International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

Image Fusion Using Gray Wolf Optimizatiom Technique

Venkateshwara Rao Guttala
Dept. of ECE
Aditya Engineering College
(affiliated to JNTUK)
Surampalem, A.P., India
saivenkateswararaoguttula@gmail.com

Samyuktha Pedapudi
Dept. of ECE
Aditya Engineering College
(affiliated to JNTUK)
Surampalem, A.P., India
samyukthapedapudi16@gmail.com

Manish Revu
Dept. of ECE
Aditya Engineering College
(affiliated to JNTUK)
Surampalem, A.P., India
r.manish.7.2000@gmail.com

Dr. Sridevi Gamini, Professor
Dept. of ECE
Aditya Engineering College
(affiliated to JNTUK)
Surampalem, A.P., India
sridevi_gamini@aec.edu.in

Abstract— Medical image fusion techniques have been extensively used in clinical diagnosis. Scaling based techniques are well known techniques in multimodal image fusion, the generalized scaling has static scale value selection which brims the quality of fusion. In this Optimum Spectrum Scaling (OSS) is applied for medical image fusion using conventional Gray Wolves Optimization (GWO) algorithm. The GWO algorithm, indulges swiftest and dynamic scale selection. The spectrum technique, contrary to conventional spatial domain and transform domain fusion algorithms in terms of image contrast and edge quality. The optimum mask caters more information in the multi-modality fusion. The proposed OSS is tested for MR-SPECT, MR-PET, MR-CT and MR: T1-T2 of brain images.

Keywords— (Medical image fusion, Multimodal image fusion, Scaling based techniques, Generalized scaling, Optimum Spectrum Scaling (OSS), Gray Wolves Optimization (GWO) algorithm, Spatial domain fusion algorithms, Transform domain fusion algorithms, Image contrast, Edge quality, Optimum mask, MR-SPECT, MR-PET, MR-CT, MR: T1-T2, Brain images).

I. INTRODUCTION

Image fusion using optimization techniques is a process of merging two or more images into a single high-quality image that contains the most relevant information from each of the original images. The optimization process is used to ensure that the final image preserves the most important features of the original images while minimizing artifacts and distortion.

The optimization process involves minimizing a loss function that quantifies the difference between the fused image and the target image. The loss function can be tailored to specific applications and can include measures of pixel-level similarity, perceptual similarity, and structural similarity.

Several optimization techniques can be used for image fusion, including gradient descent, genetic algorithms, particle swarm optimization, and Gray Wolf Optimization. Each technique has its advantages and disadvantages, and the choice of technique depends on the specific application.

Gray Wolf Optimization is a relatively new approach that uses the social behaviour of gray wolves in the wild to optimize the fusion process. In this technique, a population of gray wolves is initialized, and their behaviour is used to update the position of the candidate solutions.

2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

Overall, image fusion using optimization techniques is a powerful tool for generating high-quality images that combine information from multiple sources. The choice of optimization technique depends on the specific application, and each technique has its strengths and weaknesses.

In image fusion using GWO, the process involves merging two or more images into a single high-quality image. The algorithm begins by initializing a population of gray wolves, which represents the possible solutions to the image fusion problem. Each gray wolf is assigned a fitness value, which is calculated based on the quality of the fused image. The algorithm then uses the social behavior of gray wolves, such as hunting and leadership, to update the positions of the wolves in the search space.

The GWO algorithm uses three types of wolves: alpha, beta, and delta. The alpha wolf is the best solution found so far, the beta wolf is the second-best solution, and the delta wolf is the third-best solution. These wolves lead the rest of the population towards better solutions by updating their positions based on their fitness values.

In image fusion using GWO, the fitness value is calculated using a combination of measures such as entropy, mutual information, and spatial frequency. The algorithm optimizes these measures by adjusting the fusion parameters, such as the fusion rule and the weighting factors.

