Tumor Tissue Identification Technology by Estimating Features of Immunostaining Images from Hematoxylin-Eosin Stained Images using Convolutional Neural Networks

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Background

Pathologists visually observe hematoxylin-eosin (HE) stained images under a microscope to perform pathological diagnosis. If it is not possible to sufficiently diagnose by judging shape using HE-stained specimens alone, it is necessary to add another evaluation method such as immunohistochemistry (immunostaining).

Methods

In order to accurately and rapidly identify a tumor, this study proposes a method of automatically identifying a tumor in a pathological image by estimating features of immunostaining from an HE-stained image. The method[1] consists of three steps:

1. features of tumor presence or absence are extracted from the HE-stained image and immunostaining image using a convolutional neural network (CNN),
2. a classifier is created so that the features obtained from the HE-stained image approach the features of the presence or absence of a tumor stained by immunostaining by using the CNN, and
3. the presence or absence of a tumor is judged by using the classifier and HE-stained image only.

Fig. 1 Flow of training image creation

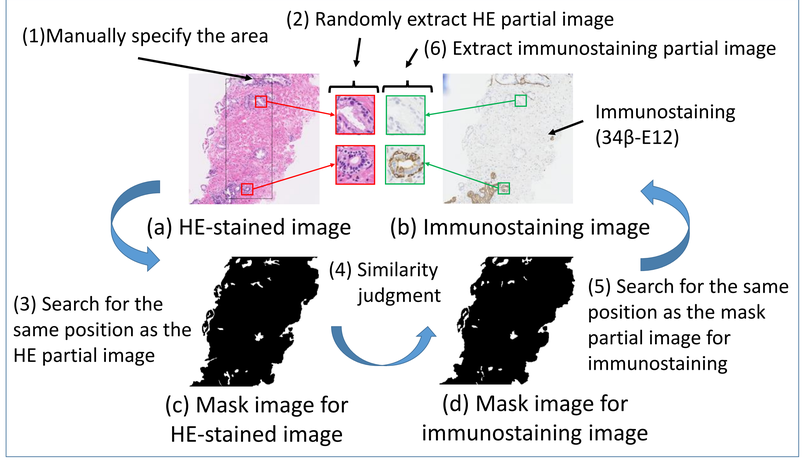


Fig. 2 Convolutional neural network (CNN)

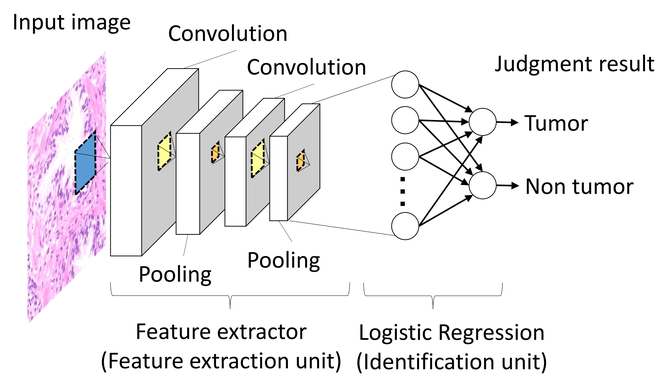


Fig. 3 Feature extractors A and B (Step 1)

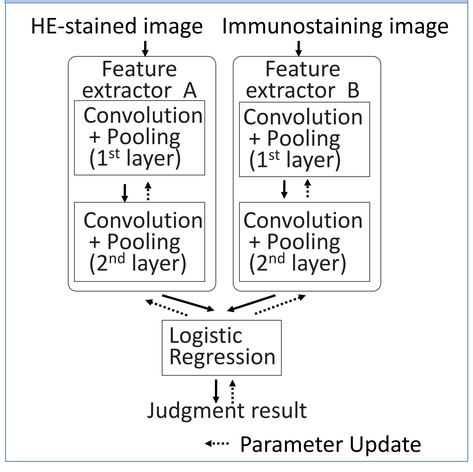


Fig. 4 Creation of feature extractor C (Step 2)

