ISSN 2277-2685
IJESR/Jan-Mar. 2025/ Vol-15/Issue-1/167-173
Turimella Bhanu Krishna Prasanna Kalki et. al., / **International Journal of Engineering & Science Research**

Embedded Night-Vision System For Pedestrian Detection

[1]**Turimella Bhanu Krishna Prasanna Kalki**, *bhanukrishna367@gmail.com*
[2]**M Naresh,** *nareshmtech08@gmail.com*
[1&2]*Newton's Institute of Engineering, Guntur, Andhra Pradesh*

Abstract
Assistive vision-based solutions for the driver extend the capabilities of human vision and support safe travel. Unfortunately, their widespread usage is generally limited to expensive cars. Interestingly, a high price is most likely a derivative of the costs incurred in the research instead of the value of hardware components. In the article we show that a mobile system for pedestrian detection in severe lighting conditions can be build using state of the art algorithms and widely available hardware. The proposed night-vision system for pedestrian detection processes thermal images using a proprietary ODROID XU4 microcomputer under Ubuntu MATE operating system. We applied a cascade object detector for the task of human silhouette detection in context of thermal imagery and contrasted the results with the state of the art deep learning approach.

Keywords: *Pedestrian Detection, Night Vision System, Road Safety, Embedded System*

1. INTRODUCTION

The rapid advancements in intelligent transportation systems and automotive technologies have underscored the importance of research in driver assistance solutions for enhancing road safety. Among the various challenges faced by drivers, night-time visibility remains a critical concern due to limited lighting, adverse weather conditions, and environmental factors. These challenges significantly increase the risk of pedestrian-related accidents. Therefore, the development of reliable and efficient pedestrian detection systems suitable for low-light conditions has become a key focus of research. An embedded night-vision system for pedestrian detection offers a promising solution by leveraging thermal or infrared imaging combined with intelligent algorithms to detect pedestrians in real-time, even under challenging visibility conditions. The system's embedded nature ensures compactness, energy efficiency, and adaptability for automotive integration and portable surveillance applications. This research aims to investigate and develop a robust embedded night-vision system that can accurately detect pedestrians using

infrared imaging, advanced signal processing, and deep learning models. The study involves extensive exploration of hardware-software co-design for efficient data processing, real-time detection, and system optimization to overcome computational and environmental constraints. Through this research, we seek to address key challenges such as improving detection accuracy, minimizing false positives, and enhancing system performance in dynamic environments.

