National Technical University of Ukraine "Kyiv Polytechnic Institute" Faculty of Biomedical Engineering Department of Biomedical Engineering

Diploma thesis
for bachelor's degree
in the specialty 163 "Biomedical Engineering"
on the topic:

The method of estimating the size oncological neoplasms on MRI-images of the heart

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Topicality

- The need to increase the likelihood of early diagnosis of tumors and the development of new, more effective approaches to their treatment.

- Automation of the diagnostic process of detection of cancer in the heart to increase the likelihood of diagnostic findings.
- Reduction of the dependence of the diagnostic conclusion on the experience and psycho-emotional state of the doctor, an objective assessment of the functional state of the myocardium from the knowledge of typical features, own experience in the analysis.

Purpose and tasks

- **The purpose of the work:**

Automation of detection of cancer on MRI images of the heart to increase the probability of early diagnosis of tumors.

- **Object of study:**

Computer analysis and digital segmentation of malignancies on MRI images of the heart.

- **Task:**

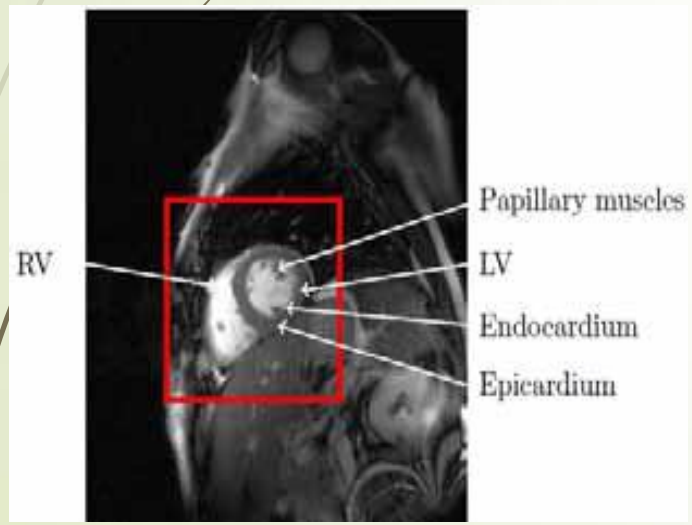
1. Analyze scientific information regarding the current state of segmentation and imaging of cancer on MRI images of the heart;
2. To develop an algorithm for segmentation of malignant neoplasms in the myocardium and visualize the contours of cancer on the MRI images of the heart;
3. Conduct clinical studies of a software algorithm for the determination of tumor contours on MRI images of the heart.

Theoretical foundations of the study

- Research on the analysis and interpretation of MRI images of the heart:
  - publications on MRI imaging techniques
  - clinical manifestations of heart mix and complexity of their diagnosis
- Visual and computer diagnostics problems:
  - image segmentation methods and principles
  - methods of automatic tumor segmentation
- Experimental testing of the method:
  - algorithm for the operation of the Canney loop detector
  - clinical trials of MRI imaging
- Startup project:
  - technological audit of the project idea
  - marketing program for a startup project

Research materials

- clinical base of MRI images of the heart
- Canny's software algorithm
- visualization of the contours of tumors on MRI images



Quantitative characteristics of segmentation methods:

- RV mass of ventricular myocardium;
- LV mass of ventricular myocardium;

Algorithms for visualization of tumors:

- the use of the Hoff transform;
- pixel Fourier transform.

