ANALYSIS AND COMPARISON OF DISCRETE WAVELET TRANSFORM BASED MULTIMODAL MEDICAL IMAGE FUSION USING MAXIMUM AND AVERAGE FUSION RULE WITH IMPROVED CORRELATION AND JOINT ENTROPY

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Abstract

Aim: The goal of the work is to compare the Discrete Wavelet Transform (DWT) of multimodal medical image fusion with enhanced correlation and joint entropy by utilizing the innovative maximum fusion rule and average fusion rule.

Materials and Methods: Brain tumor images are taken from the Kaggle website. The samples are separated into two categories. Each group has a sample size of 10 images. Using parameter values from previous iterations, clinical.com was used to calculate sample size. The pretest G power is set at 80% and the confidence interval is set at 95%. The DWT is estimated with the standard dataset and MATLAB programming.

Results: Comparison of DWT is done by independent sample t-test using SPSS software. There is a statistical significant difference between innovative maximum fusion rule and average fusion rule with $p=0.044$ ($p<0.05$) showed better results in comparison to maximum algorithm.

Conclusion: Maximum fusion rule algorithm of DWT values found to show better results than an average fusion rule algorithm for the detection of brain tumor.

Keywords: Discrete Wavelet Transform, Innovative Maximum fusion rule, Average Fusion rule, Correlation, Brain Tumor, MATLAB Programming.

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1. Introduction

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). DWT was previously used in diagnosis by certain researchers. As a result, DWT is one of the most effective methods for image analysis (A. 2011; Hu et al. 2013). It's simple but efficient at separating objects from their backgrounds. The goal of this study is to use DWT to detect brain tumors.

2. Materials And Methods

This study is conducted in the Simulation lab, Saveetha School of Engineering. The samples are divided into two groups. Sample size for each group is 10. Sample size calculation is done using Clinical.com by applying the parameter values from previous iterations (V. and Krishnappa 2015). The pretest G power value is set at 80% and confidence interval at 95%. Matlab programming is used in this work to fuse CT and PET images.

Sample preparation using given algorithms

Statistical analysis validates the results of both the algorithms. Statistical analysis was done using IBM SPSS Software. As the algorithms are independent of each other, an independent sample t-test was performed for the independent variable correlation. There are no dependent variables. Sample preparation for the two processes was done for preparing group 2 with 40 samples. First, the input images from the dataset rescaled to 512x480 pixels. Next feature, extraction and classification is carried out by using Innovative maximum fusion rule and averaging rule. The estimated sample values are exported in MATLAB programming for further statistical analysis. Rules are 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 a successful recognition.

Testing setup and testing procedure

All the experimental setup was done in the Windows platform with resolution of 512 x 480 pixels and MATLAB programming software 2020 version with add ons required for complete training and testing purposes. Low resolution images 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 output contains more feature information and has 433 dimensions, allowing for better retrieval performance. Finally the recognition of the brain tumor image is done.

Statistical Analysis

To validate the results of both the algorithms, statistical analysis is done using IBM SPSS software. As the two algorithms are independent to each other, an independent sample t-test was performed for the independent variable correlation. There are no dependent variables.

3. Results

In this research of detecting the brain tumor the average fusion rule is found better than the maximum fusion rule giving a higher correlation. The correlation value given by maximum joint entropy is 0.560. The value of correlation given by the innovative maximum fusion rule algorithm and the average fusion rule algorithm using matlab programming. Table 1. Correlation results show that the average fusion rule gives better results than the maximum fusion rule. Table 2 Comparison of Independent sample test for maximum and average correlation.The significant 2-tailed value is found to be 0.566, which is less than normal significant value 0.044. Table 3 shows the statistical results of maximum and average joint entropy. It is observed that the mean correlation is higher for the innovative maximum fusion rule algorithm (0.560) than the mean of the average fusion rule algorithm (0.466). The significant 2-tailed value is found to be 0.288, which is less than normal significant value 0.045 as shown in Table 4.

The simple bar graph compares the mean accuracy values of groups as given in Fig. 1. Fig. 2. gives the simulated results of CT, PET image. In results, Fig. 2a is CT image, Fig. 2b is PET image, Fig. 2c are the fusion results of CT and PET images using innovative maximum fusion rule and average fusion rule algorithms. Fig. 3. Simulation result (a) CT image, (b) PET image and (c) Fusion of CT and PET image using average fusion rule. This strategy suggested that the brain tumor can be cured if it is detected early. These results show that average fusion rule can be used to detect brain tumor at an early stage in comparison with maximum fusion rule that interacts with Discrete wavelet transform. The comparison of two means of the algorithms were found to be statistically significant ($p<0.05$). This shows that the method innovative maximum fusion algorithm is found to be effective.

