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Ovarian Cyst Detection by Region Based Convolutional Neural Network in MATLAB

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Abstract:
For female reproductive system ovaries are one of the most important parts. The two ovaries in female body mainly are to produce ovum and sex hormones. Nowadays, it has become very common of affecting cyst at ovaries which can lead to infertility commonly and widely even cancer. That's why it is actually very important to detect and treat as early as possible. For the increasing rate of ovarian cyst cases raises anxiety towards women and the people of poor medical facilities areas are facing rapid growth of ovarian cancer because of late diagnosis. The main purpose of this research is to detect very fast and even small areas from ultrasound images whether the ovaries are cyst affected or not. The proposed methodology is the implementation of regions with convolutional neural networks (RCNN) on real patients' ultrasound images in MATLAB platform. Both cystic and non-cystic images are used for detection and the mean accuracy of detecting cyst is 94.3 %.

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1.0. Introduction:

The reproductive system of women with ovaries of lower abdomen on both sides of the left and right side of uterus. They are basically responsible for the production of eggs and estrogen and progesterone as well. female ovaries can easily be affected by fluids which is filled sac or pocket. The cyst is usually painless. A woman with ovarian cyst usually has an irregular menstrual cycle. According to Srivastava et al. (2020), in the early stages, Symptoms of ovarian cysts include pain of Low back or hips, nausea, and vomiting, swelling of the pelvis and pain before or after menstruation. Gore MA et al. (1995) analyzed the morphological and functional changes of follicles during their development. Many women develop ovarian cyst at some point. Ovarian cysts which are mildly uncomfortable or harmless, disappear within a few months without treatment. Nevertheless, ruptured ovarian cyst can cause severe symptoms.

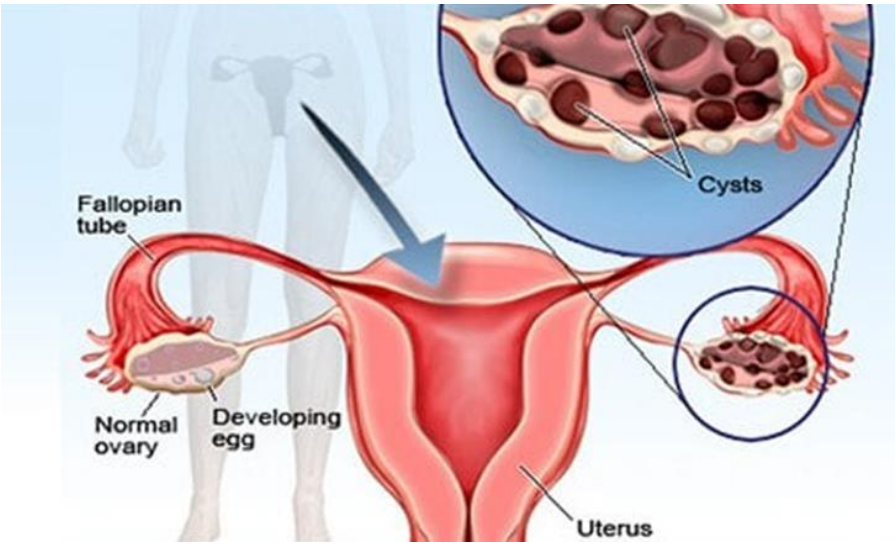


Fig 1: Ovarian Cyst (MedicineNet, 2021).

Diagnostic ultrasound is currently the most popular medical imaging method. Indeed, the first step roadmap for the diagnosis of ovarian cyst is the ultrasound of the ovaries. Ovarian ultrasound directs a gynecologist to detect and treat cysts. These cysts develop due to incomplete development follicles in the ovaries. Usually found in ultrasound images of some dark areas, darker than others areas in the same image, thus drawing a kind of border one elliptical geometric shape. Doctor's manual analysis usually diagnostic. Usually the dimensions are measured periodically, the texture and shape of the follicle for a few days is the main thing evaluation tool. However, right now, it's automatic software that can help doctors identify cysts and reduce the burden of clinical diagnosis for A distinction can be made between malignant and benign cysts in accordance.

RCNN is mainly region-based convolution neural network which is a part of machine learning family. In proposed method RCNN is used because of detecting cyst even if it affects in very small region.