Figure 1 - Full-size short-term MRI cardioimaging

GENERAL INFORMATION ON MIXED HEART

Morphological features of tumors

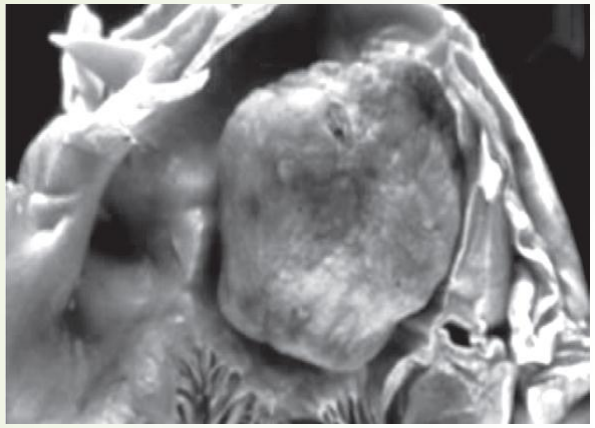


Fig. 2 - Myxoma of the heart

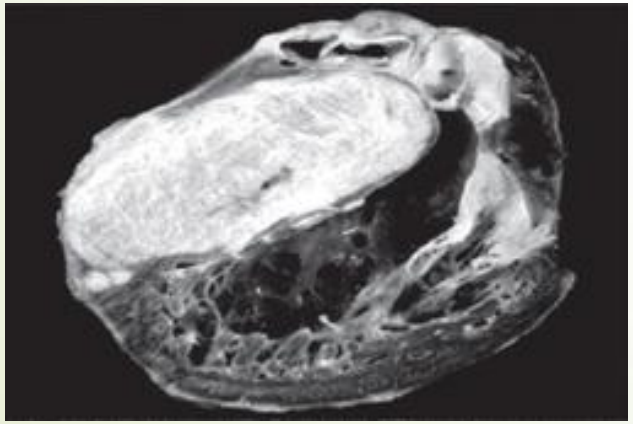


Fig. 3 - Fibraxoma of the heart

Methods for the diagnosis of tumors

Fig. 4 - Echocardiogram of myxoma

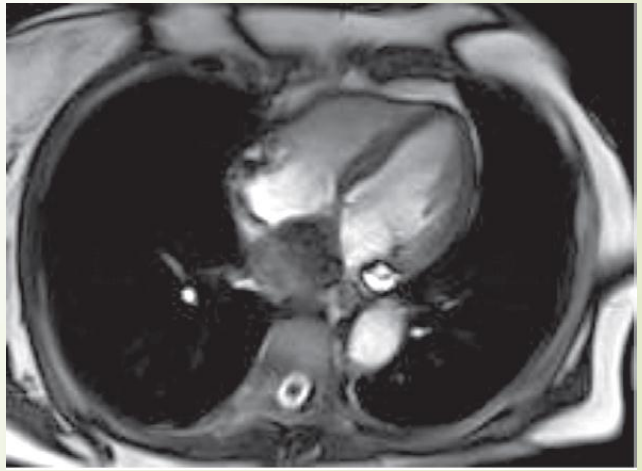


Fig. 5 - MRI of myxoma

GENERAL INFORMATION ON MIXED HEART

Highly sensitive and highly specific research methods:

- MRI diagnosis of the heart;
- Contrast CT diagnosis of the heart.

Conclusions:

1. The methods help to evaluate the character paracardial structures;
2. Determine the presence of tumor invasion in large vessels.

COMPUTER ANALYSIS OF DIGITAL IMAGES

Methods of automatic segmentation

1. Threshold Segmentation Methods (Threshold Image Processing Algorithms);
2. Clustering methods (color space clustering);
3. Methods of growing regions (taking into account the spatial location of centers of heterogeneous structures);
4. Methods of crushing and merging (algorithms for splitting the image into homogeneous regions);
5. Modeling the image by Markov field (takes into account textures during segmentation);
6. Methods of graph theory (the image is represented as a weighted graph).
7. Normalization methods (search for eigenvalues of the pairwise distance matrix).

Methods of nonlinear dynamics (most effective for dynamic objects)

Mathematical models

- Dynamic processes in biomedical systems;
- Taking into account a random set of factors;
- Irregularity of contours of structures

MRI image processing algorithms

- Determination of heterogeneities based on the distribution of pixel brightness levels;
- The approximation is calculated perimeter of the structure;
- Highlight certain image properties.

Threshold segmentation techniques for digital object images (functional diagram of the developed method)

