ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09–11 December 2025 | Online

MDPI

Automating the Detection of Unplanned Urban Constructions through AI-Powered Super-Resolution and Multi-modal Data Fusion

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INTRODUCTION & AIM

In urban studies, monitoring unplanned constructions is vital to achieve sustainable cities (SDG 11). However, ALSAT-2 imagery (10m / 2.5m pansharpened) lacks the spatial detail required to detect small-scale informal settlements. This work introduces an AI pipeline that combines super-resolution and multimodal fusion (RGB + LST) to automatically map unauthorized urban growth in Oran, Algeria.

METHOD

This study evaluates two protocols for detecting informal settlements:

1. In Protocol A, Super-Resolution models (EDSR and MFFAGAN) with a x2 upscaling factor were trained on ALSAT-2 and benchmark datasets to enhance image detail.
2. In Protocol B, a U-Net with ResNet-50 backbone was adapted to process four input channels: Google Earth RGB imagery combined with Land Surface Temperature (LST), representing the radiative temperature of urban surfaces. Segmentation performance was measured using IoU, Dice, Precision, and Recall..

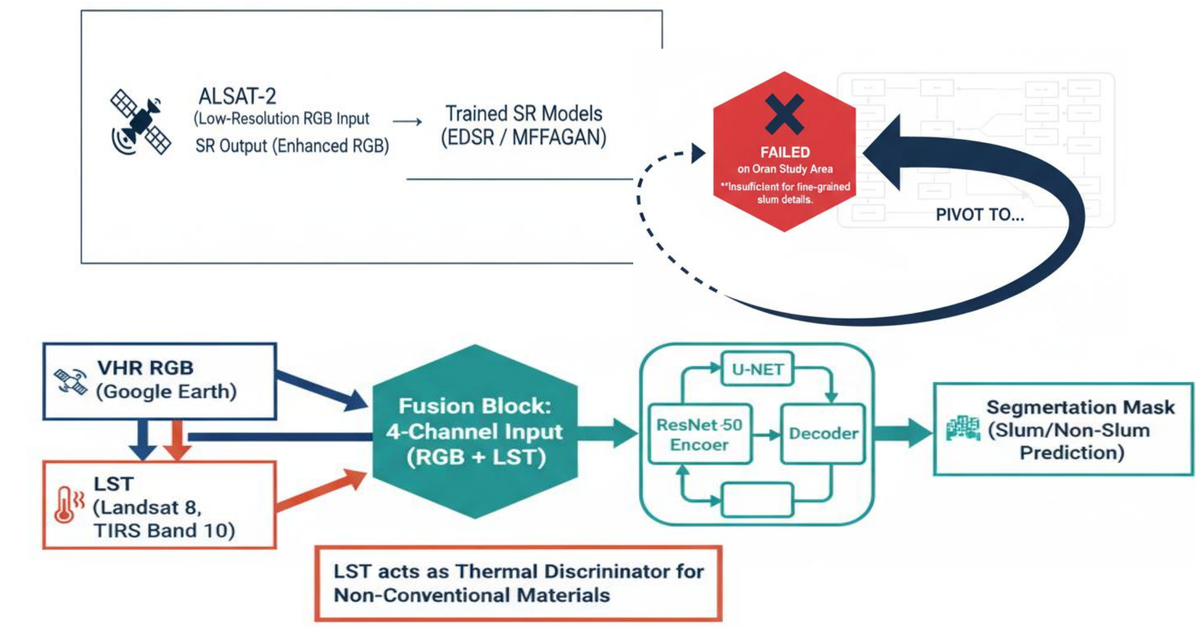


Figure 1: Methodological Workflow of AI Segmentation Approaches for Informal Settlement Detection

