ANALYSIS AND COMPARISON OF SWT BASED MEDICAL IMAGE FUSION ALGORITHM USING MAXIMUM AND AVERAGE FUSION RULE WITH IMPROVED PSNR AND SSIM

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Abstract

Aim: The aim of this research work is to detect the presence of brain tumor using Stationary wavelet transform and comparing the peak signal to noise ratio (PSNR) between maximum and average fusion rule algorithm.
Materials and Methods: The sample images were taken from kaggles website. Samples are considered as N=20 for maximum rule and N=20 for average rule algorithm in accordance with total sample size calculated using clinicalc.com by keeping alpha error-threshold value 0.05, enrollment ratio as 0.1, 95% confidence interval, G power as 80% . The PSNR is calculated by using the MATLAB Programming with a standard data set.
Results: Comparison of PSNR is done by independent sample t-test using SPSS software. There is a statistical significant difference between maximum fusion rule and average fusion rule algorithm, that showed better results in maximum fusion rule algorithm. The comparison of two means of the algorithms were found to be statistically significant ($p<0.05$).
Conclusion: Maximum rule algorithms were found to give higher PSNR than in average fusion rule algorithms for the detection of the brain tumor.

keywords: Brain Tumor, Innovative Simplified Maximum Fusion Rule, Average Fusion Rule, SWT, MATLAB Programming, PET, CT.

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1. Introduction

This research uses contemporary algorithms such as innovative simplified Maximum fusion rule algorithm and average fusion rule algorithm to detect the presence of brain tumor. The Stationary Wavelet Transform (SWT) is a wavelet transform technique developed to overcome the Discrete Wavelet transforms lack of translation invariance (Pawar et al. 2019). A brain tumor is an abnormal cell growth or mass in the brain (Abujamra 2011). There are many distinct types of brain tumors. Some brain tumors are benign (noncancerous), while others are cancerous (malignant) (Jumah and Al Jumah 2013). The symptoms of brain tumor are headaches that become more regular and severe over time, nausea or vomiting, blurry vision, double vision or loss of peripheral vision as well as gradual loss of sensation or movement in an arm or leg etc. For a long time and for a variety of tests, image processing has been employed in the medical area(Garrido and Muñoz 2015). Doctors recommend tests such as positron emission tomography (PET), computed tomography (CT) and the most well-known and widely utilized magnetic resonance imaging (MRI) for detecting brain tumors (Halefoğlu 2018) (Gupta et al. 2019).

About 87 Google Scholar and 96 ScienceDirect articles related to this research were followed, which was carried out in recent years(Menze and Bakas 2021) (Jumah and Al Jumah 2013). SWT is a well-known and most effective tool in medical image decomposition(Institute and National Cancer Institute 2020) (Gupta et al. 2019). Its concept is based on separate objects of interest in an image from the background depending on their gray level distribution (Bohr and Memarzadeh 2020). Our institution is passionate about high quality evidence based research and has excelled in various domains (Vickram et al. 2022; Bharathiraja et al. 2022; Kale et al. 2022; Sumathy et al. 2022; Thanigaivel et al. 2022; Ram et al. 2022; Jothi et al. 2022; Anupong et al. 2022; Yaashikaa, Keerthana Devi, and Senthil Kumar 2022; Palanisamy et al. 2022).As a previous work some researchers used SWT in diagnosis. Therefore, one of the most effective methods used for the decomposition of images is SWT. It is simple but effective in isolating the objects from the background (Menze and Bakas 2021). This research work deals with the detection of brain tumors using SWT. The classification technique has achieved 91.03 % accuracy.

2. Materials and Methods

This study is conducted in a Simulation lab, Saveetha School of Engineering. There is no ethical concern required for this study. There are two groups involved containing CT images and MRI images. Sample size for each group is 20 (Menze and Bakas 2021). Sample size calculations are done using clinalcalc.com by applying the parameter values from previous iterations. The pretest G power value is 80% and the threshold value is set to be 0.05 and confidence interval as 95%. Matlab programming is used in this work to fuse CT and PET images.

Sample preparation using given algorithms

Sample preparation using given algorithms for the two processes are done for preparing group 2 with 20 samples. First the input images from the dataset are rescaled into 512 x 480 pixels. Next feature extraction and classification is carried out by using SWT. The estimated sample values are exported in MS-Excel for further statistical analysis (Fong, Dey, and Joshi 2020).

Algorithm is trained with features of all the images, instead of individual images and while testing rather than the predicted label of the testing image a whole label of obtained features is predicted. If the image of the majority of features is matching with that of the expected image it is considered as a successful recognition.

Testing setup and testing procedure

All the experimental setup was done in a windows platform CRT monitor with resolution of 1024 x 768 pixels with MATLAB programming software 2018 version with add ons required for complete training and testing purposes. Low resolution image samples are given as an input for testing procedure. In the pre-processing stage, scaling was done to resize the images to 512 x 480 pixels. The brain tumor image for the feature extraction and the output, contains more feature information and has 433 dimensions, allowing for better retrieval performance. Finally the recognition of the brain tumor image is done. The image decomposition is obtained by testing the dataset on a SWT. The sample value stored in MS-Excel is used for statistical analysis in the SPSS IBM tool (Satapathy et al. 2017).

