

Towards the Early Diagnosis of Alzheimer's Disease via a Multicriteria Classification Model

Amaury T. Brasil Filho, Plácido R. Pinheiro, and André L.V. Coelho

Graduate Program in Applied Informatics, University of Fortaleza,
Av. Washington Soares 1321, J30, Fortaleza CE, Brazil
abrasil@gmail.com, {placido,acoelho}@unifor.br

Abstract. The very early detection of Alzheimer's disease (AD) has been deeply investigated in numerous studies in the past years. These studies have demonstrated that the pathology usually arises decades before the clinical diagnosis is effectively made, and so a reliable identification of AD in its earliest stages is one of the major challenges clinicians and researchers face nowadays. In the present study, we introduce a new approach developed upon a specific Multicriteria Decision Aid (MCDA) classification method to assist in the early AD diagnosis process. The MCDA method is centered on the concept of prototypes, that is, alternatives that serve as class representatives related to a given problem, and has its performance index very dependent upon the choice of values of some control parameters. In such regard, two techniques, one based on ELECTRE IV methodology and the other on a customized genetic algorithm, are employed in order to select the prototypes and calibrate the control parameters automatically. Moreover, a new database has been designed taking as reference both the functional and cognitive recommendations of the Scientific Department of Cognitive Neurology and Aging of the Brazilian Academy of Neurology and a neuropsychological battery of exams made available by the well-known Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Various experiments have been performed over this database in a manner as to either fine-tune the components of the MCDA model or to compare its performance level with that exhibited by other state-of-the-art classification algorithms.

1 Introduction

The Alzheimer's disease (AD) is a progressive and degenerative disease of the brain which causes a serious impairment over its two main activities: thinking and memory. According to Celsis [5], AD is the most common form of dementia among the elderly population, comprising up to 75% of all dementia cases. AD causes a gradual loss of intellectual abilities with deterioration in cognition, function, and behavior, affecting many aspects of an individual life.

This way, with the decline of the normal functioning over the nervous and other bodily systems, and with the natural behavioral and personality changes, the identification of what constitutes abnormal impairment becomes a hard task. Davidoff [6] argues that the problem over the AD diagnosis is not only related to

the current level of understanding of the disease, but also to the comprehension of the normal process involving the patients age. For the author, there are yet no consistent established set of values for what would be a normal level of impairment in the elderly. To overcome these difficulties, some authors [2,9,17] have demonstrated that the AD first symptoms appears relatively early in life, and it evolves during lifetime. This fact raises the chances of identifying the pathology decades before a clinical diagnosis of dementia can be made.

In the present study, a Multicriteria Decision Analysis (MCDA) classification approach, which is developed upon the method recently proposed by Goletsis et al. [14] (referred to hereafter as *gMCDA classifier*), is employed towards the effective early diagnosis of Alzheimer's disease. The gMCDA classifier makes use of the concept of prototypes, that is, special alternatives representing the classes of a problem, and has associated with itself some control parameters related to the expert's preference modeling process. As some of the experiments reported here reveal, the appropriate selection of prototypes as well as the calibration of control parameters are key issues to leverage the gMCDA classifier's performance. This way, our approach combines two complementary techniques, one based on ELECTRE IV methodology [25] and the other on a customized genetic algorithm [8], in order to select the best prototypes and effectively calibrate the control parameters, respectively.

Trying to detect potential patients with AD as early as possible, many studies [3,4,20,22] have investigated potential tests and exams that, through a functional and cognitive analysis, may help the early AD detection. In this context, to evaluate the effectiveness of our MCDA classification approach in the early AD detection, we have developed a special-purpose AD-related database by following the recommendations of the Scientific Department of Cognitive Neurology and Aging of the Brazilian Academy of Neurology [23] and by making use of a neuropsychological battery of exams made available by the well-known Consortium to Establish a Registry for Alzheimer's Disease (CERAD) [12]. Various experiments have been performed over this database in a manner as to either fine-tune the components of the MCDA model or to compare its performance level with that exhibited by other state-of-the-art classification algorithms.

The rest of the paper is organized as follows. The next section presents an overview of some related work concerning the themes of AD and MCDA classification. The third section outlines the main conceptual ingredients of the gMCDA classifier and the methodologies that were employed to solve the prototype and parameter selection tasks. The fourth section provide details of the database we have designed while the fifth section is dedicated to discuss the AD classification experiments we have conducted so far over the new database. Finally, the last section concludes the paper and brings remarks on future work.

2 Related Work

A classification problem refers to the assignment of a group of alternatives to a set of predefined classes, also known as categories. During the last decades these