Chapter 18
Context-Aware Medical Image Retrieval for Improved Dementia Diagnosis

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ABSTRACT
Progress in medical imaging technology together with the increasing demand for confirming a diagnostic decision with objective, repeatable, and reliable measures for improved healthcare have multiplied the number of digital medical images that need to be processed, stored, managed, and searched. Comparison of multiple patients, their pathologies, and progresses by using image search systems may largely contribute to improved diagnosis and education of medical students and residents. Supporting image content information with contextual knowledge will lead to increased reliability, robustness, and accuracy in search results. To this end, the authors present an image search system that permits search by a multitude of image features (content), and demographics, patient’s medical history, clinical data, and ontologies (context). Moreover, they validate the system’s added value in dementia diagnosis via evaluations on publicly available image databases.

INTRODUCTION
The human brain, although protected by the skull, suspended in cerebrospinal fluid, and isolated from the bloodstream by the blood-brain barrier, has a delicate nature susceptible to damages and diseases. Among the various disorders affecting the brain, dementias usually caused by a neurodegenerative disease, such as Alzheimer’s, are a devastating subgroup because they are increasingly prevalent and incurable (Williams, 2002).

For the clinical diagnosis of dementia, the practice guidelines recommend the usage of medical imaging together with cognitive and behavioral assessment, laboratory investigations and genetic
testing. The guidelines further advice that Magnetic Resonance (MR) imaging, when available, should be preferred over computed tomography or X-ray, because it provides greater contrast between different soft tissues of the body and uses no harmful ionizing radiation (Waldemar, et al., 2000).

As there exists high variation in the characteristics of different dementia subtypes, and their causes and progress are still not yet fully known, a promising way to improve their diagnosis is to compare multiple patients, their pathologies, and progresses by Content-Based Image Retrieval (CBIR) systems among large repositories of brain MR images.

CBIR in the multimedia domain is known to have a challenging nature (Lew, et al., 2006), while its application in the medical domain demands also consideration for domain or modality-specific differences and challenges, such as ever-increasing quantities of digital images used for diagnosis and therapy that need to be stored, managed, addressed, and searched, subtle focal differences that need to be detected for some pathologies, and image-related variations such as bias field and spatial misalignment of images that need to be handled properly.

Recent research in medical image retrieval has shown improved search capabilities when content-based search is combined with context information. Consequently, to assist the medical experts in the diagnosis of dementia, we are working towards a context-aware medical image retrieval system that allows improved case retrieval via augmenting image-based features with contextual information captured by ontologies. The retrieval system permits the expert to select a query from previously diagnosed cases, to define the search space, to specify the features to be extracted, and to view images of the search result along with the diagnosis-relevant metadata.

In the proposed search system, search space can be defined by restricting the search in two ways: 1) specifying a Volume-Of-Interest (VOI) via an atlas registered on the query image, through a structured list of anatomical entities (anatomical ontology), or by a manual delineation, and 2) confining the search to a disease group selected from a structured list (disease ontology). Moreover, a combination of intensity, texture and shape features from the VOI can be extracted and exploited for retrieval.

In this work, we will introduce our search system from both functional and architectural aspects and validate its added value in dementia diagnosis via evaluations on publicly available image databases.

The chapter is organized as follows. First, we give a general background on image-based diagnosis via search and retrieval, followed by a concise literature review and our contributions. Then we present a clinically-relevant and robust brain MR feature—specifically lateral ventricle shape change—used in this work and explain how it is employed in a search scheme for population analysis. In the following section, the architecture of the system is detailed with emphasis on the system sub-components such as query formation level and the relevance feedback scheme. The proposed system is evaluated in a neuroimaging search and retrieval scenario, where the task is to differentiate sub-groups of neurodegenerative diseases, specifically dementia and Alzheimer's. Accordingly, subjects and imaging data used in this study are introduced, and the corresponding experimental results are presented. The chapter is concluded with future research directions in medical image search and retrieval, and conclusion.

**BACKGROUND**

In the medical domain, a diagnosis by a specialist often requires a visit to a radiology department to obtain various images that highlight the suspected pathology. Despite the high resolution of the acquired images, image based diagnosis often utilizes a considerable amount of qualitative measures. To improve the diagnosis and ef-