2.0. Related Previous Works:

Nima Tajbakhsh et al. (2016) proposed deep convolutional neural network (CNN) for involving classification, detection, and segmentation for medical images. With classifying the ultrasound images into follicle or non-follicle with false acceptance rate (FAR) of 2.00% and false rejection rate (FRR) of 0.32%, Jyothi R Tegnoor (2012) noticed and classified ovarian cysts. In his works, SVM was used to classify image. Nawgaje DD and Kanphade RD (2013) proposed a method which was a hardware implementation of the genetic algorithm. The research detailed including coding scheme with the implementation of a Digital Signal Processor TMS320C6713. This research was very important to ovarian cancer segmentation. A new detection method was proposed for detection of follicles with extracting five geometric elements. False acceptance rate (FAR) of 12.6% and a false rejection rate (FRR) of 5.7% were achieved in that research (Hiremath PS and Tegnoor JR, 2010).

Hiremath PS and Tegnoor JR (2014) used the fuzzy logic method to understand ultrasound images of detecting follicles. The classification is done with the help of fuzzy logic where seven geometric objects were used as input. This Fuzzy logic block type inference system classified the data.

Vasavi G and Jyothi S. (2017) suggested identification and classification studies on ovarian cysts from their ultrasound images. Follicle ultrasound images were detected using gaussian low-pass filter for pre-processing, operator for edge detection and multiple intervals to classify. In addition, morphological expansion was used to remove noisy edges in preprocessed images to identify follicles. Dency Treesa John et al. (2016) implemented ANN to classify ovarian cyst through pre-processed ovarian cyst images. The ANN as input and the trained images were used to classify images.

3.0. Methodology Details:

In this proposed research, region-based convolutional neural network (RCNN) is implemented to detect cyst. Moreover, RCNN is a family of machine learning models for computer vision.

3.1. RCNN

In proposed RCNN model, mainly there are following four steps for detecting cyst:

a. Input image
b. Extract image and regional proposal
c. CNN layers Computing
d. Cyst Detection

The proposed detection method has been started with generating regional proposals. The next part is implementation of CNN and finally classifying the object. The block diagram of whole method is in Fig 2.

3.1.1. Input Image:

The input image is needed to be specified as height(H) and width (W) by C- numeric array. Moreover, the Images must be real, no-sparse, grayscale or RGB image. C is defined as the channel size. Each image has to be equal to the network's input channel size. C must be equal to 1 for grayscale and for RGB color images must be equal to 3.

3.1.2. Extract image and regional proposal:

Multi-dimensional feature Vector is extracted from each region proposal. Features are computed by forward propagating a mean-subtracted 640x420 RGB image through fifteen

convolutional layers. Computing features for a region proposal, the image data in that region into a form must be converted initially which evaluates through the CNN. Here, the simplest regions are applied through bounding box around the architecture of fixed 32x32 pixel size. There are variety of methods for regional proposals. Selective search (J. Uijlings et al, 2013), category-independent object proposals (I. Endres and D. Hoiem, 2010) constrained parametric min-cuts (CPMC) (J. Carreira and C. Sminchisescu, 2012) etc. are few of them. Here, RCNN is the particular region proposal method.

