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DEEP LEARNING OF CONVOLUTION NEURAL NETWORKS IN IoT

The formation of the IoT environment is based on telecommunications (currently 5G and WiFi) and sources of information from sensors. This requires complex mathematical processing of large streams of signal information and can not do without neural networks. The main task is to create an architecture of information processing sources and connections between them. Convolutional neural networks with deep learning cope best with this. The possibility of creating an IoT environment is due to the miniaturization of the element base and quantum sources of information, especially in the THz range. For the first time, our team, where the Chief Designer was M. Kosovets, used elements of artificial intelligence in building on-board collection systems, information processing to achieve survivability of the aircraft, system fault tolerance, providing dependable calculations. It is impossible to solve these problems using known backup methods due to a lack of resources. But the solution was expensive and was used only in aircraft construction. Also the Boeing company followed this path. The neural network was called a distributed multiprocessor. Interesting analogies with the work of the human brain, especially latter publications of about the ensembles of neurons, homogeneity and heterogeneity of neuronal structures, reticularity and cognitive of the brain. Each stage of development of artificial neural networks uses algoritm the work of the brain, but the task is not to copiring working, but to build an IoT environment with the help of knowledge about neural networks.

The use of convolutional neural networks expands the capabilities of IoT radar sensors for mine detection, medicine, through-the-Wall radar, searching drugs, monitoring environmental pollution, etc.

A fundamental underlying concept of cognitive radar is the “Perception-Action-Cycle”. Cognitive radar continuously adapts its sensing parameters to the environment, in order to optimize its performance in a closed-loop fashion. The complex receive signal $y = y_{s,i} + w = (h_i + c) * s + w$ is represented by a convolution radiation of the waveform s with the target response **hi** and the clutter **c**. The concept of Matched Illumination maximizes the signal to noise ratio, under the constraint of an energy limitation Ex. The so called water-filling solution is defined respect to the power spectral density of the clutter Gcc (f) and the noise Gww (f).

$$|S(f)|^2 = \max[0, \frac{\sqrt{|H(f)|^2 G_{ww}(f)}}{G_{cc}(f)} (E_x - \sqrt{\frac{G_{ww(f)}}{|H(f)^2}})]$$

Because this solution does not provide further information about the waveform realization in time, algorithms like the minimization of a quadratic constraint has to be solved.

Artificial neural networks have been modeled based on theories and observations of the function and structure of neural synapses in the brain. It can be argued with good reason that general artificial intelligence can not only match, but also surpass human intelligence.

Radars have experienced parallel developments, and are particularly well suited for integration of cognition as they possess multiple degrees of freedom via waveform agility and electronically steered antenna arrays. An early, fundamental radar signal processing algorithm that embodies principles of cognition is the least-mean-squares algorithm. This approach enables an antenna array to adaptively form a main lobe, with its direction and beamwidth determined by a control signal, as well as place nulls so as to reject any unwanted signals or noise outside the main lobe, such that themean-square error isminimized.

Most modern CNNs have several of these layers, the final of which feeds into a fully-connected layer. Fully-connected layers are like standard feedforward networks in that they do not have a spatial layout or restricted connectivity.

Deep learning is a specific set of techniques from the broader field of machine learning that focus on the study and usage ofdeep artificial neural networks to learn structured representations of data.

Convolutional neural networks are built using a particular type of layer, aptly called the convolutional layer. These convolutional layers apply filters over the input data, oftentimes radio images represented as a two-dimensional matrix of values, to generate smaller representations of the data to pass to later layers in the network. These filters, like the previously mentioned traditional weights, are then updated throughout the training process, i.e., learned by the network, to support a given task.

Artificial neural networks learn higher-level features that are useful for class discrimination as training progress. By using visualization during the training process, there is potential to monitor one’s model as it learns to closely observe and track the model’s performance.