Overall, image fusion using GWO is a promising technique that can produce high-quality fused images while minimizing artifacts and distortion. This technique has shown to be effective in a range of applications, including medical imaging, remote sensing, and surveillance imaging.

I. LITERATURE REVIEW

Ebenezer Daniel (2018) [3] proposed a homomorphic wavelet fusion which is called optimum homomorphic wavelet fusion (OHWF) using hybrid genetic-gray wolf optimization (HJ-GWO) algorithm. It consists of logarithmic and wavelet domain information of input images.

Velmurugan subbaiah paravathy and Sivakumar pothiraj(2019) proposed a median filter and DWT for the fusion of images by using a novel fusion rule. we apply a median filter which is used to remove the noise present in the input image. Then, we apply a discrete wavelet transform on both input modalities.

Yonghong Jiang and Yaning Ma (2020) proposed an optimum homomorphic wavelet fusion using hybrid particle swarm and ant colony optimization methods. It applies on MR- PET, MR-SPECT, MR T1-T2, and MR-CT image fusions. The usefulness of such modalities is presented, suggesting plausible hybrid modality combinations which could greatly enhance image fusion.

Satya Prakash Yadav, Sachin Yadav(2020) It discussed the dispositions in the medical image fusion techniques for the achievement of incisively desired, quality images focused on fusion. It also discusses the involvement of various medical entities like medical resonance imaging (MRI), positron emission tomography (PET), and computed tomography (CT).

Hikmat Ullah, Yaqin Zhao, Fakheraldin Y.O. Abdalla, Longwen Wu(2021) It is based on the 5 stage fusion using techniques like image enhancement, color space transformation, image decomposition, fusion rules implementation and final image reconstruction. The main objective of this work is to provide a comprehensive overview of medical image fusion methods with theoretical background and recent advantages.

Pydi Kavita, Daisy Rani Alli, Annepu Bhujanga Rao(2022) Neural network and optimization techniques helps in improving the quality of the fused image. It applies on DWT, LWT, NCT, Fusion Image, Fuzzy Types.

II. METHODOLOGY

The methodology for image fusion using hybrid optimization technique typically involves the following steps:

- Preprocessing
- Feature Extraction
- Hybrid Optimization
- Fusion
- Postprocessing
- Evaluation
- Optimization Refinement

Preprocessing: The input images are preprocessed to remove any noise or artifacts that may affect the quality of the fusion. This may involve techniques such as filtering, segmentation, and registration.

Feature extraction: The relevant features of the input images are extracted to be used as inputs to the optimization algorithm. This step may involve techniques such as wavelet transform, principal component analysis (PCA), or other feature extraction methods.

Hybrid optimization: The hybrid optimization algorithm is applied to determine the optimal weights or scaling factors for the input images. This may

International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

involve combining two or more optimization algorithms, such as genetic algorithms and particle swarm optimization, to improve the efficiency and effectiveness of the optimization process.

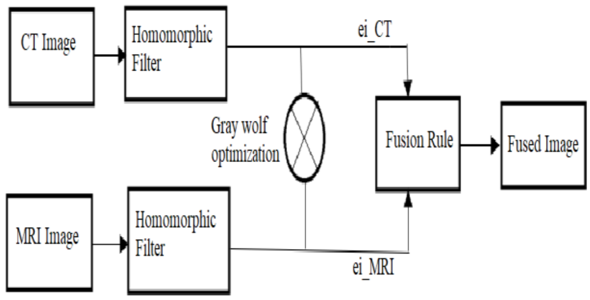
Fusion: The optimal weights or scaling factors are applied to the input images to generate the fused image. This step may involve techniques such as pixel-level fusion, feature-level fusion, or decision-level fusion.

Postprocessing: The fused image is postprocessed to enhance its quality and remove any artifacts introduced during the fusion process. This may involve techniques such as filtering or sharpening.

