

# Effectiveness assessing of softwares with AI for chest area x-ray images post-processing.

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**Abstract**—Diagnostic radiology is a branch of medicine describes of ionizing radiation using to study the structure and functions of normal and pathological altered human organs and systems for the prevention and detection of diseases. X-ray irradiation is the most common diagnostic method in Radiology and it makes possible to identify and diagnose diseases and injuries for further treatment of patients.

In particular, development of artificial intelligence (AI) has led the creation of different software for X-ray images processing to improve pathologists recognition by operator. At this moment there are lots of means and methods have been developed by different software engineers to find out "the perfect solution" for this problem.

Respiratory diseases occupy one of the leading places in Ukraine. The main share of pathologies is acute viral infections, bronchitis, pneumonia and tuberculosis. In one year, about 15.5 million chest X-ray studies perform in Ukraine only for tuberculosis detection. It was the reason to select chest X-ray studies for processing's effectiveness assessing.

For effectiveness assessing we have made quantitative contrast measurements for selected areas on original and processed chest X-ray images.

**Keywords**—X-ray, tomosynthesis, digital radiology, contrast deviations, AI

contrasted structures such as lung tissue, fragments of the bronchial tree or blood vessels.

The similar technique was proposed in this article.

There are persist a lot of different software post-processing package which are believed as affective but those should be checked in the most interesting chest areas were selected or agreement with radiologists.

Different image processing packages using now leads to different diagnostic sensitivity of X-ray examinations.

It is noted in the existing literature that the diagnostic sensitivity for chest pathology is amount from 0.2 - 0.3 for oncological formations and 0.5 for tuberculosis relative on CT examinations.

CT examinations are considered as "gold standards" and equal 1, however, it is accompanied with height exposure dose for a patient.

Observed values for diagnostic sensitivity are consistent with the most effective post-processing software.

Despite this, from 50 to 70% of examinations do not identify pathologies. Thus, on the one hand the relatively low efficiency of radiographic examination requires continuous post-processing algorithms improvement and, on the other, development effective X-ray chest examination techniques like Tomosynthesis and CT [3-9].

## I. INTRODUCTION

In particular, artificial intelligence development has led to the creation of different software for X-ray images processing which should improve visual perception and pathology recognition on chest X-ray images [1,2].

To compare processing effectiveness it is necessary to have quantification method of different type for image processing.

It is necessary that such quantitative assessment be carried out on the most interested chest areas selected by doctors. Due to agreement with radiologists there have been selected four the most important parts on X-ray chest images and those parts are listed below.

The effectiveness assessment can be carried out by contrast measuring on the rather large objects or small

## II. MATERIALS AND METHODS:

Due to agreement with radiologists there have been selected four the most important areas (Fig. 1) to get contrast quantitative measurement for the following parameters:

1. Lumbar spine contrast against of the stomach background;
2. The gas bubble contrast in the stomach;
3. The lung tissue structure contrast in the sinuses;
4. Pulmonary structures contrast in the lungs roots region.

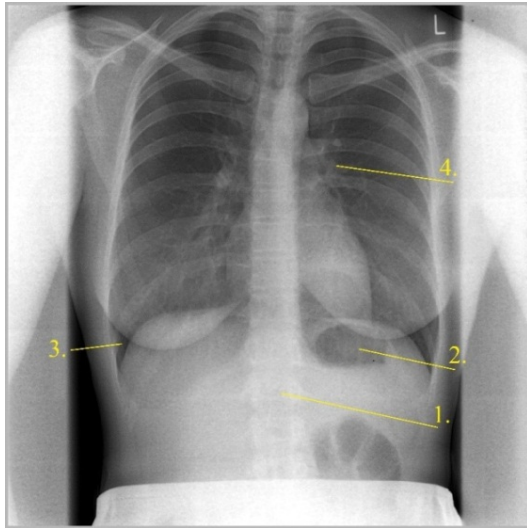


Fig. 1. Selected measuring points

In accordance with this, it was proposed to measure objects brightness ratio against to the surrounding background for area 1 and 2, and signify the measurements results as contrast value  $k_{1,2}$ :

$$k_{1,2} = (B_o - B_b) / B_b, \quad (1)$$

where  $B_o$  – object brightness;

$B_b$  – background brightness.

In areas 3 and 4 - to get measurements of the relative brightness of fine-grained objects on surrounding background, and signify them as contrast deviations -  $k_{3,4}$ :

$$k_{3,4} = \sigma / B_b, \quad (2)$$

where  $\sigma$  – fine-grained formations brightness.

