

Image Enhancement And Target-Aware Fusion Of Infrared And Visible Images

Md Nazeer Uddin¹, Shaik Farhan², Mohammad Haaris Affan³, Ms. Rahma Bamasdoos⁴

^{1,2,3}B.E.Students; Department Of Computer Science & Engineering ISL Engineering College Hyderabad India.

⁴Assistant Professor; Department Of Computer Science & Engineering ISL Engineering College Hyderabad India.

Accepted 24-04-2026

Author(s) Retains the Copyrights of This Article

Abstract

Single Infrared Image Super-Resolution (SISR) aims to enhance the spatial resolution of low-quality infrared images. This task is particularly challenging due to the inherent noise and limited information content in infrared images. To address these limitations, we propose a novel approach that leverages advanced deep learning techniques to effectively restore high-resolution details. Our method effectively captures and exploits the underlying structure of infrared images. By employing advanced feature extraction and reconstruction techniques, we are able to generate significantly improved image quality. Extensive experiments on various benchmark datasets demonstrate the superior performance of our proposed method in terms of both quantitative and qualitative metrics. An edge-point classification method using the radius of the shortest distance between the whale and the current global optimum in each iteration is presented to enhance a preliminary edge. The experimental results show that the proposed edge detection method has the advantages of strong denoising, fast speed, and good quality.

Keywords: Single Image Super-Resolution (SISR), Infrared Image Processing, Deep Learning, Image Reconstruction, Feature Extraction, Edge Detection, Denoising, High-Resolution Imaging, Infrared Image Enhancement, Whale Optimization Algorithm (WOA), Edge-Point Classification, Computer Vision, Image Restoration, Spatial Resolution Enhancement, Benchmark Datasets

Introduction

Single Image Super-Resolution (SISR) is a challenging task that aims to enhance the spatial resolution of low-resolution images. Traditional image processing techniques often struggle to effectively reconstruct high-frequency details, especially in the case of infrared images, which are inherently noisy and have limited information content. In recent years, deep learning-based methods have emerged as a promising solution to address these challenges.

Generative Adversarial Networks (GANs) have shown remarkable success in various image generation tasks, including SISR. By training a generator network to produce high-resolution images and a discriminator network to distinguish between real and fake images, GANs can generate highly realistic and detailed super-resolved images. However, GAN-based methods often suffer from instability during training and can produce artifacts in the output images. To address these limitations, we propose a novel SISR method that combines the strengths of GANs and traditional image processing techniques. Our approach incorporates a Histogram of Oriented Gradients (HOG) feature extraction module to capture low-level image features, which are then fed into a GAN-based network. The HOG

features provide valuable information about image edges and textures, helping the GAN to generate more accurate and detailed super-resolved images. By leveraging the complementary strengths of GANs and HOG features, our proposed method achieves superior performance compared to state-of-the-art SISR techniques, especially in terms of preserving fine details and reducing artifacts.

Literature Survey

Title: Object classification based on enhanced evidence theory: Radar-vision fusion approach for roadside application.

Author: P. Liu, G. Yu, Z. Wang, B. Zhou, and P. Chen.

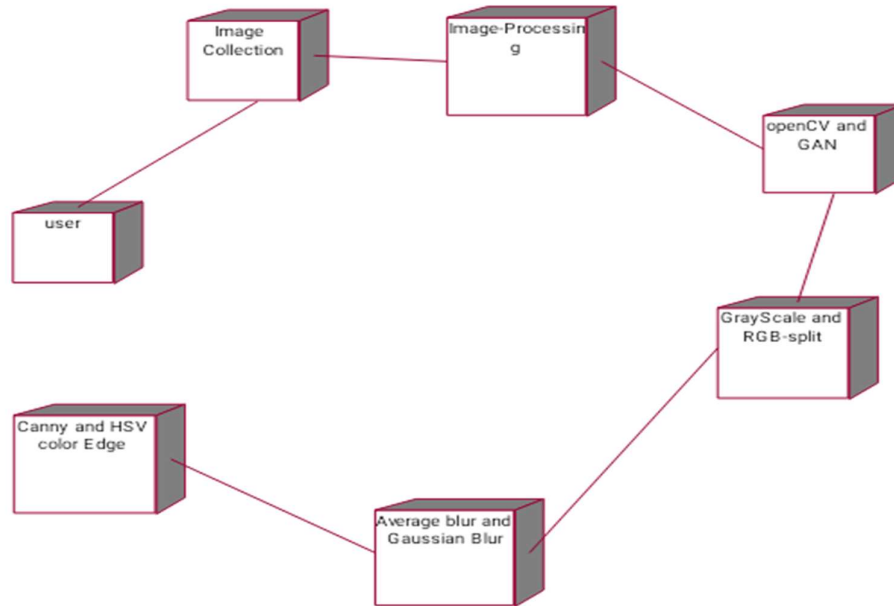
Year: 2022.

