

Streszczenie w języku angielskim

The dissertation is a monothematic cycle of scientific publications devoted to the no-reference perceptual image quality assessment using artificial intelligence methods, with particular emphasis on deep neural networks. The work is interdisciplinary in nature, combining achievements in technical computer science and telecommunications with applications in medicine and remote sensing. It focuses on two main research areas: the quality assessment of magnetic resonance imaging (MRI) and pansharpened satellite images (PS).

For MRI images, methods have been developed that allow for the analysis of various distortions without the need for their explicit classification. In the case of PS images, the dissertation proposes approaches based on multi-level data representations and modifications of neural network architectures, adapted to the perceptual processing of multispectral image channels.

Considering the above, the following research hypothesis was formulated:

The application of artificial intelligence methods, particularly various architectures of neural networks, enables no-reference image quality assessment of satellite and magnetic resonance images, ensuring high consistency with subjective expert evaluations. The developed methods are not inferior in predictive performance to the state-of-the-art approaches found in the literature.

In light of the obtained results, it can be stated that the performance of the proposed methods is comparable to or better than existing solutions. Their effectiveness has been largely confirmed through experimental studies on various datasets, by accomplishing the following research tasks:

- 1) A literature review of the latest methods for MRI image quality assessment, including typical distortions, application protocols, and utilized databases.
- 2) Development of tools for perceptual quality assessment of pansharpened satellite images and a platform for MRI image quality evaluation.
- 3) Application of deep neural networks for no-reference quality assessment of satellite and medical images to develop methods consistent with subjective assessments and competitive with literature-based solutions, using:
 - a) external fusion of deep convolutional neural network architectures,
 - b) internal fusion of two network architectures,
 - c) a network structure composed of three sub-networks,
 - d) features extracted from network layers.
- 4) Conducting experiments using the developed methods, comparing the results with literature-based methods, and analyzing and interpreting the outcomes.

Task 1. Literature review of the latest methods for assessing the quality of magnetic resonance images, including typical distortions, application protocols, and utilized databases.

The task was completed by reviewing the literature on state-of-the-art MRI quality assessment methods, considering the most common types of distortions in this imaging modality, such as thermal noise, motion artifacts, geometric deformations, and magnetic field inhomogeneities. Their impact on image quality and diagnostic interpretability was discussed. A review of the most widely used datasets was also presented, providing an overview of current trends and identifying directions for future research and potential challenges in this domain.

Task 2. Development of tools for perceptual quality assessment of pansharpened satellite images and a platform for MRI image quality assessment.

The task was carried out by developing two dedicated tools: TIQA-MRI and TIQA-PSI. TIQA-MRI supports the quality assessment of MRI images, offering advanced features such as nine IQA methods, flexible experimental configurations, and statistical significance testing. TIQA-PSI allows for the assessment of pansharpened satellite image quality using 30 methods, including 16 specifically designed for sharpening techniques. Both tools integrate comprehensive statistical analyses, such as the Wilcoxon significance test and correlation coefficient calculations, enabling accurate and robust image quality evaluation.

Task 3. Application of deep neural networks for no-reference image quality assessment of satellite and medical images, in order to develop methods aligned with subjective evaluations and competitive with literature-based approaches.

- a) The task was accomplished by developing an MRI image quality assessment method based on the fusion of deep convolutional neural networks and transfer learning, enabling effective evaluation of MRI quality. For satellite images, a method combining ResNet-18 and VGG-19 architectures was developed, enabling PS image quality assessment without the need for reference images.
- b) A method was proposed for fusing multidimensional features extracted from network layers such as ResNet-18 and ResNet-50. Kernel PCA was used for dimensionality reduction, and an SVR model was used for precise quality prediction. Retraining the networks significantly improved their ability to distinguish perceptual quality in MRI images.
- c) A method combining two complementary network architectures (ResNet-18 and ResNet-50) was implemented. Using transfer learning and a dedicated training procedure, high precision in MRI quality assessment was achieved.
- d) A three-branch neural network was developed for perceptual quality assessment of pansharpened satellite images, optimized for the analysis of spatial and spectral

features. The model demonstrated significant advantages over existing PS quality assessment methods using metrics such as SSIM, confirmed by extensive testing on large datasets.

Task 4. Conducting experiments using the developed methods, comparing results with literature methods, and analyzing and interpreting the outcomes.

The task was completed by conducting experiments using the developed methods for assessing the quality of MRI images. This included the application and fusion of deep neural network architectures to extract multi-level representations of image quality features, as described in publication [A-3]. Both individual ResNet18 and ResNet50 models, as well as their internal fusion, were used to capture various perceptual aspects of MRI images. Furthermore, in publications [A-3] and [A-2], the obtained results were compared with existing methods such as BRISQUE, GWH-GLBP, CurveletQA, MEON, and other traditional techniques based on local and global feature analysis. Additionally, the effectiveness of methods originally designed for natural or satellite images (e.g., MLPSIE) and adapted to medical images was discussed in publications [A-5] and [A-2]. The comparative analysis was conducted using MRI datasets evaluated by experienced radiologists, incorporating subjective expert assessments [A-3], [A-2]. The interpretation of the results showed the superiority of the proposed methods, especially in predicting subjective image quality without the need for reference images.

Keywords: image quality assessment, deep neural networks, magnetic resonance imaging, satellite images, pansharpening, deep network fusion.