2. LITERATURE SURVEY

Survey reviews key research contributions to understand the progress and challenges Numerous studies have explored advancements in pedestrian detection systems, particularly focusing on night-vision technologies and their integration into embedded systems. This literature in this domain. Muñuzuri et al. [1] examined logistics challenges in urban environments, underscoring the need for efficient transportation systems, a factor closely related to pedestrian detection technologies for enhancing traffic safety. Weller and Schlag [2] developed road user behavior models, highlighting the critical role of driver assistance systems for improved traffic management and pedestrian safety. Driver fatigue remains a leading cause of accidents, as discussed by Craig [3], emphasizing the necessity for intelligent detection systems to enhance driver awareness. Krishnasree et al. [4] proposed an improved real-time driver fatigue monitoring system, leveraging advancements in signal processing to reduce accidents caused by driver drowsiness. Cyganek and Gruszczynski [5] further contributed by designing a hybrid computer vision system for monitoring drivers' eye movements to assess fatigue levels. In the context of pedestrian detection, Etinger et al. [6] presented a non-imaging millimeter-wave frequency-modulated continuous wave (FMCW) sensor, demonstrating its effectiveness in detecting pedestrians during night conditions. Gidel et al. [7] explored pedestrian detection using multilayer laser scanners, showcasing advancements in urban pedestrian tracking systems. Video-based analysis techniques were extensively surveyed by Wu et al. [8], who reviewed algorithms for vehicle behavior analysis, including pedestrian interactions. Nowosielski [9] explored vision-based solutions for driver assistance systems, underscoring the need for robust image processing in dynamic traffic environments. Källhammer [10] discussed the requirements and possible roadmaps for near-infrared (NIR) and far-infrared (FIR) night vision systems, emphasizing their importance in enhancing driver visibility during nighttime. Heo et al. [11] advanced the field by employing deep neural networks and saliency maps for pedestrian detection at night, achieving significant improvements in detection accuracy. Traffic sign recognition approaches were evaluated by Forczmanski and Małecki [12], contrasting visual and RFID-based techniques, while Iwan et al. [13] emphasized mobile applications for enhancing traffic management systems. Małecki and Watróbski [14] further demonstrated mobile decision-making systems for road threats. Ahmadi and Machiani [15] examined drivers' performance using adaptive curve speed warnings, revealing the effectiveness of personalized solutions for enhanced road safety. Reinmueller and Steinhauser [16] investigated adaptive forward collision warnings, highlighting the impact of imperfect technology on driver behavior. Pedestrian detection in severe lighting conditions was studied by Nowosielski et al. [17], who compared human performance with thermal imaging-based automatic systems. Feldstein et al. [18] contributed by developing an infrared-based in-vehicle head-tracking system, demonstrating advancements in real-time driver monitoring. Ragesh and Rajesh [19] provided a comprehensive understanding of state-of-the-art pedestrian detection in automotive safety, emphasizing the need for advanced night-vision systems. Shao et al. [20] proposed an embedded infrared HOG-based pedestrian detection system for outdoor autonomous searching UAVs, showcasing novel applications beyond automotive safety. Nanda and Davis [21] developed a probabilistic template-based pedestrian detection technique in infrared videos, providing insights into template-based approaches for night-vision applications. Lastly, Piniarski et al. [22] presented video processing algorithms for pedestrian detection, emphasizing computational efficiency and real-time performance in dynamic environments. This review of literature highlights the significant advancements in pedestrian detection systems, with a particular emphasis on night-vision technologies and embedded system integration. The insights gained from these studies will serve as a foundation for further research aimed at developing efficient, real-time solutions for enhanced road safety.

3. MATERIALS AND METHODS

Figure.1 illustrates a neural network architecture designed for image-based tasks, likely for segmentation or object detection, given the presence of attention modules, skip connections, and an encoder-decoder structure. The architecture comprises three primary sections: encoder, decoder, and prediction modules. The encoder module, represented by blue blocks, consists of multiple convolutional layers (Conv-3, Conv-5, Conv-7, and Conv-6-2) responsible for hierarchical feature extraction from the input image. As the image passes through deeper layers, the extracted features become increasingly abstract, capturing more complex spatial details. The decoder module, depicted in red, reconstructs the feature maps back to the original image dimensions while predicting the target output. It contains blocks D1 to D4, which gradually upsample the encoded feature maps. Skip connection blocks (marked "C") are employed between corresponding layers of the encoder and decoder to retain spatial information lost during feature extraction and to address vanishing gradient issues. This ensures a more accurate prediction by leveraging both low-level and high-level features.

The architecture also incorporates attention modules (green blocks marked "A") to enhance feature extraction by focusing on significant regions of the image, effectively filtering out irrelevant information. These attention modules enable the network to learn and prioritize essential spatial details, improving detection accuracy. Finally, the prediction module, represented in yellow, processes the outputs from the decoder to generate the final prediction, such as a segmented image or a detection map. The output typically highlights detected regions, potentially indicating objects of interest. This architecture effectively balances high accuracy and computational efficiency, making it suitable for real-time applications such as pedestrian detection in night-vision systems.

