clusters and a specific set up for the workflow steps, an important reduction of several hours in the processing time was recorded, especially compared to classic photogrammetric programs processed on a single workstation with commercial softwares.

The high quality of the image details can be used for land cover classification and preliminary change detection studies using Machine Learning techniques. A subset of the whole image dataset has been considered to

test the performance of several Convolutional Neural Networks using progressively more complex layer sequences, data augmentation and callback functions for training the models. All the results are given in terms of model accuracy and loss and performance evaluations.

Summary

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