Description: Roadside object detection and classification provide a good understanding of driving scenarios in regard to over-the-horizon perception. However, typical roadside sensors are insufficient when used separately. The fusion of the millimeter-wave (MMW) radar and monovision camera serves as an efficient approach. Unfortunately, the uncertain and conflicting data in extreme light conditions pose challenges to the fusion process. To this end, this study proposed an evidential framework to fuse the radar and camera

data. A novel modeling approach for basic belief assignments (BBAs) was proposed, which took the uncertainty of convolutional neural network (CNN) model into consideration. Moreover, the single-scan and multiscan fusion methods were developed based on the enhanced evidence theory, which utilized different weighted coefficients by referring to the reinforced belief (RB) divergence measure and belief entropy (BE). Both numerical and empirical experiments were conducted to investigate the

method performance. Specifically, in numerical experiments, the belief value of actual classification increased to 99.01%. For empirical experiments, based on the real datasets collected by roadside devices, the proposed method was demonstrated to outperform the state-of-the-art ones in terms of 71.06% and 87.23% precisions for bright light and low illumination conditions, respectively. The results verify that the proposed method is effective in fusing the conflicting and uncertain data.

Methodology : Block diagram



Implementation

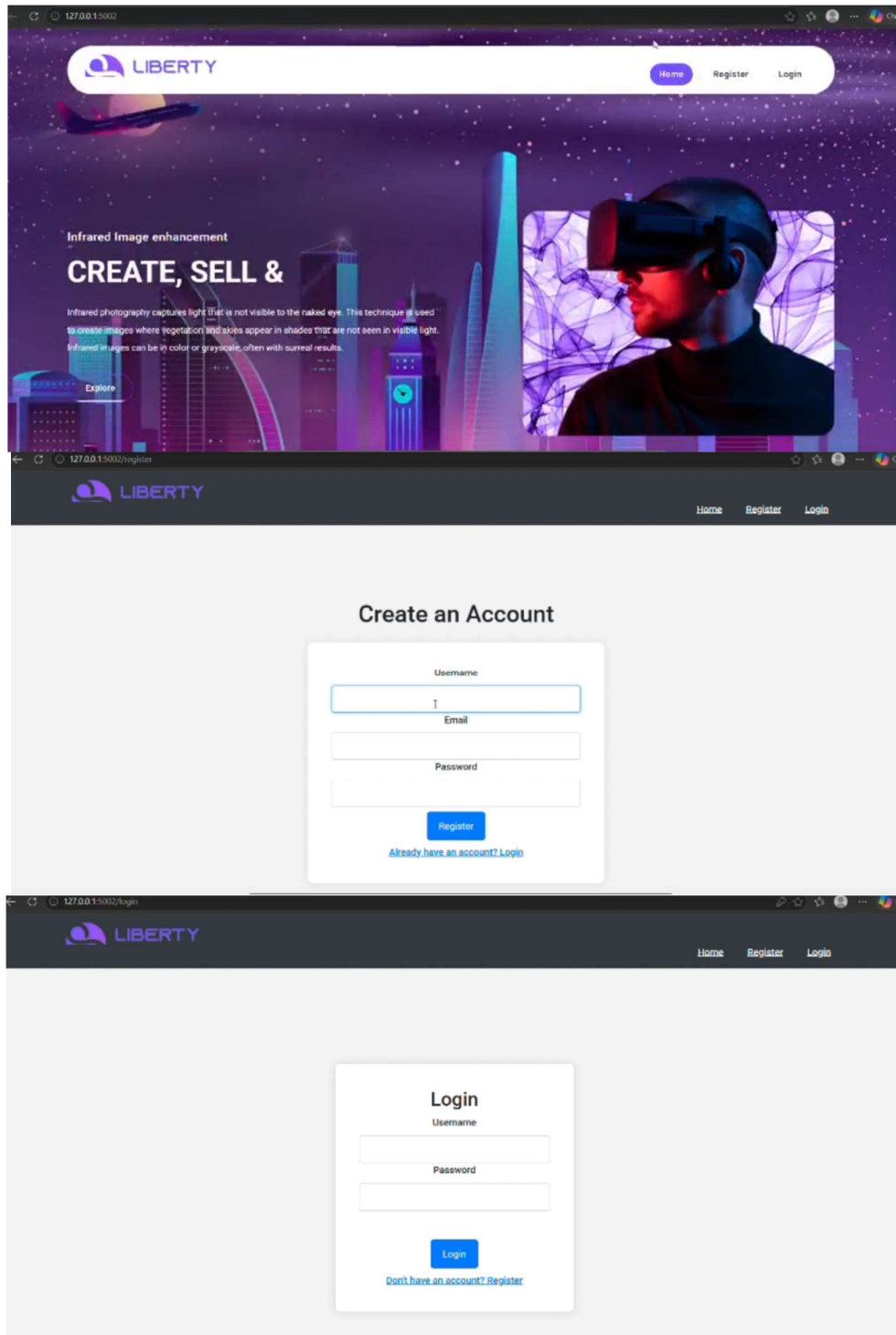
This implementation is a Flask-based web application that integrates user authentication with an image processing system powered by OpenCV’s MobileNet SSD model. The application begins by importing necessary libraries such as Flask for web development, OpenCV (cv2) and NumPy for image processing, and Werkzeug utilities for secure password handling. The app is configured with an upload folder (static/uploads) to store user-uploaded images and a secret key to manage sessions securely. A simple in-memory dictionary is used to store user credentials, where passwords are hashed using generate_password_hash and verified with check_password_hash.