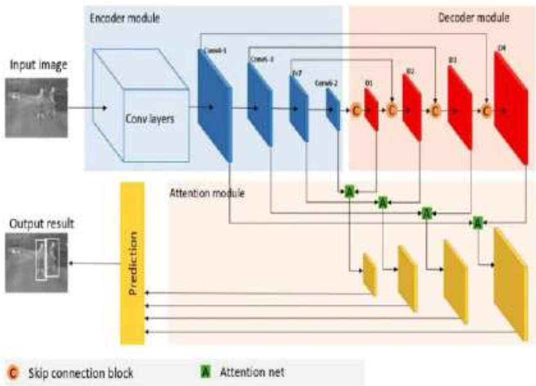

Fig.1. Architecture of the proposed model

4. RESULTS AND DISCUSSION

Fig.2 presents a GUI for an embedded night-vision pedestrian detection system. It features a title bar followed by functional buttons for efficient user interaction. The "Upload Night Vision Image" button allows users to load images for processing. Two detection options are available: "Night Vision Pedestrian Detection using YOLOv2," known for real-time and accurate detection, and "Detection using HAAR + AdaBoost," a classical approach leveraging HAAR features and AdaBoost for robust performance. An "Exit" button provides a simple way to close the application. The vibrant magenta background and color-coded buttons enhance user navigation. This GUI demonstrates a comprehensive approach by integrating both advanced and classical detection techniques, offering opportunities for comparative analysis in terms of accuracy, false positives, and speed. It provides a valuable platform for evaluating pedestrian detection efficiency in varying night-vision conditions.

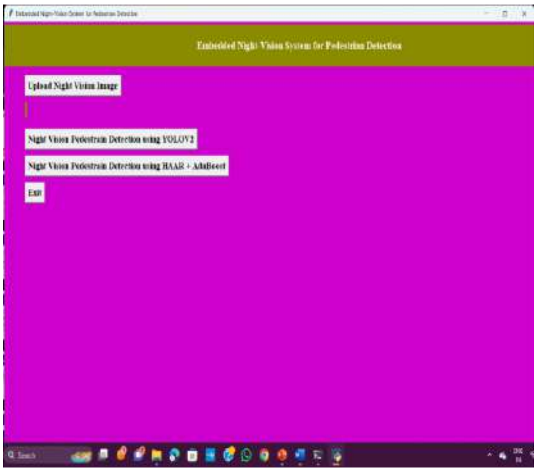

Fig.2. Uploading night vision image for pedestrian detection

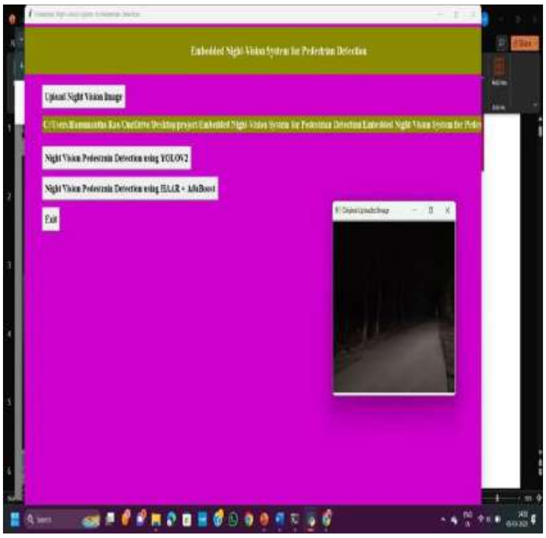

Fig.3. Uploaded Night vision Image

Fig.3. image showcases a user-friendly GUI for an embedded night-vision pedestrian detection system. It features a title bar followed by essential functional buttons. Users can upload a night-vision image using the "Upload Night Vision Image" button, with the file path displayed below for confirmation. Upon successful upload, the selected image is displayed in a separate pop-up window. Two detection options are available: "Night Vision Pedestrian Detection using YOLOv2" for real-time, high-accuracy detection and "Detection using HAAR + AdaBoost" for a robust, classical approach. The "Exit" button provides a convenient way to close the application. The vibrant magenta background enhances visibility, offering an intuitive interface for seamless image processing and pedestrian detection tasks.

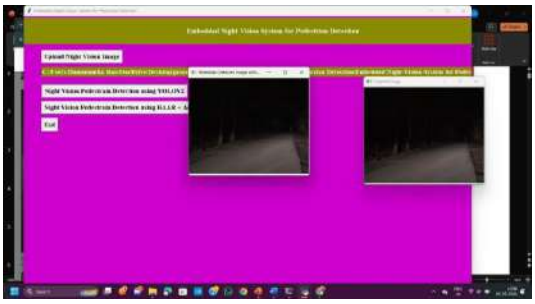

Fig.4. pedestrian detection using YOLOv2

Fig.4. shows that prediction of pedestrian in night vision image, and Fig.5. shows the detection of pedestrian in night vision by using Fig.5.Pedestrian detection using HAAR + AdaBoost model.

