PET-CT IMAGING AND DIAGNOSIS SYSTEM FOLLOWING DOCTOR'S METHOD

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Abstract: Computer Assisted Diagnosis (CAD) is one of the promising technologies for the future Medical Image Processing Systems. Among them, whole-body PET (Positron Emission Tomography) and X-ray CT (Computer Tomography) image based cancer detection has been playing an essential role in the modern medical world. Using PET-CT images the Radiologist can find a very small cancer or a malignant tumor. On the other hand, this diagnosis process is very stressful work, because such area is too small and localized but may appear at any place of patient bodies. This paper presents an automated diagnosis system in order to improve the above difficulties. The system consists of three parts, Diagnosing Algorithm, Algorithm Interpreter(Engine) and Image Viewer. The algorithm and the engine can reproduce doctor's methods faithfully as the rule-based inference system. Using this system, we made an retrospective studies for the actual group of patients and the results shows the usefulness of this approach.

1 INTRODUCTION

Computer assisted diagnosis systems are an important issue in the world of modern medicine. Computer-based interpretations of 2-D images (such as CT, MRI, etc) are among this group of systems which have been utilized by physicians with promising results. Because of this, a great deal of research on computer-assisted-diagnosis support systems (CAD; Computer Aided Diagnosis) have been proposed (Jiang et al, 2000) (Toriwaki et al, 2000) (Tsai et al, 2001) (Cheng et al, 1998) (Ukai et al, 2000), especially for diagnostic imaging tools.

The diagnostic method for cancer detection using the PET (Positron Emission Tomography) and X-ray CT (Computed Tomography) images is a core technology, which attracts the interests of many medical scientists (Murakami, 2003). During cancer inspection by a PET scan, drugs called FDG (Fluorodeoxyglucose: a glucose-mimicking radioactive element) are administered to the patient, and the gamma rays emitted from the patient are photographed by the nuclear imaging system. The PET images show the various level of absorption (SUV: Standard Uptake Value) of the FDG through out the body. As a result, we can observe the FDG concentration absorbed by the tissues and organs. This is useful because malignant cancer cells have an increased glucose metabolism, so much more FDG is taken into a cancer cell, and so, a SUV value will become much higher than a normal cell. This is referred to as an "abnormal accumulation." However, more FDG will also be taken into areas where inflammation has occurred or organs (such as kidneys, urinary bladder, liver, etc.) which take in more glucose naturally even without the effects of cancer. This latter is called a "physiological accumulation." The purpose of an automated diagnosis system is finding out which areas have signs of an abnormal accumulation based on the images of the whole body PET scan.

During a PET scan of the whole body, tomography is performed by rotating the camera around the axis of the body at intervals of about 3mm. From the results of a whole body tomography (from a femoral region to the parietal region), a physician receives about 3000 slice images per patient. In order to manually analyze these images a physician needs to have much knowledge and experience of PET scans as well as time and effort to interpret these images. This creates a very large burden for the physician, there by increasing fatigue and decreased concentration which may lead to a misdiagnosis. Moreover, the number of physicians who can perform an interpretation of PET image is insufficient.

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On the other hand, in general during a medical check up for cancer by PET diagnostic imaging, 90 percent or more of the samples are normal images. These images lack any indication of cancer. Even still searching for cancer cell is stressful work for the radiologists.

Based on this information, an automated diagnostic support system is a very effective tool for analyzing and pinpointing potentially cancerous areas of the human body.

For the above purpose, existing works are mostly focusing on the specific organs such as the lung (Takeo et al, 2005). Also most researches are based on CT images and the recognition of area are on the combination of filters. On the other hand, our method are based on PET images. However, as for several critical area such as bone and lung, 3D shape and scale are extracted from CT slices. We confirmed that a similar process has been executed in the actual radiologist's diagnosing.

In this paper, design principle of the diagnosis system is introduced in the section 2, and the experimental results are presented and evaluated in the section 3.

2 A SYSTEM WHICH IMITATES DIAGNOSIS OF PHYSICIAN

2.1 Basic Principles for the System's Configuration

The basic principles of the automated diagnosis system which we created are summarized by the following two points.

- In order to use this diagnosis system for mass screenings, the fundamental function is to 'classify' cases into two categories:
  - "The possibility of abnormality followed by a careful examination"
  - "Normal with no need for further inspection"

  Then the next step is to reduce the chance of a misdiagnosis by preventing false-negative results from occurring.
- In order to get the trust of physicians and satisfy the two principles above, the system must reproduce the physician's diagnostic process as faithfully as possible. Our strategy for building this system is to interview many physicians and radiologists to have a greater understanding as well as the feasibility of creating a diagnostic support system. We are establishing a replica of the physician's diagnostic process with an automated computer system. To meet this end we have developed a description language to reproduce the process of a PET scan diagnosis through computer algorithms.

2.2 Feature Analysis of a PET Image

A PET image, unlike CT or MRI, does not express morphological information such as the shape of an organ, but expresses functional values (for example the differences in the amount of glucose metabolized) in the undefined areas. The images are often low resolution and very coarse. Therefore, it is difficult to determine the specific cancerous region within tissue with just PET scan image.

While interpreting the PET images, a physician utilizes his/her knowledge of previous PET scan test cases in order to make a proper diagnosis. Also, the outline image of organs from a CT scan is very useful to confirm the location of the accumulation of cancer. With this in mind, we decided to create a software package that interprets a physician's methodology during PET scan diagnosis and uses the proper PET terminology to describe the program's actions so that it would mimic the performance of the physician. This system is designed so that a physician can monitor the process of diagnosis from the local to global (whole body) level, to evaluate diagnosis's validity and to recommend improvement.