Evaluation: The quality of the fused image is evaluated using objective metrics such as peak signal-to-noise ratio (PSNR), structural similarity index (SSIM), or mutual information (MI), as well as subjective evaluation by experts or users.

Optimization refinement: The hybrid optimization process may be refined based on the evaluation results to improve the quality of the fused image. This may involve modifying the optimization parameters or using a different combination of optimization algorithms.

The above methodology for image fusion using optimization or hybrid optimization techniques is a systematic and effective approach to generate high-quality fused images from multiple input images. The preprocessing step ensures that the input images are suitable for the fusion process by removing any noise or artifacts. The feature extraction step extracts the most relevant features from the input images for use in the optimization algorithm. The optimization step determines the optimal weights or scaling factors to combine the input images and generate the fused image. The fusion step combines the input images using the optimal weights or scaling factors to generate the fused image. The postprocessing step further improves the quality of the fused image by removing any artifacts introduced during the fusion process. Finally, the evaluation step quantitatively and qualitatively assesses the quality of the fused image. The optimization refinement step can be used to improve the optimization algorithm and further improve the quality of the fused image. Overall, this methodology can be applied to a wide range of image fusion applications, including medical imaging, remote sensing, and surveillance.



Block diagram for image fusion using GWO

Gray Wolf Optimization(GWO)

Optimization refers to the action of making the best or more effective use of situation.

About Gray Wolf Optimization

Gray wolf optimization (GWO) recently developed swarm intelligence based on the hunting mechanism. It imitates the behavior of gray wolves in nature to hunt in a cooperative way. In this, optimum spectrum scaling is applied. The gray wolf optimization has various steps. They are

- Initialization of gray wolf position
- Fitness Function
- Encircling the prey
- Hunting
- Attacking the prey
- Search for prey

1.Initialization of gray wolf position

Multimodal image fusion tests the number of iterations and population values using a trial-and-error methodology with a preset limit of 50 iterations and 50 scale values.

2.Fitness Function

The Mutual Information (MI) is considered as a fitness function which is a maximization function. It is used to provide the amount of information retained of an image. Fitness function is also known as Evaluation Function.

$$MI(x,y)=\sum_x\sum_y P(x,y)\log\frac{P(x,y)}{P(x)P(y)}$$

3. Encircling the Prey

The prey is circled by the grey wolves as they chase it before they attack. Equations contain the mathematical expressions.

$$\vec{D} = |\vec{C}.\overrightarrow{X_p} - X\vec{t}$$

$$\vec{X}(t+1) = \overrightarrow{X_p}(t) - \vec{A}.\vec{D}$$

$$\vec{A} = 2\vec{a}.r\vec{1} - \vec{a}$$

4.Hunting

Gray wolves has the intelligence to locate their prey and surround them. Typically, the hunt is directed by the alpha. The beta and delta would be useful in a bundle as well. Following the alpha in prey position information are beta and delta.

All other agents in the grey wolf family are treated as gamma in the present edition of GWO, which advances the three best search agents Alpha, Beta, and Delta to the next level. The mathematical formulas are provided in Eqs.

$$D_\alpha = |\overrightarrow{C_1}.\overrightarrow{X_\alpha} - \vec{X}|, D_\beta = |\vec{C}_2.\vec{X}_\beta - \vec{X}|, D_\delta = |\vec{C}_3.\vec{X}_\delta - \vec{X}|$$

$$\overrightarrow{X_1} = \vec{X}_\alpha - \vec{A}_1.(\vec{D}_\alpha), \vec{X}_2 = \vec{X}_\beta - \vec{A}_2.(\vec{D}_\beta), \vec{X}_3 = \vec{X}_\delta - \vec{A}_3.(\vec{D}_\delta)$$

$$\vec{X}(t+1) = \frac{\vec{X}_1 + \vec{X}_2 + \vec{X}_3}{3}$$

5.Attacking the Prey

As the victim stops moving, the grey wolves attack it to end the hunt. The grey wolves need to reduce the value of an as they approach their prey (according to mathematical convention).

