Semi-Supervised GANs with Complementary Generator Pair for Retinopathy Screening

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Abstract

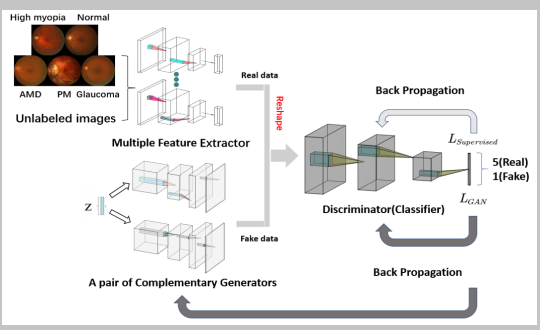
Several typical types of retinopathy are major causes of blindness. However, early detection of retinopathy is quite not easy since few symptoms are observable in the early stage, attributing to the development of non-mydriatic retinal cameras, these cameras produce high-resolution retinal fundus images that provide the possibility of CAD via deep learning to assist diagnosing retinopathy. Deep learning algorithms usually rely on a large number of labeled images that are expensive and time-consuming to obtain in the medical imaging area. Moreover, the random distribution of various lesions that often vary greatly in size also brings significant challenges to learn discriminative information from high-resolution fundus images. In this paper, we present generative adversarial networks simultaneously equipped with a "good" generator and a "bad" generator to make up for the incomplete data distribution given limited fundus images. To improve the generative feasibility of the generator, we introduce a pre-trained feature extractor to acquire condensed features for each fundus image in advance. Experimental results on integrated three public iChallenge datasets show that the proposed GBGANs could fully utilize the available fundus images to identify retinopathy with little label cost.

Materials

All of the 3200 images are all centered at the posterior pole with both macula and optic disc in the field, each image was cropped to a square shape which included the most tightly contained circular area of the retinal fundus, and the image sizes are 1444 × 1444, 1634 × 1634, and 2124 × 2056, respectively.

Type	Source	Amount	Total
Healthy		161	
High Myopia	iChallenge-PM	26	
Pathological Myopia		213	569
Glaucoma	iChallenge-GON	80	
AMD	iChallenge-AMD	89	
Unlabeled	iChallenges	2631	2631

Framework



Improved Methods

- Dynamic Labeling Mechanism for GANs Convergence

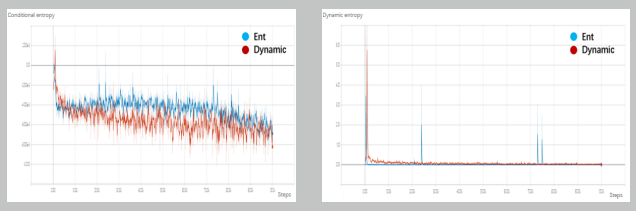


Figure 1:Trend of conditional entropy and dynamic entropy during the training process.

- Good Generator and Bad Generator

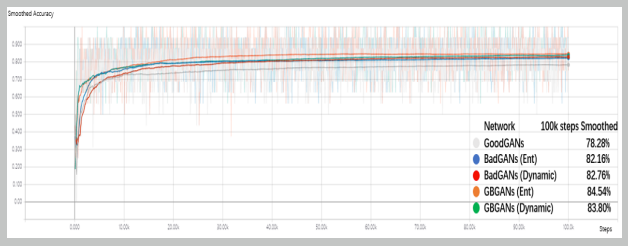


Figure 2:Comparison on the trend of smoothed accuracy on validation set among GoodGANs, BadGANs, and our GBGANs during the training process.

Results

Our methods achieve superior performance, where higher MacroF1 demonstrate appreciable performance on small sample category, which is in line with our expectation.

Methods	Accuracy	Macro-F1	Cohen kappa score
SSGANs	0.8772	0.8711	0.8260
FMGANs	0.8860	0.8158	0.8375
AMGANs	0.8421	0.8421	0.7689
BadGANs	0.9035	0.8645	0.8634
GBGANs	**0.9123**	**0.9029**	**0.8750**

Conclusion

We proposed a GANs framework named GBGANs based on the assumption that complementary generators can defeat the challenge induced by the inadequacy of medical imaging data. Under this framework, a fixed feature extractor is used to extract the generic features from high-resolution fundus images, and a pair of complementary generators are employed to help discriminator further exploring incomplete actual distribution provided by a limited number of fundus images. Moreover, a dynamic labeling mechanism is proposed as a choice to satisfy the convergence condition assumption. Empirically, our proposed approach achieves superior performance and presents to be promising in our task, taking a step for GANs-based semi-supervised learning.

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