論文 / 著書情報
Article / Book Information

題目(和文)	H&E染色ハイパースペクトル画像を用いた弾性繊維及び膠原繊維の分別に関する研究
Title(English)	Elastic and Collagen Fibers Discrimination Methods using H&E Stained Hyperspectral Images
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種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	Engineering Information and Communication Engineering	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	(Engineering)
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

Specimen staining is an important process in pathology diagnosis. The color information from tissue structure shows the tissue's condition. Currently, the standard staining in pathology diagnosis is Hematoxylin and Eosin (H&E) stain which shows the general information of the morphological structure of the tissue. In the particular diagnosis, pathologist needs to observe the growing progress of specific component i.e. elastic fibers over time. However, it is difficult to recognize the elastic fibers using H&E stained image, because it has a similar color and pattern with the collagen fiber. To recognize elastic fibers, Verhoeff's Van Gieson (EVG) stain is commonly used. However, EVG stain is an additional staining method after H&E stain has been done, which needs an additional effort and cost.

This study proposes a new method to classify elastic fibers from collagen ones with H&E stain using hyperspectral images (HSI). The proposed method performs pixel wise classification, which makes it possible for pathologists to observe the growing progression of the elastic fibers precisely. Consequently, it would improve the efficiency and accuracy of the pathology diagnosis process. The proposed method analyzes the spectral and spectral-spatial information of hyperspectral images in segmenting elastic and collagen fibers from the H&E stained images. The spectral features of the H&E hyperspectral image are investigated using Linear Discriminant Analysis (LDA) in segmenting elastic and collagen fibers. The proposed method adobts U-net based architecture deep learning to improve the discrimination accuracy using a combination of spectral-spatial features of the hyperspectral image. The experimental results were evaluated visually by pathologists and statistically by comparing to the segmentation of EVG stained image as ground truth image. The dissertation consists of five chapters as follows.

Chapter 1 introduces the pathology workflow process and background including problems as well as the objective of this study. It also explains the overview of HSI and reviews previous related studies.

Chapter 2 explains the broad outline of the experimental procedure including material and apparatus such as the tissue samples, hyperspectral camera specification and some preprocessing methods.

Chapter 3 explains the elastic and collagen fibers segmentation based on spectral features using LDA. There are two possible factors to classify elastic and collagen fibers components in the HSI; they might be from the ratio of eosin and hematoxylin stain in the whole 61 wavelength bands from 420 to 720 nm and peak shift differences between elastic and collagen components. Therefore, a discriminant filter obtained from this spectral information is possible to separate elastic and collagen more accurately, which might not be found in RGB with three wavelength bands. The segmentation result showed that the

hyperspectral image is superior to RGB imaging not only confirmed visually by pathologists but also quantitatively by T-statistic based on the dice coefficient. The paired T-Test statistic of elastic and collagen segmentation results using spectral information for the RGB image and the HIS was 3.5082, with a p-value less than 0.05. It indicates that elastic and collagen segmentation based on spectral features in the HIS performs significantly better than RGB image.

Chapter 4 explains elastic and collagen fibers segmentation based on spectral-spatial features using U-net based architecture deep learning. The conventional machine learning needs lots of calculations for getting many spatial features in hyperspectral images corresponding to each wavelength to map and to fuse spatial and spectral features. On the other hand, U-net enables to train of both features automatically without redundancy from many calculations. Trial experiments obtained the optimum U-net parameter set. The segmentation result showed that the HSI is superior to RGB image not only visually by pathologists but also in quantitative evaluation using a T-Test analysis based on the dice coefficient again.

Chapter 5 contains discussion and conclusion, which explains elastic fibers segmentation performance comparison between spectral features and spectral-spatial features from pathologist and statistic perspective. The paired T statistic between spectral features and spectral-spatial features of the hyperspectral image indicates that elastic and collagen segmentation based on spectral-spatial features of HSI performs significantly better than spectral features only.

This study observes the potential method to segment elastic and collagen fibers using the H&E stained image as a standard stain in pathology diagnosis based on spectral and spectral-spatial features of HSI. The method is not only for visualization but also for pixel wise classification purposes. It would increase diagnostic accuracy and has the potential towards substituting the usage of the EVG staining method which is only used to recognize elastic fibers. Hyperspectral imaging systems are more expensive than RGB camera systems in general. However, it provides an accurate analysis result and increases the diagnosis efficiency. It also can be used not only for elastic fibers analysis but also for other tissue structures analysis purposes. The wider use of the HSI system stimulates increasing HSI system production which effects in decreasing the price.