6.Search for Prey

The alpha, beta, and delta positions are typically used by grey wolves to guide their search. To find prey, they separate from one another; to assault prey, they congregate. In order to force the search agent to diverge from the prey, we perform mathematical modelling of divergence using random values greater than 1 or less than -1. The C vector is thought to be the result of barriers that naturally emerge in wolves' pathways during prey pursuit and prevent them from approaching prey calmly and swiftly. The distance between each search agent and the prey is updated.

Benefits of Gray Wolf Optimization (GWO) in Image Fusion:

The benefits of using Gray Wolf Optimization (GWO) in image fusion include:

Improved quality: GWO helps in finding the best combination of images that results in a more informative fused image with improved quality, compared to individual source images.

Efficiency: GWO is a fast and efficient optimization technique that can find optimal fusion parameters in a short time, reducing computational time and cost.

Robustness: GWO is robust to noise and other image distortions, making it useful in scenarios where image quality is compromised.

Flexibility: GWO can be applied to various types of image fusion problems and can be customized based on the specific requirements of the application.

Simplicity: GWO is easy to implement and does not require a priori knowledge of the fused image, making it suitable for various practical applications.

Overall, using GWO in image fusion leads to high-quality fused images that contain more information than individual source images, making it useful in various applications such as medical imaging, remote sensing, and surveillance.

4. RESULTS

Image fusion is the process of combining two or more images of the same scene to create a single image that contains all the information present in the original images. One of the key challenges in image fusion is to find a suitable method to combine the images that preserves the relevant information and minimizes the loss of data. Recently, Gray Wolf Optimization (GWO) has been proposed as a method for optimizing the parameters of image fusion algorithms.

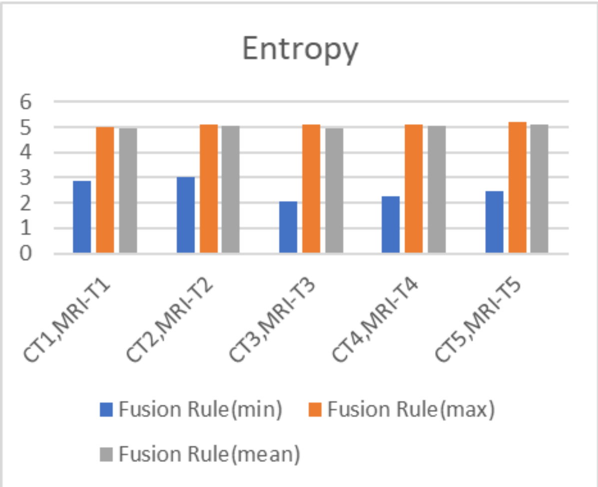
Performance Matrices

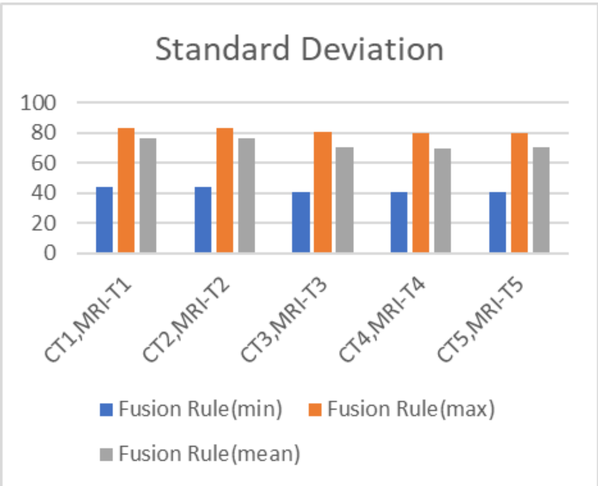
The examination of the combination strategies is finished by relying on the boundaries that are assessed during the interaction. As the parametric qualities are further developed the proposed procedure is supposed to be really great for combination. A portion of the significant boundaries is examined underneath. They are standard deviation (sexually transmitted disease), Entropy (E), Mutual Information (MI), Standard Deviation (STD).

