Automated planning for fMRI paradigms design

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Abstract — **Within the last decades, neuroimaging has used several techniques to assess brain activation patterns. In order to achieve the best modeling for assessing brain patterns within and across subjects, designing a task is one of the most important challenges for fMRI enthusiasts. Every subject has their own way to model their functional connectivity, and this functional process differs across subjects. An fMRI experiment relies on precise and effective paradigm design. In order to facilitate the process of task creation, this work has the objective of to design an fMRI paradigm planner. Planning a paradigm, to ensure good experimental design, is especially important for fMRI experiments. For this particular problem, it is intended to create a path-finding algorithm, treating the issue as a search problem.**

I. Introduction

Functional Magnetic Resonance Imaging (fMRI) is a non-invasive method and is a widely used technique to analyze brain functions [1]. fMRI attempts to measure neuronal activity by measuring the concentration changes of oxy- and deoxy-hemoglobin in the stimulated area. This is an indirect measure and it is called Blood Oxygen Level Dependent (BOLD) or hemodynamic response [2].

To develop an fMRI study, first a research question is necessary. Then, the researchers start the design of the fMRI protocol. During a fMRI experiment, specific paradigms are used to evoke hemodynamic response or brain activation in certain areas of the brain. Paradigms are the activities performed or stimulus received by the subject during an exam [3]. The brain areas evoked in an exam are possibly related to the research question, due functional differences between subjects. Visual, motor, language and memory are some examples of common paradigms. In order to activate the brain area of interest, it is necessary to work with a paradigm which will increase the BOLD signal of those regions. The paradigm of an fMRI experiment needs to change according to the specific research question asked.

The fMRI research works with hypotheses that the activity in the determined brain area will be evoked by some task. There are extensive study designs and softwares available for fMRI projects [4]. The main problem is choosing one of the available designs and combining this with a research question. Selecting the most appropriate paradigm is crucial to a correct interpretation of the results and represents a lower cost on the research. Generally, the researchers consult the literature related to the research in question, choosing existing paradigms or creating your own based on theory. An fMRI experiment relies on precise and effective paradigm design. If the paradigm does not show the interest brain areas, all of that investment in time and money may be wasted.

Planning is an area in Artificial Intelligence interested in the automated generation of behavior for achieving goals [5]. The classical planning is the problem of finding a sequence of actions, or plan, then when applied in the initial state of the problem results in a goal state [6]. Trying to solve the paradigm choice problem, we propose to use automated planning techniques.

II. Technical Approach

A. *Planning research*

First, a research on how this specific problem will be modeled in the planning domain is necessary. The initial idea is to solve the problem with a path-finding algorithm. The planner goal is determined in the beginning of the algorithm execution. In this case, the goal will be the cerebral region we wanted to be activated. The expected result is a step-by-step well-described way to achieve the goal. For example: the objective is activate the motor area; the result will be a text with the instructions to activate the motor area (i.e. move the right hand for at least 20s; wait for 20s until the next motor movement).

B. Dataset

Researchers at the Brain Institute of Rio Grande do Sul (BraIns) had interest in this study. Therefore, in this work, we will use the task database provided by BraIns. This dataset is composed of paradigms that activate areas related to: motor skills, language, visual, auditive, memory, attention network and default mode network.

III. Project Management

In this initial phase of the project, we intend to use only tasks designed for control subjects. Control subjects are participants without any kind of illness. After the planner validation, we intend to apply the algorithm in populations with specific conditions that could affect the functional organization of the brain. The project execution was divided in three phases:

First step (first week): Select planning techniques that will be used to solve the problem.

Second step (second week): In the sequence, a paradigm database from BraIns will be used. The dataset will be organized according to the brain areas they activated. Also, probably a classifier to relate the paradigm time series to respective activated areas will be created. These steps are essential to properly develop the planner.

Third step (third and fourth weeks): The last step is to develop the planner, joining the studied planning techniques with the paradigm database.

IV. Conclusion

In this work, we aim to design a paradigm planner for fMRI studies. Through the knowledge of the literature on the brain areas that are activated during a certain type of task, we will develop a planner to indicate the proper task according to the research questions. This work aims to reduce the difficulties in the creation of an fMRI task design.

References

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