Image Fusion Emerging Applications and Techniques

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GITAM (Deemed-to-be) University

Capstone Project – Introduction (PROJ2999)

Department of Electrical Electronics and Communication Engineering

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Objective and Goals

Objective

- Study existing image fusion techniques (pixel, spatial, transform domains).
- Implement traditional methods for multi-focus, multi-exposure, and thermal-RGB fusion.
- Compare algorithms using qualitative & quantitative metrics.
- To evaluate the potential real-world applications of the developed techniques in areas such as medical imaging, computer vision, and security.

Goals

Main Goals :-

- Identify the most effective method for each application.
- Propose an optimized framework for image fusion.

Additional Goals :-

- Evaluate real-world applications (medical imaging, computer vision, security).
- Contribute to robust and adaptive fusion techniques.

Project Plan

Gant Chart - Milestones and Activities
Resources : Canva.com

Literature Survey

Key Publications

•**Li, S., Kang, X., & Fang, L. (2017).** Pixel-level image fusion: A survey of the state of the art. *Information Fusion, 33*, 100–112.
→ Comprehensive survey of pixel-based fusion methods.

•**Zhang, Y., et al. (2020).** DenseFuse: A fusion approach to infrared and visible images. *IEEE TIP, 29*, 4795–4805.
→ Deep learning-based IR + visible fusion.

•**Ma, J., et al. (2019).** FusionGAN: A generative adversarial network for infrared and visible image fusion. *Information Fusion, 48*, 11–26.
→ GAN-based approach; preserves texture and thermal cues.

•**Liu, Y., et al. (2017).** Multi-focus image fusion with dense SIFT. *Signal Processing, 130*, 38–51.
→ Classical multi-focus fusion using handcrafted features.

Key Resources – Whitepaper| Application Notes | Datasheet| Others

•**ASTM D4788-03 (2013):** Standard test method for detecting delaminations in bridge decks using infrared thermography.

•**Fluke (2021):** *What does infrared mean?* – Application note on thermal imaging basics.

•**FLIR Systems:** Datasheets for *FLIR One Pro*, *FLIR T-Series* (thermal camera specs).

•**ASCE (2020):** *Changing the infrastructure equation* – Infrastructure monitoring with asset management.

Existing Implementations – Products| Opensource| GitHub etc

•*FLIR One Pro, FLIR T-Series* – Commercial IR cameras for SHM.

•*Fluke TiX series* – Industrial thermal cameras.

