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Artificial neural networks application in medical images

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***Abstract*---**Diagnostic examinations through analog and numerical images are today the main method of diagnosing various diseases. Numerical images can be obtained with different methods depending on the technique used. Basically, any technique of obtaining medical images is nothing but the connection of a physical process of interaction of radiation with the subject / environment and with the help of the computer, these processes became visible through numerical images. Given the nature of the physical phenomena used and the lack of perfection of detection systems, the result is not perfect but is an estimate/price of "true value" which remains unattainable. Adding to this the human error during a medical examination, the patient's movements, etc., can flow very important artifacts, which must first be understood and analyzed and then using numerical methods, to correct them in the final version of the numerical image. This paper analyzes some numerical methods of numerical image correction such as interpolation and convolution, implemented in MATLAB program. In particular the interpolation technique is applied using Artificial Neural Networks (ANN), feedforward. The results are significant, as with some transformations, imaging technicians and physicians can manage to correct the defects that a medical image can carry during the process of obtaining them with the help of diagnostic equipment.

***Keywords*---**feedforward, medical images, neural networks, numerical methods, interpolation.

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Introduction

As is known in medicine we have two types of medical images: analogue and digital, Analog images are taken directly (through radiological films) and digital images obtained with the help of computer. A digital image is the coding of physical signal information which can be presented in the form of an image on the basis of an agreement under which a numerical value is put in correspondence a color or gray level. Digital image is then a table of numbers with L-rows and C- columns. [1]. We will assume that the images are square, where L = C = N. Each “box” image called “pixel “(picture element). Pixel located at row (l) and column (c) indicated (l, c), its value is written I (l, c). Rows are numbered from top to bottom and the columns from left to right, [6]; This unusual orientation of the coordinate axes is handy in computing. The basic characteristics of a digital image are spatial resolution and intensity resolution, [10].

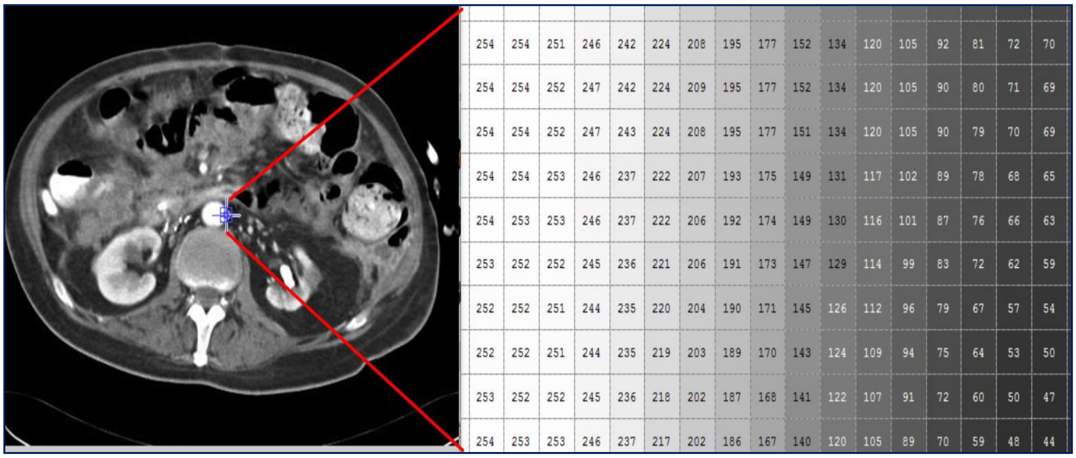

Figure 1. CT image, visualized with MATLAB

For a given image, the spatial resolution is determined by the number of columns and number of rows. Reduction of spatial resolution strongly aggravates image quality. Resolution in intensity is the number of different values that pixels can take, regardless of how they are presented visually / visual. This resolution (or depth) is expressed by the size of computer memory that takes the appearance of each pixel. Corresponding values obtained by means of interpolation starting from the known values. Artificial Neural Networks are sets of one or more neuron layers connected to each other. A layer contains one or more neurons. Each neuron represents a known transfer function f (the most known functions are: *hardlim*, *purelin*, *logsig*, *tansig*) where the input quantity p (scalar or vector) is transmitted through a connection that multiplies it by the weight w (scalar, vector or matrix) and adds a bias b (like a weight that has a constant input of 1) and the output a (scalar or vector) is $a = f\ (p \cdot w + 1 \cdot b)$. w and b are both adjustable parameters of the neuron. Commonly neural networks are adjusted, or trained, so that a particular input leads to a specific target output.

