Medical Image Seminar

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Outline

1. (MICCAI 2017) Accurate Pulmonary Nodule Detection in Computed Tomography Images Using Deep Convolutional Neural Networks
2. (ISBI 2019) An End-to-End Framework for Integrated Pulmonary Nodule Detection and False Positive Reduction

Accurate Pulmonary Nodule Detection in Computed Tomography Images Using Deep Convolutional Neural Networks

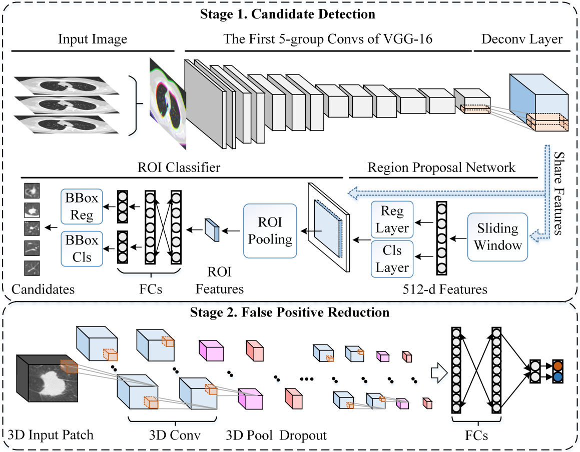

Figure 1: The framework of the proposed CAD system.

Objective Function

$$\mathcal{L}_t = \frac{1}{N_c}\sum_i \mathcal{L}_c(\hat{p}_i, p_i^*) + \frac{1}{N_r}\sum_i \mathcal{L}_r(\hat{t}_i, t_i^*) + \frac{1}{N_{c'}}\sum_j \mathcal{L}_c(\tilde{p}_j, p_j^*) + \frac{1}{N_{r'}}\sum_j \mathcal{L}_r(\tilde{t}_j, t_j^*)$$

- $\hat{p}_i$ and p_i^* respectively denote the predicted and true probability of anchor i being a nodule
- $\hat{t}_i$ is a vector representing the 4 parameterized coordinates of the predicted bounding box of RPN, $t_i = (t_z, t_y, t_x, t_d)$
- $\tilde{p}_j$, p_j^* , $\hat{t}_j$ and t_j^* denote the corresponding concepts in the ROI classifier
- L_c is softmax loss, L_r is soomth L1 loss

Data Augmentation

- **Crop** For each 40 * 40 * 24 patch, we crop smaller patches in the size of 36 * 36 * 20 from it, thus augmenting 125 times.
- **Flip** For each cropped 36 * 36 * 20 patch, we flip it from three orthogonal dimensions, thus finally augmenting 8 * 125 = 1000 times.
- **Duplicate** To balance the number of positive and negative patches in the training set, we duplicate positive patches by 8 * 1000 = 8000 times.

Results

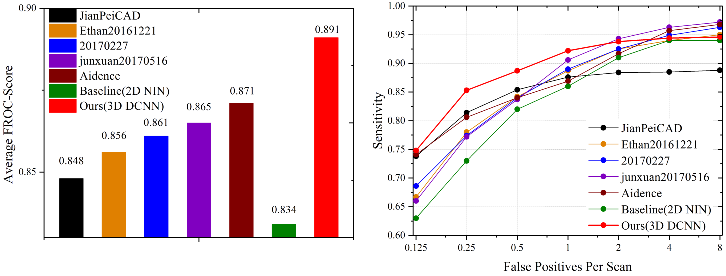

Figure 4: Comparison of performance among our CAD system and other submitted approaches on the LUNA16 Challenge. (a) Average FROC-scores (b) FROC curves

Contribution

- Present an end-to-end framework for nodule detection, integrating nodule candidate screening and false positive reduction into one model, trained jointly.
- Improves the performance by 3.88% over the two-step approach, while at the same time reducing model complexity by one third and cutting inference time by 3.6 fold.

Method

2 stage

1. Generating nodule candidates using 3D Nodule Proposal Network (adapted from Faster-RCNN).
2. Nodule candidate classification for false positive reduction. (Nodule proposal is then used to crop features using 3D Region of Interest (RoI) Pool layer, fed as input to the nodule false positive reduction branch.)

