Chang S., Chen Z., Lee S. (edts.) Recent Advances in Visual Information Systems, Lecture Notes in CS 2314, 2002 (187-193)

MEDIMAGE – A Multimedia Database Management System for Alzheimer's Disease Patients

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Abstract. Different brain databases, such as: (1) the database of the anatomic MRI brain scans of children across a wide range of ages to serve as a resource for the pediatric neuroimaging research community [6], (2) Brigham RAD Teaching Case Database Department of Radiology, Brigham and Women's Hospital Harvard Medical School [2], (3) Brain Web Simulated Brain Database site of a normal brain and a brain affected by multiple sclerosis [3] are using from many researchers. In this paper, we present MEDIMAGE – a multimedia database for Alzheimer's disease patients. It contains imaging, text and voice data and it used to find some correlations of brain atrophy in Alzheimer's patients with different demographic factors.

1 Introduction

We determined topographic selectivity and diagnostic utility of brain atrophy in probable Alzheimer's disease (AD) and correlations with demographic factors such as age, sex, and education. A medical multimedia database management system MEDIMAGE was developed for supporting this work. Its architecture is based on the image database models [4, 7]. The system design is motivated by the major need to manage and access multimedia information on the analysis of the brain data. The database links magnetic resonance (MR) images to patient data in a way that permits the use to view and query medical information using alphanumeric, and feature-based predicates. The visualization permits the user to view or annotate the query results in various ways. These results support the wide variety of data types and presentation methods required by neuroradiologists. The database gives us the possibility for data mining and defining interesting findings.

2 The MEDIMAGE System

The MEDIMAGE system architecture is presented in the Figure 1.

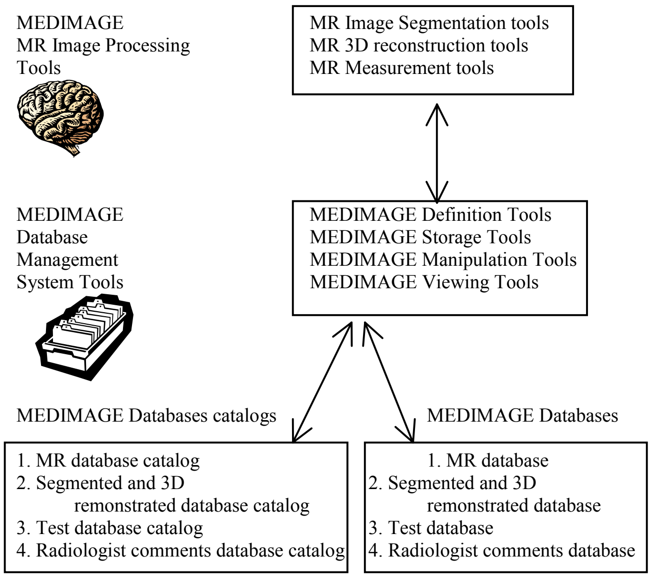

Figure 1. The MEDIMAGE system architecture

2.1 MEDIMAGE System Databases

In the MEDIMAGE system there are four databases:

1. **MEDIMAGE MR Database**. For brain volume calculation we store a two-spin-echo sequence covering the whole brain. 58 T2-weithed 3 mm slices are obtained with half-Fourier sampling, 192 phase-encoding steps, TR/TE of 3000/30, 80 ms, and a field-of-view of 20 cm. The slices are contiguous and interleaved. We collect and store also 124 T1-weighted images using TR/TE of 35/5 msec, flip angle of 35 degrees. Finally we collect patients and scanner information such as: acquisition date, image identification number and name, image modality device parameters, image magnification, etc.
2. **MEDIMAGE Segmented and 3D reconstructed database.** This is the collection of process magnetic resonance images – segmented and 3D rendered.
3. **MEDIMAGE Test database.** The test date includes patient's results from the standard tests for Alzheimer's disease and related disorders.
4. **MEDIMAGE Radiologist comments database.** This data are in two types: text and voice. They contain the radiologist findings.

2.2 MEDIMAGE MR Image Processing Tools

In the MEDIMAGE system there are three main tools for image processing.

1. **MEDIMAGE MR Image Segmentation tools.** These tools include bifeature segmentation tool and ventrical and sulcal CSF volume calculation tool. The CSF denotes the fluid inside the brain.
   - **Bifeature segmentation tool.** Segmentation of the MR images into GM (gray matter), white matter (WM) and CSF is perform in the following way: thirty points per compartment (15 per hemisphere) are sampled simultaneously from the proton density and T2-weigted images. The sample index slice is the most inferior slice above the level of the orbits where the anterior horns of the lateral ventricles could be seen. Using a nonparametric statistic algorithm (k-nearest neighbors supervised classification) the sample points are used to derive a "classificator" that determined the most probable tissue type for each voxel.
   - **Ventrical and sulcal CSF volume calculation tool.** A train observer places a box encompassing the ventricles to define the ventrical CSF. Subtraction the ventical from the total CSF provided a separate estimate of the sulcal CSF.

