E-ISSN : 2963-4946
Vol. 2 No. August 11, 2024

Asian Journal of
Social and Humanities
https://ajosh.org/

Application of Fusion Technique with ImageJ Stacks Feature for Brain Tumor MRI Image Optimization

Nur Wahyu Tajuddin, Bambang Satoto, Rini Indrati, Donny Kristanto Mulyantoro, Darmini, Gatot Murti Wibowo
Poltekkes Kemenkes Semarang, Indonesia
E-mail: nurwahyutajuddin1999@gmail.com, bambang99satoto@gmail.com, riniindrati@poltekkes-smg.ac.id, donny.kristanto@yahoo.com, da12mini@gmail.com, gatotmurtiw@gmail.com

***Correspondence:** nurwahyutajuddin1999@gmail.com

KEYWORDS

MRI Brain Tumor; Fusion; Stacks ImageJ; Axial T2-Flair; Axial T1-GD (T1-weighted post-contrast)

ABSTRACT

Fusion techniques on MRI for brain tumors can provide comprehensive visualization by combining Axial T2-Flair and Axial T1-GD (T1-weighted post-contrast) sequence images. Fusion MRI in brain tumors is able to clearly display the location, size and characteristics of the tumor. However, not all institutions can install such additional fusion software due to significant additional costs. Therefore, this study aims to prove that the Stacks feature on ImageJ as an alternative can be optimal in visualizing brain tumor image information through MRI fusion techniques. This study used 17 image samples with a quasi experimental design post test only without control group design to compare three analysis methods, namely fusion maximum intensity, minimum intensity and average intensity so that the most suitable projection can be determined. The evaluation of image quality was carried out through a histogram which was then analyzed with a crucal-wallis and the Mann Whitney u test, while the analysis of pathological information used a crucal-wallis, followed by a post hoc test and continued with Mann Whitney u for further analysis. The results show that the stacks feature on ImageJ can be used in the application of fusion techniques so that it will improve the contrast and sharpness of MRI images, especially in areas with high tumor activity. MRI images of brain tumors with maximum fusion intensity produced images with the highest average gray level and the best pathological information.

Introduction

Brain tumors are abnormal growths of cells in brain tissue, which need to be examined with an MRI of the brain. Symptoms include severe headaches, behavioral changes, visual or hearing impairments, difficulty speaking, seizures, or movement coordination problems. An MRI Brain examination provides a detailed picture of a brain tumor, such as its type, size, location, and characteristics. The incidence of brain tumors continues to increase in the United States and Europe at around 24 cases per 100,000 population in 2020. About 24,000 new cases of primary brain tumors are diagnosed each year in America, with the death rate in the first 5 years reaching 4%. In the Republic of Korea in 2020, there were 11,200 cases of brain tumors, 600 of which were in children under 19 years old (5%), more common in women (62%) than in men (38%). Most diagnosed brain tumors are benign (70%), twice as common in women (Andre et al., 2021; Heranurweni et al., 2018; Kemenkes RI, 2020; Monroy-Sosa et al., 2020)

MRI is highly accurate in visualizing the type, size, location, and characteristics of brain tumors and is capable of providing a detailed picture of the structure of the brain. Brain imaging protocols include various image sequences such as T2 Weighted Axial, T1 Weighted Axial, FLAIR and Diffusion Imaging Axial for axial images, T2 Weighted Sagital and Sagital T1-W for sagittal images, as well as Coronal T2-W TSE for coronal images. Specific sequences such as Axial T2-FLAIR and Axial T1-GD are used specifically to visualize brain tumors (Foster et al., 2023)(Elkholy et al., 2020). The use of axial cut-outs in Brain MRI examinations is very common because it provides a clear and easy-to-understand picture of the structure of the brain and the surrounding anatomy (Foster et al., 2023).

Brain MRI examination with Axial T2-FLAIR sequence is a variant of the inversion recovery sequence that is specifically designed for optimal contrast between brain structures and reducing the signal intensity of cerebrospinal fluid. This sequence is often used in the diagnosis of brain tumors, aiding in the identification of peritumoral edema and evaluating pathological changes around the tumor (Elkholy et al., 2020)(E. Asdiantoro, H. Siswanto, A. D. Sensusiati, 2021). T1-Gd (T1-weighted post-contrast) Axial Sequence is a magnetic resonance imaging (MRI) method that has an important role in the visualization of brain tumors by using gadolinium contrast material to distinguish tumor tissue and normal brain. Its advantage lies in its ability to clearly identify the location, size and characteristics of tumors, essential for the monitoring and planning of brain tumor treatment (Suárez-García et al., 2020)(Jin et al., 2021).

