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**FACULTY OF AUTOMATIC CONTROL, ELECTRONICS
AND COMPUTER SCIENCE**

Doctoral dissertation

The use of machine learning methods in the processing and analysis of astronomical images

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Abstract

The continued growth of computing power has allowed the implementation of increasingly complex machine learning algorithms over the last decade. This has enabled the field to develop rapidly, leading to the creation of tools capable of solving problems on an unprecedented scale. This is particularly evident in the case of neural networks, which, thanks to their ability to analyze massive datasets and detect complex patterns, are finding widespread use in scientific research, often outperforming previously used algorithms and heuristics.

In astronomy, the use of these tools is primarily concentrated in large observational centers that have advanced computing infrastructure and access to vast amounts of high-quality data from modern ground-based and space-based telescopes. Much less attention is paid to small units that, using more modest resources and simpler instruments, support many scientific projects. This work attempts to fill this gap by analyzing the potential use of selected neural network architectures, particularly convolutional autoencoders, for processing images obtained by telescopes with limited technical capabilities.

The research used images from telescopes of the SUTO (Silesian University of Technology Observatories) research group, which correspond in quality to data collected by observatories of a similar class. They are characterized by low resolution and noticeable noise, mainly due to atmospheric turbulence. The entire work focuses on the problem of reducing this noise and covers four main areas:

1) comparative analysis of neural network training methods in the absence of reference data ("clean" images, completely free of noise) using synthetic and real images,
2) analysis of the impact of the size and complexity of the network architecture on the quality of results in the context of limited computing resources,
3) analysis of the quality of the resulting images relative to the number of input images regarding the performance of the MFBD (Multi-Frame Blind Deconvolution) algorithm on solar data,
4) practical implementation of tested solutions, taking into account processing time and hardware requirements.

The results of the work indicate that appropriately selected neural networks can effectively support the work of smaller observatories while maintaining acceptable quality of

processed data and low computational costs, while also constituting a good alternative to currently used solutions. This opens up possibilities for implementing machine learning-based methods in smaller research units, contributing to increasing their observational potential and wider inclusion in research projects.