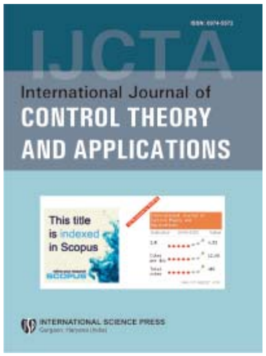

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Recent Advances and Perspective of Studies on Visual Attention Models for ROI Extraction in Medical Images

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Abstract: New advances in Medical imaging have made a great impact on diagnosis and treatment planning. The most important part of medical image processing is the identification of reliable and accurate ROIs. The technological advances in the field of medical image processing require that the capabilities of the human perceptual system are taken into account for identification and extraction of ROI. In general, the main objective of these approaches is to achieve higher-accuracy rate and lower computational costs. This study summarizes the visual attention modeling and discusses the various available visual attention modals used for ROI extraction in medical image processing.

Keywords*: Visual Attention, Medical images, ROI, Saliency.*

1. INTRODUCTION

The amount of image data produced in the field of medical imaging in the form of Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) and ultrasound images has been increased during the last years. Medical imaging is integral to the provision of modern medical care; it provides a wealth of information that is increasingly relied upon in the clinical management of patients and treatment planning. The acquired medical imaging data costs to the community in terms of radiation exposure and the human resources, infrastructure and time involved in the acquisition of medical images. Such information should not be discarded lightly and required to be preserved in such a way and for such a period of time as to maximise the value of initial imaging procedure and minimise the risk of unnecessary repeat tests [1]. Researchers have been focusing on developing automatic systems for these tasks which can effectively aid radiologists for medical diagnosis. In medical images, only some part of the image has the diagnostically important information.To obtain such results it is necessary to first identify the Region Of Interest (ROI) and then carefully analyze it. It was shown that identification of ROI in medical images is a very difficult task due to the complexity of the anatomical structures and their changing with different physiological states.

Psychological studies have revealed that humans detect regions of interest before doing any processing [2]. In identifying an object, Human brain has the strong ability than any computational system. The human eye can focus on a salient location in an input scene and select interesting visual information to process in the brain.The researchers also showed that computer algorithms could be crafted to find ROIs similar to those determined by people.

Various methods are being used for extraction of ROI. The choice of method is important because it highly affects the overall performance of the system. ROIs are acknowledged as the parts of the image where radiologists focus their visual attention. As the automatic identification of ROI is still a challenging research area in medical image processing [3], the use of visual attention models may help to solve this problem of ROI identification and extraction.

2. VISUAL ATTENTION

Visual attention is an ability of the human vision system to rapidly select the salient and relevant objects in an image. The main objective of visual attention is to achieve the required amount of visual information to be processed to solve the complex tasks. There are two types of factors that drive attention: 1) bottom-up factors 2) top-down factors [4]. The factors which are solely derived from the visual scene are called the bottom-up factors [5]. In bottom-up attention, areas of interest which attract human attention are called salient regions. The sufficient discriminance of the responsible features regarding this reaction with respect to the surrounding features must be present. However, the attention which is driven from the cognitive factor e.g. knowledge, expectations and current goals is called the top-down attention [6].