2.3 Architecture of PET Automated Diagnosis System

In order for a computer to faithfully reproduce physician's judgment, this based on experience and knowledge of physician as well as a strict usage of the grammar and language of PET scan diagnosis. The person who translates a physician's methodology into a description language will be called a knowledge engineer. Figure 1 shows the complete concept of the automated diagnosis system.

The knowledge engineer interviews the physician about knowledge and techniques used for the interpretation of PET images. When the diagnostic method is understood, the knowledge engineer translates this information into a diagnostic algorithm. This automated procedures preformed by the computer must be understood and be able to be examined by the physician directly. In order to do this, the system imitates the diagnosis procedure of a physician step by step. Furthermore, image processing functions are needed to visualize the automated diagnosis. So we divide the diagnosis into several parts and provide a proper description of the diagnostic process at each step as well as for each data-processing function that is called.

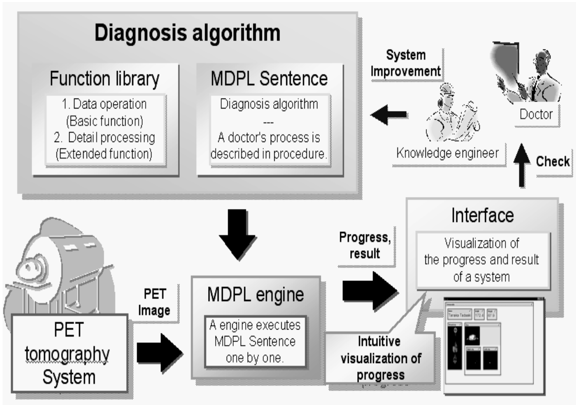

Figure 1: Architecture of PET automated diagnosis system.

And by allowing a physician to view each portion of the diagnostic process, the physician can examine and validate each part of the diagnosis by checking the functions of that particular step of the process and viewing intermediate results, without having to understand the underlying computer program language (Endo et al, 2004). Herewith, a physician can understand and check each individual diagnostic process which the system performs.

In order to express intermediate result data, we developed the logical data structure NEW (Nested Entity Window) (Hasegawa et al, 2005), and we regard the diagnostic process as data manipulation to NEW. Then we also propose programming in language MDPL (Multimedia Data Processing Language) (Hasegawa et al 200) in order to describe the diagnostic process. With MDPL, we can express a particular section of the process in NEW, which has a complex structure.

3 AN EXPERIMENT ON THE COMPUTER-BASED DIAGNOSTIC METHOD

We experimented about the described diagnostic method.

In our laboratory, the MDPL interpreter, NEW manager, and Database System are currently being developed as an independent project. Therefore, in this experiment, we implemented the basic data-processing functions required for building the diagnostic method with suitable parameter. Moreover, we recorded various states of NEW as it was processed by a sequence of functions. Then we could reproduce the flow of the structural change of NEW at the time a particular MDPL statement is called.

3.1 Basic Experimental Data

The data used for the experiment are as follows.

- 12 normal example
- 18 cases of cancer
- Total number of accumulations which have possibility of cancer is 22

3.2 Experimental Result

After applying the computer-based diagnostic method to all examples, the system pointed out 110 ‘abnormal’ accumulations (having possibility of cancer). On the other hand, the professional radiologist pointed out 22 abnormal accumulations. Fig.2 shows the above results as a Venn diagram.

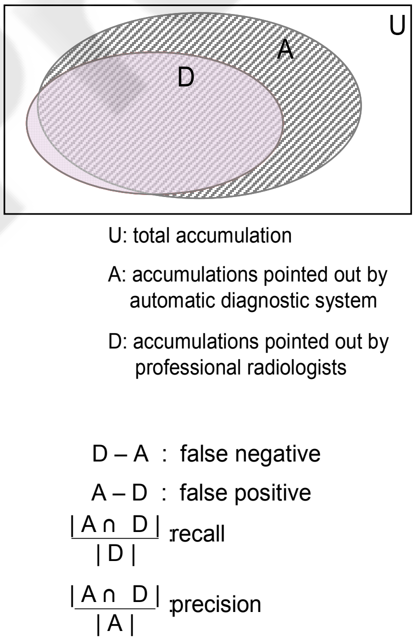

Figure 2: Experimental result based on a diagnostic method.

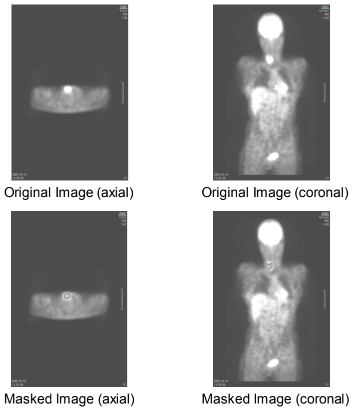

Figure 3: Result of Automated Diagnostic System (thyroid gland cancer).

In the diagram, for example, D-A indicates a set for ‘false negative’ accumulations. That is, each instance of D-A indicates the accumulation that were pointed out as abnormal one pointed by professional radiologist but not pointed out by the automated diagnostic system. Such instance must be kept from occurring in the Computer Assisted Diagnosis.

In our preliminary experiment, the results are as follows:

False negative	0 %
False positive	80.0 %
Precision ratio	20.0 %
Recall ratio	100 %

4 CONCLUSIONS

During this research, we developed and configured a cancer automated diagnosis system and tested its capabilities. It is able to imitate the “real” diagnosis of a physician. The physicians can evaluate the validity of the result by themselves. Also, through the constant feedback and discussions with physicians, we could acquire more information, and, as a result, make improvements to the diagnosis system. Currently we are working to ensure that this system will be able to properly diagnosis and provide a detailed description about any abnormal spots any where in the human. We continue to improve the system in order for the successful utilization in the medical field.

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