•**Open Source / GitHub:**

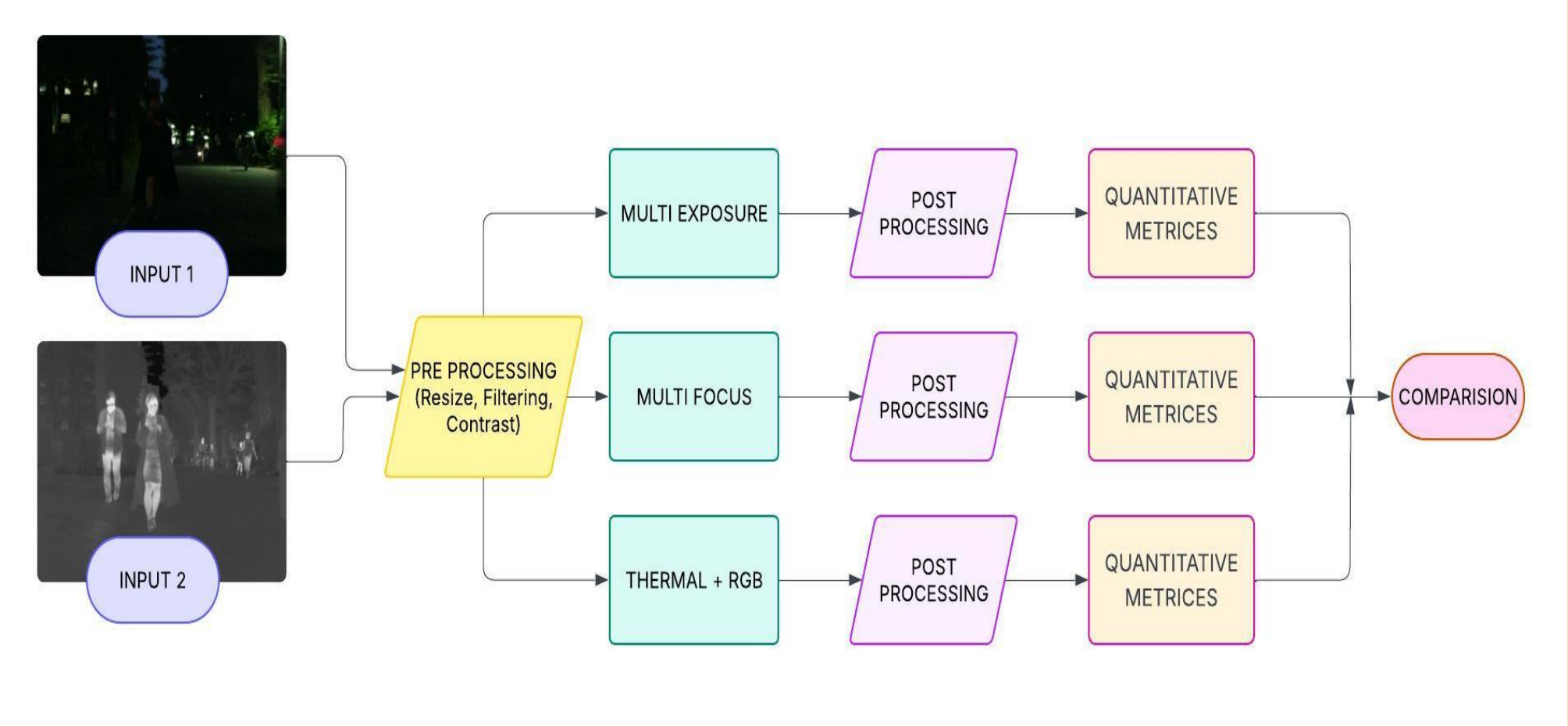
•*DenseFuse* (https://github.com/hli1221/densefuse-pytorch) – PyTorch implementation of infrared–visible fusion.

•*Deep Image Fusion Toolbox* (MATLAB File Exchange).

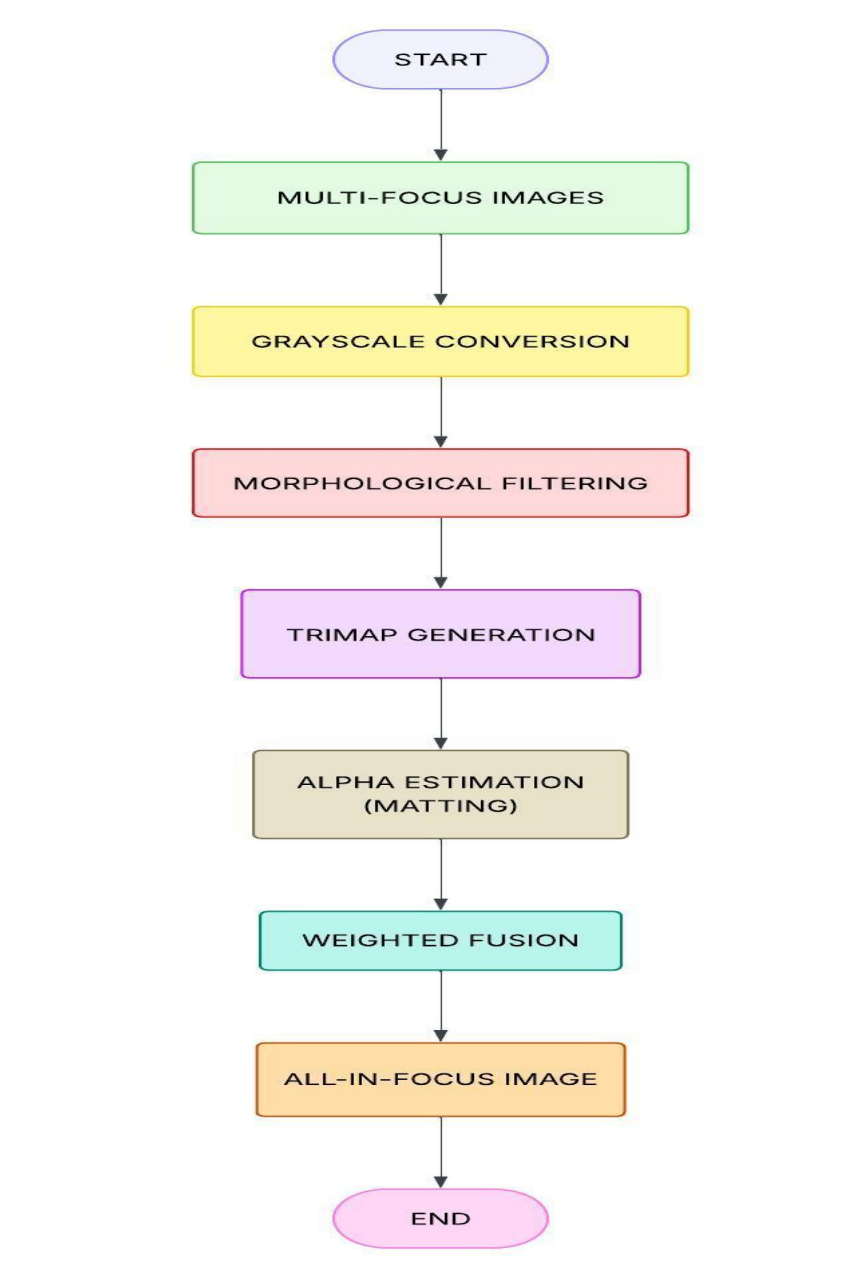
•*Exposure Fusion* (https://github.com/rocapp/exposure-fusion).