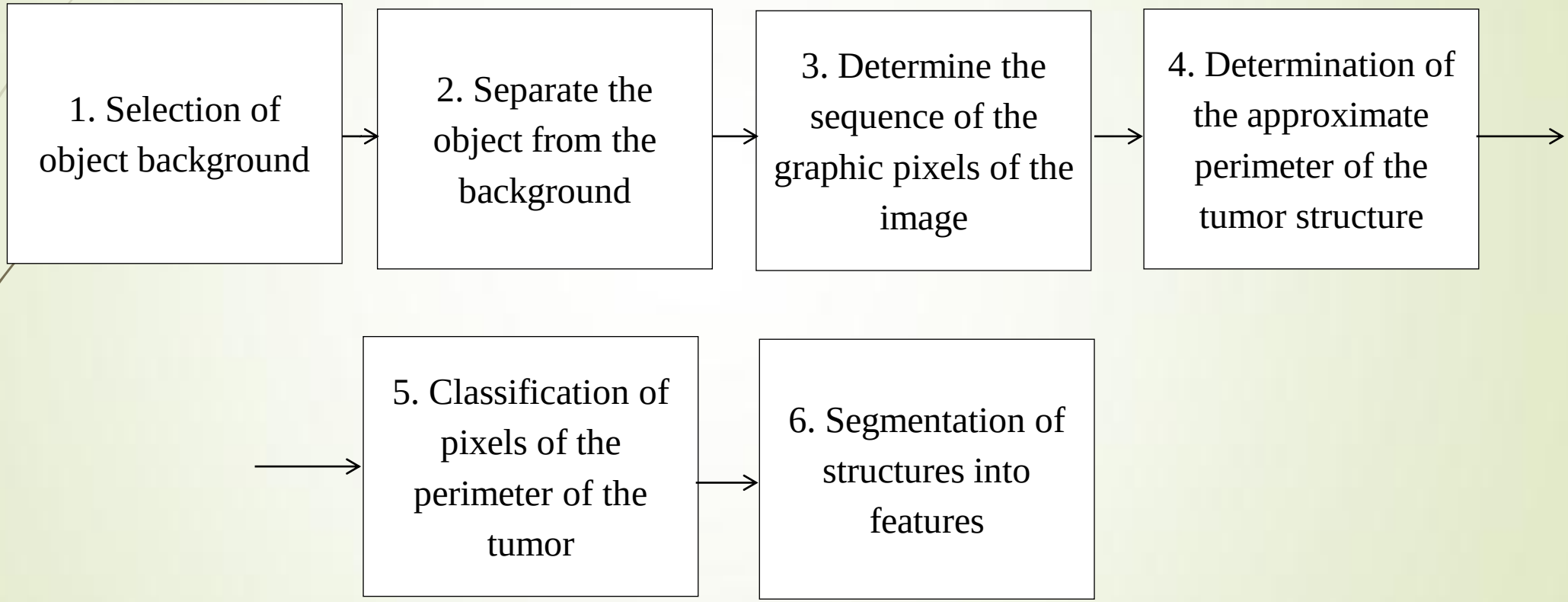
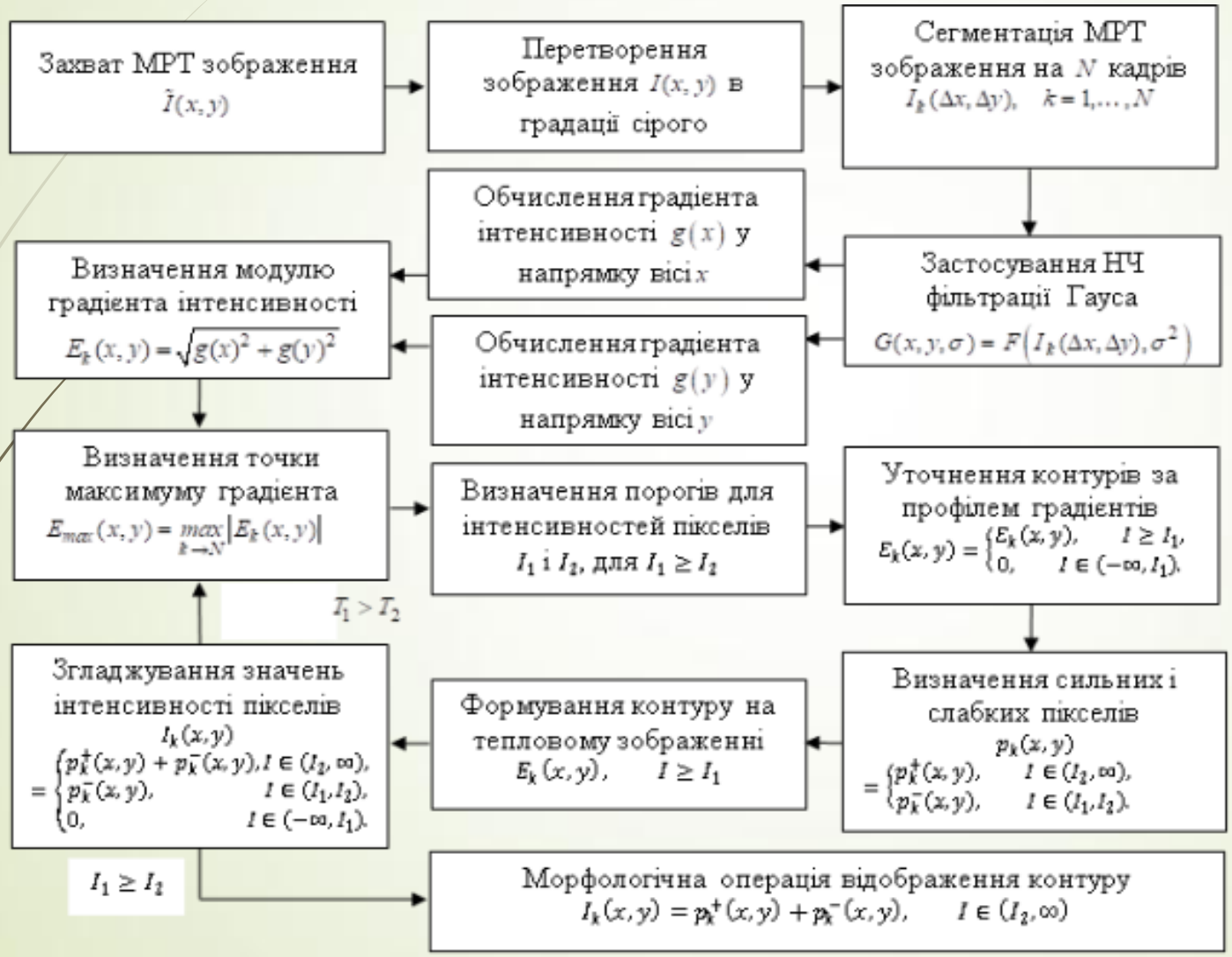