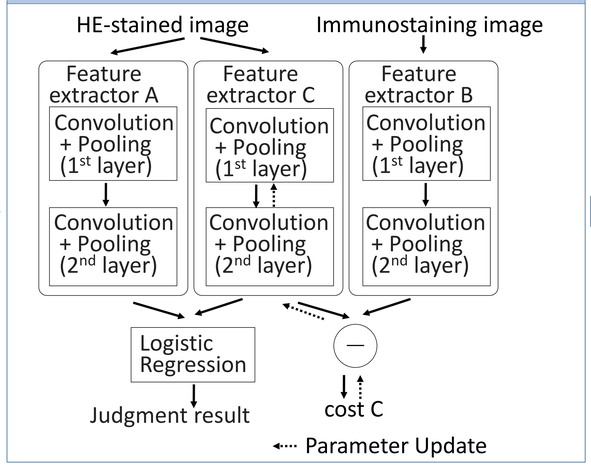
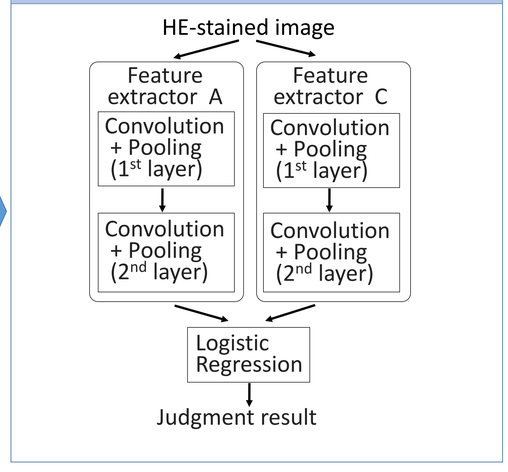


Fig. 5 Tumor classifier configuration (Step 3)



Results

The experimental results using digital images of pathological tissue specimens of prostate cancer show improved identification accuracy. The proposed method improved 10.6%(to 92.5%) for sensitivity and 2.5%(to 86.9%) for specificity compared with a classifier created using only features extracted from HE-stained images.

Table 1 Classification accuracy of prostate cancer

Classifier for each image group type (Number of images)	Sensitivity	Specificity
Classifier IA using only HE-stained images (320)	81.9%	84.4%
Classifier IB of the proposal method (320)	92.5%	86.9%
Classifier IC using HE-stained and immunostaining images (320)	99.4%	93.1%
Classifier ID using only the features of the immunostaining image estimated from the HE-stained image (320)	46.3%	93.1%

Fig. 6 ROC(Receiver operating characteristic) of each classifier

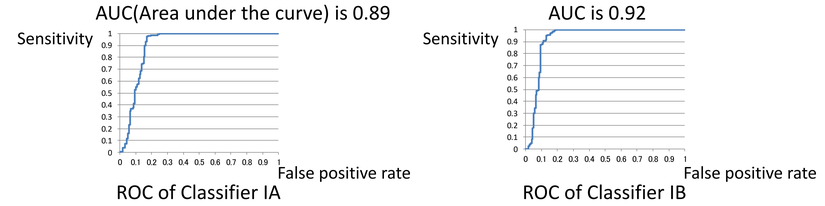
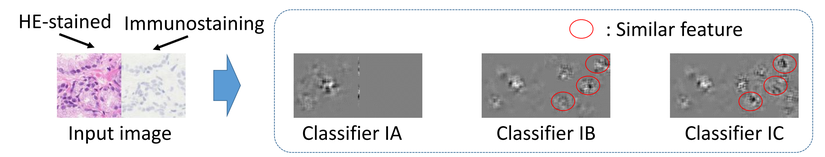


Fig. 7 Visualization of classification basis [2]



When the classifier IA and the classifier IB are compared, the classifier IB can estimate features similar to those of the classifier IC. In addition, it is not feasible to prepare HE-stained and immunostaining images aligned for classifier IC at the time of pathological diagnosis.

Conclusions

By this method, not only the features of HE-stained image but also the features of immunostaining estimated from HE-stained image is used to create a classifier, which improves the accuracy of tumor identification in pathological images. Therefore, it was shown to be effective as a method for identifying pathological images.

References [1] Hattori H, Kakishita Y, Sakata A, Yanagida A. Tumor Tissue Identification Technology by Estimating Features of Immunostaining Images using Convolutional Neural Networks. Medical Imaging Technology. 2019;37:147-154.
[2] Kakishita Y, Hattori H. Classification Reasons Visualization of Deep Neural Network Using Model Inverse Analysis. Transactions on Mathematical Modeling and its Applications (TOM). 2019;12:20-33.