Position Paper: Towards an automatic approach based on MAPE-K for the registration of multi-modal data in medical imaging

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Abstract

Nowadays, combining the medical data is important to improve the medical analysis. Several work are interested in enhancing the image registration process in terms of accuracy and CPU consumption. However, the imaging data is more and increasing and heterogeneous which require manual complex intervention. Our work aim to perform the registration process as automatically as possible on a large set of imaging data based on MAPE-K.

Keywords

MAPE-K loop, Fully automatic registration, Medical image, Multi-modal images registration

1. Introduction

In the medical imaging field, there is a huge amount of medical images generated to perform several analysis [1] [2].

Our work is expected to use a large amount of 2D and 3D images from different modalities such as micro Computed Tomography (CT), Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), UltraSound and PhotoAcoustic (USPA) and histological sections. We aim to combine these images and to describe their relative relation in space and time with a multi-modal image registration process .

The collected images for the registration process are heterogeneous in terms of color systems, gray levels, resolutions and dimensions. Also, they may be provided by different scanners in several institutes [3]. In fact, two scans with the same modality but provided by two different scanners may have different gray intensities.

Thus, the multi-modal image registration is a complex task and it requires several manual interventions by the user/expert of the domain to adjust the image registration parameters properly to the characteristics of the processed imaging data.

In literature, several studies are interested only on the registration algorithm enhancement like enhancing the accuracy of the image matching, improving the computing time, etc. Nevertheless,

TACC'22: The 2nd Tunisian-Algerian Joint Conference on Applied Computing, December 13-14, 2022, Constantine, Algeria
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each provided solution is dealing with only one modality combination and don't address the heterogeneity, diversity of modality combinations and big amount of data, in the registration process.

These solutions require an important effort of the user/expert. The expert needs to usually perform several parameters adjustment manually to ensure the proper functioning of the registration process for each type of modality combination.

In our work, we propose a novel architecture for a fully automatic multi-modal registration process without the expert intervention. The automatic multi-modal registration process can be applied in different modality combination and address a big amount of heterogeneous data. This architecture is based on a MAPE-K loop [4] inspired by the architecture of autonomous systems [5].

The rest of the paper is organized according the directives of presenting a position paper [6] as follows: Section 2 presents the opinion of studies which think that the expert intervention is essential to any images registration process. Section 3 introduces our work which presents an approach of fully automatic registration process to address heterogeneity and big amout of data in the registration process. The conclusion is reported on Section 4.

2. Counter Argument

In literature, there are different studies addressing medical images registration process [7][8][9][10][11]. Each registration process handles only a specific modality combination and data-set owning the same characteristics (same color system, same resolution,..).

Nevertheless, several modality combinations are needed to be provided to perform some indispensable medical analysis.

Thus, the experts of the domain need to combine two different inputs from two different modalities.

So, the experts needs to perform the following processes manually:

- Providing registration parameters: pixel-size, segmentation threshold,etc
- Deciding the needed pre-processing: converting, filters, segmentation,etc
- Deciding the registration workflow: 1) converting, 2) segmenting, 3) registering
- Managing the data scan by scan

The user manual interventions can be divided into 2 main categories :

- Setting parameters (to deal with heterogeneity)
- Deciding registration workflow (to deal with the divers modality combinations and big amount of data)

The existing solutions in literature give great importance for the manual interventions performed by the expert, especially when we need to combine two different images from tow different modalities.

They focus only on the registration algorithm enhancement, to improve the computing time and the accuracy of the matching. But there is almost no work handling with the whole process of the registration which requires an important effort by the expert.

3. Arguments

Due to the characteristics of the medical imaging data, the expert has to make a huge manual effort to manage this data and perform image registration. The manual intervention of the expert for collecting and selection of the appropriate parameters according to the different/diverse modalities, structure, color system and the decision of the workflow steps are time consuming and complex task.

Thus, our aim is to perform the registration in a dynamic way, taking into account the characteristics of the medical images with the minimum of manual interventions. To fulfill this need, we aim to provide a fully automatic registration process for big amount of heterogeneous medical images. To achieve these objectives we decided to bring the solution from the software architecture field [12, 13], based on the work in literature that are interested in eliminating the manual user intervention, namely the autonomous systems using MAPE-K loop [4].

In our work, we proposed an automatic registration process, inspired from MAPE-K loop. In the following, we detail its four steps illustrated in Figure 1, namely, Monitoring (M), Analysis (A), Planning (P) and Execution (E) as well as the Knowledge module (K).

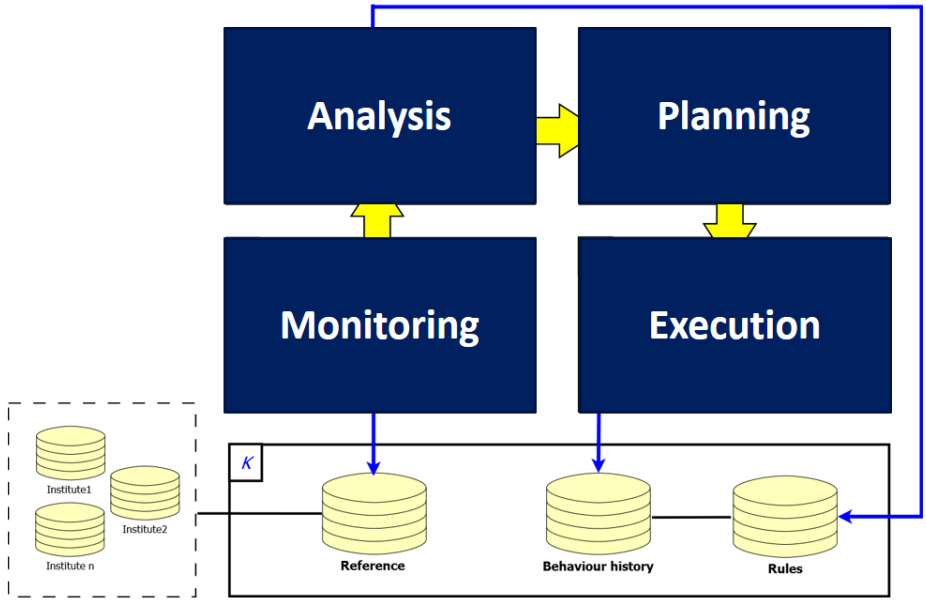

Figure 1: MAPE-K loop steps

The Monitoring phase (M) is responsible in collecting the relevant information about the changing context of the system. In our approach the relevant information are the parameters required in the different steps of the registration process.

In Analysis phases (A), the system makes the needed diagnosis based on the collected relevant information [14]. Then, it plans possible plans of decision to be executed. In our approach the possible plan of decision consists in a set of suggested registration workflow.

In the Execution phase (E), the system execute the most appropriate plan of decision.

The knowledge layer (K) is composed of a “Reference database", a “Rules database" and “Behaviour history database". The “Reference database" contains the information about the structure of the data and how it is stored each external database. The “Rules database" and the “Behaviour history database" are connected to each others to store the behaviour of the system and the information about the executed registration process.

Thus, in our approach, The expert intervention are replaced by the knowledge layer (K) based on learning techniques.

4. Conclusion

Due to the increasing amount of imaging data in the medical domain and the heterogeneity of these data, the registration process require complex manual tasks from the expert of the domain. We propose a novel automatic approach to make the registration process automatically on a large set of imaging data. Our proposed approach, based on MAPE-K loop aims to adapt automatically the functioning of the solution according the changing characteristics of the imaging data.

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