Figure 6 - Functional diagram of threshold segmentation of digital MRI images

Tumor contouring method based on Cannian boundary detector algorithm



Features from the OpenCV Computer Vision Library used in C ++

CVAPI (void) cvCanny (<variables>)

Figure 7 - Algorithm of Cannian Bound Detector Method Using a Gaussian Low Pass Filter

An algorithm based on the Cannian boundary detector method

1. Averaging MRI pixel intensities:

$$I(x,y)=\sum_{k=1}^{N} I_k(\Delta x,\Delta y)$$

2. Gaussian low pass filtering :

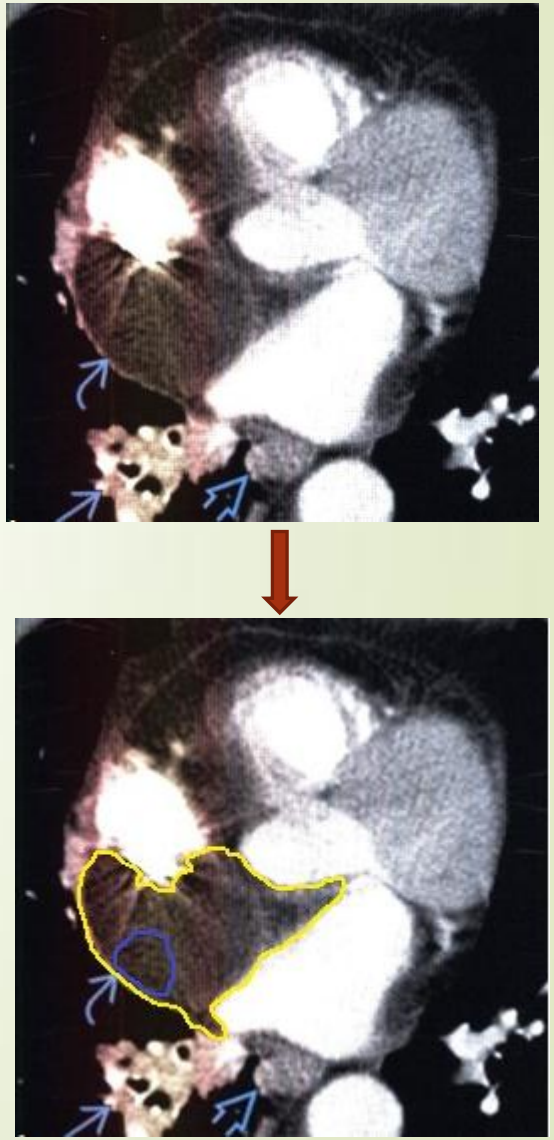
$$G(x,y,\sigma)=\frac{1}{2\pi\sigma^2}\exp\left(\frac{x^2+y^2}{2\sigma^2}\right)$$

3 . Determination of the pixel intensity gradient module :

$$E_k(x,y)=\sqrt{g(x)^2+g(y)^2}$$

4. Formation of the contour of the three-dimensional formation :

$$I_k(x,y)=\begin{cases} p_k^+(x,y)+p_k^-(x,y), & I\in(I_2,\infty),\\ p_k^-(x,y), & I\in(I_1,I_2),\\ 0, & I\in(-\infty,I_1). \end{cases}$$



THE EXPERIMENTAL PART (STANDARD METHODS FOR TREATING HEART MRI)

1. Hoff's transformation

Functional characteristics definition:

- RV mass of ventricular myocardium;
- LV myocardial masses of ventricles

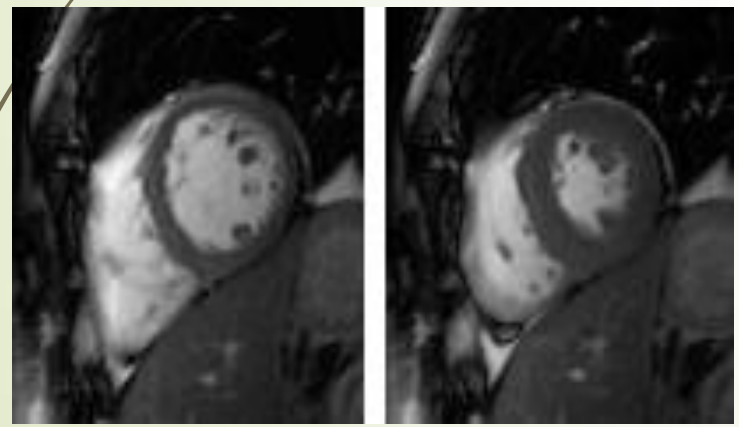


Fig. 8: Automatic calculation of MRI images of the heart based on Hoff pixel transformation