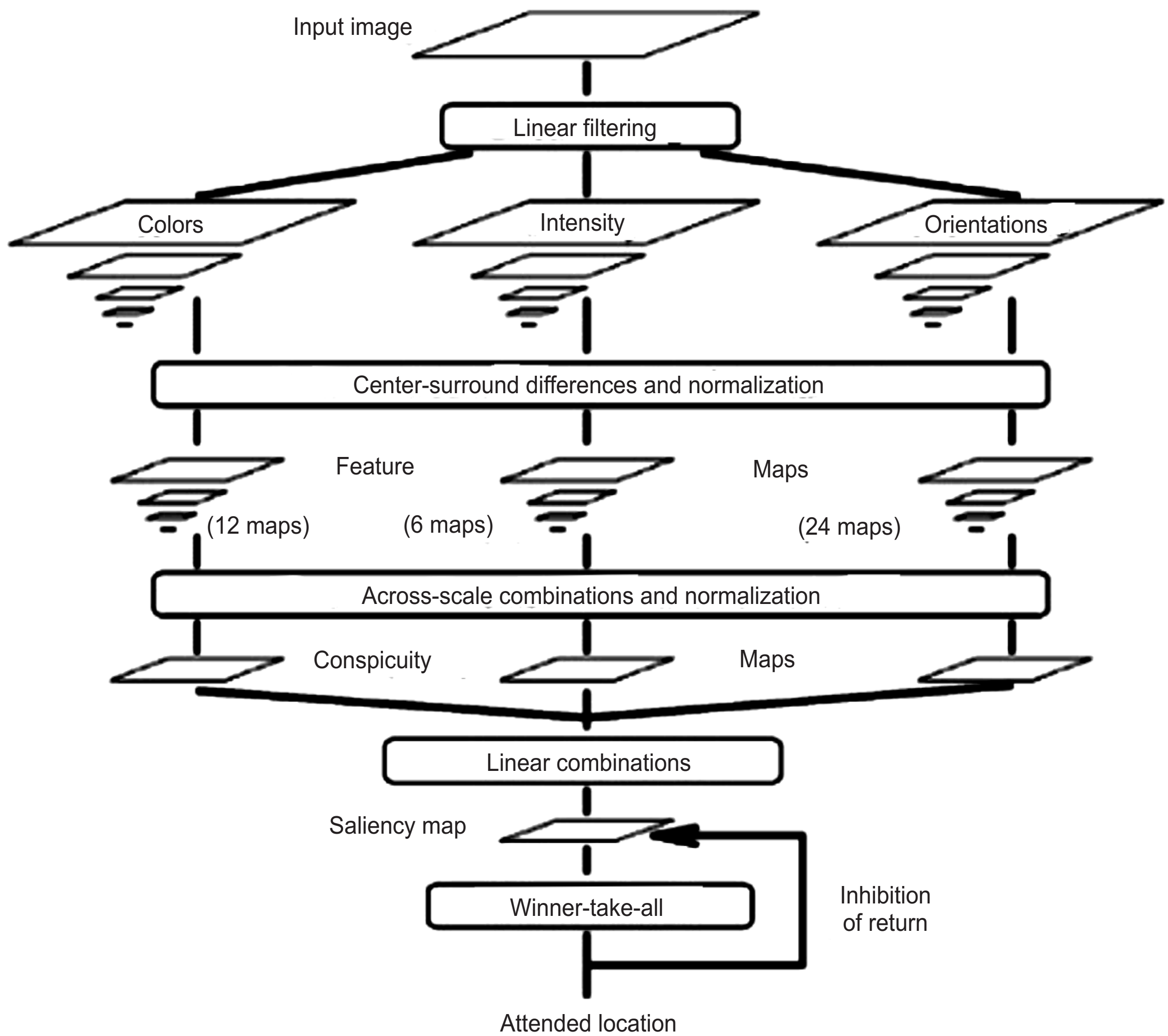

Figure 1: Itti's saliency map detection model [7]

One of the most popularly used computational models has been presented by the Koch and Ullman [7]. This model is bio-inspired, data driven and bound to provide bottom-up computations. This means that the model only considers the image data to accomplish the attentional shifts. Figure 1 illustrates the three main principles on which this model relies. • A unique scalar map that represents the saliency of the locations over entire visual field is called the saliency map. This saliency map corresponds to the feature integrations theory's master location map. • The surrounding area strongly influences the saliency of the scene locations. • There are two suitable mechanism 1) Winner Take All (WTA) 2) Inhibition of Return, which allow the deployment of attention over the visual field. The model starts the process by extracting a set of scene features *e.g*. orientation, color, motion etc in a parallel manner. Then the lateral inhibition mechanism is used to compute the conspicuity maps for the each considered feature in a parallel manner. Then each conspicuity map highlights the visual scene parts that differ strongly from their surroundings, with the accordance of their corresponding feature. It is suitable to use the multi-scale center-surround filters for the implementation of conspicuity transformation. In the next step, different conspicuity maps are merged in one map of attention which is called as the saliency map. The saliency map, with respect to all considered features, accomplishes the topographical encoding for the location saliency over the entire scene. After computing the saliency map for a visual scene, the next step is to find the most salient locations in the scene. For this purpose, the Focus of Attention (FOA) network is generally implemented by using the Winner Take All (WTA) mechanism, which allows the selection of the most salient locations in a visual scene.