Use of techniques *Fusion* MRI brain tumors make it easier to identify and determine the exact location of tumors, increasing the efficiency and accuracy of diagnosis and treatment planning. No technique *Fusion* in the MRI examination of the Brain in the case of brain tumors, difficulties arise in interpreting MRI images with a low level of accuracy. Radiologists have to rely on individual MRI sequences and manual evaluations, so it will take more time and thought to provide interpretation results (Nadra et al., 2022).

The fusion of T1-weighted imaging with contrast (T1-GD) and T2-FLAIR is the right combination for brain tumor detection. These two sequences have different characteristics and when combined, can provide more complete and accurate information about the presence and characteristics of the tumor and its impact on the surrounding tissues. The selection of ImageJ was done because it is open-source software. Additionally, ImageJ is free to use, making it more affordable and accessible to a wide range of users without the additional expensive licensing fees. ImageJ can also run on a variety of platforms, including Windows, Mac and Linux allowing for greater flexibility in choosing the appropriate hardware (Schroeder et al., 2021).

The application of *fusion* techniques in ImageJ can be done using the Stacks feature which includes several methods, one of which is stack to images, images to stack and z project. Stack to images is used to convert stacks of images into separate images. Images to stack is used to combine a series of images into a single image and Z project is used to create projections from stacks of images with different types of projections such as maximum intensity, minimum intensity and average intensity.

In general, app integration *Fusion* in the MRI modality has become a built-in part in some software. However, software installation *Fusion* in the MRI modality device requires a significant cost expenditure, reaching around 150 million rupiah. Unfortunately, not all hospitals have enough resources to adopt the software (Nadra et al., 2022). Because of this, there is a need for an alternative to be able to do the *Fusion* if the MRI modality is not equipped with software *Fusion* at the same time can specify the type of projection *Fusion* which is optimal in evaluating brain tumor images.

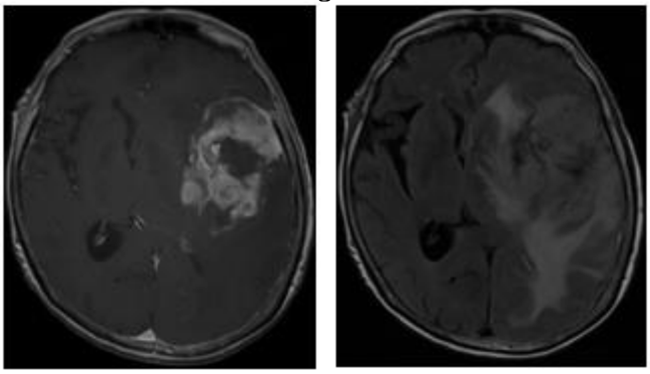
Research Methods

This study used 17 image samples with a quasi-experimental design of post test only without control group to compare three analysis methods, namely fusion maximum intensity, minimum intensity, and average intensity. Each image sample is analyzed using these three methods, so that each method has 17 analysis results from the same image sample so that the most suitable projection can be determined. The evaluation of image quality was carried out through a histogram which was then analyzed with a crucal-wallis and the Mann Whitney u test, while the analysis of pathological information used a crucal-wallis, followed by a post hoc test and continued with Mann Whitney u for further analysis.

Results and Discussions

Result

The image processing process begins by burning MRI images stored in the local database in dicom format. The research sample was MRI images of Axial T2-FLAIR and Axial T1-GD (T1-weighted *post-contrast*) brain tumors which had *a field of view* (FOV) = 220 mm and slice thickness = 5 mm. MRI images of Axial T2-FLAIR and Axial T1-GD sequence brain tumors can be seen in figure 1 as follows:



(a) (b)

Figure 1. MRI images of brain tumor sequences (a) Axial T1-GD (T1-weighted *post-contrast*) and (b) Axial T2-FLAIR sequences

MRI images of brain tumors of the Axial T1-GD sequence (T1-weighted *post-contrast*) and Axial T2-FLAIR sequence were carried out by the Stacks feature in the ImageJ software to be applied to fusion techniques with *projection type* maximum intensity, minimum intensity and average intensity. The process of processing *fusion* images with the Stacks feature in ImageJ software can be seen in figure 2 as follows:

