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Advanced methods and deep learning for video and satellite data compression

By

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Advanced methods and deep learning for video and satellite data compression

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This thesis presents several works aimed at the advancement of the field of data compression across several types of signals. In particular it deals with the development of new techniques for the compression of video, multi-spectral images and SAR raw data.

In all of these fields the advancement of the compression methodologies is fundamental. In the case of video, the ease of access to high-resolution cameras and the resulting deluge of content in the current social media environment makes the creation of new video-compression techniques necessary to respond to this explosion of data generated. For multi-spectral images and SAR raw data, compression is quite important especially when in a remote-sensing setting, in which the throughput for the communication channel can be quite limited.

The first few chapters describe our work on video coding. Due to the recent advancements achieved with deep learning, especially for image and video processing problems, we decided to develop a deep learning algorithm for video compression. In particular, we developed tools to improve the inter-prediction performance of current video coding standards, like H.265/HEVC. Inter-prediction is a fundamental step in most video compression algorithms, whose aim is to take advantage of the correlation between different frames in a video sequence.

This problem was tackled in two ways: first we developed a filter-generating network capable of predicting a given frame starting from previous ones. We then considered a different approach and concentrated on taking the estimates already provided by the motion-compensation algorithm and enhancing them using previous frames as guide. The designed network is a CNN united with an optical flow network used to align the previous frames to the one that is being enhanced. This method was implemented in the standard H.265/HEVC and we were capable to achieve an average reduction of the Bjøntegaard metric for rate-distortion of -1.69 %.

The following chapters describe our experiments with the low-complexity coding standard for multi-spectral and hyper-spectral images CCSDS 123.0 B-2.

First, we experimented its use for the compression of SAR raw data. SAR is a form of radar, so its raw captures are not actual images, but are instead a grid of complex numbers which describe the echoed signal from the environment in response to an emitted impulse from the sensor. These samples are difficult to compress as they have very limited correlation with each other. Furthermore, in remote sensing settings like earth observation from satellites, the algorithm must be low-complexity, due to hardware limitations.

For this reason, we tried to test the performance achieved by the standard CCSDS 123.0 B-2. This is advantageous because this standard would already be available in modern satellites, and the overall processing architecture would not be burdened by another compression algorithm for SAR data. After few experiments we managed to beat the de-facto standard for the task: block-adaptive quantization. This methodology was adopted in the Horizon 2020 project EO-Alert.

The last work proposed concerns the reduction of optical data sent to ground segments from satellites by skipping the pixels covered by clouds. In remote sensing, clouds are problematic as they represent regions of a captured image which do not provide useful information to the ground segment. We successfully designed multiple techniques to effectively skip the pixels of the image covered by clouds, and to correctly signal the skipped areas to the ground segment. This was achieved by replacing the cloudy regions with dummy values designed to minimize the rate in the file compressed using CCSDS 123.0 and by finding ways to transmit a map of the pixels affected by clouds to the ground. Thanks to this work is possible to significantly reduce the amount of data sent from satellites.