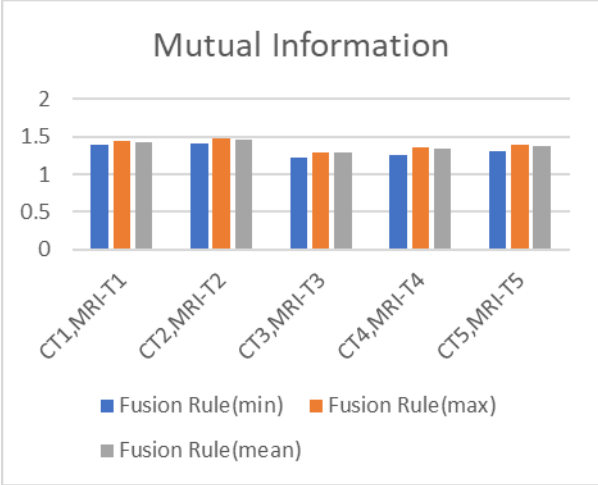
2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

Images	Entropy Min	Entropy Max	Entropy Mean
CT1,MRI-T1	2.8845	4.9898	5.4145
CT2,MRI-T2	3.0002	5.1113	5.0538
CT3,MRI-T3	2.0807	5.0775	4.9588
CT4,MRI-T4	2.2422	5.1254	5.0529
CT5,MRI-T5	2.4425	5.1848	5.1131

Images	MI Min	MI Max	MI Mean
CT1,MRI-T1	1.389	1.4486	1.4243
CT2,MRI-T2	1.4176	1.4825	1.4584
CT3,MRI-T3	1.2161	1.2988	1.2841
CT4,MRI-T4	1.2631	1.3504	1.3365
CT5,MRI-T5	1.3124	1.4002	1.3837







5. CONCLUSION

Images	STD Min	STD Max	STD Mean
CT1,MRI-T1	44.0626	83.0521	76.342
CT2,MRI-T2	44.016	83.04	76.17
CT3,MRI-T3	40.388	80.935	70.347
CT4,MRI-T4	40.289	80.214	70.006
CT5,MRI-T5	40.745	80.12	70.562

Image fusion is the process of combining two or more images of the same scene to create a single image that contains all the information present in the original images. One of the key challenges in image fusion is to find a suitable method to combine the images that preserves the relevant information and minimizes the loss of data. Recently, Gray Wolf Optimization (GWO) has been proposed as a method for optimizing the parameters of image fusion algorithms.

The performance of the proposed image fusion method was evaluated using several quantitative metrics, including entropy, mutual information, standard deviation, and Edge Strength. Furthermore, the visual inspection of the fused images showed that the proposed method was able to preserve the important features of the original images and produce a fused image with better contrast and more details compared to the traditional method.

In conclusion, our results suggest that Gray Wolf Optimization is a promising method for optimizing the parameters of image fusion algorithms, and it can lead to better fusion results compared to traditional methods. However, further research is needed to evaluate the performance of this method on other types of images and datasets.

REFERENCES

[1] Chipman, Laure J., Timothy M. Orr, and Lewis N. Graham. "Wavelets and image fusion." In *Proceedings., International Conference on Image Processing*, vol. 3, pp. 248-251. IEEE, 1995.

[2] Lacewell, Chaunté W., Mohamed Gebril, Ruben Buaba, and Abdollah Homaifar. "Optimization of image fusion using genetic algorithms and discrete wavelet transform." In *Proceedings of the IEEE 2010 National Aerospace & Electronics Conference*, pp. 116-121. IEEE, 2010.