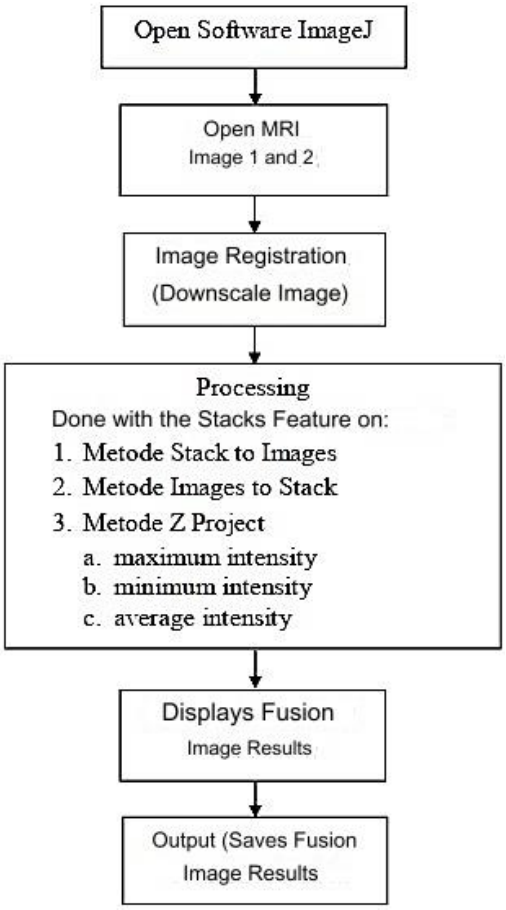


Figure 2. Process Flow of the ImageJ Fusion technique on MRI Brain Tumor with Stacks Feature

The flow of *the fusion* process with the Stacks feature in the ImageJ software above begins by opening the ImageJ application, then opening the two images, namely the MRI image of the Axial T1-GD (T1-weighted *post-contrast*) and Axial T2-FLAIR sequence brain tumors, then the *downscale image* is carried out as a pixel size demonstration with the images to stack method which is in the Stacks feature {(*copy*(*center*)}, if the pixel size is different between the two images to be *fused*. The next step is to do various methods found in the Stacks feature, namely Stack to Images, the implementation can be done by selecting "Image" > "Stacks" > "Stack to Images", used to convert the image stack into separate images.

Once in a single separate image, the images to stack method can be performed by selecting "Image" > "Stacks" > "Images to Stack", used to combine the two images that have been generated previously. Then the last method is carried out by the "Z Project" method by selecting "Image" > "Stacks" > "Z Project", used to make projections on the image that has been stacked into the form of maximum intensity, minimum intensity and average intensity images, After the fusion image display appears, the last step is to save the fusion image results which can be done with various storage formats. The display of *fusion image* results on MRI brain tumors with the Stacks feature on ImageJ with maximum intensity, minimum intensity and average intensity projections can be seen in figure 3 as follows:

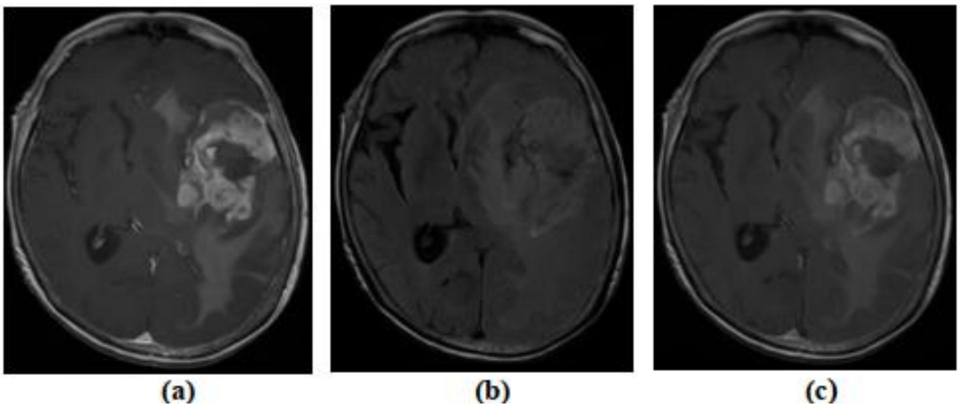


Figure 3. *Fusion* MRI Brain Tumor Projections Maximum Intensity with Features of Stacks (a) Manimum Intensity (b) and Average Intensity (c)

Fusion images that have been obtained previously, then assessments are carried out from the aspects of image quality and pathological information.

Image Quality

The quality of the image in this study was measured from *the gray level* value in each slice of the entire MRI fusion *image* of brain tumors produced from the Stacks feature on ImageJ *fusion results with* projection type *maximum intensity, fusion results with* projection type *minimum intensity and fusion results* with *projection type* average intensity. The gray *level* value is obtained from the display of the value displayed on the histogram using ImageJ software.

