Diagnostic System of Breast Cancer based on Imaging Data of Mammography using Fuzzy Logic

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ABSTRACT

The number of patients with breast cancer is recently increasing in Japan. It is very important to find the patients quickly with accuracy. In this paper, we deal with the imaging data of the mammography of 40 patients concerning with breast cancer and analyze the clinical finding.

We constructed the diagnostic system of breast cancer based on evaluation of findings of the mammography using the Fuzzy inference. From the results obtained by application of this system to clinical practice, it was suggested that this system was effective to judge whether malignant or benign tumor.

KEYWORDS: Diagnosis, Breast Cancer, Mammography, Fuzzy Logic, Images data

1. INTRODUCTION

Mammography is used to diagnose breast cancer and to judge whether malignant or benign tumor. It is an important and widely used method that is noninvasive, and rapidly allows observation of cancer markers [1][2]. However, it is not easy for medical doctors to diagnose the disease using mammography, the evaluation of descriptions of mammography such as the evaluation on shape of cancer greatly depends on a subjective view of individual examiners and the diagnostic logic varies widely between examiners. The diagnosis based on imaging data has mainly two kinds of fuzziness, one is fuzziness on the imaging data and another is ambiguity in subjective diagnosis by examiners [3]. This fuzziness causes substantial fluctuations in the accuracy of mammography. A highly accurate diagnostic system based on the images of mammography would certainly be an important contribution to breast cancer.

Zadeh [4] proposed a fuzzy theory to analyze the vague information using the membership function and the fuzzy logic. Fuzzy theory was applied to many kinds of medical field such as the diagnosis of cancer based on the imaging data of ultrasonic wave graphs, diagnosis for the depressing using information of complaints such as anxiety and so on [5][6].

The present paper focuses on these two kinds of fuzziness in the diagnosis based on mammography and proposed a new supporting system for diagnosis of breast cancer. Fuzziness in image diagnosis is discussed and the new diagnostic system is constructed by the fuzzy logic using clinical data. The advantages and problems with associating medical application to cancer are discussed.

2.THE FUZZINESS IN THE DIAGNOSIS BASED ON THE IMAGING DATA

The Japanese Society for the Breast Cancer proposed the judgment criteria for disease diagnosis [7]. However, the accuracy of image diagnosis is greatly affected by the skillfulness of examiners. The fuzziness of image diagnosis is explained in Table 1.

Table 1. Fuzziness of Image Diagnosis

(1) Description evaluation of image detail is subjective.
(2) Description evaluation of image details varies.
(3) Description evaluation level varies from one image interpretation to another.
(4) The method used to select image details is affected by the nature of the image and the subjective view of the examiner.
(5) Evaluations of different image details interact.
(6) The first impression of an image carries much weight.
(7) Evaluation of other items is strongly affected by first impressions.
(8) Weighting of cancer diagnosis based on obtained description is subjective and not definite.
(9) The course of diagnostic logic from description evaluation of individual items to final diagnosis is unclear.
(10) The structure and weight of image details within diagnostic logic vary fluidly with changing images and subjective view of the examiner.
(11) Diagnostic logic fluctuates widely according to diagnostic results (especially with immediately preceding incorrect diagnosis).
(12) Image diagnosis is not reproducible. (The same result will not necessarily be obtained even when the same image is interpreted by the same examiner.)

In this paper, we proposed the system of evaluation on findings and the system of diagnostic logic combing of the evaluations of many findings using Fuzzy Inference.

3.DIAGNOSIS OF BREAST CANCER BASED ON THE MAMMOGRAPHY

We propose the diagnostic system, which contains two parts, the one is the set of findings and the another is the diagnostic logic combing the evaluation of findings.

We show an example of the findings and their scales for the diagnosis of breast cancer in Table 2.

And we prepared the two kind of fuzzy tools such as the fuzzy scale for the evaluation of each finding and the fuzzy logic for the diagnosis combining the evaluations of six findings.

Table 2 Fuzzy scales and clips judgment

Item	Fuzzy Scale	Clips judgment
[1] Size	Small Moderate Large	Small **Large**
[2] Shape	Regular Moderate Irregular	**Regular** Irregular
[3] Concentration	Light Moderate Deep	Light **Deep**

3.1 Set of Findings Japanese Breast Cancer

The findings such as shape, size, concentration are import factor to detect the cancer. When a description evaluation is expressed using n findings $(x_1, x_2, \cdots, x_n)$, the resultant input membership function grade for each detail is calculated, the weighted membership function for diagnosis of cancer is obtained accordingly. The overall process of weighted membership functions of a cancer diagnosis based on description evaluations of overall evaluation details and weighted membership function of successively evaluated details are summarized.