Materials and Methods

As we mentioned before the network is adjusted, based on a comparison of the output and the target, until the network output matches the target, [7]. The NN used for medical image preprocessing (image reconstruction and image restoration are; Hopfield NN, Feed forward NN, Self-organizing map NN, Fuzzy NN, Cellular NN etc., [10]. Digital images can be obtained with different methods depending on the technique used. The most important techniques of obtaining digital medical images are computed tomography (CT), Magnetic Resonance (MRI) and Positron Emission Tomography (PET – CT), [3]. During the processes of archiving of medical images, many factors affect quality of medical images; such are the patient's movements, non-perfect instruments and human errors, etc., can derive many important artifacts, which initially must be understood and analyzed for correction of these artifacts. Interpolation method, used to present a magnified portion of a digital image (zoom) or to reconstruct an artificial image in a given direction, starting from a series/sequence of images recorded in one direction. An interpolation of values is necessary for the presentation "natural" to enlarge a portion of a digital image. Interpolation lies in the transformation of the values of pixels of each tile in order to give the impression of continuity, [8], [9]. In this paper we will use ANN to improve the resolution and to fulfill the missing data in MRI and CT images. We will estimate the values of "missing pixels" in the medical image, removing these values and replacing with calculated values from NN. As we mention above, the main goal of our work is to show the possibilities of using ANN on correction of defects and artifacts of medical images. Let's suppose that our image (CT abdominal, figure 1), has a defect (white point as is shown in figure 2 a, and contoured area in 2.b). In MATLAB we can read the image with "imread" function and we can convert it into a matrix A (1583 x 2171) with values for each αij = [0 - 255] of gray level. All values of pixels on the countered area must be replaced with right values calculated by NN. In MATLAB we can interpolate with functions; interp2 which can be used for 2D interpolation, supports nearest, linear, cubic and sinc interpolation. For higher dimensions we can use *interp3*, *interpn*. Also, we can use *imfill* function to fill the holes in a binary image [www.amthworks.com]

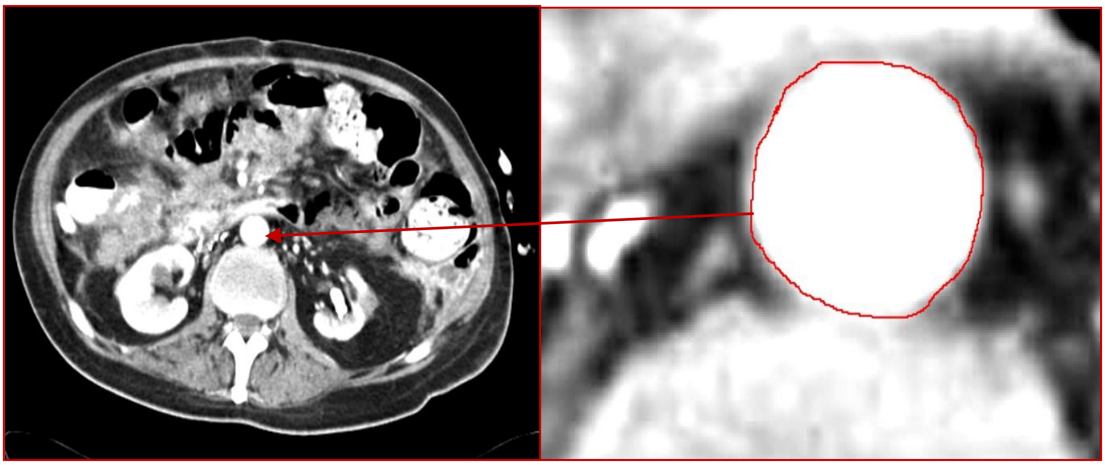

Figure 2. Contoured structure of medical image whose values will be recalculated

The first problem is to remove the values of pixels outside the image because (with 0 value) these values can influence on NN training process. Image resolution R is 3436693, where 1341616 pixels have the value = 0, [10].

