A Comparative Objective Assessment on Mesh-Based and SVM-Based 3D Reconstruction of MRI Brain

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ABSTRACT

Three-dimensional reconstruction is the process of acquiring the volumetric information from two dimensions, converting and representing it in three dimensions. The reconstructed images play a vital role in the disease diagnosis, treatment and surgery. Brain surgery is one of the main treatment options following the diagnosis of brain damage. The risk associated with brain surgery is high. Reconstructed brain images help the surgeons to visualize the exact location of tumor, plan and perform the surgical procedures from craniotomy to tumor resection with high precision. This survey provides an overview of the three-dimensional reconstruction techniques in MRI brain and brain tumors. The triangle generation methods and support vector machine methods are briefly described. The advantages and disadvantages of each method is discussed. The comparison reveals that Immune Sphere Shaped Support Vector Machine is the best choice when execution time is considered and triangle mesh generation algorithm is the best when visual quality is considered.

KEYWORDS

3D Reconstruction, Brain, Brain Tumor, Delaunay’s Triangulation, Immune Sphere Shape Support Vector Machine, Marching Cubes, MRI, One Class Support Vector Machine

INTRODUCTION

The brain is an intricate organ in the human body. The brain is constantly active and controls all the other organs in the body. Human brain is composed of soft tissues which are very irregular, and the reconstruction of such tissues is a complicated task. Brain tumors are abnormal and uncontrolled proliferations of cells in brain. Apart from brain tumor, these are some disorders like stroke, cerebral palsy, Parkinson’s disease, traumatic brain injury, Alzheimer’s disease, Batten’s disease that lead to intense brain damage. The physicians and surgeons use computer aided diagnosis system to improve the accuracy of diagnosis. Three-dimensional reconstructed brain aids in viewing the pathology of brain related diseases. Brain surgery is one of the main treatment options following the diagnosis of brain damage. The risk associated with brain surgery is high and is very difficult to make an accurate

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A detailed and well-planned surgery can reduce the potential risk associated with brain surgery. Imaging technology plays an important role in the diagnosis of disease. High-reliability images are produced by medical imaging which offers the potential for advances in medical field. Magnetic Resonance Imaging (MRI) is the long-established imaging technique to acquire the images of soft tissue in brain. The MRI images provide information in two dimensions which needs to be converted to three-dimensional images or models that provides better visual effects. Reconstruction is the process through which these images can be obtained. The three-dimensional reconstructed images help the surgeons in examining the surface and anatomical structures of the brain. The patient-specific reconstructed images improve the confidence of neurosurgeons while handling complex cases (Lamata et al., 2010). The requisite of powerful visual aids that assist in pre-procedure planning for reducing the risk in brain surgery is the motivation of the survey.

Magnetic Resonance Imaging was introduced into clinical practice in the early 1980s. MRI plays an important role in clinical diagnosis and biomedical research. The technology has undergone tremendous growth during the past thirty years and now MR is one of the preferred diagnostic imaging modalities. The brain images are acquired with MRI. MR imaging is non-invasive and safe, since they do not use ionizing radiation for producing the images. The pre-processing steps make the medical images suitable for further processing. The contaminations in MRI images can be modelled as non-additive Rician noise. A non-local means-based filtering algorithm proposed by (Vikrant Bhatheja, Tiwari, & Srivastava, 2015) suppresses Rician noise without disturbing the structural details and provides high-performance denoising. Technical developments are applied to improve and optimize conventional MRI. Rapid development in MRI is marked by the emergence of new pulse sequence such as Chemical Exchange Saturation Transfer MRI (CEST-MRI) and Diffusion-weighted Whole-body Imaging with Background body signal Suppression (DWIBS) (Dong, Andrews, Xie, & Yokoo, 2015). Compressed Sensing MRI and MR fingerprinting (MRF) are the emerging techniques widely used in research. The following literatures are related to MR model reconstruction in two dimensions that gain the attention of researchers. MR image acquisition considers the k-space data as input and the reconstruction algorithms are applied on to the obtained input. Model-based reconstructions help in the quantitative measurement of tissue properties. (Sumpf, Uecker, Boretius, & Frahm, 2011) developed a model-based reconstruction technique for a standard spin–echo MRI sequence with Cartesian encoding. This method provides a higher extent of undersampling than the conventional parallel MRI for T2 mapping. The new paradigm of MRF introduced by (Ma et al., 2013) replaced the qualitative measurements of clinical MRI with quantitative multiparametric measurements. This method improves the accuracy by pairing with suitable pattern matching algorithm. Bayesian inference algorithm is suggested by (Dikaios, Arridge, Hamy, Punwani, & Atkinson, 2014) to approximate the functional parameters directly from (k, t) - space data for the reconstruction. (Trémouilhac, Dikaios, Atkinson, & Arridge 2014) presented reconstructions based on Robust Principal Component analysis, where the MR signal is decomposed using sparse components and low rank. The method proposed by (Zhao, Lam, & Liang, 2014) desegregates the signal model with sparsity constraints on its parameters, for the direct reconstruction of parameter maps. (Hamy et al., 2014) introduced robust principal component analysis as a registration technique for motion correction in Dynamic Contrast Enhanced MRI. (Li, Chen, Yang, & Huang, 2018) proposed similarity measure for multimodal image registration that can be applied for two images as well as for batch of images. (Bhatheja, Patel, Krishn, Sahu, & Lay-Ekuakille, 2015) introduced a superior method for fusing the images from MRI and CT. The combination of Stationary Wavelet Transform (SWT) and Non-Subsampled Contourlet transform (NSCT) are employed in two stages to obtain the fused image. The technique of NSCT used for multispectral image fusion by (Bhatheja, Srivastava, Moin, & Lay-Ekuakille, 2016) provides superior performance on comparison using fusion metrics. With the aim of accurate diagnosis of brain tumor, computer-aided detection system was proposed by (Raj, Alankrita, Srivastava, & Bhatheja, 2011) The features of cerebral MRI were improved by enhancement techniques in spatial domain and frequency domain for obtaining the desired result.
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