Method

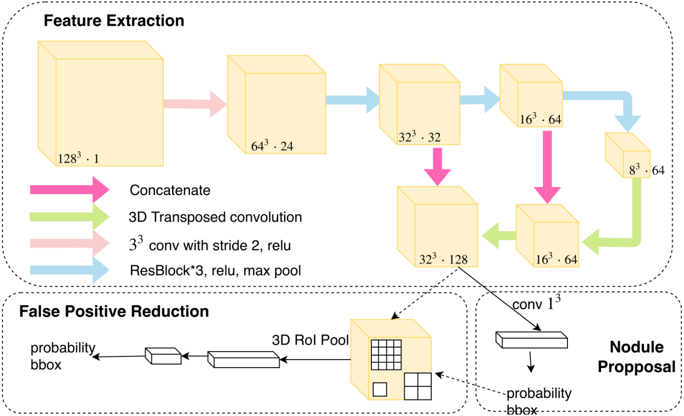

Fig. 1. End-to-end pulmonary nodule detection framework

Objective Function

$$L(\{p_i\},\{t_i\}) = \frac{\sum_i L_{cls}(p_i, p_i^*)}{N_{cls}} + \lambda \frac{\sum_i L_{reg}(t_i, t_i^*)}{N_{reg}} \quad (1)$$

- i is the index of an anchor in one mini-batch
- p_i is the probability that anchor contains a nodule candidate
- λ is a hyper-parameter for balancing classification and regression losses (set it to 1 in this case)
- t_i is a vector representing the four parametrized coordinate offsets of the predicted bounded box, $t_i = (t_z, t_y, t_x, t_d)$
- L_{cls} is binary cross entropy loss, L_{reg} is L1 loss

Training

- Train the whole network in an end to end fashion.
- First train the nodule proposal network using Stochastic Gradient Descent (SGD) for 60 epochs and then we train both network together for another 100 epochs.
  - This is because, in the beginning the nodule proposal network predicts random nodule candidates which would be time-consuming for training the false positive reduction branch.
- To improve the generalization ability of the network, input volume is randomly shifted, randomly flipped along all 3 axis, and randomly scaled between 0.9 and 1.1.

Results

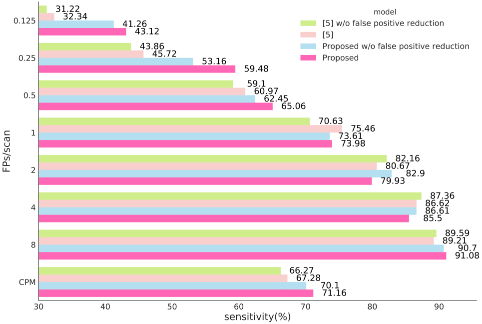

Fig. 2. Performance comparison

	# Parameters	Inference Time
[5]	15903490	10.2s/CT
Proposed	9618523	2.8s/CT

Table 1. Comparison of number of parameters and time for inference between separate two stage framework [5] and the proposed framework

[5] Automated pulmonary nodule detection using 3d deep convolutional neural networks. (ISBI 2018)

Comparison

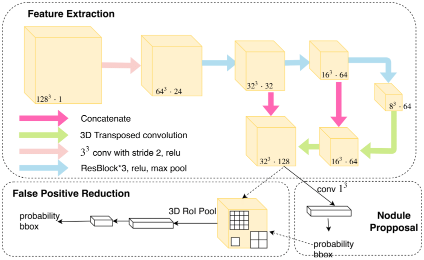

Fig. 1. End-to-end pulmonary nodule detection framework

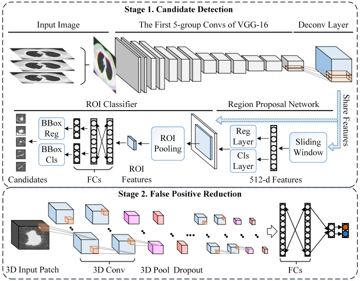

Figure 1: The framework of the proposed CAD system.

The End