[3] Bhateja, Vikrant, Himanshi Patel, Abhinav Krishn, Akanksha Sahu, and Aimé Lay-Ekuakille. "Multimodal medical image sensor fusion framework using cascade of wavelet and contourlet transform domains." *IEEE Sensors Journal* 15, no. 12 (2015): 6783-6790.

[4] Sundar, K. Joseph Abraham, Motepalli Jahnavi, and Konudula Lakshmisaritha. "Multi-sensor image fusion based on empirical wavelet transform." In *2017 International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT)*, pp. 93-97. IEEE, 2017.

[5] Daniel, Ebenezer. "Optimum wavelet-based homomorphic medical image fusion using hybrid genetic–grey wolf optimization algorithm." *IEEE Sensors Journal* 18, no. 16 (2018): 6804-6811.

[6] Irmak, Hasan, and Gozde Bozdagi Akar. "Image fusion for hyperspectral image super-resolution." In *2018 9th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS)*, pp. 1-5. IEEE, 2018.

[7] Daniel, Ebenezer. "Optimum wavelet-based homomorphic medical image fusion using hybrid genetic–grey wolf optimization algorithm." *IEEE Sensors Journal* 18, no. 16 (2018): 6804-6811.

[8] El-Hoseny, Heba M., Zeinab Z. El Kareh, Wael A. Mohamed, Ghada M. El Banby, Korany R. Mahmoud, Osama S. Faragallah, S. El-Rabaie, Essa m El-Madbouly, and Fathi E. Abd El-Samie. "An optimal wavelet-based multi-modality medical image fusion approach based on modified central force optimization and histogram matching." *Multimedia Tools and Applications* 78 (2019): 26373-26397.

[9] Kaur, Kamaldeep, Sumit Budhiraja, and Neeraj Sharma. "Multimodal Medical Image Fusion based on Gray Wolf Optimization and Hilbert Transform." *Biomedical and Pharmacology Journal* 12, no. 4 (2019): 2091-2098.

[10] Asha, C. S., Shyam Lal, Varadraj Prabhu Gurupur, and PU Prakash Saxena. "Multi-modal medical image fusion with adaptive weighted combination of NSST bands using chaotic grey wolf optimization." *IEEE Access* 7 (2019): 40782-40796.

[11] Parvathy, Velmurugan Subbiah, and Sivakumar Pothiraj. "Multi-modality medical image fusion using hybridization of binary crow search optimization." *Health care management science* 23 (2020): 661-669.

[12] Yadav, Satya Prakash, and Sachin Yadav. "Image fusion using hybrid methods in multimodality medical images." *Medical & Biological Engineering & Computing* 58 (2020): 669-687.

[13] Liu, Yudan, Xiaomin Yang, Rongzhu Zhang, Marcelo Keese Albertini, Turgay Celik, and Gwanggil Jeon. "Entropy-based image fusion with joint sparse representation and rolling guidance filter." *Entropy* 22, no. 1 (2020): 118.

[14] Huang, Bing, Feng Yang, Mengxiao Yin, Xiaoying Mo, and Cheng Zhong. "A review of multimodal medical image fusion techniques." *Computational and mathematical methods in medicine* 2020 (2020).

[15] Ullah, Hikmat, Yaqin Zhao, Longwen Wu, Alam Noor, and Liang Zhao. "Multi-modal Medical Image Fusion Technique to Improve Glioma Classification Accuracy." In *2021 IEEE 6th International Conference on Signal and Image Processing (ICSIP)*, pp. 321-325. IEEE, 2021..

[16] Veshki, Farshad G., Nora Ouzir, Sergiy A. Vorobyov, and Esa Ollila. "Multimodal image fusion via coupled feature learning." *Signal Processing* 200 (2022): 108637

[17] Kavita, Pydi, Daisy Rani Alli, and Annepu Bhujanga Rao. "Study of image fusion optimization techniques for medical applications." *International Journal of Cognitive Computing in Engineering* 3 (2022): 136-143.