4. Discussion

Mean accuracy value, Standard deviation and Standard Error Mean for maximum and average correlation are obtained for 20 images. It is observed that the average correlation performed better than the maximum correlation and is given in (Gupta-Kagan 2016). Independent sample t-test for mean difference, standard error difference determination and 95% confidence intervals of the difference are given, it also shows that average fusion rule gives better results. Mean accuracy value, Standard deviation and Standard Error for maximum and average joint entropy are obtained for 10 images. It is observed that the average joint entropy performed better than the maximum joint entropy (Valdes-Sosa et al. 2020). Comparison of Independent sample t-test for maximum and average joint entropy, maximum joint entropy value performed better than the average joint entropy. The mean accuracy of Maximum correlation is denoted as 0.466. The mean accuracy of average correlation is denoted as 0.560 (Alyafei 1999). Some of the factors that are affecting this study are 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.

In the near future, we will examine the application of detecting brain tumors in the healthcare field and improving the mean value for the taken diseased images. As a result, this work will have a glowing future in continuation to this aspect, where the manual work can be simplified and reduced and can be easily converted into the computerized output at a low cost (Jackson, LaDuca, and Bergner 2017). A better dataset of real time and its application with various other machine learning or deep learning algorithms such as maximum and average fusion rule may give better results. The comparison of two means of the algorithms were found to be statistically significant ($p<0.05$). This shows that the method innovative maximum fusion algorithm is found to be effective.

5. Conclusion

Innovative simplified maximum fusion rule values of DWT (Discrete Wavelet Transform) gives better results than an average fusion rule algorithm for the detection of brain tumor using MATLAB Programming. This work 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.

Declarations

Conflict of Interests

No conflict of interests in this manuscript.

Authors Contributions

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

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Tables And Figures

Table 1: Statistical results of maximum and average correlation. Mean accuracy value, Standard deviation and Standard Error Mean for maximum and average correlation are obtained for 10 images. It is observed that the average correlation performed better than the maximum correlation.

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
VALUE	MAXIMUM CORRELATION	10	0.466	0.399	0.126
	AVERAGE CORRELATION	10	0.560	0.318	0.100

Table 2: Comparison of Independent sample test for maximum and average correlation.The significant 2-tailed value is found to be 0.566, which is less than normal significant value 0.044.

		Levene's Test for Equality of variance		t- test for equality of mean						
		F	Sig	t	df	Sig 2 tailed	Mean Diff	Std Error Diff	95% Confidence Interval of the Diff	
									Lower	Upper
VALUE	Equal variances assumed	0.560	0.044	0.584	18	0.566	0.095	0.162	-0.244	0.433
	Equal variances not assumed			0.584	17.14	0.567	0.094	0.161	-0.246	0.434

Table 3: Statistical results of maximum and average joint entropy. Mean accuracy value, Standard deviation and Standard Error Mean for maximum and average joint entropy are obtained for 10 images. It is observed that the average joint entropy performed better than the maximum joint entropy.

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
VALUE	MAXIMUM JOINT ENTROPY	10	10.75	1.5211	0.4810
	AVERAGE JOINT ENTROPY	10	11.42	1.2148	0.3841

Table 4:Comparison of Independent sample test for maximum and average joint entropy. The significant 2-tailed value is found to be 0.288, which is less than normal significant value 0.045.

		Levene's Test for Equality of variance		t- test for equality of mean						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
VALUE	Equal variances assumed	1.809	0.045	-1.09	18	0.288	-0.674	0.615	-1.967	0.618
	Equal variances not assumed			-1.09	17.16	0.288	-0.674	0.615	-1.972	0.623

