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Synthesis of Neural Pulse Interference Filters for Image Restoration

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Abstract—The synthesis of nonlinear pulse interference filters in the form of three-layer and polynomial perceptrons has been considered in this study. Neural filters were used for removing the "salt and pepper"-type pulse interference from half-tone images. It was shown that a three-layer perceptron filter in terms of the filtration accuracy is not inferior to its polynomial analogues and its mathematical model is mush simpler than the Volterra model. Neural and polynomial filters ensure a higher level of pulse interference suppression as compared with median filters.

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The problem of the pulse interference filtration has to be solved quite often in the fields of electrical engineering, radio engineering, electronics, and electromagnetic compatibility. Pulse interferences emerge during the switching of different electronic devices, in cases of mechanical damages of surfaces of the data storage devices, during the operation of internal-combustion engines, under the expose to various atmospheric phenomena, etc. The methods of controlling pulse interferences are used for improving the quality of restoration and recognizability of signals.

The median filtration is a classical method of pulse interference suppression. Median filters (MF) can successfully liquidate pulse interferences. However, in this case they significantly distort the numerous sections of signals that are not affected by the interference [1–3]. That is why the development of methods ensuring the high quality filtration is a pressing problem.

A number of operator methods for reducing the pulse interferences are known [4–8]. On the basis of the methods developed one can build polynomial models of filters in the form of the Volterra truncated series [4, 5] and a polynomial of split signals [6–8]. Polynomial filters ensure a higher accuracy of signal processing as compared with MF [4–8]. The practical realization of polynomial filters does not pose any difficulties due to a swift growth of the performance of computers and digital signal processor. A poor causality of the system of equations solved during the approximation of a high degree nonlinear operator is a problem in the field of devices under consideration. This problem can be partially resolved by synthesizing polynomial filters by the splitting method in the frequency domain (when the approximation high-dimensional problem is divided into several approximation smaller-scale problems [7, 8].

This study contains a proposal to synthesize neural pulse interference filters, which are free of the problem of poor causality and have the accuracy in terms of signal restoration that is not inferior to polynomial filters. The synthesis of neural filters is executed over the class of two-dimensional signals (signals of transforms). The filter models are three-layer and polynomial perceptrons [9–11].

NONLINEAR FILTRATION PROBLEM AND ITS SOLUTION METHODS BASED ON NEURAL CIRCUITS

The problem of synthesizing the digital pulse interference filters can be solved within the framework of the "black box" principle [12], when filter operator F_s establishes a unique relationship between the set of input $x(n)$ $(x(n) \in X)$ and output $y^{\text{out}}(n)$ $(y^{\text{out}}(n) \in Y^{\text{out}})$ signals of the device

$$y^{\text{out}}(n) = F_s\left[x(n)\right],$$

where $n \in [0, G_n]$ is the normalized discrete time, G_n is the duration of input signals.