2. Fourier transform

Dynamic Image Segment Definition:

- visualization of the first harmonic of the image;
- visualization of local structures

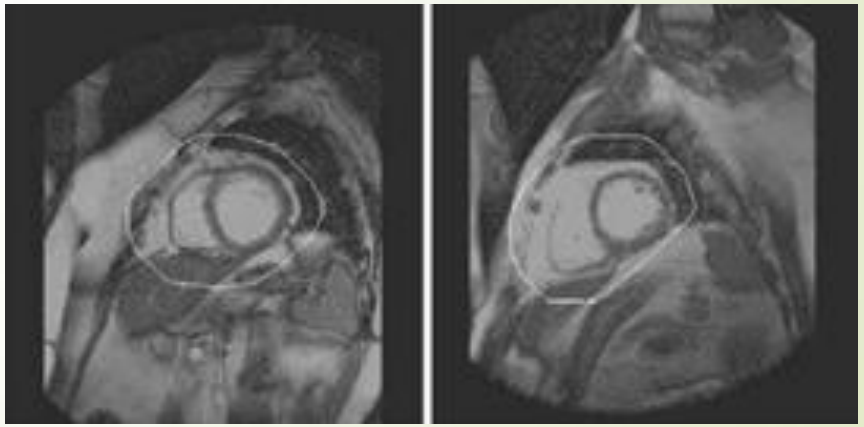


Fig. 9: Automatic calculation of MRI images of the heart based on Fourier pixel transformation

THE EXPERIMENTAL PART (HEART MRI TREATMENT METHOD DEVELOPED)

1. Cannes contouring algorithm

Identifying image segments in the brain:

- processing of MRI images of the brain;
- visualization of small-scale artifacts

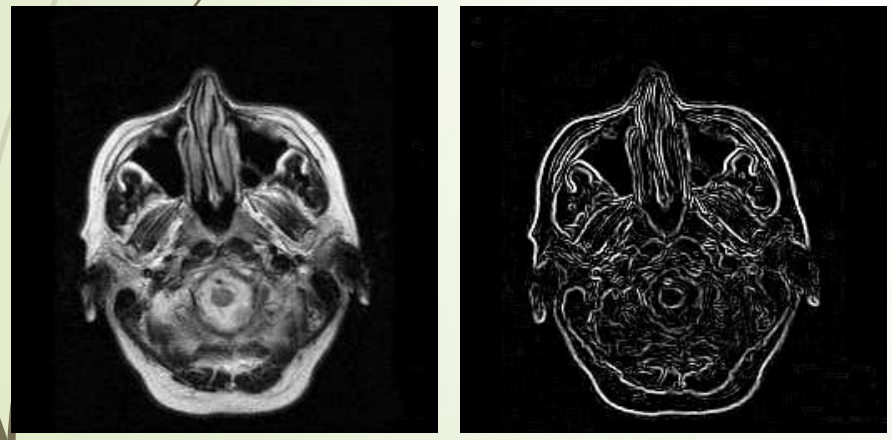


Fig. 10: Automatically calculate MRI images of the brain based on the Canny contouring algorithm

2. The method of contouring of tumors is developed

Identifying heart image segments:

- MRI imaging of the heart;
- visualization of small myocardial structures

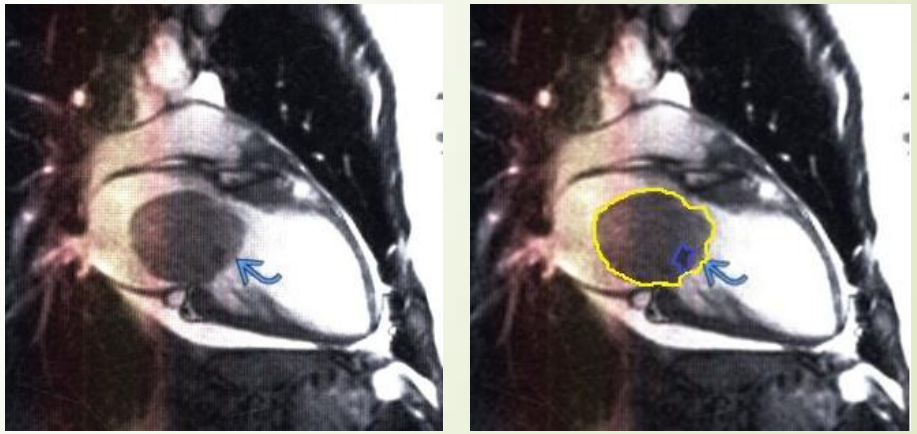


Fig. Figure 11: Automatically calculates MRI images of the heart based on the Canny contouring algorithm