Statistical Analysis

To validate the results of both the algorithms, statistical analysis was done using IBM SPSS software. As the two algorithms are independent of each other, an independent sample t-test was performed for the independent variable PSNR and

Structural Similarity Index (SSIM). There are no dependent variables.

3. Results

In this research of detecting the brain tumor, an innovative simplified maximum fusion rule was found to be better than the average fusion rule giving a higher PSNR (Prakash, Kumar, and Khare 2014). The Representation of group statistics comparison of maximum and average psnr is given in table 1.

It is observed that the mean PSNR is higher for the innovative simplified maximum fusion rule algorithm (12.843) than the mean of the average fusion rule algorithm (10.895).

Maximum fusion rule algorithm has the highest PSNR in comparison to the average fusion rule algorithm. Representation of group statistics comparison of maximum and average psnr as given in table 1.

The descriptive statistics in table 2 gives an independent sample t-test for equality of means and standard error difference. In table 3 the representation of group statistics comparison of maximum and average SSIM is given. Independent Sample t-test for Equality of Means and standard error difference for SSIM is given in table 4.

Figure 1 gives the simple bar graph that compares the mean accuracy values of groups. The mean accuracy of Maximum psnr is denoted as 12.843. The mean accuracy of average is denoted as 10.895. Mean accuracy of detection +/- 1SD. Figure 2 (a), represents the input CT image of brain tumor and Fig. 2(b) represents the PET image of brain tumor (Satapathy et al. 2017; Menze and Bakas 2021) Fig. 2(c) is the fusion of CT and PET image using maximum fusion rule algorithm. Figure 3(a) is the input of CT image, Fig. 3(b) PET image, Fig. 3(c) is the fusion of CT and PET image using average fusion rule algorithm. There appears to be a statistically significant difference ($p=0.014$, $p<0.05$) in both the methods using independent sample t-test as shown in table 2. This strategy suggested that the brain tumor can be detected accurately by using the maximum fusion rule algorithm. These results show that innovative simplified maximum fusion rule algorithms can be used to detect brain tumors accurately in comparison with average fusion rule algorithms (Najarian and Splinter 2016).

4. Discussion

In this research work of detecting brain tumors the highest PSNR values obtained using the innovative simplified maximum fusion rule algorithm, in comparison with average fusion rule algorithm. The standard deviation of maximum fusion rule is 3.918 and for average fusion rule is 5.771 psnr respectively. The results obtained were compared and validated (Gupta et al. 2019) using psnr values. The standard deviation of maximum and average SSIM is 0.184 and 0.158 respectively. From the observation, the maximum fusion rule algorithm is giving better results than the average fusion rule algorithm.

Some of the factors that are affecting this study might be due to the color contrast where subjective image consistency is critical for human perception, pixel size, aspect ratio of the image contrast changes depending upon the medium and image brightness. The aspect ratio and size of the image is considered to be one of the most important parameters (Garrido and Muñoz 2015). Although the above performed algorithm have several advantages over the other algorithms in detecting brain tumor and differentiating the other diseases, its limitations are caused due to certain factors, inefficient real time algorithm which can be considered as more convenient to detect the brain tumor and modifications in algorithm to obtain real time application and further more better PSNR (Russ 2016).

In the near future, as a result, this project will have a glowing future and in continuation to this aspect, where the manual work can be simplified, reduced and can be easily converted into the computerized output at a low cost (Bohr and Memarzadeh 2020). The limitation of this research work is that better dataset of real time images and application with various other machine learning or deep learning algorithms such as maximum algorithm fusion rule and average fusion rule algorithm may give better results (Brownlee 2018).

5. Conclusion

In this study of brain tumor detection, the maximum fusion rule algorithm that operated using the MATLAB programming is found to give better results compared to the average fusion rule algorithm. The peak signal to noise ratio gets improved by considering more and more datas, which is not seen in any other algorithm. This project has great potential and can be efficient in holding, improving and detecting brain tumor images, hence it can be implemented in hospitals and neurologist sectors.

Declaration

Conflict of Interests
No conflict of interests in this manuscript.

Authors Contributions
Author PR was involved in data collection, data analysis, manuscript writing. Author KPI was involved in conceptualization, data validation, and critical review of manuscript.

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Tables and Figures

Table 1. Representation of group statistics comparison of maximum and average psnr.

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
VALUE	**MAXIMUM PSNR**	10	12.843	3.918	1.239
	AVERAGE PSNR	10	10.895	5.771	1.825

Table 2. Independent Sample t-test for Equality of Means and standard error difference.

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
VALUE	**Equal variances assumed**	0.818	0.378	-0.883	18	0.389	-1.947	2.206	-6.582	2.686
	Equal variances not assumed			-0.883	15.84	0.390	-1.947	2.206	-6.628	2.732

Table 3. Representation of group statistics comparison of maximum and average SSIM.

