Noise reduction in digital images is one of the most important issues in digital signal processing. The need to create new efficient image enhancement algorithms is due to the rapidly evolving techniques of multi-channel imaging, particularly in medicine and biology, astronomy, military and industrial applications. In all of these areas, the problem of noise reduction plays a very important role, as the improvement of image quality determines the success of its further processing and analysis.

The quality of color digital images is often decreased by various types of interferences caused by the thermal noise of the photosensitive matrix, shot noise caused by fluctuations in the photon flux, quantization errors of analogue converters, damaged matrix pixels, noise generated by electromagnetic interferences, aging of the storage material and transmission errors. These noise types are often modeled as a mixture of Gaussian noise, mainly responsible for dark and shot currents, and impulse noise, introducing pixels with random channel intensity values.

The aim of the research project is to develop and analyze the properties of effective families of filters intended for the suppression of mixed Gaussian and impulsive noise in color digital images. The concept of the proposed new image enhancement methods is based on the use of robust metrics of pixel similarity evaluated in their surrounding and also on the cost of digital paths exploring the local neighborhood of image elements. Introducing new pixel similarity measures will allow to overcome the limitations of popular filters, which are related to their inability to eliminate impulsive noise. Thus, the result of the project will be the development of new classes of universal methods, capable of improving the quality of degraded images by both Gaussian and impulsive noise, as well as their mixtures.

The developed within the research project new filter families will be created using a novel measure of the similarity between image elements, defined as the truncated sum of the distances between the pixel and the filtering window in the center of the processing block. This measure will be generalized by means of digital paths connecting the pixels with the central filtering window of the processing block. The connection cost of a pixel to the elements of the filtering window will be determined by the generalized distance transformation, which takes into account the local image structures.

The applicants also plan to use the similarity measures to design a family of filters, robust to outliers introduced by impulsive noise, using an anisotropic diffusion scheme and its biased version, which is characterized by the convergence of the iterative process of image smoothing. The subject of the study will also be the creation of fast algorithms based on the quick shift concept, which is based on the idea of shifting the local filtering window only to the neighboring pixels.

The research effort will be also focused on the application of the generalized distance transformation, which assigns the smallest total cost of the digital path leading from the central pixel of the processing block to its border. In addition, new switching filters will be created to enable the detection and removal of impulsive pixels.

Another direction of research will concentrate on extending the concept of pixel similarity to the filtering window onto the costs of digital paths connecting the pixels from the processing block to the window at its center.

An important element of the project will be the creation of a publicly accessible internet system, which will allow the assessment of the effectiveness of the created algorithms and their comparison with existing noise filtering techniques. The web based platform will allow researchers to test their own solutions by comparing their effectiveness with the filters developed by the applicants using a large database of color images disturbed by mixed Gaussian and impulsive noise.

The research results can be widely used in any field that uses visual information subjected to various types of noise disturbances.