The histogram results of MRI *fusion* images of brain tumors produced from the Stacks feature on ImageJ *are fusion results with* projection type *maximum intensity, fusion results* with *projection type* minimum intensity and fusion results with *projection type* average intensity can be seen in figure 4 as follows:

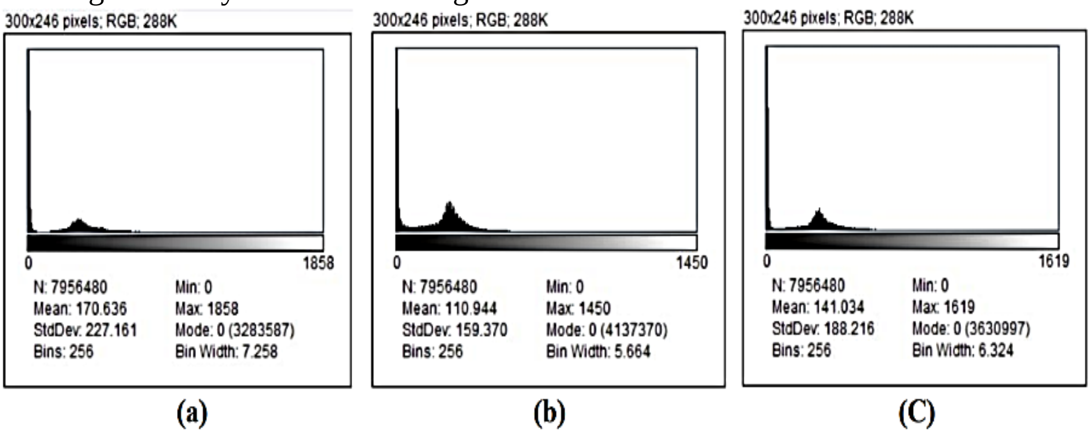


Figure 4. Histogram of *Brain Tumor MRI Fusion* Results Projecting Maximum Intensity with Stacks Features (a) Minimum Intensity (b) and Average Intensity (c)

The information obtained from the display of the MRI image of the brain tumor above is the *mean value* of the density of the brain tumor image in fusion with the maximum intensity being at the highest value of 163.37 which means that the intensity range provides the maximum contrast between the tumor and the surrounding normal tissue. The *mean value* of fusion with a minimum intensity is 114.52 which means that the intensity range highlights the subtumor details well. And the *mean value* of fusion with an average intensity is 139.19 which means that it reflects a balanced combination of contrast between the tumor and normal tissue. The histogram also displays the standard deviation value, the lowest density value and the highest density. The size of the image matrix and the range of density (*gray level*) from 0-2301 that explain the configuration of the dicom image bit from the MRI image of the brain tumor.

The results of the overall image quality assessment of *MRI fusion* of brain tumors are shown from the average (*mean*) gray *level* value which can be seen in table 1 as follows:

Table 1. Average Gray *Level Value* of MRI *fusion* image of Brain Tumor with *projection type* Maximum Intensity, Minimum Intensity and Average Intensity

	N	*Gray Level*		
		Maximum	**Minimum**	**Mean**
Fusion Maximum Intensity	17	283,64	143,75	185,12
Fusion Minimum Intensity	17	148,08	86,52	114,35
Fusion Average Intensity	17	216,1	116,36	149,98

There was an average *gray level of* MRI fusion *images* of brain tumors with a *projection type* maximum intensity of 185.12, for the average *gray level* of MRI brain tumors with *a projection type* minimum intensity of 114.35 and then the average *gray level* for MRI of brain tumors with *a projection type* average intensity of 149.98.

The quality of *MRI fusion* images of brain tumors with *projection type* maximum intensity, minimum intensity and average intensity was analyzed using *the crucial-wallis* test from *the mean* data of *the gray level value.* The test results are seen in table 2 as follows:

Table 2. Analysis of the Results of the Quality Difference Test of *MRI Fusion* Images of Brain Tumors with *projection types* Maximum Intensity, Minimum Intensity and Average Intensity

Variable	***p-value***
Fusion MRI Brain Tumor with Maximum Intensity	< 0.001
Fusion MRI Brain Tumor with Manimum Intensity	
Fusion MRI Brain Tumor with Average Intensity	

The test results showed that there was a significant difference in the quality of MRI fusion images of brain tumors with *projection type* maximum intensity, minimum intensity and average intensity because it had a *p-value* of < 0.001.