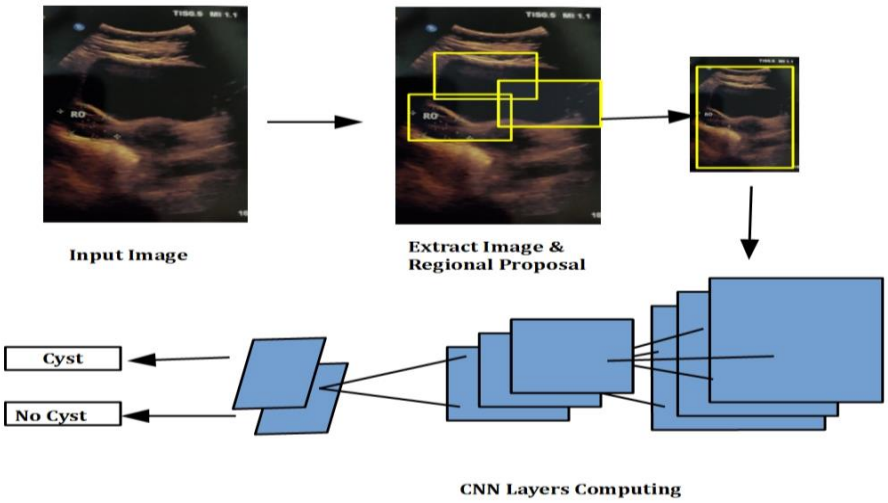


Fig2: RCNN Based Cyst Detection

3.1.3. CNN Layers Computing:

CNN is computed through different layers. First-layer filters can be understood directly and easily (A. Krizhevsky et al., 2012). In this step, the color and edges get extracted. At RCNN a simple method is applied and it can be directly showed. The main idea is to identify a particular feature in the network and detect object through the feature. Here, the particular feature is region proposal. The efficiency of region proposals suggests from best action to lowest activation, not maximum performance. The area with the highest score is suppressed and displayed mainly. This method works as selected units to accurately indicates the input and also avoid averaging with checking different visual modes. The aggression is calculated by the unit. Here, the discussed method is measuring layers without fine tuning. All layers are mainly the step by step implementation of convolution layers, pooling layers, ReLULayers and softmax layers.

3.1.3.1. Pooling layers:

Layers with pools provide an approach to sampling feature maps by summing the presence of features in areas of the feature map. Average pooling and maximizing are two pooling methods that summarize the average presence of an element and the most active presence in an element respectively. Fig 3 represents the concept of pooling layers.

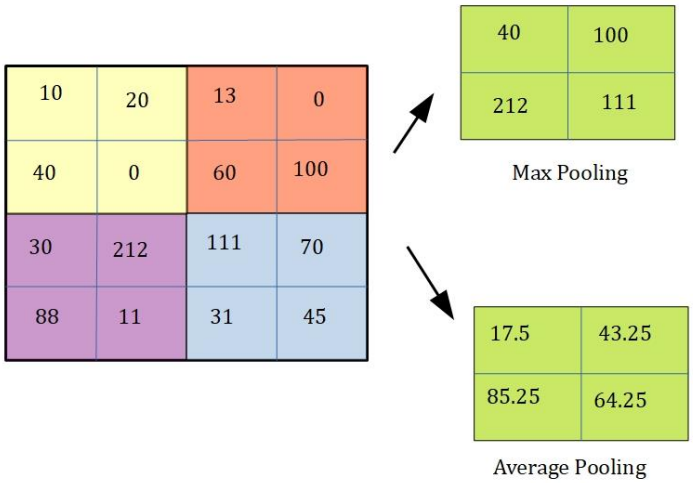


Fig 3: Pooling Layers

3.1.3.2. ReLULayers:

ReLULayer is mainly included in convolution layer. Rectified Linear Unit (ReLU) is the function to increase the non-linearity in our images. Our experimental images are generally non linear in different manners like colors, sizes etc.

3.1.3.3. Softmax:

Softmax mainly used at the last step of CNN. This function is used as an activation function in the output layer of the neural network models to predict the polarity probability distribution.

3.1.4. Cyst Detection:

In this paper, RCNN method is used for detecting ovarian cyst. Here, the steps are discussed below.

3.1.4.1. Data Overview:

In this proposed method, the real ultrasound images are used for training and testing. The age of the patient is within of 30 to 45 years. There are the images of different type of cysts and without any cyst in this experiment. Fig 4 is the images of ovaries with cyst and without cyst from the patient of the mentioned age group.

The width and height of the images are accordingly 440 mm and 650 mm. The cyst detection dataset is split into two sets: test dataset and train dataset. Number of images in each set is in parentheses distribution. These images are similar in complexity. For example, they have similar number of objects, the number of anomalies, the difference of triggers, etc. Test data is very completely annotated. All classes are marked with a bounding box. On the other hand, the train components were not similarly classified for image distribution manner. They are variable in complexity. They are even out of labeling including negative image.