Thus, the measurements were carried out in the selected image areas that were interest for radiologists during patient examinations.

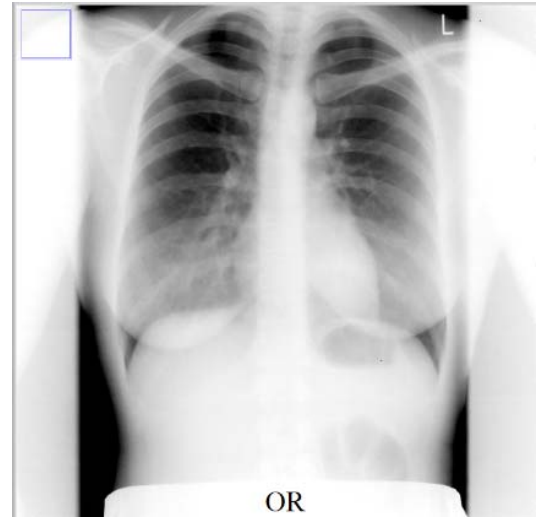
The study's objective was evaluation of contrast deviation increment on processed images that characterize the observability of lung tissue in the segments and lumbar spine contrast, as well as the gas bubble relative to the background.

The effectiveness of software with artificial intelligence can be evaluated with the contrasts comparing on original images, images processed by the reference program and images processed by test program. (Figure 2).

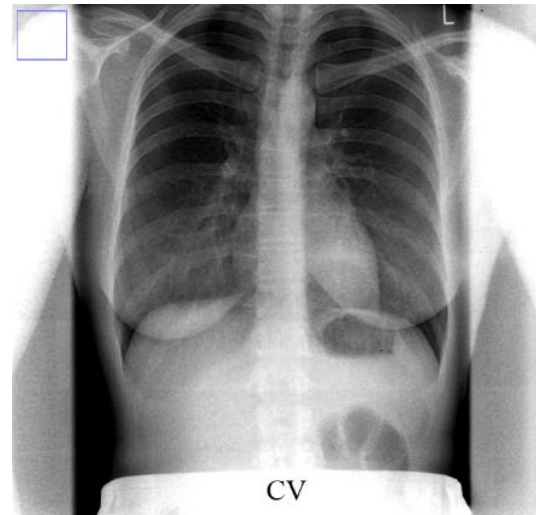
The Context Vision software was chosen as referent software.

With three decades of experience in medical imaging, ContextVision continues to set new standards with the versatile GOP technology at its core. The GOP technology involves a large set of contextual operations that can easily be cascaded. These contextual operations are based on consistent information representation computed from the image. The GOP representation is divided into a hierarchical computing structure, and filtering is performed with large and optimized filtering kernels. GOP is inspired by the human visual system in the way it finds information and

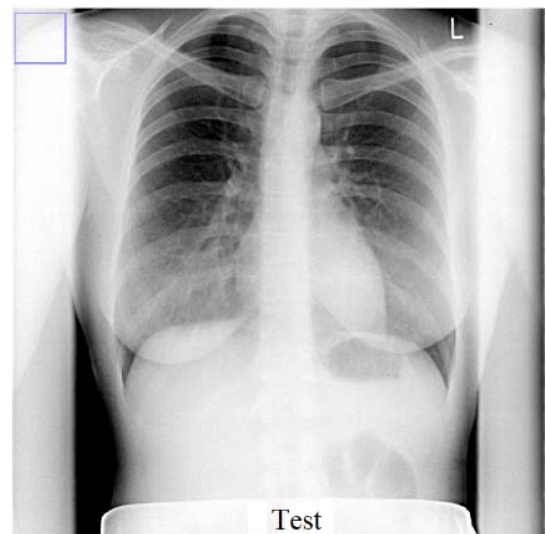
analyzes structures. With this method, we can separate objects from background, based on texture. GOP software is the basis of our image enhancement software products.



a)



b)



c)

Fig. 2. a) original image, b) image processed by the reference program c) image processed by test program

Today they train machines to recognize objects by feeding a range of images into a deep network, which then predicts an output. The output of the network is compared with the correct answer and a feedback signal updates the weights in the network until predictions are sufficiently correct.

ImageJ was used for measurements. Comparative results are given below separately for female chest images (Table 1) and separately for male chest images (Table 2).