Follow-up tests to determine the difference in the quality of *MRI fusion* images of brain tumors with *projection types* maximum intensity, minimum intensity and average intensity were carried out by analyzing *the Mann Whitney U test.* The results of *the Mann Whitney* test can be seen in table 3 as follows:

Table 3. Analysis of the Results of the Quality Difference Test of *MRI Fusion* Images of Brain Tumors with *projection types* Maximum Intensity, Minimum Intensity and Average Intensity

Variable	*p-value*
Brain Tumor MRI Fusion Image Quality Assessment with Maximum Intensity - Brain Tumor *MRI Fusion* Image Quality Assessment with Minimum Intensity	< 0.001
Assessment of Brain *Tumor MRI Fusion Image Quality with Maximum Intensity* - *Brain* Tumor MRI Fusion Image Quality Assessment with Average Intensity	< 0.001
Assessment of Brain Tumor MRI Fusion Image Quality with Minimum Intensity - Brain Tumor MRI Fusion Image Quality Assessment with Average Intensity	< 0.001

These results provide information that the difference in the quality of *MRI fusion* images of brain tumors with *projection type* maximum intensity and minimum intensity is obtained *p-value* = < 0.001, which means that there is a significant difference between the quality of *MRI fusion* images of brain tumors with *projection type* maximum intensity and minimum intensity. The difference in the quality of *MRI fusion* images of brain tumors with *projection type* maximum intensity and average intensity was obtained *p-value* = < 0.001, which means that there was a significant difference between the quality of *MRI fusion* images of brain tumors with *projection type* maximum intensity and average intensity. The difference in the quality of *MRI fusion* images of brain tumors with *projection type* manimum intensity and average intensity was obtained *p-value* = < 0.001, which means that there was a significant difference between the quality of *MRI fusion* images of brain tumors with *projection type* minimum intensity and average intensity.

Pathology Information

Pathology information is assessed by a radiologist on the overall slice of *the brain tumor imagery by* looking at the clarity of the structure and boundaries of the edges of the brain tumor image, whether it is bright and firm so that it clearly visualizes the brain tumor and the lesion tissue around the tumor. The assessment is divided into 3 categories, namely unclear, quite clear and clear.

The results of the assessment of pathological information from two observers obtained pathological information from the results *of the fusion* of MRI images of brain tumors with *projection types* maximum intensity, minimum intensity and average intensity seen in the appearance of the structure and boundaries of the edges of the brain tumor image, whether it is bright and firm so that it clearly visualizes the brain tumor and the lesion tissue around the tumor. Before data analysis, the assessment of pathological information was carried out by two observers and then a kappa test was carried out to obtain a close relationship or harmony from the two observers. The results of the alignment test between observers can be seen in table 4 as follows:

Table 4. Results of Alignment Test between Observers

Variable	Kappa Coefficient	*p-value*
Information on *Brain Tumor MRI fusion* pathology with projection type maximum intensity, minimum intensity and average intensity	0,76	< 0.001

The results of the alignment test between observers with the kappa method obtained excellent agreement between the two observers in providing an assessment of pathological information because it has a kappa value of 0.76 with *a p-value* = <0.001.

The results of the assessment of pathological information as a whole, MRI fusion images of brain tumors for each variable can be seen in table 5 as follows:

Table 5. Assessment of Pathological Information of *MRI Fusion* Images of Brain Tumors with *projection types* Maximum Intensity, Minimum Intensity and Average Intensity

	N	Amount/T.Score	Percentage (%)
Fusion MRI Brain Tumor with Maximum Intensity	17	95/102	93,14
Fusion MRI Brain Tumor with Minimum Intensity	17	40/102	39,22
Fusion MRI Brain Tumor with Average Intensity	17	69/102	67,65

Pathology information on *MRI fusion* image of brain tumors with *projection type* maximum intensity had a total score of 95 with a percentage (93.14%). The assessment of pathological information of *MRI fusion* image of brain tumors with a *minimum intensity projection type* had a total score of 40 with a percentage (39.22%). The assessment of pathological information of *MRI fusion* image of brain tumors with *projection type* average intensity had a total score of 69 with a percentage (67.65%).