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
VALUE	SSIM AVERAGE	10	0.619	0.184	0.058
	SSIM MAXIMUM	10	0.684	0.158	0.050

Table 4. Independent Sample t-test for Equality of Means and standard error difference for SSIM.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
VALUE	Equal variances assumed	0.102	0.014	-0.84	18	0.412	-0.064	0.076	-0.225	0.096
	Equal variances not assumed			-0.84	17.6	0.412	-0.064	0.076	-0.226	0.097

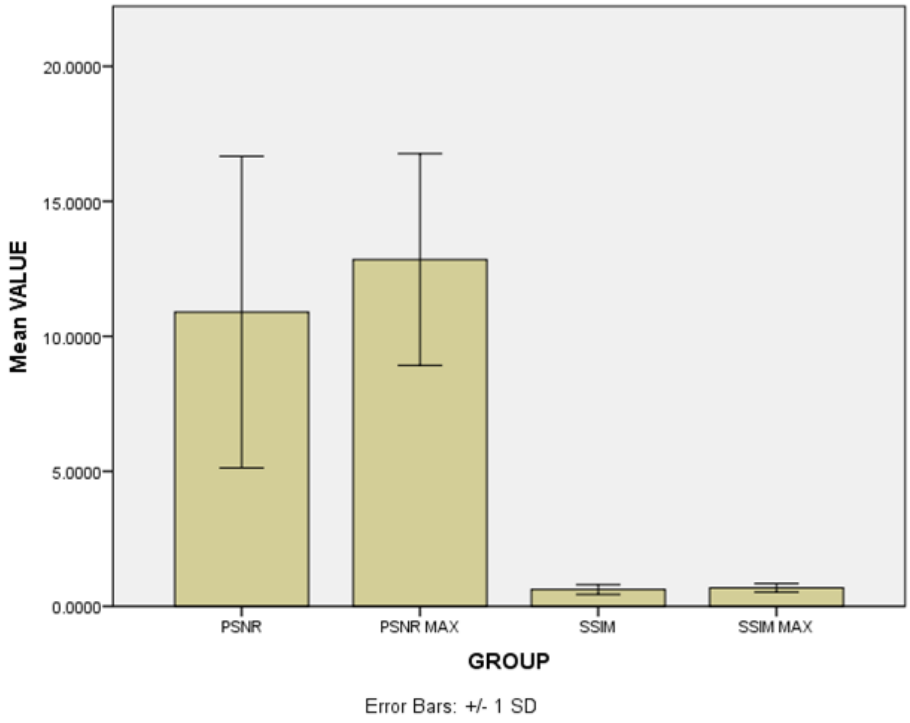

Fig. 1. The simple bar graph compares the mean accuracy values of groups. The mean accuracy of Maximum psnr is

denoted as 10.895. The mean accuracy of average psnr is denoted as 12.843. Mean accuracy of detection +/- 1SD.

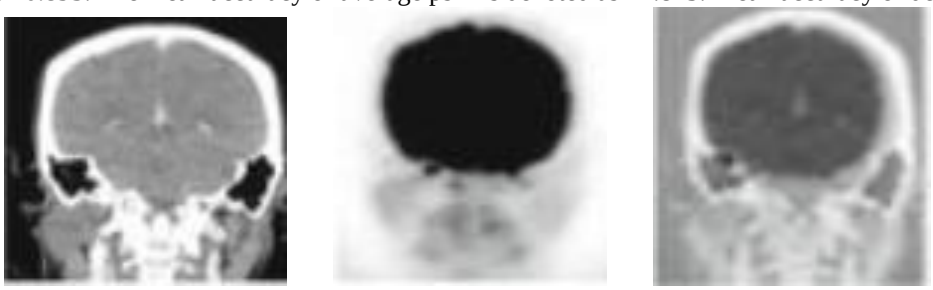

Fig. 2(a) **Fig. 2(b)** **Fig. 2(c)**

Fig. 2.(a) CT image, 2(b) PET image, 2(c)Fusion of CT and PET image using maximum fusion rule algorithm.

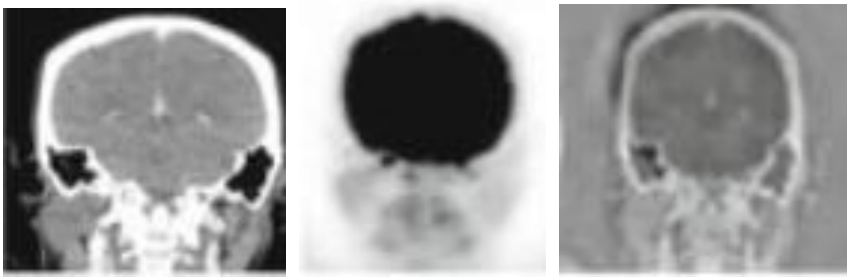

Fig. 3(a) **Fig. 3(b)** **Fig. 3(c)**

Fig. 3.(a) CT image, 3(b) PET image, 3(c) Fusion of CT and PET image using average fusion rule algorithm.