



Abstract of the Thesis



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Title of the Thesis: EDGE DETECTION FOR BRAIN TISSUE
SEGMENTATION IN MR IMAGE

Abstract

Edges are a crucial aspect of object and image representation and analysis. They separate an object from its background, highlighting the object's surface characteristics and defining its inter-object boundaries and internal textures. In semi-automatic or fully automatic image analysis and understanding, edges play a significant role in the detection and representation process. They serve as a prominent characteristic feature for representing the shape of an object.

Magnetic resonance imaging (MRI) or nuclear magnetic resonance imaging (NMRI) is primarily a medical imaging technique used in radiology to visualize the internal structure of the body. MRI provides a much greater contrast between different soft tissues of the body. This ability makes it useful for neurological, musculoskeletal, cardiovascular, and oncological imaging. Human brain matter tissues can be categorized as White matter (WM), Gray matter (GM), and Cerebrospinal fluid (CSF). Most of the brain structures are anatomically defined by the edges of these tissues. Detection of these edges is an important step for quantitative analysis of the brain and its anatomical structures. It is also an important step for the detection of various pathological conditions affecting brain parenchyma. It is also used for surgical planning, simulation, and three-dimensional visualization to diagnose and detect abnormalities. It is also useful in the study of brain development and human aging. As a result of low contrast, various sources of noise, partial volume effects, structural variations, and various types of artifacts the edge detection process of MRI images of the brain is non-trivial.

Starting from the basic definition of the edge, the phenomenon of the appearance of edges in the image, different models used to model the edge like step, ramp, line, and roof edge models are presented. The well-known traditional edge detectors like Roberts Edge Detector, Prewitt Edge Detector, Sobel - Feldman Edge Detector as well state of art and cutting-edge edge detectors like Holistically-Nested Edge Detector, Richer Convolutional Features Edge Detector, Bi-Directional Cascade Network for Perceptual Edge Detector and Dense Extreme Inception Network Edge Detector are implemented and analyzed.

MRI images always contain a significant amount of noise caused by operator performance, equipment, and the environment. This noise can lead to major inaccuracies in the edge detection process and hence in segmentation results. We conduct research in measuring the performance of Edge Detectors for edge detection in different noise levels for MRI images. To validate the accuracy and robustness of these Edge Detectors we carried out experiments on MRI brain scans. The performance of the edge detectors is analyzed by different quantitative measures. These quantitative measures like accuracy and F measure. As a result of the increasing amount of noise in the MRI image, the performance of the edge detector degrades. The noise in the image causes spurious edges and results in a decrease in the accuracy of the edge detector. We proposed an edge detector with the ability to withstand the increasing amount of noise in the MRI image. We also proposed one variation of the proposed method with a spatial variation edge detector to improve the accuracy of the edge detector in the presence of noise.

List of Publications:

1. Parmar, G. D. and Shah, T. V. "Traditional and state-of-the-art edge detectors" Stochastic Modeling & Applications Journal Vol. 25 No. 3 Page. 2048-2054, 2021
2. Parmar, G. D. and Shah, T. V. "Effectiveness Analysis of Holistically-Nested Edge Detector for Brain Tissue Segmentation in Single-Channel MR Image" Stochastic Modeling & Applications Journal Vol. 26 No. 3 Page. 441-449, 2022
3. Parmar, G. D. and Shah, T. V. "Effectiveness Analysis of Richer Convolutional Features Edge Detector for Brain Tissue Segmentation in Single Channel MR Image" NeuroQuantology Journal Volume 21, Issue 1 Page. 150-157, 2023