TABLE I. FEMALE CHEST IMAGE

	Chest images					
	<i>I(5)NO</i>	<i>I(5)TEST</i>	<i>I(5)CV</i>	<i>I(9)NO</i>	<i>I(9)TEST</i>	<i>I(9)CV</i>
<b>Spine</b>						
m	15360,0	30552,7	12233,5	15348,6	24500,3	13786,0
Background	15346,6	30682,9	11571,0	15337,3	24979,4	12962,3
$\Delta$	13,4	130,2	662,5	11,3	479,1	823,7
k	0,09%	0,42%	5,73%	0,07%	1,92%	6,35%
<b>Blowhole</b>						
m	15314,6	32279,5	7259,1	15317,4	25407,1	11792,6
Background	15384,3	30922,5	10938,8	15337,6	24918,8	12855,1
$\Delta$	69,6	1357,0	3679,7	20,1	488,3	1062,5
k	0,45%	4,39%	33,64%	0,13%	1,96%	8,27%
<b>Pulmonis</b>						
m	15224,2	35417,3	5247,9	15114,3	32001,4	5917,4
$\sigma$	26,09	632,47	580,22	40,71	1391,17	780,07
k	0,17%	1,79%	11,06%	0,27%	4,35%	13,18%
<b>Sinus</b>						
m	15238,9	36485,69	4179,93	15290,2	24992,23	8655,85
$\sigma$	32,77	512,89	539,40	894,70%	202,27	183,35
k	0,22%	1,41%	12,90%	0,06%	0,81%	2,12%

TABLE II. MALE CHEST IMAGE

	Chest images					
	<i>I(17)NO</i>	<i>I(17)TEST</i>	<i>I(17)CV</i>	<i>I(35)NO</i>	<i>I(35)TEST</i>	<i>I(35)CV</i>
<b>Spine</b>						
m	15347,1	29480,0	12903,4	15345,9	25135,3	14237,1
Background	15329,8	29696,8	12188,5	15338,0	25143,8	13872,2
$\Delta$	17,4	216,8	715,0	7,9	8,5	364,9
k	0,11%	0,73%	5,87%	0,05%	0,03%	2,63%
<b>Blowhole</b>						
m	15207,0	33942,4	6642,6	15151,5	30548,9	7123,1
Background	15304,8	31210,1	8956,3	15303,2	26118,0	11931,5
$\Delta$	97,80	2732,4	2313,7	151,7	4430,9	4808,4
k	0,64%	8,75%	25,83%	0,99%	16,97%	40,30%
<b>Pulmonis</b>						
m	15061,1	37939,7	5348,8	14959,0	29759,4	5473,6
$\sigma$	46,3	1375,8	649,8	41,2	4492,8	484,9
k	0,31%	3,63%	12,15%	0,28%	15,10%	8,86%
<b>Sinus</b>						
m	15155,6	36152,8	5912,8	15147,0	30300,9	6967,8
$\sigma$	16,7	886,2	468,5	28,4	565,6	508,4
k	0,11%	2,45%	7,92%	0,19%	1,87%	7,30%

For this objective we selected total 40 images with chest study (20 male and 20 female). All of those images were grouped to section 1 which includes only chest images. From this section 1 we selected for data providing only 4 images with numbers 5, 9 for female table and 17, 35 for male table.

### III. DISCUSSION

Based on an analysis of this research the special attention was paid to required excess of 5% contrast which is taken as the boundary of confident observability of selected objects according to Weber – Fechner law. The principle that the intensity of a sensation varies by a series of equal arithmetic increments as the strength of the stimulus is increased geometrically.

On original images usually object can be observed at the limit of visual perception. Objects contrast is not higher than 1%, however on processed images we can see that object contrast is increased which can be approved by numerical measurements and for referent software it is amount from 2% to 35%. The summarized results from data showed in tables are presented on Figure 3.

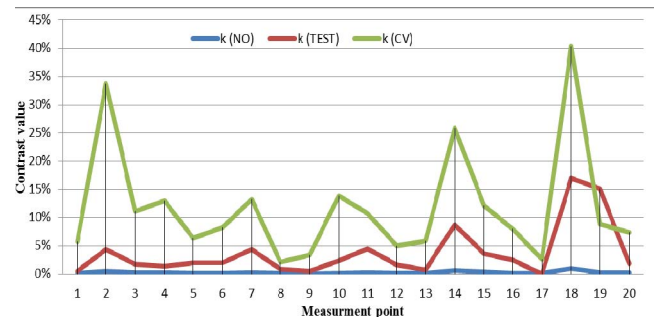


Fig. 3. Summarized results for quantitative contrast measurements

Study results have verified the post-processing software effectiveness for images. According to quantitative contrast measurements on processed images the testing software has given contrast increase for four times, but this result has not given visual reception improvement at the same time referent software has shown quantitative contrast measurement increase and visual perception improvement.