Diagnosis System 1 seems to be effective in the early stages, when relation between details and judgment of cancer is unclear. It is stable and resists fuzziness of image information and input fluctuations. All details in Diagnostic System 1 have values on the fuzzy scale from benign to cancer, and judgments can be expressed in one dimension.

3.2 Diagnosis System 2 (Initiation based on Synergistic Effect)

The tumor on a mammography does not necessarily demonstrate a shape characteristic of cancer in all details. In such case, System 1 yields diluting overall results. To prevent these effects, Diagnosis System 2 was prepared, when, if the description (initiation) of more than one is recognized in specific details, an inference based on the fuzzy rule attributable to those details is done and membership functions of other details are eliminated.

System 2 selects a detail, which focuses on a judgment based on the effective findings of cancer.

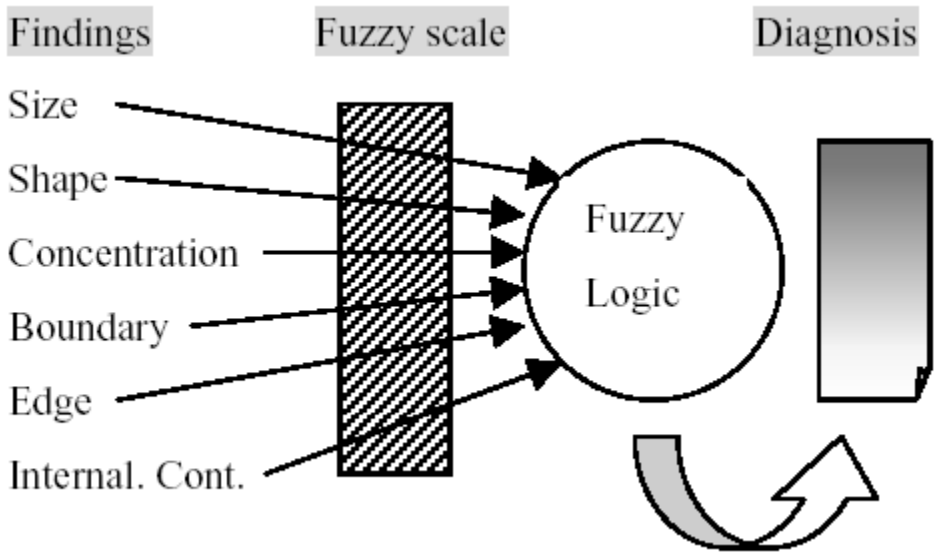


Figure 1. Fuzzy Logic for the diagnosis of Breast Cancer based on the imaging data of Mammography

4. RESULTS

Imaging data of patients with informed consent were from the Hospital of Kawasaki Medical School at Kurashiki in Japan. For 18 cases of breast and 12 cases of benign diagnosed by medial doctors, their mammography were examined by the diagnostic system using fuzzy inference. First we show a reprensentative mammography with the breast cancer in Fig 2. From this mammography, an examiner gave the evaluation of six findings in Table 2.