Information on *MRI fusion* pathology of brain tumors with *projection type* maximum intensity, minimum intensity and average intensity was analyzed using *the crucial-wallis* test and the results obtained can be seen in table 6 as follows:

Table 6. Analysis of the Results of the Difference Test of Pathological Information *of Brain Tumor MRI fusion* with *projection types* Maximum Intensity, Minimum Intensity and Average Intensity

Variable	*Mean Rank*	*p-value*
Fusion MRI Brain Tumor with Maximum Intensity	78,50	< 0.001
Fusion MRI Brain Tumor with Manimum Intensity	23,50	
Fusion MRI Brain Tumor with Average Intensity	52,50	

The results of the analysis in the Krukal-Wallis *test* obtained the lowest pathological information in *the fusion* MRI of brain tumors with a *projection type* minimum intensity with *a mean rank value* of 23.50 and the highest pathological information in the *fusion*

MRI of brain tumors with a *projection type* maximum intensity with *a mean rank* value of 78.50. Meanwhile, fusion MRI brain tumors with *projection type* average intensity have pathological information between *fusion* MRI brain tumors with *projection type* maximum intensity and *fusion* MRI brain tumors with *projection type* minimum intensity, namely a *mean rank* value of 52.50. The results *of this crucial test-wallis test* also obtained a *p-value* = < 0.001. This means that there is a significant difference between MRI fusion of brain tumors with *projection types* maximum intensity, minimum intensity and average intensity.

Follow-up tests to determine the difference between the variables of MRI fusion pathology information of brain tumors with *projection type* maximum intensity, minimum intensity and average intensity were carried out by analyzing *the Mann Whitney U test.* The results of *the mann whitney u test* can be seen in table 7 as follows:

Table 7. Analysis of the Results of the Pathological Information Difference Test between *MRI Fusion* Variables of Brain Tumor with *Maximum* Intensity, Minimum Intensity and Average Intensity projection types

Variable	*p-value*
Assessment of Brain Tumor MRI Fusion *Pathology Information* with Maximum Intensity - Assessment of Brain Tumor *MRI Fusion* Pathology Information with Minimum Intensity	< 0.001
Assessment of Brain Tumor MRI Fusion *Pathology Information* with Maximum Intensity - Assessment of Brain Tumor *MRI Fusion* Pathology Information with Average Intensity	< 0.001
Assessment of Brain Tumor MRI Fusion *Pathology Information* with Minimum Intensity - Assessment of Brain Tumor *MRI Fusion* Pathology Information with Average Intensity	< 0.001

The results of the pathological information analysis found that the difference in the pathological information *of MRI fusion* of brain tumors with *the projection type* maximum intensity and minimum intensity was obtained *p-value* = < 0.001 which means that there is a significant difference between the pathological *information of MRI fusion* of brain tumors and the *projection type* maximum intensity and minimum intensity. The difference in brain tumor MRI fusion *pathology* information with *projection type* maximum intensity and average intensity was obtained *p-value* = < 0.001 which means that there was a significant difference between brain tumor MRI fusion *pathology* information with *projection type* maximum intensity and average intensity. The difference in brain tumor MRI fusion *pathology* information with *projection type* manimum intensity and average intensity was obtained *p-value* = < 0.001, which means that there is a significant difference between brain tumor MRI fusion *pathology* information with *projection type* minimum intensity and average intensity.

Discussion

Image Quality

Assessment of MRI image quality of brain tumors based on differences in grayness (*Gray Level*). Average *Gray Level* for imagery *Fusion* MRI with a maximum projection of intensity was 185.12, higher than the minimum projection of intensity (114.35) and average intensity (149.98). Optimal image quality on 16-bit imagery is determined from the value of the *Gray Level* distributed in the range of 0 to 65,535 shades of gray (Utama et al., 2020). Fusion of MRI imagery is important for combining information from different types of imaging, such as conventional MRI, MRI with contrast, and PET/CT, to produce a more comprehensive picture of the tumor and its structure.

Valuation *Gray Level* allowing in-depth analysis and better understanding of the characteristics and structure of MRI brain tumors (Widhiarso et al., 2018). The selection of the right projection according to the evaluation objectives is helpful in the diagnosis, treatment planning, and monitoring of tumor progression. Difference in mean value *Gray Level* of the three types of projection reflect different approaches to highlighting pixel intensity. Maximum Intensity Projection (MIP) displays the highest value of each voxel, emphasizing high-intensity areas that are important for diagnosis. Minimum Intensity Projection (MinIP) displays the lowest value, highlighting areas with low intensity, while Average Intensity Projection provides a balanced picture of intensity. The maximum intensity projection is optimal because it focuses on the areas with the highest intensity, allowing for clear identification of areas with high tumor activity, which is important for accurate diagnosis and treatment planning. The results of the Kruskal-Wallis test showed a significant difference between the three projections with a p-value < 0.001. Further analysis using the Mann-Whitney U test showed a significant difference between all projection pairs with a p-value < 0.001.