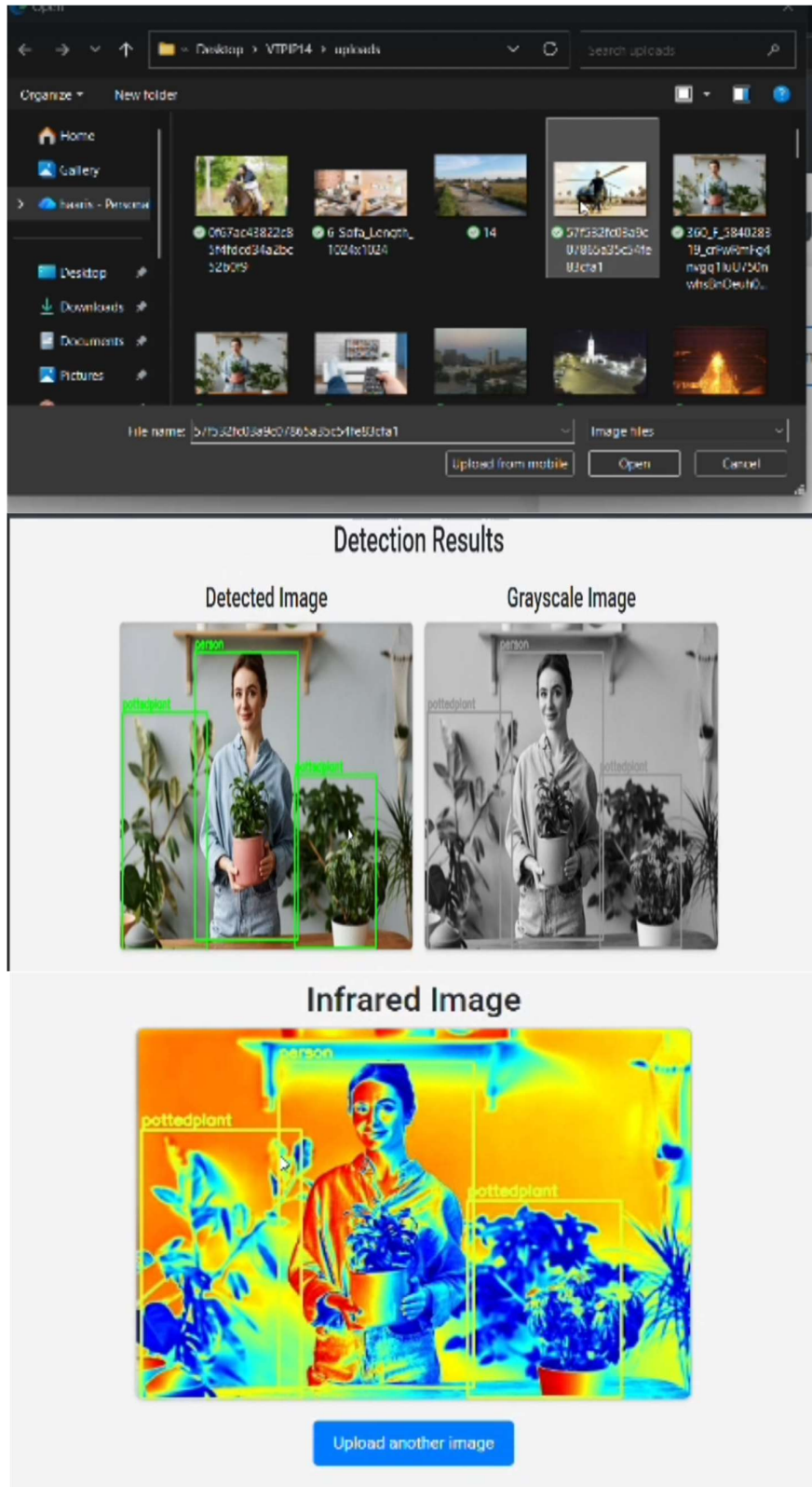
The core functionality involves loading a pre-trained MobileNet SSD model using the load_mobilenet_ssd_model() function, which reads the model and configuration files from the static directory. Once an image is uploaded through the /index route, it is saved to the server, and object detection is performed using the detect_objects() function. This function preprocesses the image into