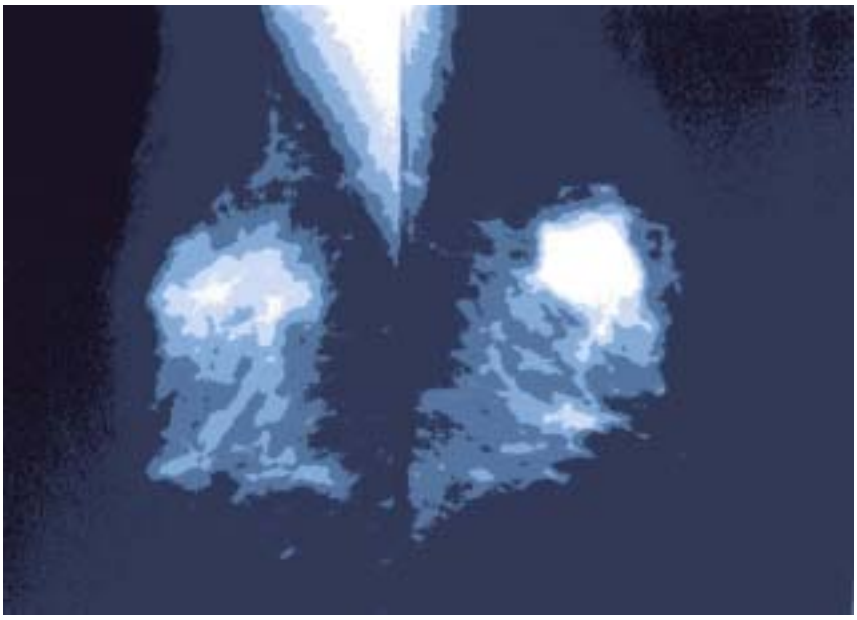
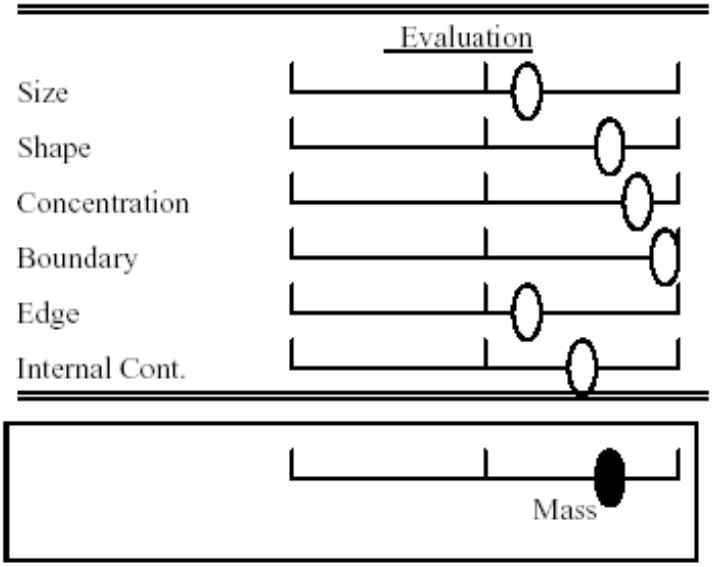


Figure 2. An example of Mammography of a patient with breast cancer

Table 2. An example of examiner's evaluation based on the mammography by Fuzzy Logic.



For our diagnostic system using Fuzzy theory, we adopted the fuzzy scale, which has a continuous scale form 0 to 1, the membership functions for the input data and the score, and the fuzzy rule for detecting the cancer.

We summarized the evaluation of diagnostic results by Fuzzy Logic in Table 3.

Table 3. Diagnosis Results of Breast Cancer by Diagnosis Method1 based n the mammography.

		Fuzzy Computer Diagnosis			
		5	4	3	total
Conventional Evaluation	5	14	0	0	14
	4	5	13	0	18
	3	0	2	6	8

5. DISCUSSION

The method of mammography gives the advantage to diagnose the breast cancer. However, it is very difficult for many medical doctors to diagnose the breast cancer by the imaging data of mammography, because of two kinds of fuzziness in the diagnosis. That is the mammography involves the fuzzy information covering the cancer over the mammary gland.

This diagnosis by Fuzzy theory gives the following advantages.

1.) It can deal with the vague boundary information. Though in the conventional diagnosis, we could only chose two value judgments. Our fuzzy diagnosis allows continuous evaluations from 0 to 1 on the fuzzy.

2.) It can make clear the diagnostic logic. The diagnosis of medical doctors by the conventional method was unclear and subjective. The diagnostic system using Fuzzy Logic prevents the flexible method to breakthrough this difficulty of the fuzziness in the diagnosis. From application of this new method to clinical data, it was suggested that this fuzzy system would be useful to diagnose breast cancer based on the imaging data of mammography.

3.) The breast cancer is diagnosed from two aspects of masses and calcifications. The masses are evaluated by many findings such as shape, size, concentration, and so on. The calcifications are by findings such as the distribution and so on.

In this paper, we mainly focused on the diagnosis of masses from findings, and the total diagnosis of breast cancer should be evaluated by combining the evaluation of masses and that of calcifications. We with to discuss the total diagnosis of cancer by combing the evaluation of masses and calcifications in future study.

6. REFERENCES

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