Magnetic Resonance Imaging and Magnetic Resonance Spectroscopy Cloud Computing Framework

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ABSTRACT

Magnetic Resonance Imaging (MRI) and Magnetic Resonance Spectroscopy (MRS) are two non-invasive techniques that are increasingly being used to identify and quantify biochemical markers associated with certain diseases, e.g., choline in the case of cancer. The associating of MRI/MRS images, patient’s electronic health record, genome information, and environmental factors increase the precision of diagnosis and treatment. The authors present a collaboration framework based on Cloud Computing which allows analysis of MRI/MRS data based on advanced mathematical tools, advanced combination, and link discovery between different data types, so as to increase the precision and consequently avoid non-appropriate therapy and treatment plans.

Keywords: Breast Cancer, Cloud Computing, Magnetic Resonance Imaging (MRI), Magnetic Resonance Spectroscopy (MRS), Prostate Cancer

INTRODUCTION

Magnetic Resonance Imaging (MRI) and Magnetic Resonance Spectroscopy (MRS) are two non-invasive techniques that are increasingly being used to identify and quantify biochemical markers associated with certain diseases, e.g., choline in the case of cancer. These two modalities are complementary, the former providing morphological information to the clinician,
the latter chemical. Even though both are useful for diagnosis, current practice often considers each one separately.

We strongly believe that by developing advanced mathematical tools to automatically analyze MRI/MRS images, and by correlating the findings of these tools with the patient’s electronic health record, genome information as well as environmental factors, we will be able to greatly enhance the value of MRI/MRS. Some possible applications include; (a) development of models for disease risk evaluation; (b) risk profile of cancer detected by MRI/MRS only; (c) monitoring the response to cancer therapies; (d) improving the accuracy of lesion diagnosis; (e) MRI/MRS screening for certain categories of patients; (f) evaluation of non-conventional MR techniques such as contrast-enhanced perfusion studies for kinetic evaluation, diffusion-weighted imaging, and proton MRS; (g) value of CAD systems for automated tumor volume determination; and (h) differential diagnosis of inflammation from cancer, etc.

The vision of the proposed MRI & MRS Cross Border Collaboration Framework is to leverage the quality of results, to accelerate the evolution, and to strengthen the MRI and MRS analysis combined with EHR and genome research by providing the scientific community with a new-generation, more sophisticated, high performance and global collaborative environment for self-adaptive experiment design and execution with full support for acquisition, storage and user interface.

In this context, the framework aims to combine three fundamental and complementary advanced Technological objectives, namely MRI & MRS, Electronic Health Record Data and Bioinformatics via avant garde computing paradigms, with Cloud computing, Service Oriented Architectures and Semantics in order to provide a reference architecture and to deploy fully operational research pilot experiments.

The ultimate aim of this framework is to build an MRI & MRS International Center of Reference and Excellence. Users (researchers, clinical physicians etc.) will be able to compare their particular MRI & MRS images with those of the database and apply quantitative image processing and analysis tools developed by our team, along with EHR and genomics data analysis, for any of the applications mentioned previously and possibly others.

The tools, the methodology and the infrastructure we will develop will be applicable to many diseases and related or predictive factors, such as genomics. However, for the purposes of this framework we shall limit ourselves to prostate and breast cancer.

PROSTATE AND BREAST CANCER

Prostate cancer is the most frequently diagnosed cancer and the second leading cause of cancer death among men in the U.S. In 2010, it accounted for 217,000 (28% of the total) new cases, and 32,000 deaths. The incidence for prostate cancer has fluctuated considerably in 1975-1995, and much less since. The reasons for this are not clear, with studies on screening producing conflicting results (Eheman et al., 2012; Jemal, Siegel, Xu, & Ward, 2010).

In Europe the incidence is lower than that of the U.S. and Canada; however, there exist large disparities between different European countries. In the developing world the incidence rates are significantly lower, due to the fact that prostate cancer is a disease of the elderly. The late onset of the disease and its slow progression combined with the low life expectancy in the developing world make prostate cancer less of a concern in these countries. However, the aging of the population in the Western world, the rising of the middle class in countries such as China, and the associated increase in life expectancy suggest that prostate cancer will be a major health concern in the 21st century (Quinn & Babb, 2002).

Screening and diagnosis of prostate cancer is mainly based on the level and kinetics of the prostate-specific antigen (PSA) serum and a digital rectal exam (DRE). When these tests are performed alone, the positive predictive values (PPV) are 42% and 31% respectively. When the
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