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Mdical image segmentation criteria's disadvantages

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ABSTRACT

Segmentation is one of the vital procedures in medical image processing. The results of none accurate segmentation may lead to a none accurate diagnosis. To assess the segmentation results there are common used criteria such as Sensitivity, Specificity and Accuracy. This paper discusses of disadvantages of the mentioned criteria in assessment the tumor segmentation on MRI images.

Keywords:*Medical images; Segmentation; Sensitivity; Specificity and Accuracy*

1. Introduction

At present, digital imaging methods are widely used in medicine to solve problems of various complexity, including preprocessing (filtration and morphological operations), segmentation and object recognition. Segmentation means the process of dividing an image into regions or objects that have the same (similar) properties or attributes[1]. For example, on the MRI image of the brain it is necessary to segment (highlight) the area of pathology (tumor). At the same time, the reliability of the diagnosis and the effectiveness of the subsequent treatment depend on the quality of this procedure.

The article deals with the disadvantages of using sensitivity, specificity and accuracy as criteria for evaluating the results of segmentation of pathology on MRI images. Examples of Over-segmentation and Under-segmentation are given where these disadvantages are manifested.

2. Theory

Sensitivity characterizes the percentage of pixels of the pathology area that are correctly (truly) segmented as pathology, and calculated by the following formula[2]:

$$Se=TP / (TP+FN)\times 100\%, \quad (1)$$

where TP - true-positive pixels, characterizing the tumor pixels, which are correctly identified as pathology;

FN - false - negative pixels, which characterize the pixels of the pathology, which were incorrectly segmented as non-pathology.

Specificity characterizes the percentage of pixels of normal tissues that are correctly (truly) segmented as normal (not pathology) and calculated as[2]:

$$Sp=TN / (TN+FP)\times 100\%, \quad (2)$$

where TN- is true-negative pixels, which characterize the non-tumor pixels that are correctly identified as a non-tumor;

FP-false-positive pixels, non-tumor pixels, which were incorrectly segmented as a tumor.

Accuracy characterizes the proportion of pixels of pathology that are correctly segmented as pathology and pixels of normal tissues that are correctly segmented as normal and calculated according to the following formula[3]:

$$Acc=TN+TP / (TN+FN+TP+FP)\times 100\%, \quad (3)$$

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3.Expierement

The disadvantage of the above criteria is manifested in such well-known cases as Over-segmentation[5,6], when a large number of no tumor areas are allocated, or Under-segmentation[5,6], when the desired region is not fully allocated. Figure 1 shows such cases.

A B C D

Figure 1. Over-segmentation and under-segmentation: the original MRI image.

A. Gold standard; B. re-segmentation at threshold 50 (in); pre-segmentation at the threshold of 220 (g).

The results of applying the criteria for evaluating segmentation results (over-segmentation and under-segmentation) are shown in Table 1.

Segmentation Type	**Se**	**Sp**	**Acc**
Over-segmentation	5.54	100	30.80
Under-segmentation	99.87	96.69	96.75
Golden Standard	100	100	100

Table 1. Segmentation results

Analysis of Table 1 shows that in the case of pre-segmentation:

- the value of the criterion of specificity shows a false result, according to which the majority of normal tissues are recognized as a tumor;

- the value of the sensitivity criterion shows a false result, meaning that most of the area of pathology is recognized as normal tissue;

- the value of the accuracy criterion does not show a reliable result, since most of the pathology is recognized as normal tissue.

In the literature[7], there are other formulas for calculating the criteria for sensitivity and specificity.

$$Se=(R\cap GS) / GS\times 100\%, \quad (4)$$

$$Sp=(1-R) \cap (1-GS) / (1-GS)\times 100\%, \quad (5)$$

where R – segmentation result;

GS – Golden standard.

The evaluation of sensitivity and specificity criteria according to formulas 4 and 5 gives the following results (Table 2).

Segmentation Type	**Se**	**Sp**
Over-segmentation	100	33,97
Under-segmentation	33.94	100
Golden Standard	100	100

Table 2. Segmentation results

Analysis of Table 2 shows that in the case of:

a) the over-segmentation: the sensitivity criteria shows a false result, as can be seen from **Figure 1**, c, where most normal tissues are recognized as a tumor;

b) Under-segmentation: the specificity criteria shows a false result, as can be seen from **Figure 1**, d, where the majority of the pathology is recognized as normal tissue;

4. Discussion and Conclusion

To assess the effectiveness of the segmentation procedure, universally accepted criteria are used: sensitivity and specificity. However, the conducted studies, in this work, of the depending of assessment criteria on the formula that used for their calculation showed that in case of Over-segmentation and Under-segmentation the values of these criteria can lead to false results. In order to increase the reliability of the segmentation results assessment on medical images, it is obvious that formulas 1 and 2 should be used to estimate the sensitivity and specificity in the case of Over-segmentation, and in the case of Under-segmentation, formulas 4 and 5.

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