EXPERIMENTAL INVESTIGATION ON SPACE CONFIGURATION AND INFLUENCE OF ELECTROMAGNETIC FIELD OF MICROWAVE APPARATUSES IN MEDICAL THERAPY

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Abstract

The application of microwave equipment in medical therapy is well known. The frequency band of these devices is 2 to 3 GHz. These frequencies and wavelengths are most effective and allow for a much deeper and more reliable results. In the experimental set-up used an antenna with a circular emitter. The antenna system provides the effect of the electromagnetic field of a small part of the human body. Because the distance between the antenna system and the living tissue is very low, it is difficult to determine the electromagnetic field distribution of values and the power of the field in the region of the patient. It's difficult to be provided one exact mathematical description of electromagnetic field in this area taking in account deformation of this field because of live tissues additionally. Because of that one experimental investigation of electromagnetic field in the patient's area would be useful in this case.

The obtained results can be connected with X-ray images of respective alive tissues. X-rays are especially useful in the detection of pathology of bony structures. These images are no truly isotropic and its quality varies depending on penetration of X-rays in the anatomical structures and on the technologies of their obtaining. In most cases they need to be enhanced. This investigation is also the goal of the paper.

1. INTRODUCTION

At the high frequencies of electrical field, the polarizing molecules fail completely to change their spatial orientation and vibrations occur of the dipoles around neutral position. This process is associated with generate the heat. In microwave therapy, the patient is set in electromagnetic fields with frequencies a few GHz, which means that the wavelength is from 10 to 70 cm. The energy of microwaves, absorbed from the body tissues, is converted into heat, significantly more effective than the energy of longer wavelengths.

2. THEORETICAL SOLUTION

The effects of microwaves on the patient's body can be achieved by dipole antennas with hemispherical or semi-cylindrical reflector. Reflectors are placed directly on the area, which has to be heated, or at some distance from it. Reflectors can be closer or further away, so they can adjust their distance to the skin, which must be 2-10 cm. When determining the shape of the area of the plane, which the simulation is performed, the main consideration is the reporting of the configuration of the antenna's system, and its deployment of the appropriate part of the patient area. [1]

Figures 1a, 1b, 1c illustrate the most commonly used antennas in microwave physiotherapy. Figure 1a depicts the antenna, which the research is doing, namely comical antenna or "circular field" antenna, which is used mainly for localized joint (e.g. elbow, wrist, knee, instep) and pediatrics applications. Figure 1b shows rectangular antenna or "long rectangular field" antenna: used for treatment of larges areas (rachis, upper and lower limbs, etc.) and figure 1c: three dimensional antenna or "surrounding field" antenna: mainly used for shoulders, neck and rachis.

It is apparent that the reflector radiator may have an arbitrary location in the space according to the treatment area of the patient's body. In order to facilitate and accelerate the sampling, streamline and simplify the calculation is appropriate the area of space to be approximated by regular geometric figure. This would allow using the available symmetry for an optimization the developed algorithms for sampling and calculation. We also use geometric figure should cover the maximum radiating surface. If we use the formal requirement of symmetry suitable plane figures are rectangle, square, circle. This coincides with the usual forms of radiation surfaces. The following figure 2 shows the change of the power density in a plane transverse to the axis of the transmitter (antenna) in a nearby area where the black dots are the maximum of the directional diagram. [4]

a)

b)

c)

Figure 1. Antennas for microwave therapy

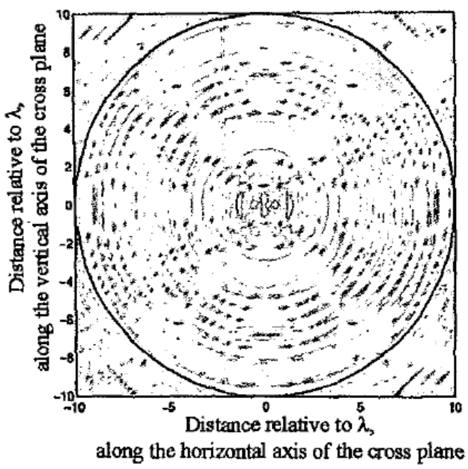

Figure 2. Modification of the power density

3. RESULTS AND ILLUSTRATION OF THE EXPERIMENTAL INVESTIGATION OF THE ELECTROMAGNETIC FIELD

Experimental measurements of the physical power of the electromagnetic in nearby area under real clinical conditions were incurred in connection with the article. Measurements were performed in the usual regimens used in the process of therapy, namely continuous transmission mode of the electromagnetic field. Figure 3 shows the experimental setup for these measurements. To facilitate the measurement and interpretation of the results was used and graphical representation.