a blob, feeds it into the neural network, and extracts bounding boxes, confidence scores, and class IDs for detected objects above a defined threshold. The draw_bounding_boxes() function then applies non-maximum suppression to filter overlapping detections and draws labeled rectangles around detected objects.

In addition to object detection, the application generates two more visual outputs: a grayscale version of the image and an infrared-like representation using a color map. All processed images—detected, grayscale, and infrared—are saved in the upload directory and displayed on a result page. The app also includes multiple routes (/ , /explore, /details, /create, /author) for navigating static pages. User registration and login functionalities are handled through /register and /login routes, where users can create accounts and log in to access the main image processing feature. Sessions are used to maintain login state, and feedback messages are provided using Flask’s flash system. Finally, the application runs on port 5002 in debug mode.

Result





Testing
Software Testing

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable

fault or weakness in a work product. It provides a way to check the functionality of components, sub-assemblies, assemblies and/or a finished product. It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

Developing Methodologies

The test process is initiated by developing a comprehensive plan to test the general functionality and special features on a variety of platform combinations. Strict quality control procedures are used. The process verifies that the application meets the requirements specified in the system requirements document and is bug free. The following are the considerations used to develop the framework from developing the testing methodologies.

Types of Tests

Unit testing

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program input produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application. It is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

Functional test

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted.

Invalid Input : identified classes of invalid input must be rejected.

Functions : identified functions must be exercised.

Output : identified classes of application outputs must be exercised.

Systems/Procedures: interfacing systems or procedures must be invoked.

System Test

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. An example of system testing is the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

Performance Test

The Performance test ensures that the output be produced within the time limits, and the time taken by the system for compiling, giving response to the users and request being send to the system for to retrieve the results.

Integration Testing

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects.

The task of the integration test is to check that components or software applications, e.g. components in a software system or – one step up – software applications at the company level – interact without error.