The use of *fusion* imagery can combine the advantages of each imaging technique, improve the ability to determine the location, size, biological properties, and response to brain tumor treatment, as well as assist in precise treatment planning and monitoring of tumor progression. The results of the analysis showed that the maximum intensity projection was more optimal than other projections because it provided maximum contrast between the tumor and normal tissue, with a high and sharp histogram peak, clearly separating the tumor from the normal tissue.

Statistical tests show significant differences between these three types of projection, with maximum projection intensity producing the best image quality, essential for accurate diagnosis and proper treatment planning. The *fusion* method using ImageJ software, specifically the Stacks feature, allows merging multiple images into a single stack that makes image analysis easier. Fusion of radiological imagery provides a more comprehensive picture, making it easier to identify and locate tumors, improving the efficiency and accuracy of diagnosis and treatment planning. Therefore, the maximum projection intensity is assessed as the optimal *fusion* method for MRI brain tumors.

This is in accordance with the results of the study which explains that Maximum Intensity Projection (MIP) will be able to improve image quality such as contrast and image sharpness. Thus, these projections will provide a clearer and more detailed picture of areas with high tumor activity so that it can ultimately improve the accuracy of diagnosis, therapy planning and effective patient monitoring (Naeem et al., 2022).

1) Pathology Information

Assessments from two observer radiologists show that the image *Fusion* MRI of brain tumors with a projection of maximum intensity is more optimal than the other two projections. This projection obtained a score of 95 with a percentage of 93.14%, while the minimum intensity projection and average intensity obtained scores of 40 (39.22%) and 69 (67.65%), respectively. Observer stated that the maximum intensity projection displayed the structure and periphery of brain tumors clearly and firmly, visualizing the tumor and surrounding lesions well. MRI is used to visualize brain tumors accurately, but without techniques *Fusion*, radiologists have to rely on individual MRI sequences that take longer to interpret (Nadra et al., 2022). Fusion MRI imagery provides a comprehensive overview of tumor structure and characteristics, aiding in diagnosis, treatment planning, and patient monitoring (Özbay & Özbay, 2023).

Maximum Intensity Projection (MIP) highlights the areas with the highest intensity, it is important to identify active areas such as vascular focuses. MinIP highlights the lowest intensity that may indicate necrosis, while the Average Intensity Projection provides a balanced picture of the intensity distribution. The cruskal-wallis analysis showed significant differences in pathological information between these three types of projections. The maximum intensity projection has the highest mean rank (78.50), while the lowest minimum intensity (23.50), and the average intensity between the two (52.50). The mann-whitney u test showed a significant difference between these three projections with a p-value < 0.001.

This difference occurs because each projection approach highlights a different aspect of pixel intensity. Maximum Intensity Projection (MIP) focuses on the area with the highest intensity, which is useful for highlighting highly active parts of the tumor. Minimum Intensity Projection (MinIP) highlights the areas with the lowest intensity, helping to identify areas that are dormant or degenerated. The Average Intensity Projection provides a balanced picture of the structure of the tumor. Based on the results of the study, MIP is a more optimal type of fusion projection because it is able to highlight areas with high tumor activity, providing a clear picture and details that are very important for diagnosis and treatment planning.

An advantage of maximum intensity projection that the other two fusion types do not have is its ability to highlight areas of the highest intensity, providing clear details about tumor activity which is important for diagnosis and treatment planning. This projection helps radiologists identify the location, size and characteristics of tumors more accurately. Thus, the diagnosis and treatment planning of patients become better. These projections also provide a highly accurate and detailed picture of the pathology, which in turn increases the effectiveness of diagnosis and therapy.

The results of this study are supported by the opinion of other researchers who show that the use of Maximum Intensity Projection (MIP) technique in medical images can improve the contrast and sharpness of images as well as pathological analysis. This confirms that the use of MIP in *Fusion* MRI is the optimal choice to improve precision in the diagnosis and treatment planning of brain tumor patients (Naeem et al., 2022).

Conclusion

The role of law in the formation of social identity in urban communities is complex and multidimensional. Law serves as a framework that regulates social interaction and maintains public order. Effective law enforcement plays an important role in creating a sense of justice and equality among city dwellers, helping to strengthen the social identity of individuals and groups by providing them with a sense of security and protection guaranteed by the law. In addition, the law also has an impact in regulating the way individuals and groups interact with each other, shaping social norms that are integral to the social identity of urban communities.

References

Andre, R., Wahyu, B., & Purbaningtyas, R. (2021). Klasifikasi Tumor Otak Menggunakan Convolutional Neural Network Dengan Arsitektur Efficientnet-B3. *Jurnal IT*, *11*(3), 55–59.