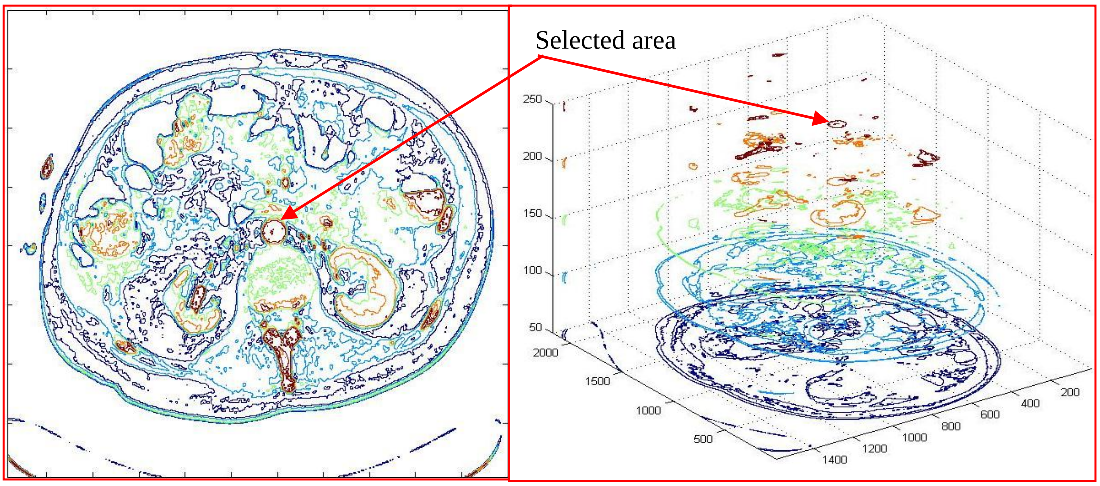

Figure 3. Segmentation of image in 2D (a) and 3D (b) in MATLAB

To consider only the pixels inside the image we apply the segmentation process to this image using "*contur2*" (2D) function in MATLAB. This function displays isolines of matrix A. Image will subdivide into constituent regions or objects as is shown in figure 3.a. Outside contour, includes all pixels of the CT image. "*Contour3*" (3D) function, draws the contours plot of matrix A in a 3D view. The number of contour levels and the values of contour levels are chosen automatically based on the minimum and maximum values of the pixels as is shown in figure 3.b. From the A matrices we get a number n = 1257 of row vectors with different dimensions *i*. These are the data which we use as inputs for NN. As we know, an artificial network performs in two different modes, learning/training and testing. During learning, a set of examples/values is presented to the network. At the beginning of the training process, the network 'guesses' the output for each example. However, as training goes on, the network modifies internally until it reaches a stable stage at which the provided outputs are satisfactory. Learning is simply an adaptive process during which the weights associated to all the interconnected neurons change in order to provide the best possible response [7]. We used feed-forward back propagation (*ffbp*) neural network (GUI of *nntool* in MATLAB). It consists of the layers, input, hidden and the output layer. The input and target samples are automatically divided into training, validation and test sets. The training set is used to teach the network. Training continues as long as the network continues improving on the validation set. The test set provides a completely independent measure of network accuracy. The information moves in only one direction, forward, from the input nodes, through the hidden nodes and to the output nodes, [2]. In our case as inputs, we can use all vectors (all values in a row or in a column). The center of our selected area on matrix A is pixel *aij*(750, 1015), and the borders/limits left/rights and up/down of this area are: row: *l1* = A' (697, 1:2171), *l2* = A' (802, 1:2171), column: *c1* = A' (1:1583, 949), *c2* = A' (1:1583, 1073), (figure 4).