In any way it should be keep in mind that original image contrast is dependent from way how they were obtained. Contrast on images that were taken with digital tomosynthesis is in 6-9 times higher than on radiographic images [10].

It is approved with different researchers that digital tomosynthesis has much better diagnostic accuracy for lungs pathologies detection than radiographic images, and it uses not too height radiation dose. Tomosynthesis, as a clarifying technique, in most cases makes it possible to exclude or confirm the presence changes in the lungs which were detected on radiographic images. Moreover, it can be used for assessing the state of pulmonary tuberculosis changes during therapy. Layer by layer visualization for digital tomosynthesis gives radiologist possibility to detect too small but very important for dynamic observation of pathological changes in lungs.

Comparison of the effectiveness of radiation diagnosis for patients with respiratory tuberculosis showed that digital tomosynthesis method is exceeds traditional radiography in sensitivity [11].

For CT images even more contrast is characterized.

Digital tomosynthesis slices are different from digital radiography images and CT image in appearance. They are contain details of equal definition of full image field on digital radiography image and CT image. On image was taken with digital thomosynthesis part of image is occupied by clear x-ray image of the layer at a certain depth and another image part is a sum of defocused and attenuated images from the nearest layers [11].

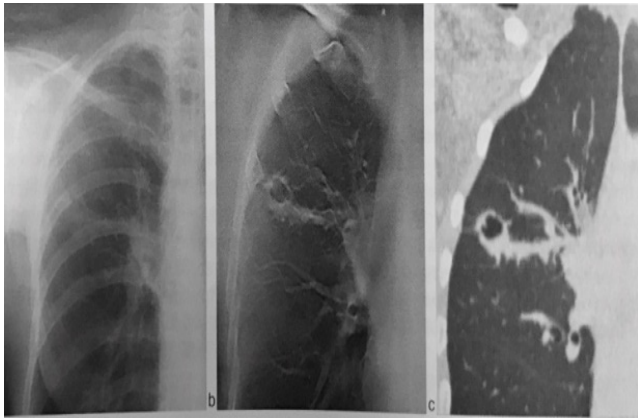


Fig. 4. Chest x-ray images

At the same time, it is possible to use software with artificial intelligence processing to both Tomosynthesis and CT.

Unfortunately, radiation dose for more detailed exams is in a few times higher for patient. Thereby, digital thomosynthesis chest exam is going with 3-5 times radiation dose increased comparing to chest digital radiography. And it takes radiation dose in 10 and more times higher for chest CT exams [12].

TABLE III. TYPICAL EFFECTIVE DOSES FOR X-RAY EXAMS.

Type of chest exam	Regular effective doses, mSv	Equivalent amount for chest x-ray	Approximate equivalent of natural background dose
Digital Radiography	0,02	1,00	3 days
Digital Tomosynthesis	0,1-0,2	1,0	<30 days
CT	2,0-8,0	100-400	3,6 years

So, based on this study results, digital radiography using is still actual for chest exams, especially for children.

Image contrast comparison for the test and reference post-processing software leads to the fact that contrast on the test program is 3 times smaller than the typical program.

Referent and test software comparing (Table 1,2) shows that images processed with test software has contrast and contrast deviation in 3 times less than referent software. Non optimal settings for test software are the most possible reason for this result. There is a possibility that presets modifying will make the difference between those softwares insignificant.

## IV. CONCLUSIONS

The methodic described at this article allows to evaluate the effectiveness of post-processing software.

In this case, quantitative estimates of the post-processing effectiveness can be obtained. Such estimates are based on the most important chest images areas selection according to diagnostics point of view.

It is proposed to use as such areas: contrast of the lumbar spine against the background of the stomach; gas bubble contrast in the stomach; contrast of the structure of the lungs in the sinuses; pulmonary structures contrast in the area of the lung roots.

Depending of used software contrast on processed images can be increased in 15-45 times.

According to radiologists' estimates, contrast increasing allows to improve pathologies observability on chest X-ray images.

The reference software is almost 3 times superior then test software by contrast increasing at the selected object.

Using these contrast and contrast deviations measurements gave us similar results and confirmed improvement for both quantitative measurements and visual perception. This technique can be used with similar assessments in the future.

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