Brain Structures Identification Based on Feature Descriptor Algorithm for Traumatic Brain Injury

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1. INTRODUCTION

Traumatic Brain Injury (TBI) [1] is defined as an acute event that causes certain damage to areas of the brain. TBI may result in a significant impairment of an individual's physical, cognitive and psychosocial functioning. The main consequence of TBI is a dramatic change in the individual's daily life involving a profound disruption of the family, a loss of future income capacity and an increase of lifetime cost.

One of the main challenges of TBI Neuroimaging is to develop robust automated image analysis methods to detect signatures of TBI, such as: hyper-intensity areas, changes in image contrast and in brain shape. The final goal of this research is to develop a method to identify the altered brain structures by automatically detecting landmarks on the image where signal changes and to provide comprehensive information to the clinician about them. These landmarks identify injured structures by co-registering the patient’s image with an atlas where landmarks have been previously detected. The research work has been initiated by identifying brain structures on healthy subjects to validate the proposed method. Later, this method will be used to identify modified structures on TBI imaging studies.

2. METHODS

The goal of this algorithm is to detect and describe local features, considered as blobs, in T1-MRI studies. A blob can be defined as the cross point where at least six direction gradient lines match [2]. The selected detector is the Hessian matrix. The proposed algorithm is based on SURF algorithm [3] and is divided into three stages: location of points of interest, orientation assignment and descriptor generation (Figure 1). This method takes as input the cumulative distribution of image intensity values, also known as named integral image.

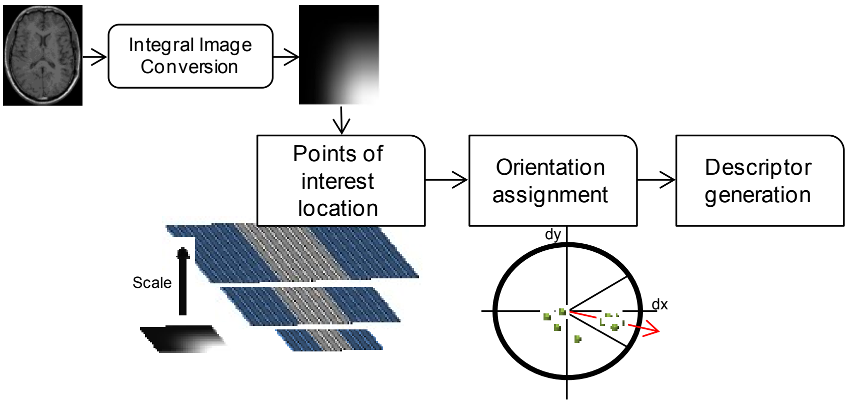

Figure 1. Algorithm Diagram

At the first stage, the aim is to detect blobs. Filters used to find them are based on the Hessian Matrix and they are structured in a pyramidal way, known as scale-space. A multi-scale approximation to a Gaussian second order partial derivative representation in x, y and xy direction is used to generate this scale-space. To make the algorithm independent from local contrast changes, these filters are divided by the standard deviation of pixel values affected by them. Detected landmarks are obtained from the maximum of the determinant of the Hessian matrix by taking into account the size of each filter. Therefore, this algorithm uses solely intensity pixel values affected by each filter and makes the intensity dispersion independent from contrast.

The orientation assignment stage obtains the maximum of the gradient's direction in the neighborhood of each landmark. Finally, information relative to location, orientation and gradient values is stored in a matrix, also known as descriptor.

3. RESULTS

A set of healthy 42 T1-MRI studies were used and 18 brain structures per study were selected. Table 1 compares the efficiency performance in the detection of brain structures between original SURF and the proposed algorithm. Efficiency is the ratio between the number of landmarks and the area of each selected brain structure.

The proposed algorithm obtains higher efficiency values than the original SURF algorithm owing to landmark distribution. It obtains landmarks homogeneously distributed on cortical and subcortical areas. SURF algorithm acquires landmarks around skull and longitudinal fissure whereas our method includes landmarks located away these two regions.

	Original SURF	**Proposed Algorithm**
Superior sagital sinus	8.2%	11.8%
Cingulate gyrus	11.9%	14.4%
Tapetum	10.3%	13.4%
Frontal Horn	57.7%	61.7%
Corpus Callosum	9.6%	13.4%
Cave of Septum Pellucidum	11.3%	13.4%
Anterior horn of lateral ventricle	14.4%	16.3%
Foramen of Monro	17.7%	25.6%
Third ventricle	12.3%	14.7%
Lateral sulcus	3.4%	5.5%
Atrium and Chroids plexus of lateral ventricle	11.0%	12.1%
Sylvian fissure	10.3%	11.4%
Parietoccipital sulcus	53.0%	58.0%
Calcarine sulcus	15.1%	17.2%
Superior sagital sinus	19.9%	21.2%
Internal capsule (anterior limb)	31.8%	35.6%
Head of caudate nucleus	20.5%	23.7%
Thalamus	20.3%	34.9%

Table 1. Efficiency per brain structure

4. CONCLUSIONS

This abstract proposes a feature-based detection algorithm to identify brain structures on TBI T1-MRI studies. This algorithm has been tested, validated and compared with SURF on healthy MRI. On future works, a volumetric extension of this algorithm will be evaluated with patient studies.

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