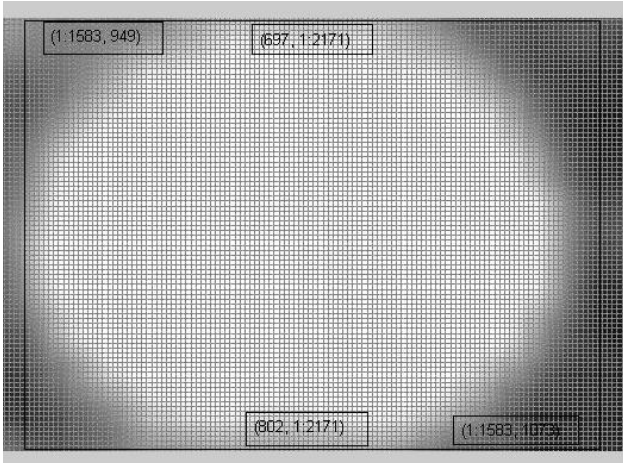

Figure 4. Coordinates of pixels which will recalculated by NN

Results and Discussions

The most important process during the NN run, is calculation of weights or NN training process. During the learning process, weights in a network are adapted to optimize the network response to a presented input. In our case are the vectors *l1, l2, c1, c2*. The way in which these weights are adapted is specified by the learning rule. In the figures 5 - 8 are shown the plots in comparative way between the real values of the area contoured and calculated values by *ffbn* in the center of selected area (vertical and horizontal calculation).

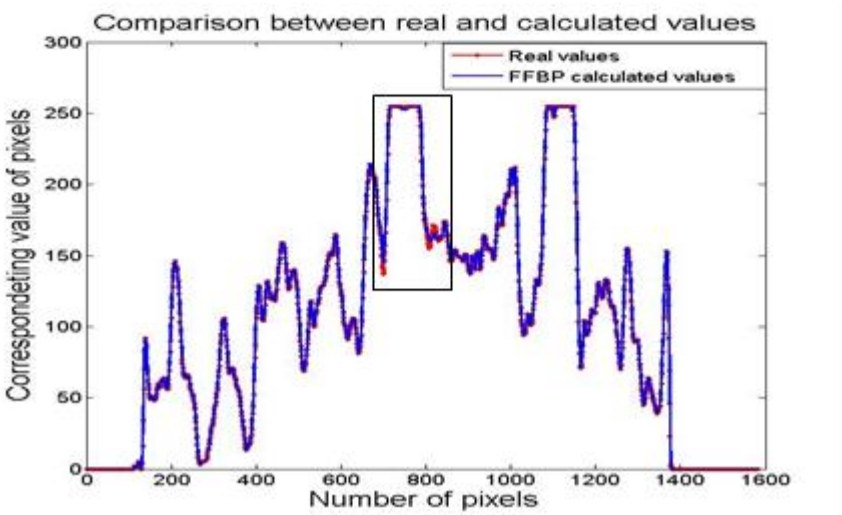

Figure 5. Comparison between real and calculated values (vertical values)

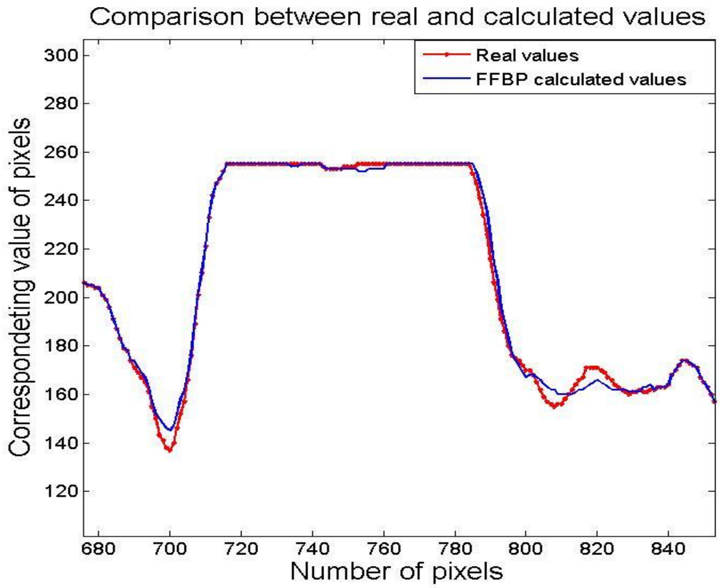

Figure 6. Calculated values for the column in center of contoured area.