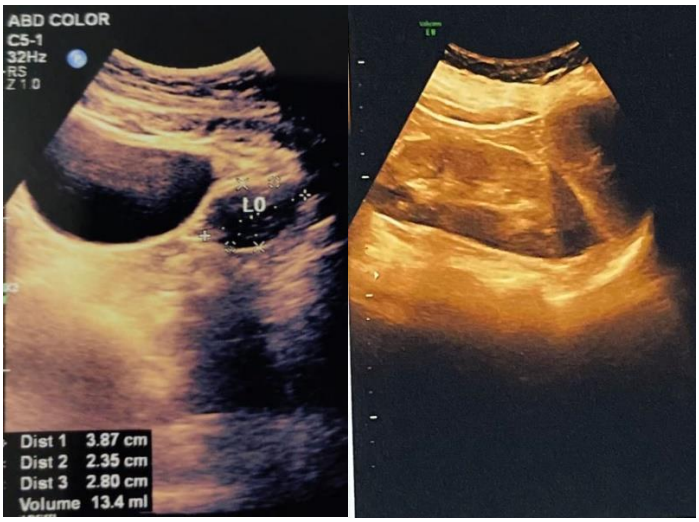


Fig 4: Ovarian Image for Detecting Cyst

3.1.4.2. Data Training:

a set of images and boxes are used to train data. In RCNN, three steps are required for data training:
(a) Fine-tuning for CNN computation,
(b) SVM training for detector, and
(c) bounding-box regressor

Here, 27 ultrasound images from different patients are used for data training. SGD iteration is used for fine tuning on training. SVM training is used and also bounding box for each image. According to Ross Girshick (2015) , the bounding box parameters are mainly continuous variables with the values predicted using regression method. Physical values representing position and size of a bounding box represent the probability of output classes.

3.1.4.3. Cyst detection Layers:

In this research, 15 layers are used to detect cyst. The layers are in the table 1.

SI No.	Name Of Layers
L1	1x1 ImageInputLayer
L2	1x1 Convolution2DLayer
L3	1x1 MaxPooling2DLayer
L4	1x1 ReLULayer
L5	1x1 Convolution2DLayer
L6	1x1 ReLULayer
L7	1x1 AveragePooling2DLayer
L8	1x1 Convolution2DLayer
L9	1x1 ReLULayer
L10	1x1 AveragePooling2DLayer
L11	1x1 FullyconnectedLayer
L12	1x1 ReLULayer
L13	1x1 FullyconnectedLayer
L14	1x1 SoftmaxLayer
L15	1x1 ClassificationOutputLayer

Firstly, the input images of a 32 years old patient are used as test data. Applying max pooling layers and ReLULayers, the image is classified through softmax layer.

The below flow diagram of Fig 5. represents the layers for the proposed method.

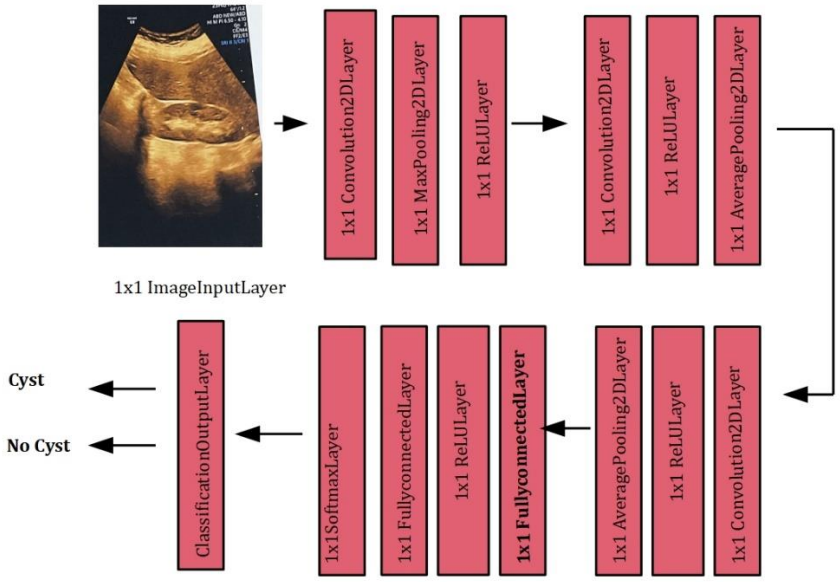


Fig 5: Layers for RCNN Based Cyst Detection

4.0. Result and Analysis:

The ovarian images are collected from the patients from Popular diagnostic center, Dhaka, Bangladesh. In this methodology, two types of images are used which are normal and cystic. With RGB colours space the sizes of the images are 650x440. The RCNN based cyst detect method is developed in MATLAB 21b. For the first ovarian image (image a) is with the cyst, Fig 6 is for the cystic ovary.

