STSM Report

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Beneficiary: Dr Tibor Lukic, Faculty of Technical Sciences, University of Novi Sad, Serbia, email: tibor@uns.ac.rs
Host: Dr Jovisa Zunic, University of Exeter, College of Engineering, Mathematics and Physical Sciences, United Kingdom, email: J.Zunic@exeter.ac.uk
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The working plan envisaged development and adaptation of digital image processing techniques to the needs of preservation, analysis and documentation of objects and artifacts of cultural heritage. Particular attention was on the development of a new digital image denoising method that can be used for quality enhancement of the previously scanned data, but also as a useful tool for analysis and understanding of the digitized cultural heritage (CH) artifacts, for example old manuscripts, pictures or plans.

Noise can appear as a consequence of inadequate conditions during the scanning process of artifacts, for example, illumination limitations caused by special conditions needed for certain CH artifacts. The failure/poor performance of image sensor may also create noise. In addition, noise can also originate from random variation in the number of photons (specific quantity of light energy) reaching the surface of the image sensor at the same exposure level. This type of noise is called photon noise. Therefore, denoising methods have important place among the quality enhancement approaches of the scanned data material. In addition, denoising methods are able to use for restoration and inpainting tasks of the digital representation of CH artifacts when there are slightly damaged by age or inadequate environmental conditions, like humid air or fire.

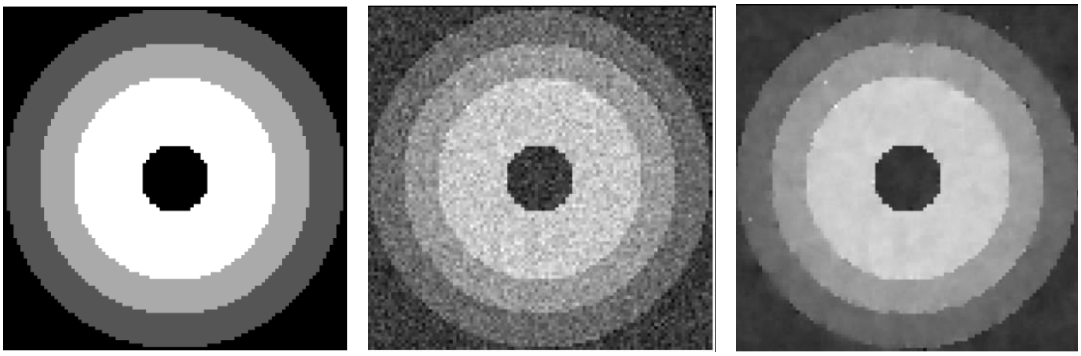
The conducted scientific work was resulted with developing a new digital image denoising method. The denoising problem is reformulated into a minimization model, where an appropriately designed objective, or energy function is minimized. The considered model can be formulate as

$$\arg\{\min_{u} E(u)\}$$

where u is the image and E is the energy function. The new method incorporates a carefully selected digital shape descriptor into the process-the shape elongation measure. Minimization of the energy function is carried out by the application of a gradient descent optimization method. Based on the performance comparison on a number of test images, we concluded that the new method outperforms three state of the art energy minimization denoising methods, previously suggested for the denoising task.

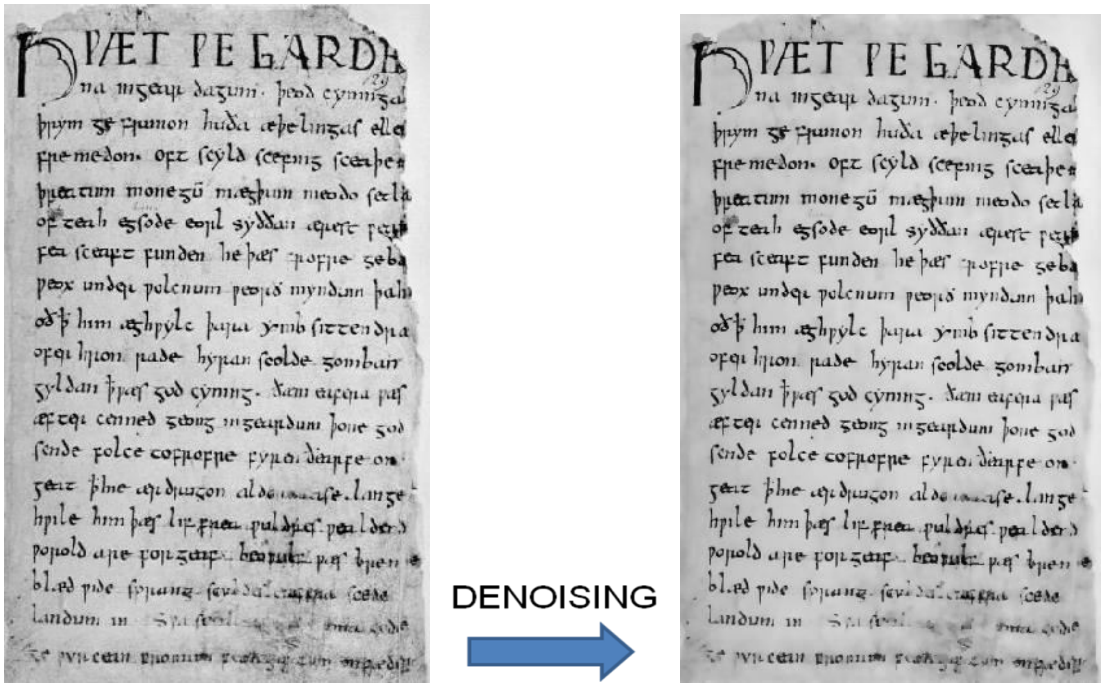
The developed denoising method is adapted and applied to quality enhancement tasks of already scanned/digitalized images of old manuscripts. The method successfully removed a part of background noise, making images clearer and sharper. Therefore, it can be used as a useful tool in restoration, analysis and documentation of CH artifacts.

- Denoising of a synthetic image (developing the denoising method)



Original image Noisy image Denoised image

- Application of the developed method to improve the quality of a scanned old manuscript



The "Beowulf" manuscript, date circa 975-1025 AD. The manuscript suffered damage from fire in 1731. Left: scanned version. Right: denoised version.