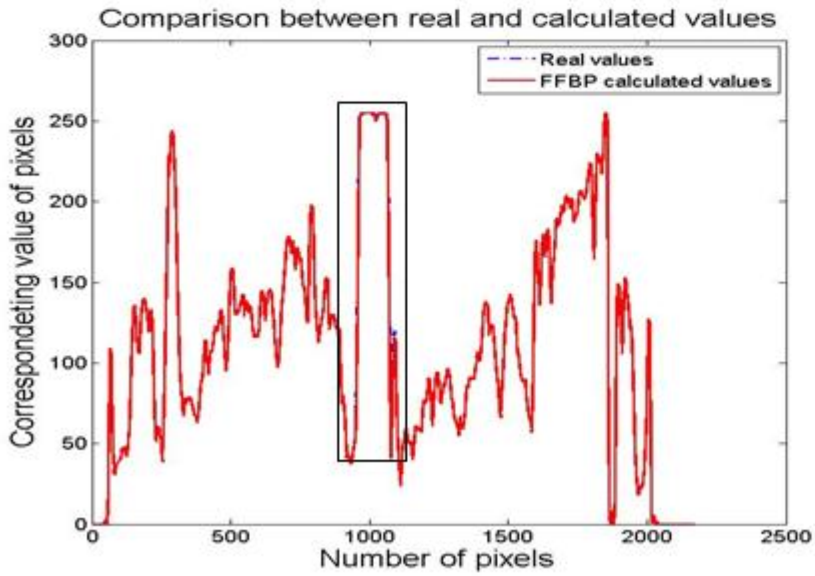

Figure 7. Comparison between real and calculated values (horizontal values).

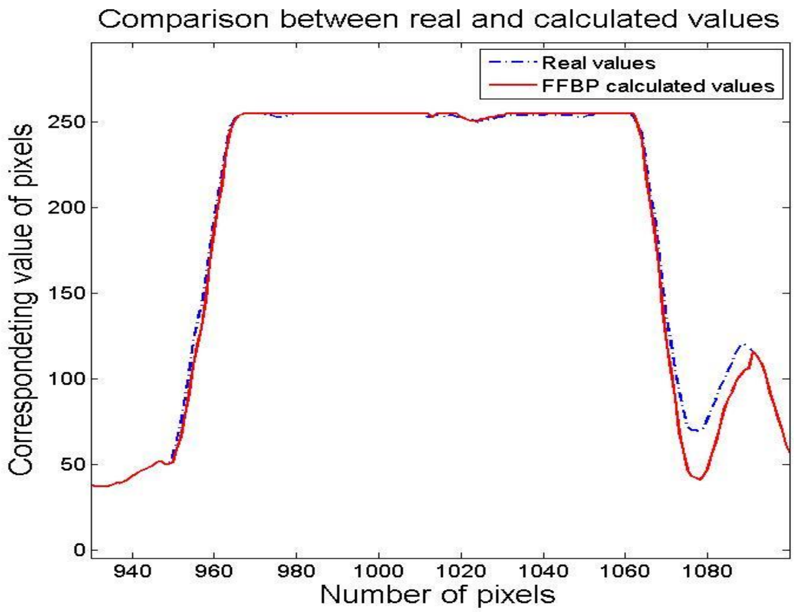

Figure 8. Calculated values for the row in center of contoured area.

As we can see on above plots, calculations values of this NN are approaching to realistic values. In the same way we can calculate all pixel's values in contoured area. When we have a large number of pixels as in our case, this process is difficult and takes time. We will focus on these topics in the future by developing a function which will include all steps of calculations.

Conclusions

Neural networks have been applied within the medical domain for clinical diagnosis, image analysis and signal analysis. The applications presented above describe a using of feed forward artificial neural network in medical image processing. As we show, by using these methods, it's possible to eliminate artifacts of image. Also, visualization of the new image which is much closer to the desired. This way gives opportunities to radiologist and technicians to use different methods for visualisation and completion of missing data in MRI and CT images. Especially in diagnostic and radiotherapy, it's possible to use NN for tumour diagnosis or calculation during tumour treatment.

Acknowledgments

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Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Both authors, D. Xhako and N. Hyka have contribute both in carried out the research and the corresponding author has written the article, but being consulted with the other author, N. Hyka.

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