THE EXPERIMENTAL PART (CLINICAL TRIAL OF CARDIAC MRI TREATMENT)

1. Patient with a history of lung cancer

The volume formation of heterogeneous structure in the left ventricle and pericardial effusion are determined

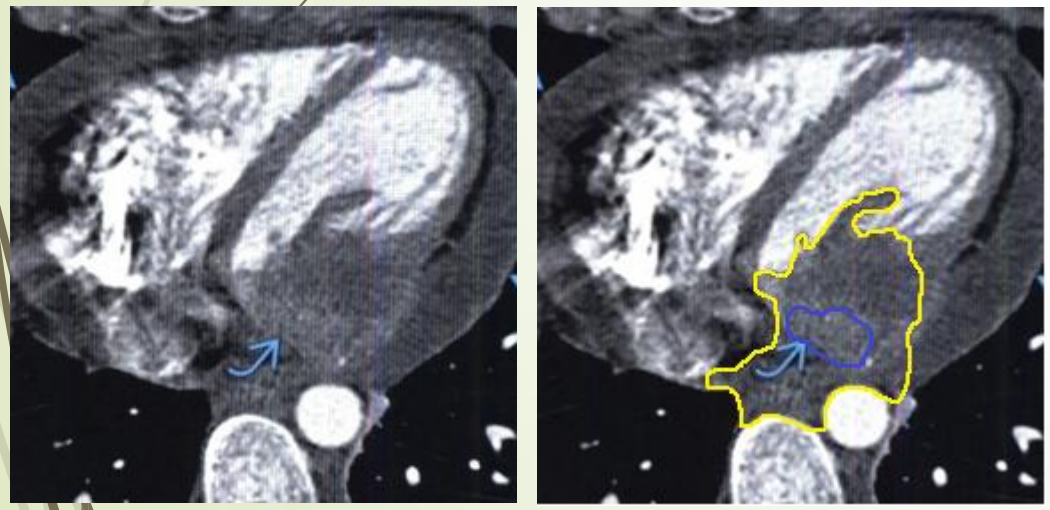


Fig. 12: Automatically calculate MRI images of the heart based on the Canny contouring algorithm

2. Patient with a history of melanoma

Visualization in the left atrium of the volumetric formation adjacent to the atrial septum

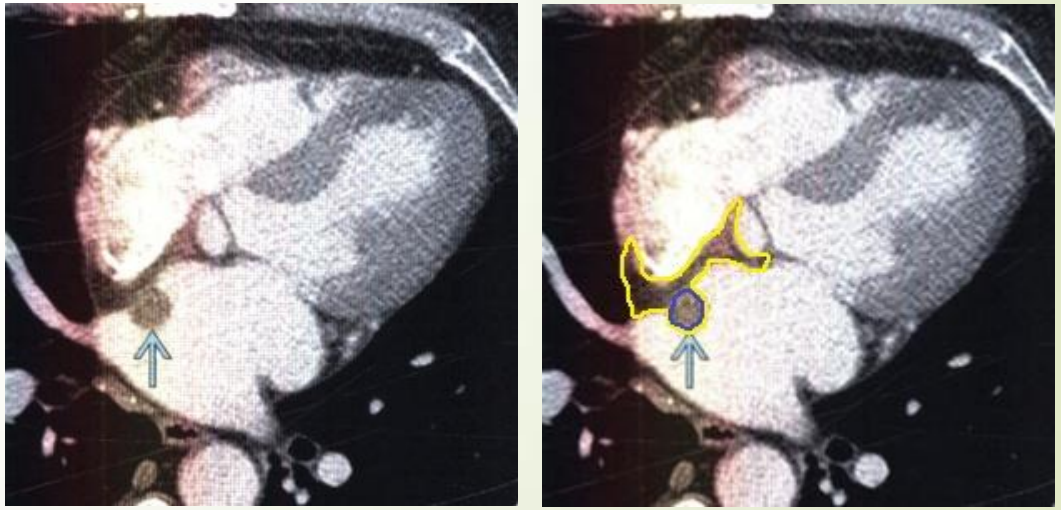


Fig. Figure 13: Automatically calculates MRI images of the heart based on the Canny contouring algorithm