Architecture

Structural Diagram



Behaviour Diagram



Architecture

Multi-Focus Image Fusion

- Takes two or more images focused at different depths.
- Detects sharp/blurred regions using focus measures.
- Generates decision maps to identify in-focus areas.
- Combines them into a single all-in-focus image.

Applications: Medical imaging, microscopic analysis, photography.

Advantages: Clear details from foreground to background.

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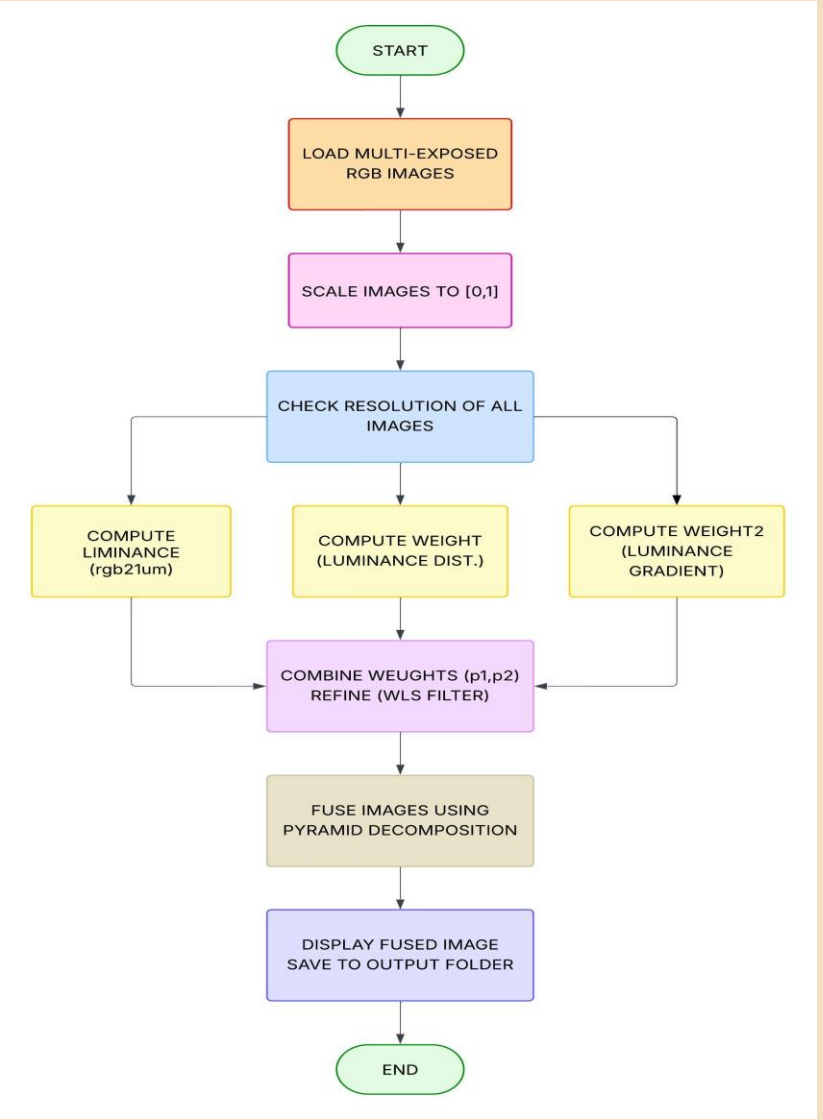
Architecture