Figure 3. The image of the experimental set-up

The measurements of power density were held at various points along the patient bed. The aim of the measurements was to study the spatial configuration of the electromagnetic field in the near zone of antenna's system (patient area). In this sense, it can be handled with relative units of power. Of course these values are related to the absolute values with an accuracy of one coefficient. In Table 1 are shown in relative units of the measured power values of the field along the length of the patient bed in parallel to the measuring antenna, and Figure 4 shows the measurement results graphically of the field, enhancement at 20dB and 29dB, with parallel placement of the measuring antenna.

Table 1. Relative values of the measured power P

Lenght, cm	-30	-27.5	-25	-22.5	-20	-17.5	-15	-12.5	-10	-7.5	-5	-2.5	0
Power P, relative units, 20 dB gain	1.75	2.5	4.2	4.7	7.1	10	11.9	9.8	7.2	4.7	4.2	7	9.4
Power P, relative units, 29 dB gain	3.6	4.7	3.6	3.8	4.4	6.9	7.45	11.1	10.2	10.3	14.75	19.7	19

Lenght, cm	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30
Power P, relative units, 20 dB gain	7.1	4.2	4.8	7	10	12	10	7	4.5	4.3	2.5	1.7
Power P, relative units, 29 dB gain	19.8	14.7	10	10	11	7.5	6.9	4.5	4	3.7	4.7	3.5

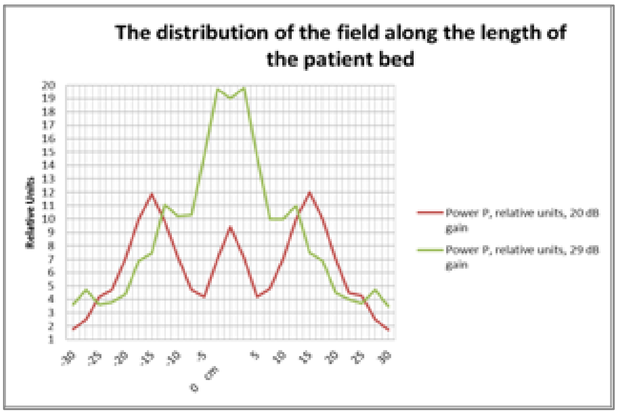

Figure 4. Graph of the measured values of the power P

Normal applications of the heat treatment are generally used to treat the following conditions: reduction of pain, improvement in collagen extendibility, reduction in articular rigidity, reduction of oedema and inflammatory exudates and increase in blood flow. [2]

4. X-RAY IMAGE ENHANCEMENT

The results of magneto therapy can be seen below, using X-ray images.

An "artifact" on a diagnostic X-ray image may appear as light or dark spots, lines, fogging, specks, etc. They can be caused by motion, poor contact between the film and the cassette that holds the film, and so on. The quantum noise is dominant and comes from the quantization of energy into photons. It is Poisson distributed and independent of measurement noise. The measurement noise is additive Gaussian noise and usually negligible relative to the quantum noise.

An integrated adaptive approach is presented to enhance the quality of the X-ray image. The algorithm consists of three basic stages [4].

