



ROZPRAWA DOKTORSKA

Rekonstrukcja nadrozdzielcza
obrazów cyfrowych
z wykorzystaniem
głębokich konwolucyjnych
sieci neuronowych

mgr inż. Paweł Benecki

promotor: dr hab. inż. Michał Kawulok, prof. PŚ
promotor pomocniczy: dr inż. Daniel Kostrzewa

dyscyplina główna: Informatyka Techniczna
i Telekomunikacja

Gliwice, 22 września 2023

Super-resolution of digital images using deep convolutional neural networks

Paweł Benecki, M.Sc. Eng.

Abstract

Super-resolution reconstruction (SR) is an area of image processing that involves improving the quality of lower resolution images by increasing the spatial resolution. The technology has found applications in photography, satellite image analysis, medicine, forensics and other fields. Among SR methods, one can distinguish between single-image super-resolution (SISR) and multi-image super-resolution (MISR). The purpose of this dissertation was to develop and improve existing MISR methods.

The first stage of the research focused on combining traditional MISR methods with SISR techniques based on deep neural networks. Significant improvements in numerical results on artificially generated data were observed. However, classical methods of assessing the quality of the results in this application proved inconsistent with observers' assessments during reconstruction of real satellite images. For this, a thorough analysis of existing metrics was performed for suitability in the SR task. A new approach to image quality assessment was also designed, incorporating image keypoint detection (*keypoint feature similarity*, KFS). That allowed better reflection of detail differences between images. To verify the usefulness of the developed method in training of leading MISR methods, a way of assessing image similarity based on the architecture of deep convolutional networks (*deep keypoint feature similarity*, DKFS) was designed. This approach can be used during training instead of the traditionally used L1 and L2 metrics. Next, training of MISR models was carried out, using similarity measures based on deep networks as loss functions. Experimental results showed improvements in reconstruction quality on both simulated data and real satellite images.

The dissertation shows that the integration of image similarity assessment methods based on keypoints and MISR methods based on deep neural networks is an effective and promising direction in the field of SR. The research described in the dissertation represents an important step forward in the field of image processing. The developed methods improve the quality of super-resolution reconstruction results, which can be of importance in the fields of science and economics, where image resolution plays an important role in decision making and data analysis.