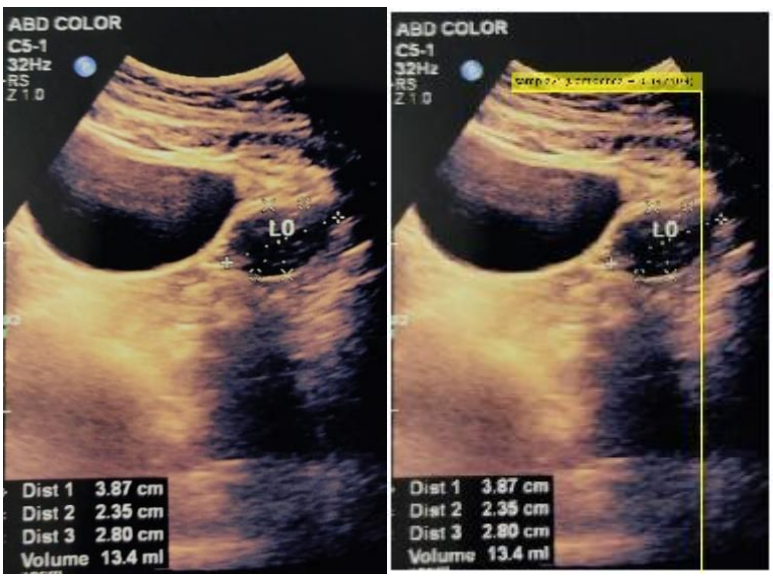


Fig 6: Cyst detection of image a

The score for image a is 0.9375.

In Fig 7, the result of detector training for image a is presented with epochs.

WORKSPACE

```
Training on single CPU.
Initializing input data normalization.
|=========================================================================================|
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Mini-batch  |  Base Learning  |
|         |             |   (hh:mm:ss)   |   Accuracy   |     Loss     |      Rate       |
|=========================================================================================|
|       1 |           1 |       00:00:00 |       96.88% |       0.0947 |      1.0000e-06 |
|       2 |          50 |       00:00:10 |       93.75% |       0.4178 |      1.0000e-06 |
|       3 |         100 |       00:00:21 |       96.88% |       0.1140 |      1.0000e-06 |
|       5 |         150 |       00:00:31 |       93.75% |       0.2391 |      1.0000e-06 |
|       6 |         200 |       00:00:41 |       90.62% |       0.9626 |      1.0000e-06 |
|       8 |         250 |       00:00:50 |       96.88% |       0.1244 |      1.0000e-06 |
|       9 |         300 |       00:01:00 |       96.88% |       0.1176 |      1.0000e-06 |
|      10 |         350 |       00:01:09 |       96.88% |       0.0549 |      1.0000e-06 |
|=========================================================================================|
Training finished: Max epochs completed.
```

Fig 7: Detector Training for image a

For the second ovarian image (image b) is with no cyst, Fig 8 is for the non-cystic ovary.