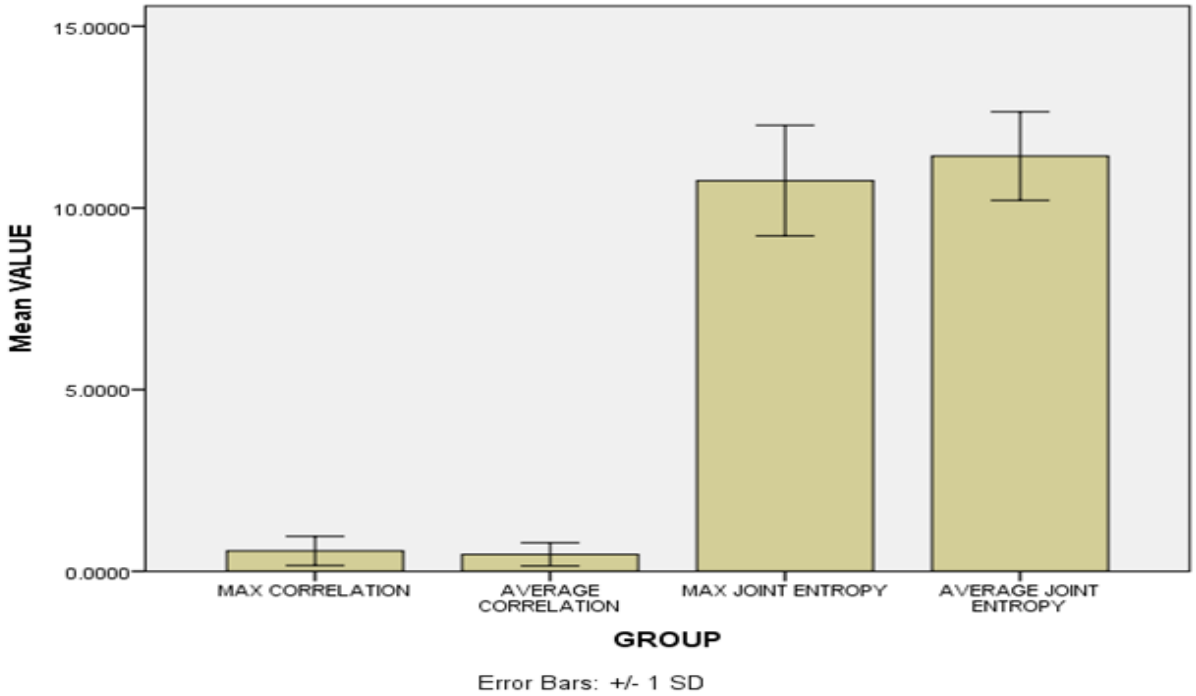
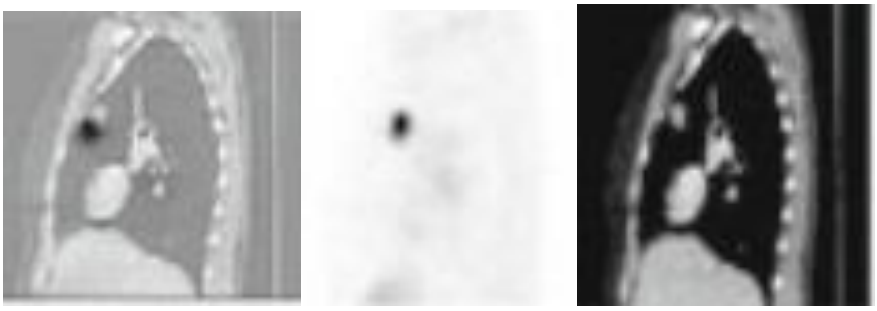
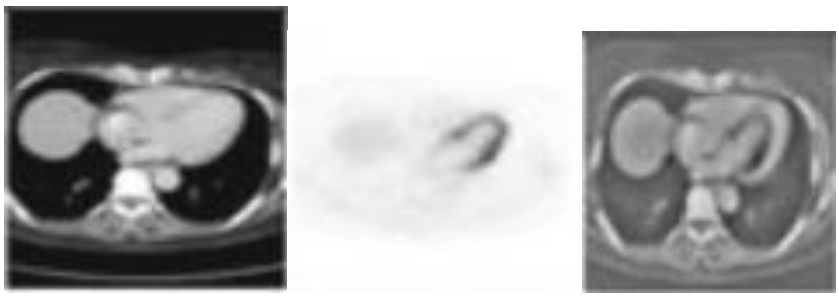


Fig. 1. Bar chart represents the comparison of maximum joint entropy and average joint entropy. Average joint entropy appears to produce the most consistent result when compared to maximum joint entropy. X-axis comparison of Correlation and Joint entropy Y-axis Mean value= ± 1 SD.



a. CT image b. PET image c. Fusion of CT and PET image

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



a. CT image b. PET image c. Fusion of CT and PET

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