Multi-Exposure Image Fusion

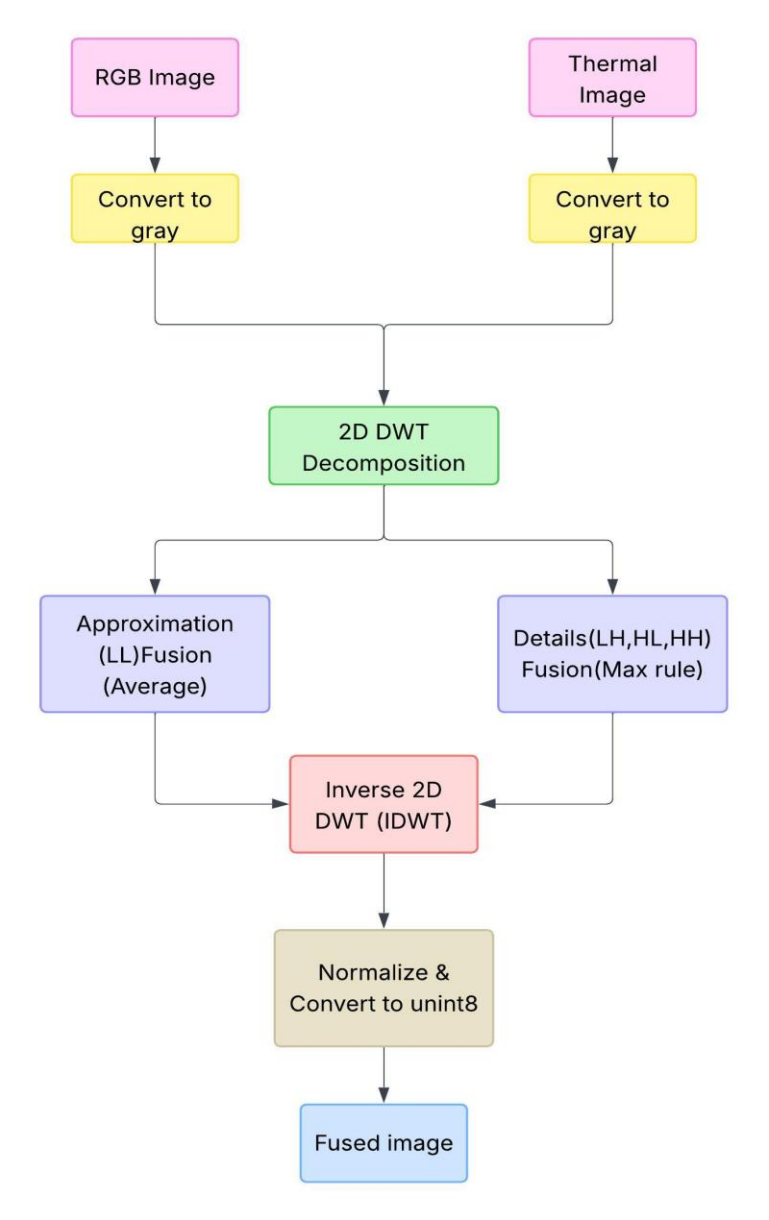
- Reads multiple images with different exposurelevels.
- Generates weight maps (well-exposedness,contrast, saturation).
- Uses guided filtering to refine maps and avoidartifacts.
- Fuses base (illumination) and detail (texture)layers for reconstruction.