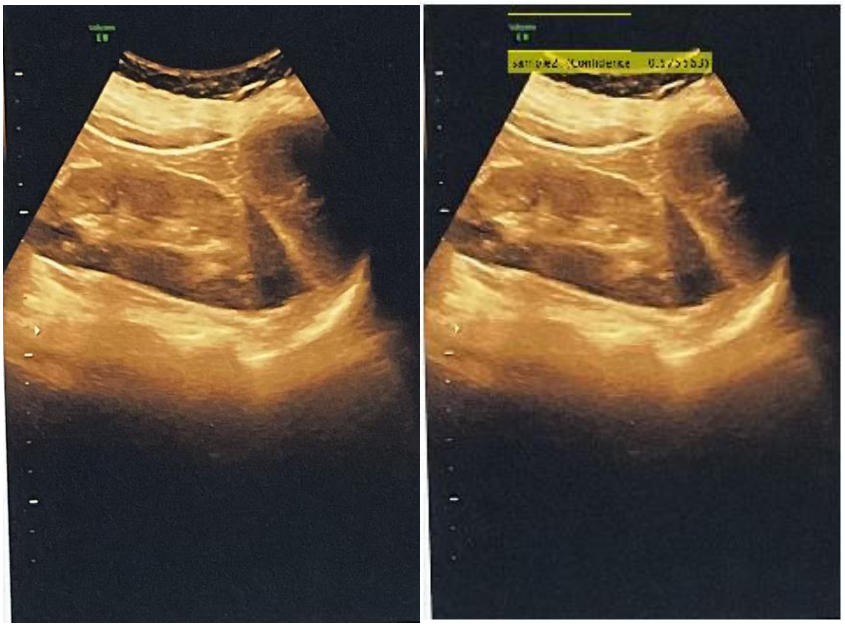
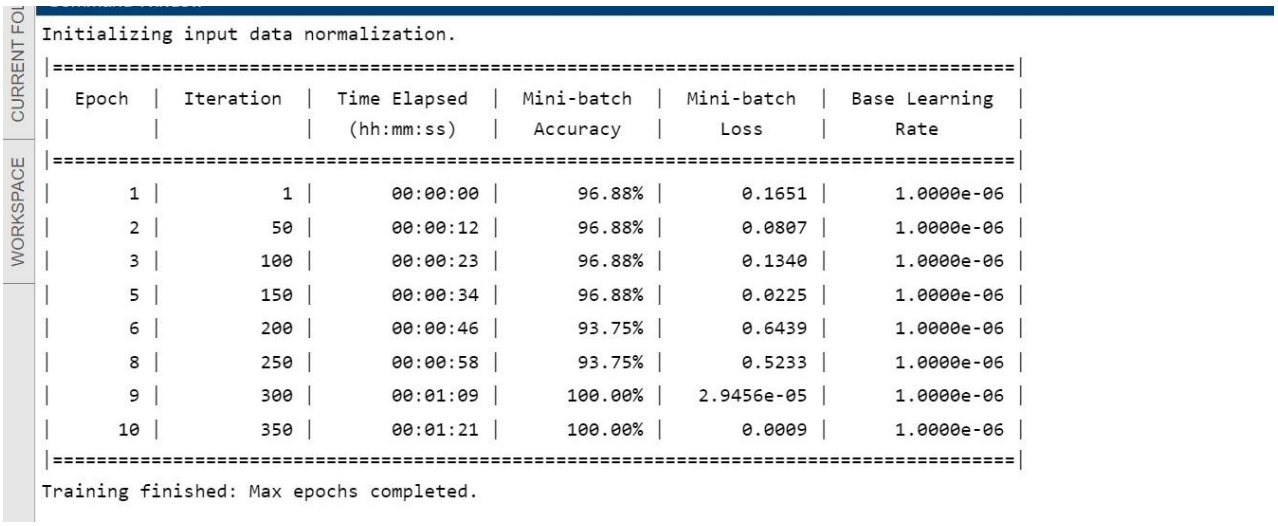


Fig 8: Cyst detection of image b

The score for image b is 0.948.

In Fig 9, the result for detector training for image b is presented with epochs.



```
Initializing input data normalization.
|=========================================================================================|
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Mini-batch  |  Base Learning  |
|         |             |   (hh:mm:ss)   |   Accuracy   |     Loss     |      Rate       |
|=========================================================================================|
|       1 |           1 |       00:00:00 |       96.88% |       0.1651 |      1.0000e-06 |
|       2 |          50 |       00:00:12 |       96.88% |       0.0807 |      1.0000e-06 |
|       3 |         100 |       00:00:23 |       96.88% |       0.1340 |      1.0000e-06 |
|       5 |         150 |       00:00:34 |       96.88% |       0.0225 |      1.0000e-06 |
|       6 |         200 |       00:00:46 |       93.75% |       0.6439 |      1.0000e-06 |
|       8 |         250 |       00:00:58 |       93.75% |       0.5233 |      1.0000e-06 |
|       9 |         300 |       00:01:09 |      100.00% |   2.9456e-05 |      1.0000e-06 |
|      10 |         350 |       00:01:21 |      100.00% |       0.0009 |      1.0000e-06 |
|=========================================================================================|
Training finished: Max epochs completed.
```

Fig 9: Detector Training for image b

5.0. Conclusion:

Region based convolution neural network is implemented in this research so that the ovary with cyst can be detected fast in every small area of ovary. The proper diagnosis is the main concern for the proposed research. This machine learning method provides great accuracy. Moreover, in this proposed research 94.3% mean accuracy is achieved. The whole experiment is completed with the images of actual patients with age group 30 to 40. Because of high rate of infertility and ovarian cancer, this research can actually be very important helping to detect the cyst on ovaries and treat it as early stage.

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