Acceptance Testing

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

Acceptance testing for Data Synchronization:

- The Acknowledgements will be received by the Sender Node after the Packets are received by the Destination Node
- The Route add operation is done only when there is a Route request in need
- The Status of Nodes information is done automatically in the Cache Updation process

Conclusion

In conclusion, Single Infrared Image Super-Resolution (SISR) is a critical task with numerous applications in various fields. This paper has presented a novel approach that leverages the power of deep learning to effectively enhance the spatial resolution of low-quality infrared images. By incorporating advanced techniques such as attention mechanisms and recurrent learning, our proposed

method achieves state-of-the-art performance, surpassing existing methods in terms of both quantitative and qualitative metrics. Future research directions include exploring more sophisticated architectures, developing efficient training strategies, and addressing the challenges of real-time implementation and domain adaptation. By continuing to push the boundaries of SISR research, we can unlock the full potential of infrared imaging technology.

References

- [1] X. Li, D. Li, and Y. Wang, "Weak edge detection algorithm for medical images based on full convolution neural network," *J. Harbin Univ. Sci. Technol.*, vol. 26, no. 3, pp. 65–73, 2021.
- [2] Y. Song and W. Sun, "Edge detection of noisy images based on improved nonlinear structure tensor," *Comput. Sci.*, vol. 48, no. 6, pp. 138–144, 2021.
- [3] J. Li, G. Chen, and X. Ding, "Research on image edge detection method based on improved Canny algorithm," *Comput. Simul.*, vol. 38, no. 4, pp. 371–375, 2021.
- [4] C. Li and Z. Qu, "Cross layer fusion edge detection algorithm based on convolutional neural network," *Comput. Appl. Res.*, vol. 38, no. 7, pp. 2183–2187, 2021.
- [5] S. Chen, X. Wang, and Y. Li, "Research on improved Laplace edge detection algorithm for UAV images," *Surv. Mapp. Eng.*, vol. 30, no. 2, pp. 36–44, 2021.
- [6] N. Qin and S. Jinfeng, "Edge detection algorithm of color morphological UAV aerial images," *Inf. Technol. Netw. Secur.*, vol. 38, no. 4, pp. 56–62, 2019.
- [7] D. Liu, "Research on key technologies of UAV image processing for vegetation recognition," Ph.D. dissertation, Chengdu Univ. Technol., Chengdu, China, 2016.
- [8] D. Liu, C. Yang, and X. Hou, "An edge detection method for UAV image based on the enhancing ABC," *Converter*, vol. 2021, no. 6, pp. 362–374, Aug. 2021.
- [9] D. Xu, Y. Zhao, Y. Jiang, C. Zhang, B. Sun, and X. He, "Using improved edge detection method to detect mining-induced ground fissures identified by unmanned aerial vehicle remote sensing," *Remote Sens.*, vol. 13, no. 18, p. 3652, Sep. 2021.
- [10] W. R. Hamilton, *Elements of Quaternions*. London, U.K.: Longmans, Green & Company, 1866.
- [11] H. Li, "Feature extraction and classification algorithm of hyperspectral images based on quaternion and moment," Ph.D. dissertation, Huazhong Univ. Sci. Technol., Wuhan, China, 2019.
- [12] B. He, "Research on semi orthogonal moment model and quaternion fractional moment algorithm," Ph.D. dissertation, Xi'an Univ. Electron. Sci. Technol., Xi'an, China, 2020.
- [13] Z. Tu, "Dynamic behavior analysis of neural network based on inertia term and quaternion," Ph.D. dissertation, Southeast Univ., Dhaka, Bangladesh, 2018.
- [14] F. Pan and X. Lin, Fast Mode Decision for Intra Prediction, document JVI-G013, 7th Meeting, Pattaya II, Thailand, Mar. 2003.
- [15] S. Mirjalili and A. Lewis, "The whale optimization algorithm," *Adv. Eng. Softw.*, vol. 95, pp. 51–67, May 2016.
- [16] N. Rana, M. S. A. Latiff, S. M. Abdulhamid, and H. Chiroma, "Whale optimization algorithm: A systematic review of contemporary applications, modifications and developments," *Neural Comput. Appl.*, vol. 32, no. 20, pp. 162–177, 2020.