The saliency-based model of visual attention is considered as the most accepted model which has been adopted for the simulation of visual attention. Various saliency models used for ROI extraction in medical images are discussed in the next section.

3. DISCUSSION ON ROI EXTRACTION USING VISUAL ATTENTION

A method to extract tumour from brain MRI images was proposed in [8]. Itti's model was modified to compute the saliency map and ROI was extracted with dynamic thresholding. Experiment was performed on 100 biomedical images. Results were compared with Itti and Hou's method. Subjective evaluation showed that proposed method extracted ROI efficiently.

A method based on visual attention model was proposed to extract ROI from medical Computed Tomography (CT) images in [9]. To strengthen the finer textures, texture features and some salient factors were selected. A saliency map was then generated by considering the texture and orientation as visual features. Saliency map highlighted the region of liver focus. Experimental results showed that the ROI detected by saliency map was more accurate and efficient than Fuzzy C-Means (FCM) clustering.

Matsumoto et al. used saliency map to find stroke lesions in brain CT images [10]. Authors applied Graph-Based Visual Saliency (GBVS) model for creating saliency map and results were compared with human eye-fixation patterns. This study investigated that bottom up mechanisms play a significant role in guiding the eye movements of neurologists looking for abnormalities.

Jampani et al. investigated the role of computational saliency models on X-ray and retinal images in the context of abnormality detection [11]. Images were taken from Diabetic Retinopathy Database Calibration Level 1(DIARETDB1) dataset. They computed the saliency maps using three models namely Itti-Koch, GBVS and Spectral Residual (SR). The obtained maps were evaluated against gaze maps and ground truth from medical experts. This study showed that bottom up saliency plays an important role in medical images.

Mendi et al. applied the selective visual attention for ROI extraction [12]. Chan-Vese active contour model is used for image segmentation and attended locations are determined by saliency map. The combination of the two techniques minimized user interaction and speeds up the entire segmentation process. An Inverse Difference Pyramid (IDP) approach was developed for image compression with the hypothesis that the image resolution exponentially decreases from the fovea to the retina periphery. This approach transferred the image layer by layer on network. This work was not compared with other methods and no metric was used for result evaluation.

Ujjwal et al. explored the role of visual saliency in Computer Aided Detection (CAD) algorithm design [13]. The authors proposed a visual saliency based framework for detecting abnormalities and illustrated it for bright lesion detection and discrimination in retinal images. The approach was evaluated on five publically available databases. HEI-MED, Diaretdb0,1 (combined and named as DiaretDB) and MESSIDOR were used for Hard Exudates (HE) detection whereas ARIA and STARE are used for drusen detection. The results showed that visual saliency can be used as an alternate avenue for automated abnormality detection.

Alpert et al. proposed the saliency based method for abnormality detection in different types of medical images [14]. They used the same algorithm for detection of lesions and microcalcifications in mammographic images, stenoses in angiographic images and lesions in Magnetic Resonance Images (MRI) of brain without parameter tuning. This algorithm showed good results on a variety of detection tasks in different modalities.

Banerjee et al. developed a visual saliency based algorithm for the identification of tumor regions from MR images of the brain [15]. The salient regions in the image were highlighted by defining a bottom-up strategy, based on a pseudo-color distance and spatial distance between image patches. MRI images of 80 subjects were used from Brain Tumor Segmentation (BRATS) database to evaluate the method in terms of the saliency map values. This method is fully automatic and unsupervised and performed better in terms of Area Under the Curve (AUC) scores.

4. CONCLUSION

The task of automatic identification of ROIs is more difficult and it becomes challenging for an algorithm to identify ROIs such that they correlate well with the ones identified by the human observer. Studying the visual attention has become a key area in the field of studies on ROI based medical image processing techniques. The human vision inspired systems are promising alternatives as far as the robustness and performance of the computer vision solutions are concerned.

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