THE EXPERIMENTAL PART (CLINICAL TRIAL OF CARDIAC MRI TREATMENT)

3. Patient with renal cell cancer

Visualization in the right ventricle and in the interventricular septum of the volumetric formation of a heterogeneous structure

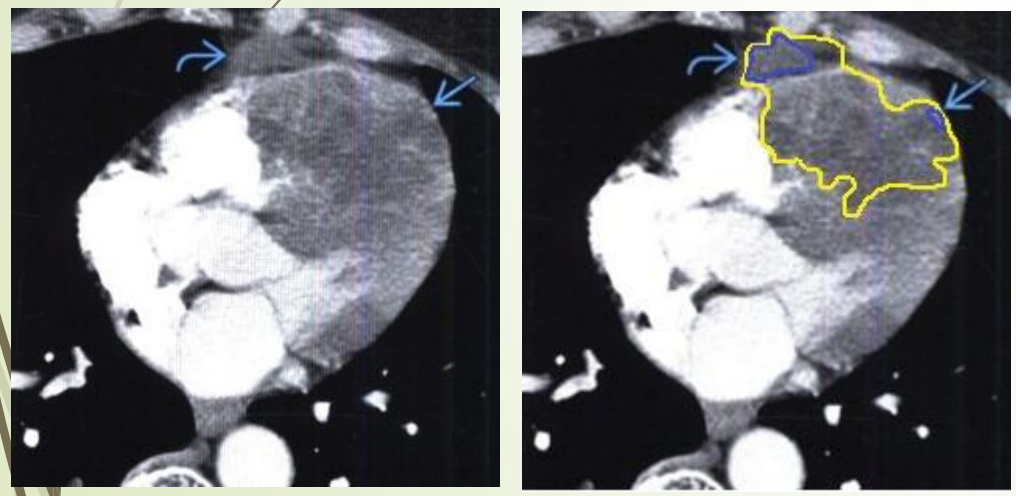


Fig. 14: Automatically calculates MRI images of the heart based on the Canny contouring algorithm

4. Patient with heart sarcoma

Determine the volume formation in the wall of the right atrium, which is hyperintensive compared to the myocardium

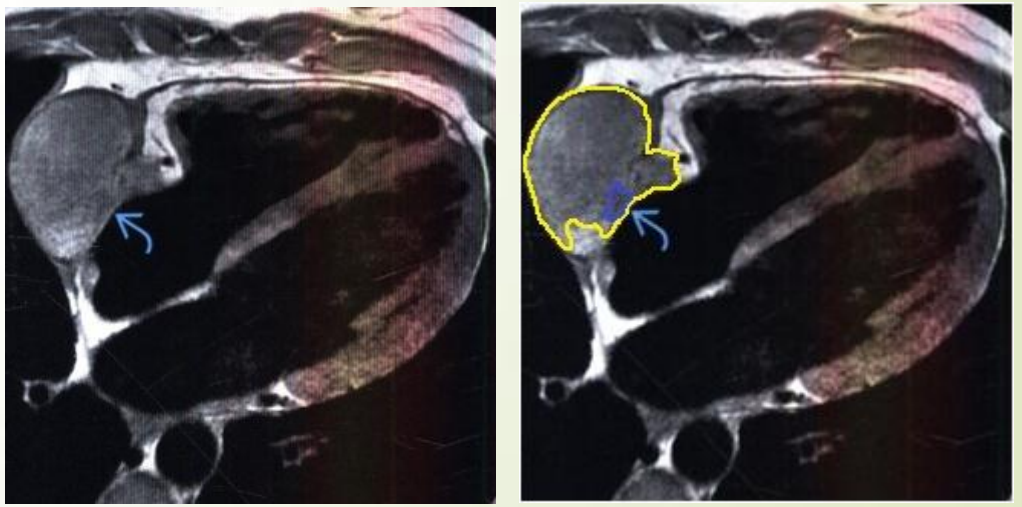


Fig. 15: Automatically calculates MRI images of the heart based on the Canny contouring algorithm

THE EXPERIMENTAL PART (CLINICAL TRIAL OF CARDIAC MRI TREATMENT)

5. Patient with lymphoma of the heart and pericardium

Determine the volumetric formation of heterogeneous structure in the right atrium, pericardial effusion

