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Investigation of the visual attention role in clinical bioethics decision-making using machine learning algorithms

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Abstract

This study proposes the use of a computational approach based on machine learning (ML) algorithms to build predictive models using eye tracking data. Our intention is to provide results that may support the study of medical investigation in the decision-making process in clinical bioethics, particularly in this work, in cases of euthanasia. The data used in the approach were collected from 75 students of the nursing undergraduate course using an eye tracker. The available data were processed through feature selection methods, and were later used to create models capable of predicting the euthanasia decision through ML algorithms. Statistical experiments showed that the predictive model resultant from the multilayer perceptron (MLP) algorithm led to the best performance compared with the other tested algorithms, presenting an accuracy of 90.7% and a mean area under the ROC curve of 0.90. Interesting knowledge (patterns and rules) for the studied bioethical decision-making was extracted using simulations with MLP models and inspecting the obtained decision-tree rules. The good performance shown by the obtained MLP predictive model demonstrates that the proposed investigation approach may be used to test scientific hypotheses related to visual attention and decision-making.

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1 Introduction

Decision-making and problem-solving capacity represent important cognitive abilities for people's daily lives. In the context of large raw datasets, data mining techniques, particularly

machine learning (ML) algorithms, have become remarkably useful in the decision-making process due to the ability to reveal hidden patterns, converting data into useful information [9].

In clinical practice, in particular in situations that involve bioethical issues, decision-making by a healthcare professional arises from a complex interaction between the work environment and neural processes parallel to cognition and emotion, leading to choices and judgments that take into account knowledge, risk, uncertainty, and regret, among other aspects [3]. Along with the use of bioethics frameworks in the decision-making process, the adoption of techniques for investigating and supporting ethical decision-making in healthcare has been discussed [11].

This is the case of mobile eye tracking (MET), a mobile technological device that enables measuring eye position and movement in order to map visual attention [27]. Recently, this tool has shown great potential for application in a wide range of fields of knowledge [21], e.g., in mental health [11], radiology and diagnostic imaging [26], human-computer interaction [14], studies of teaching-learning processes [27], and sports [4]. In addition to its broad application, the main interest in the use of MET is due to the fact that it is widely accepted as a valuable non-invasive method for studying visual attention characteristics as well as cognitive, emotional, and sensory status of a subject [11]. Therefore, MET plays an important role in advanced understanding of human perception, reasoning studies, and strategies for problem solving [26].

It is important to notice that the most challenging part of researches using MET is data analysis due to the typical small number of participants - in spite of the volume and complexity of the information produced - and due to imperfect data collection given the interferences produced in the visual exploration process. Hence, combining methodologies is recommended to enhance the analysis of the acquired data, thus optimizing the assessment of the influence of visual aspects in the cognitive process [27]. Although the aforementioned studies have shown an important evolution in eye-tracking research, they were not carried out in conjunction with advanced computational support, such as by employing ML techniques, specially in bioethics.

The present investigation was designed based on these considerations aiming to experimentally study the role of visual search - using MET - in the decision-making process in the case of euthanasia (this project was approved by the Research Ethics Committee of Federal University of Viçosa - CAAE No. 25353714.8.0-000.5153). Euthanasia, which is clearly a classic theme in clinical bioethics [12], is defined as mercy killing or dying process of an ill person, i.e, when someone other than the patient is committed to an action with the goal of alleviating ample and unbearable suffering of the patient [1]. The idea of studying MET data to relate visual features to decision-making for such a complex moral issue was first proposed by Siqueira-Batista et al. (2015) [24], and recommended by Pärnamets et al. (2015) [21]. The present work carries out the authors' proposal using advanced computational methods.

The predictive models obtained in this study resulted in interesting patterns that associate cognition-related visual aspects with the decision-making process. Those results have great potential for future research aiming to build computational tools to help in the ideal set-up of medical teams and to support the decision-making procedure in critical situations where no moral consensus has been established.

2 Materials and Methods

2.1 Machine learning framework

Although this study focuses on the specific case of correlating visual characteristics to the practice of euthanasia, it is worth pointing out that the overall idea of the procedure hereby presented may be applied to any field that uses MET resources to associate vision data with

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