E. Asdiantoro, H. Siswanto, A. D. Sensusiati, et al. (2021). *Quantification of brain tumor metabolites in magnetic resonance spectroscopy using singular value decomposition Quantification of Brain Tumor Metabolites in Magnetic Resonance Spectroscopy Using Singular Value Decomposition*. *040005*(March).

Elkholy, S. F., Sabet, M. A., Mohammad, M. E., & Asaad, R. E. I. (2020). Comparative study between double inversion recovery (DIR) and fluid-attenuated inversion recovery (FLAIR) MRI sequences for detection of cerebral lesions in multiple sclerosis. *Egyptian Journal of Radiology and Nuclear Medicine*, *51*(1). https://doi.org/10.1186/s43055-020-00298-9

Foster, S. L., Breukelaar, I. A., Ekanayake, K., Lewis, S., & Korgaonkar, M. S. (2023). Functional Magnetic Resonance Imaging of the Amygdala and Subregions at 3 Tesla: A Scoping Review. *Journal of Magnetic Resonance Imaging*, 1–15. https://doi.org/10.1002/jmri.28836

Heranurweni, S., Destyningtias, B., & Kurniawan Nugroho, A. (2018). Klasifikasi Pola Image Pada Pasien Tumor Otak Berbasis Jaringan Syaraf Tiruan (Studi Kasus Penanganan Kuratif Pasien Tumor Otak). *Elektrika*, *10*(2), 37. https://doi.org/10.26623/elektrika.v10i2.1169

Jin, T., Ge, M., Huang, R., Yang, Y., Liu, T., Zhan, Q., Yao, Z., & Zhang, H. (2021). Utility of contrast-enhanced T2 FLAIR for imaging brain metastases using a half-dose high-relaxivity contrast agent. *American Journal of Neuroradiology*, *42*(3), 457–463. https://doi.org/10.3174/AJNR.A6931

Kemenkes RI. (2020). Pedoman nasional pelayanan kedokteran tata laksana tumor otak. *Kementerian Kesehatan RI*, *5*(1), 55.

Monroy-Sosa, A., Chakravarthi, S. S., de la Garza-Salazar, J. G., Garcia, A. M., & Kassam, A. B. (2020). Principles of neuro-oncology: Brain & skull base. In *Principles of Neuro-Oncology: Brain & Skull Base*. https://doi.org/10.1007/978-3-030-54879-7

Nadra, Sugiyanto, & Gatot, M. W. (2022). Development Of Fusion Techniques Based On Matlab Computer_Fusion Programming: Comparative Study between MRI fusion and Matlab fusion. *Journal of Medical Imaging and Radiation Sciences*, *53*(4), S17. https://doi.org/10.1016/j.jmir.2022.10.056

Naeem, M. Q., Darira, J., Ahmed, M. S., Hamid, K., & Shazlee, M. K. (2022). *Comparison of Maximum Intensity Projection and Volume Rendering in Detecting Pulmonary Nodules on Multidetector Computed Tomography Comparison of Maximum Intensity Projection and Volume Rendering in Detecting Pulmonary Nodules on Multidetector Computed To*. *March 2021*. https://doi.org/10.7759/cureus.14025

Özbay, F. A., & Özbay, E. (2023). Brain tumor detection with mRMR-based multimodal fusion of deep learning from MR images using Grad-CAM. *Iran Journal of Computer Science*, *6*(3), 245–259. https://doi.org/10.1007/s42044-023-00137-w

Schroeder, A. B., Dobson, E. T. A., Rueden, C. T., Tomancak, P., Jug, F., & Eliceiri, K. W. (2021). The ImageJ ecosystem: Open-source software for image visualization, processing, and analysis. *Protein Science, 30*(1), 234–249. https://doi.org/10.1002/pro.3993

Suárez-García, J. G., Hernández-López, J. M., Moreno-Barbosa, E., & de Celis-Alonso, B. (2020). A simple model for glioma grading based on texture analysis applied to conventional brain MRI. *PLoS ONE*, *15*(5), 1–19. https://doi.org/10.1371/journal.pone.0228972

Utama, J., Indrati, R., Rochmayanti, D., & Suryono, S. (2020). Improvement of image quality with fusion in radiography of high and low intensity lateral head. *Journal of Physics: Conference Series*, *1524*(1). https://doi.org/10.1088/1742-6596/1524/1/012123

Widhiarso, W., Yohannes, Y., & Prakarsah, C. (2018). Brain Tumor Classification Using Gray Level Co-occurrence Matrix and Convolutional Neural Network. *IJEIS (Indonesian Journal of Electronics and Instrumentation Systems)*, *8*(2), 179. https://doi.org/10.22146/ijeis.34713