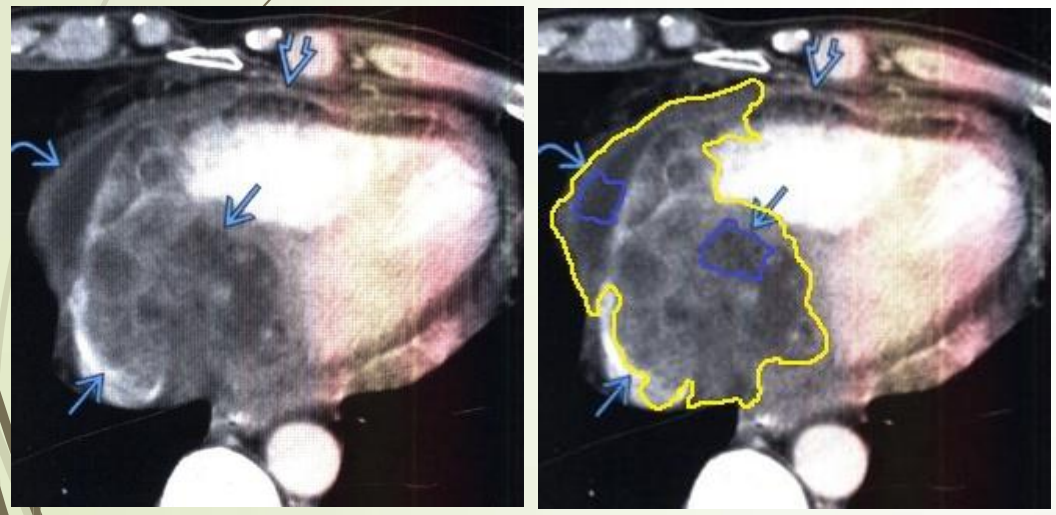


Fig. 16: Automatically calculates MRI images of the heart based on the Canny contouring algorithm

6. Patient with myxoma in the left atrium

Hypodense volume formation causing stenosis of the mitral valve is visualized

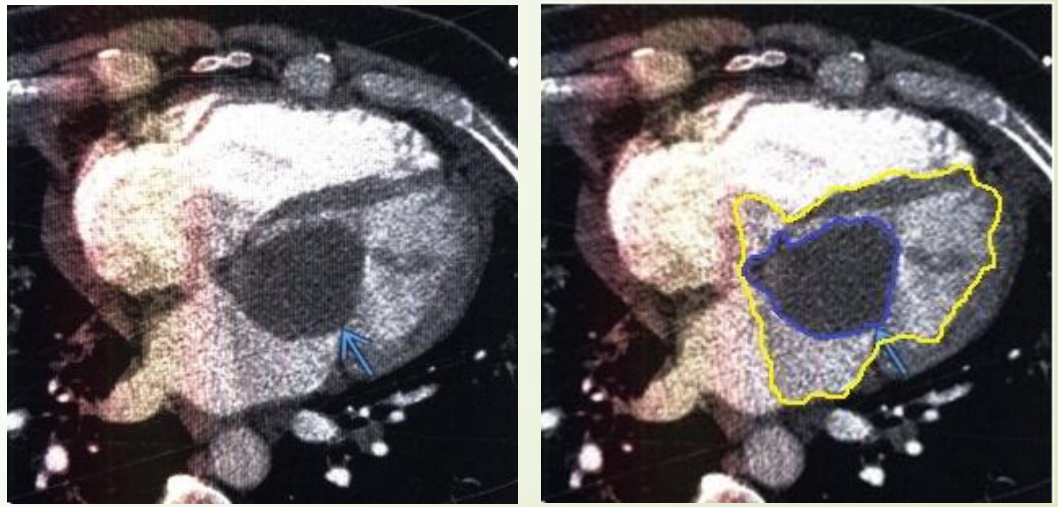


Fig. 17: Automatically calculates MRI images of the heart based on the Canny contouring algorithm

SAFETY AND PRECAUTIONS

1. Object characteristics temperature and humidity

Time of the year	Temperature, °C			Humidity, %	
	Optimal	Real		Optimal	Real
		Upper bound	Lower bound		
Cold	22 - 24	24	21	40 - 60	40 - 60
Hot	23 – 25	28	25	40 - 60	40 - 60

2. House light to illuminate the room

$$I = S / [h(A+B)] = 20 / [1.9 \cdot (4+5)] = 1.169$$

where h v estimated height of the mounting, h = 1.9 m;
A – width of the room, A = 4m;
B – length of the room, B = 5m.
Knowing the index of room I, is η = 0.47.

CONCLUSIONS

1. Analysis of scientific information regarding the current state of segmentation and imaging of cancer on MRI images of the heart showed the need to create information methods to increase the likelihood of detecting cancer;
2. The method of contouring of malignant entities in the myocardium was developed to visualize the borders of the volume oncologic formations on MRI images of the heart based on the canny software algorithm, which allows to determine the size of the affected area of the myocardium;
3. Clinical studies of the use of the developed contouring method to determine the geometric boundaries of tumors on MRI images of the heart have been conducted, which experimentally prove the effectiveness of using information methods based on the Canny algorithm to the obtained MRI images of the heart.

THANK YOU!

Diploma thesis
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