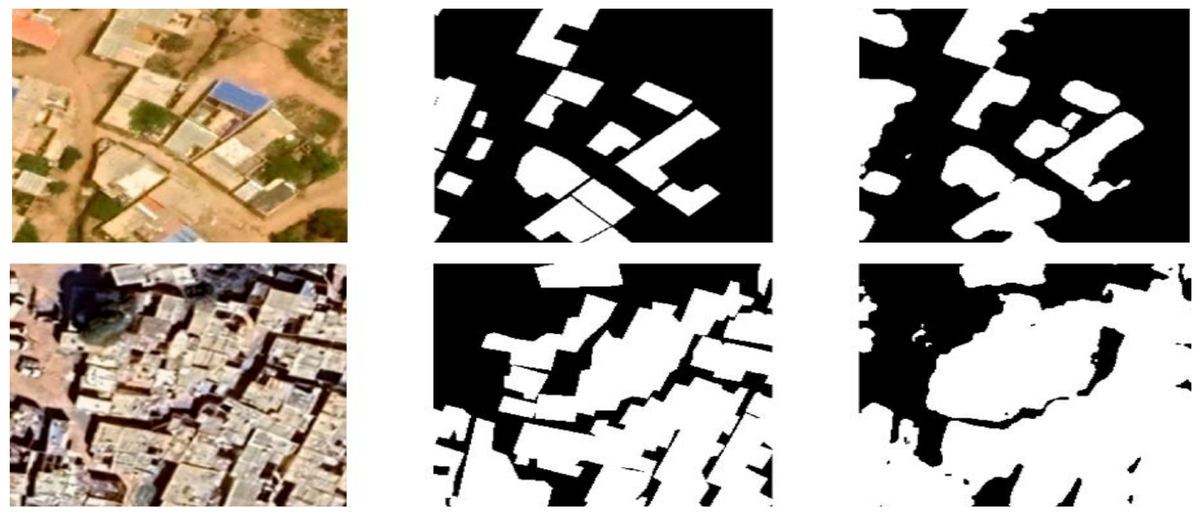
RESULTS & DISCUSSION

The results show that Super-Resolution with a x2 upscaling factor improved quantitative metrics compared to the bicubic baseline (EDSR: PSNR = 23.5 dB, SSIM = 0.89; MFFAGAN: LPIPS = 0.0859, NIQE = 8.90). However, qualitative analysis revealed that both models failed to recover the very fine, irregular structures characteristic of informal settlements, limiting their practical applicability. In contrast, the multimodal fusion approach (RGB + Land Surface Temperature) achieved substantial improvements in segmentation accuracy, with IoU = 0.7712 and Dice = 0.8350. Precision increased by 2.5%, reducing false positives, while boundaries of settlements were delineated with higher spatial coherence.

The integration of LST proved crucial for material discrimination, particularly in differentiating metal roofs and concrete surfaces, resulting in more reliable detection of unplanned constructions. These findings highlight the limitations of SR alone and demonstrate the effectiveness of multimodal fusion for urban monitoring.

Table 1: Segmentation Performance with and without the LST Channel

Metrics	Model RGB	Model RGB+LST	Gain
IoU (↑)	0.7473	**0.7712**	**+0.0239**
Dice (↑)	0.8054	**0.8350**	**+0.0296**
Precision (↑)	0.7963	**0.8210**	**+0.0247**
Recall (↑)	**0.9349**	0.9285	−0.0064
Accuracy (↑)	**0.9542**	0.9516	-0.0026



(a) Original Image (b) Ground Truth (c) Model prediction

Figure 2: Visual segmentation results using the Multimodal Fusion Framework (RGB + LST)

CONCLUSION

Super-Resolution (x2) improved image metrics but failed to recover fine informal structures. Multimodal fusion (RGB + Land Surface Temperature) achieved higher accuracy (IoU = 0.77, Dice = 0.83), confirming LST as a key discriminator for reliable slum detection.

FUTURE WORK / REFERENCES

Next steps include integrating SAR and higher-resolution thermal data, developing Explainable AI for planners, validating the framework across Global South cities, and promoting open data sharing to support collaborative research on informal settlements.

1. Meroufel, H., Amri, M. B., & Larabi, M. E. A. Poverty Areas Detection and Mapping Through Combination of Remote Sensing and Machine Learning: A Case Study of ORAN, ALGERIA. In 2023 8th ICFSP (pp. 75-78). IEEE.