The first stage is increasing of contrast based on contrast limited adaptive histogram (CLAHE). It is a generalization of ordinary histogram equalization and adaptive histogram equalization. CLAHE does not operate on the whole image works like ordinary Histogram Equalization (HE), but it works on small areas in images, named tiles. Each tile's contrast is enhanced, so that the histogram of the output area roughly matches the histogram determined by the 'Distribution' parameter.This parameter can be selected depending on the type of the input image. The presented algorithm proposes to select this parameter adaptively on the base on PSNR. For limiting the maximum slope is to use a clip limit contrast factor that prevents over-saturation of the image specifically in homogeneous areas. These areas are characterized by a high peak in the histogram of the particular image tile due to many pixels falling inside the same gray level range. The procedure of CLAHE can be applied to Y component of the selected image that is processing in YUV system as more effectiveness. The second stage is morphological processing for detail preservation capabilities. Local structures can be eradicated or local geometry of the inspected object can be customized by appropriate selection of opening and closing filtration, top and bottom hat filtration and proper form of structuring elements and its parameters. All these elements of the procedure of morphological processing can be determined on the base of the calculated estimation parameters.

The third stage of the algorithm is noise reduction. It is based on the 2D wavelet packet methods and adaptive threshold. The classical entropy-based criterion is a common concept for optimal decomposition. It is used spatial adapted threshold that allows to determinate the threshold in three directions: horizontal, vertical and diagonally. In addition the threshold can be hard or soft. The noise reduction is applied on Poison distributed noise components, which can be presented as an additive noise model for each pixel.

All adaptive procedures in the proposed algorithm are made automatically, based on calculated estimation parameters such as PSNR, Signal to noise ratio in the noised image (SNR_Y), Signal to noise ratio in the filtered image (SNR_F), Effectiveness of filtration (E_{FF}) Noise reduction ratio (NRR) in the different stages of the algorithm. PSNR and E_{FF} values are higher for better denoised X-ray image where the value of NRR is lower.

The formulated stages of processing are presented by computer simulation in MATLAB, version 7.14 environment with using the IMAGE PROCESSING and WAVELET TOOLBOXES. The obtained results for the investigated X-ray image of the foot are presented in Table 2.

Table 2. Simulations results

Method of processing	Estimations Parameters				
	PSNR [dB]	NRR	SNR_Y [dB]	SNR_F [dB]	E_{FF} [dB]
CLAHE	24.325				
Morphological processing	27.684	0.5	14.949	16.556	1.607
Noise reduction based on WPT	29.688	0.3	16.556	18.471	1.915

Visual presentations of the original and processed X-ray images are given on Figure 5.

Figure 5. Original and processed X-ray images

The corresponded histograms of the original and processed by CLAHE method image are presented in Figure 6 and Figure 7.

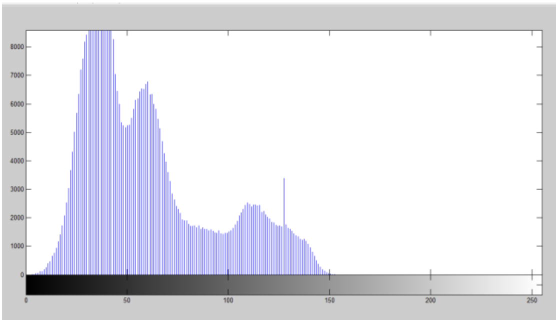

Figure 6. Histogram of the original X-ray image

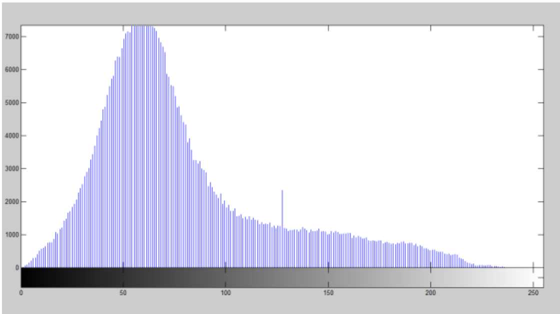

Figure 7. Histogram of the processed X-ray image

5. CONCLUSION

We can say that the study of the characteristics of electromagnetic field in the nearby area along with the study and optimization of the space-time configuration of the electromagnetic field are very important and crucial for achieving the desired therapeutic effect. X-rays are widely used in medicine for various graphics and scopic studies in order to obtain an image. In our case, they are used for the representation of the bone structure in the patient. For the improvement of their quality, different methods were used, one of them is shown in the article.

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