2. **MEDIMAGE MR 3D reconstruction tools.** These tools include total brain capacity measurement and region of interest definition tools.
   - **Total brain capacity measurement tool.** A 3D surface rendering technique is used to obtain accurate lobal demarcation. The T2-weighted images are first "edited" using intensity thresholds and tracing limit lines on each slice to remove nonbrain structures. The whole brain volume, which included brain stamp and cerebellum, is then calculated from the edit brain as an index of the total intracranial capacity and is used in the standardization procedures to correct for brain size. A 3D reconstruction is computed.
   - **Region of interest definition tool**. Using anatomical landmarks and a priori geometric rules accepted by neuroanatomic convention, the frontal, parietal, temporal, and occipital lob are demarcated manner. The vovels of the lobar region of interest is used to mask the segmented images, enabling quantification of different tissue compartments for each lobe.

3. **MEDIMAGE MR Measurement tools.** These tools include hippocampal volume determination tool.
   - **Hippocampal volume determination tool.** Sagical images are used to define the anterior and posterior and end points of the structure. Then they are reformatted into coronal slices perpendicular to the longitudinal axis of the hippocampal formation. Then the hippocampal perimeter is traced for each hemisphere. The demarcated area is multiplied by slice thickness to obtain the hippocampal volume in the slice.

2.3 MEDIMAGE Database Management Tools

In the MEDIMAGE database management system there are definition, storage, manipulation and viewing tools.

1. **MEDIMAGE Definition Tools.** Those tools are used for defining the structure of the four databases. All of them are using relational model.

2. **MEDIMAGE Storage Tools.** These are tools allowing entering, deletion and updating of the data in the system.

3. **MEDIMAGE Manipulation Tools.** Those tools allow: image retrieval based on alphanumeric, and feature-based predicates and numerical, text, voice and statistic data retrieval.
   - **Image retrieval.** The images are searched by their image description representation, and it is based on similarity retrieval. Let a query be converted in an image description $Q(q_1, q_2, \ldots, q_n)$ and an image in the image database has the description $I(x_1, x_2, \ldots, x_n)$. Then the retrieval value (RV) between Q and I is defined as: $RV_Q(I) = \Sigma_{i = 1, \ldots, n} (w_i * sim(q_i, x_i))$, where w_i ($i = 1,2, \ldots, n$) is the weight specifying the importance of the i^{th} parameter in the image description and $sim(q_i, x_i)$ is the similarity between the i^{th} parameter of the query image and database image and is calculated in different way according to the q_i, x_i values. There are alphanumeric and feature-based predicates.
   - **Numerical, text, voice and statistic data retrieval.** A lot statistical function are available in the system allowing to make data mining using the obtain measurements and correlated them with different demographic factors.

4. **MEDIMAGE Viewing Tools.** Those tools allow viewing images and text, numerical and voice data from the four databases supported by the system.

3. Results Obtaining With the MEDIMAGE System

The results of some of the image processing tools are given in Figures 2-7. Result from the statistical analysis applied to MR images in 32 patients with probable AD and 20 age- and sex-matched normal control subjects find the following findings. Group differences emerged in gray and white matter compartments particularly in parietal and temporal lobes. Logistic regression demonstrated that larger parietal and temporal ventricular CSF compartments and smaller temporal gray matter predicted AD group membership with an area under the receiver operating characteristic curve of 0.92. On multiple regression analysis using age, sex, education, duration, and severity of cognitive decline to predict regional atrophy in the AD subjects, sex consistently entered the model for the frontal, temporal, and parietal ventricular compartments. In the parietal region, for example, sex accounted for 27% of the variance in the parietal CSF compartment and years of education accounted for an additional 15%, with women showing less ventricular enlargement and individuals with more years of education showing more ventricular enlargement in this region. Topographic selectivity of atrophic changes can be detected using quantitative volumetry and can differentiate AD from normal aging. Quantification of tissue volumes in vulnerable regions offers the potential for monitoring longitudinal change in response to treatment.