Applications: HDR imaging, photography, surveillance.

Advantages: Balanced brightness, vivid colors, sharp details.



Behaviour Diagram



Architecture

Thermal–RGB Image Fusion

- Captures thermal and visible (RGB) images simultaneously.
- Aligns both images using preprocessing and registration.
- Extracts key features from thermal (heat) and RGB (texture).
- Fuses them to create a single informative image.

Applications: Surveillance, defense, search & rescue.

Advantages: Combines heat detection with clear visual context.

Use Cases & Testing

Use Cases

•**Structural Health Monitoring (SHM):** Detect cracks, delamination, moisture intrusion in concrete/bridges.
•**Surveillance:** Thermal + RGB fusion for low-light object detection.
•**Medical Imaging:** CT + MRI fusion for diagnosis.
•**Remote Sensing:** PAN–MS, thermal–RGB fusion for land cover classification.
•**Autonomous Systems:** Thermal + RGB fusion in drones for search & rescue, night-time navigation.

Test Cases

- **Multi-focus:** Fuse two partially focused images of a scene → all-in-focus output.
- **Multi-exposure:** Fuse underexposed + overexposed images → balanced illumination.
- **Thermal–RGB:** Fuse daytime RGB with nighttime IR → structure defects + heat leakage.
- **Benchmark Datasets:**
- TNO Image Fusion Dataset (thermal + visible).
- Lytro Multi-focus Dataset.
- MEF (Multi-Exposure Fusion) Dataset.
- Custom SHM datasets (USACE, crack datasets).

Implementation and Results

Iteration 1 : Thermal & RGB

RGB_RAW.png

Thermal.png

fused(raw).png

Multi_enhanced. png

thermal_clache_enhanced.png

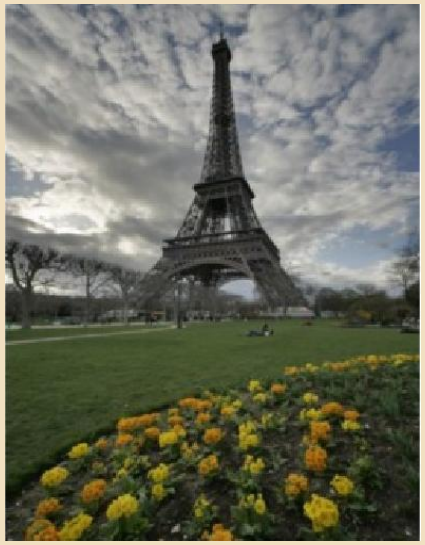
fused.png

Implementation and Results

MULTI EXPOSURE

INPUT-1

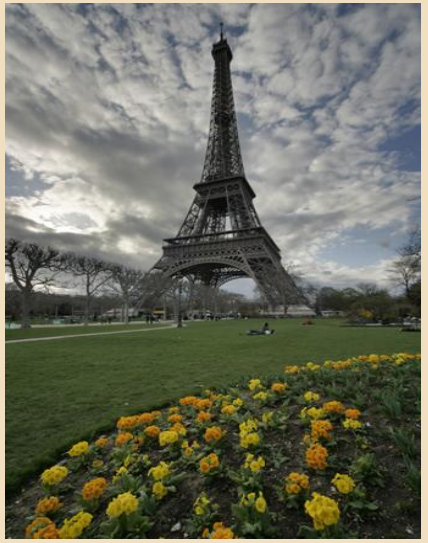
INPUT-2



INPUT-3

Preprocessed input 1

Preprocessed input 2



Preprocessed input 1

Implementation and Results

MULTI EXPOSURE

FUSED IMAGE

PRE-PROCESSED IMAGE

PRE + POST PROCESSED OUTPUT IMAGE

Conclusion:

Image fusion combines multiple image sources to enhance detail and information. Multi-focus fusion improves depth-of-field, multi-exposure fusion balances brightness and texture, and thermal-RGB fusion merges heat and visual details. These methods aid applications in medical imaging, surveillance, photography, and autonomous systems, providing richer and more interpretable imagery.

THANK YOU

Have a Great Day !