Proceedings

SY14.05 | Image Analysis III

Classification of Degree of Differentiation of Colorectal Neoplasm by Changes in the Betti Number

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Introduction/ Background

The diagnosis of pathology provides important information for determining the treatment protocol, but other than in developed countries, the number of pathologists is not sufficient. Even where the number is sufficient, they are often unevenly distributed, with most pathologists in large hospitals in metropolitan areas, and adequate services cannot be provided to all patients. For this reason, it is desirable to develop ways to allow for remote diagnosis or to develop automatic diagnostic systems. Digital diagnostic systems based on pattern-recognition techniques have been developed. Because the morphology of cancer tissue is quite complex, a library of all types of cancer morphology would be huge, it would require a high-performance computer system, and the costs in money and time would be very high. This makes it difficult to create an effective system.

Aims

Recently, a new method based on the homology theory for analyzing histological digital images has been developed. The method evaluates the Betti numbers in a unit area of an image of a colon to determine the region of interest (ROI). The Betti number is an important index for homology theory, and can be used to assess the degree of connectivity in tissue. This method, however, cannot distinguish between different types of tissue. When a tumor forms in the colon, because of the excessive growth of nuclei, the connections increase and become tight. The absolute value of b_1 (the one dimensional Betti number) will be high, and the ratio of change will be small. When a tumor becomes more poorly differentiated, it frequently happens that the ties between the cells are weakened, and the intercellular areas are filled with impurities. Because of these impurities, the absolute value of b_1 is very high. Its influence, however, will disappear immediately. Namely, b_1 decreases very quickly, when we decrease the binarizing threshold. We calculate the decay ratio of the betti number, by changing the binarized thresholds. Our aim in this talk is that using this information, we will classify the degree of differentiation of colorectal neoplasm.

Methods

In the colon, cancerous regions show stronger color intensity when stained with hematoxylin. This stains blue, and so the distribution of blue in an image indicates the cancerous areas. Thus, for each image, we measured the peak of the blue distribution, and we will refer to it as the reference value. To determine the binarizing threshold, we multiplied the reference value by 0.55 to 0.72, in increments of 0.01. The binarization was carried out in gray scale using these values. We call this interval the reference interval. We may assume that there was no pathological information outside of the reference interval.

Results

The calculated results can be approximated by quadratic functions. The distribution of the coefficient on the squared term and the x-coordinates of the vertices are shown. We can see a characteristic distribution for each type of cancerous tissue. As the binarizing threshold decreases, the images gradually fade to white, and the structure of the tissue is lost. Under the proposed procedure, in areas where the connections in the tissue are tight

and clear, b1 changes slowly. Conversely where the connections are vague, such as in a background area filled with impurities, it changes very quickly. The state of this change can be considered an expression of the strength of the connectivity, and it differs by type of cancerous tissue.