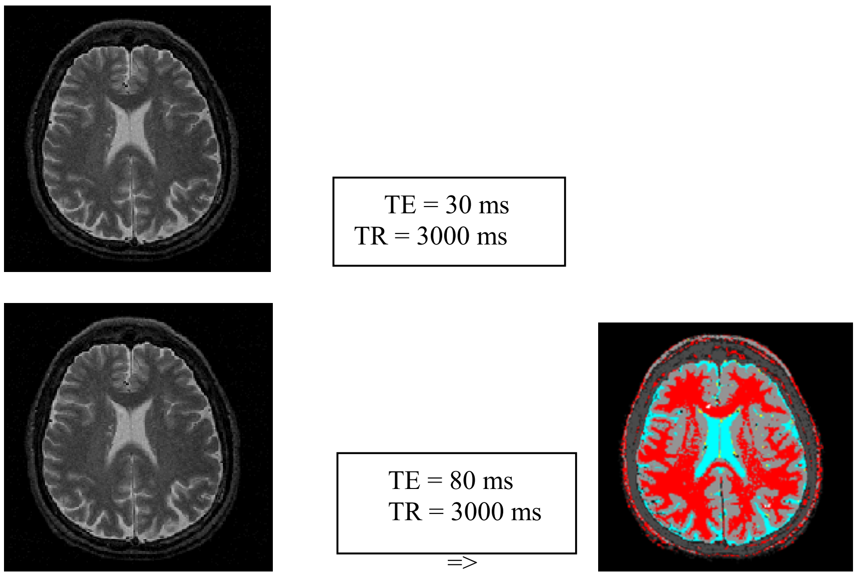

Figure 2. Bifeature segmentation

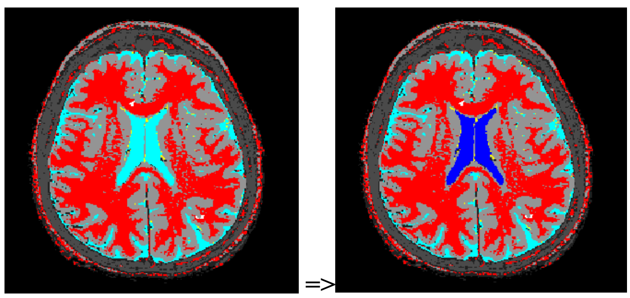

Figure 3. Ventricular and Sulcal CSF Separation

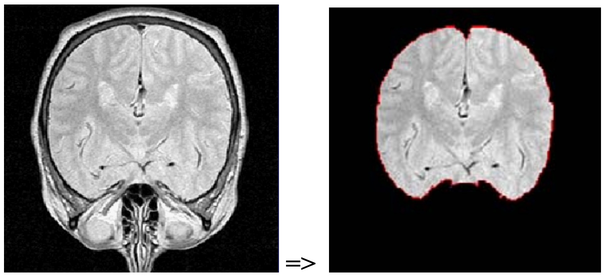

Figure 4. Brain Editing

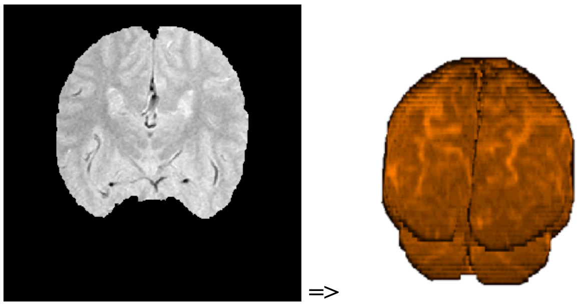

Figure 5. 3D Brain Reconstruction

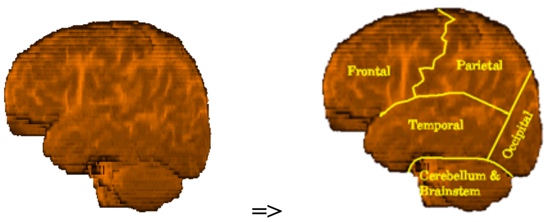

Figure 6. Region Definition

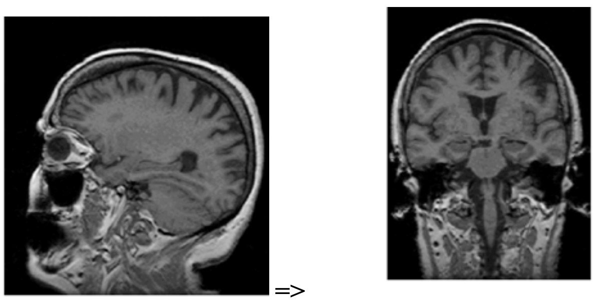

Figure 7. Hippocampal Volume Calculation

4. Conclusions

The MEDIMAGE system was developed in the Sunnybrook health science center, Toronto, Canada, on SUN Microsystems. It uses GE scanner software and ANALYSE and SCILIMAGE packages. The medical findings are described in details in [5].

The main advantages of the proposed MEDIMAGE system are:

- Generality. The system could easily modify for other medical image collection. The system was use also for corpus colosam calculations [1].
- Practical applicability. The results obtained with the system define essential medical findings.

The main conclusion of using the system is that the content-based image retrieval is not essential part in such kind of system. Data mining algorithms play essential roles in similar systems.

References

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