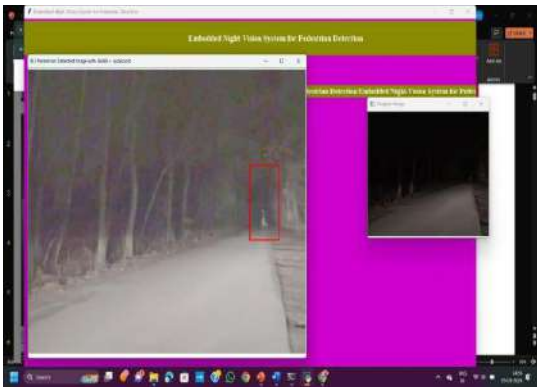

Fig.5.Pedestrian detection using HAAR + AdaBoost

5. CONCLUSION

This paper focuses on enhancing pedestrian safety on the road by developing a cost-effective sensor for human body detection in challenging lighting conditions. Unlike high-cost solutions typically installed in premium vehicles, our approach leverages widely available hardware and state-of-the-art algorithms to deliver accurate detection even in severe lighting environments. The system effectively extends human visual perception and has the potential to significantly improve road safety.

REFERENCES

[1] J. Muñuzuri, P. Cortés, J. Guadix, and L. Onieva, "City logistics in spain: Why it might never work," Cities, vol. 29, no. 2, pp. 133–141, 2012.

[2] G. Weller and B. Schlag, "Road user behavior model, deliverable d8 project ripcord-iseret, the 6th framework programme for research and technological development (6th fp)," 2007.

[3] A. Craig, "Day or night, driving while tired a leading cause of accidents," https://vtnews.vt.edu/articles/2013/04/041513-vtti-fatigue. html, 2013, accesssed 2019-06-18.

[4] V. Krishnasree, N. Balaji, and P. S. Rao, "A real time improved driver fatigue monitoring system," WSEAS Trans. Signal Process, vol. 10, p. 146, 2014.

[5] B. Cyganek and S. Gruszczynski, "Hybrid computer vision system for ´ drivers' eye recognition and fatigue monitoring," Neurocomputing, vol. 126, pp. 78–94, 2014.

[6] A. Etinger, N. Balal, B. Litvak, M. Einat, B. Kapilevich, and Y. Pinhasi, "Non-imaging mm-wave fmcw sensor for pedestrian detection," IEEE Sensors Journal, vol. 14, no. 4, pp. 1232–1237, April 2014.

[7] S. Gidel, P. Checchin, C. Blanc, T. Chateau, and L. Trassoudaine, "Pedestrian detection and tracking in an urban environment using a multilayer laser scanner," IEEE Transactions on Intelligent Transportation Systems, vol. 11, no. 3, pp. 579–588, Sep. 2010.

[8] J. Wu, Z.-m. Cui, J.-m. Chen, and G.-m. Zhang, "A survey on videobased vehicle behavior analysis algorithms." Journal of multimedia, vol. 7, no. 3, 2012.

[9] A. Nowosielski, "Vision-based solutions for driver assistance," Journal of Theoretical and Applied Computer Science, vol. 8, no. 4, pp. 35–44, 2014.

[10] J.-E. Källhammer, "Night vision: Requirements and possible roadmap for fir and nir systems," in Photonics in the Automobile II, vol. 6198. International Society for Optics and Photonics, 2006, p. 61980F.

[11] D. Heo, E. Lee, and B. Ko, "Pedestrian detection at night using deep neural networks and saliency maps," Journal of Imaging Science and Technology, vol. 61, 01 2017.

[12] P. Forczmanski and K. Małecki, "Selected aspects of traffic signs ´ recognition: visual versus rfid approach," in International Conference on Transport Systems Telematics. Springer, 2013, pp. 268–274.

[13] S. Iwan, K. Małecki, and D. Stalmach, "Utilization of mobile applications for the improvement of traffic management systems," in International Conference on Transport Systems Telematics. Springer, 2014, pp. 48–58.

[14] K. Małecki and J. W ˛atróbski, "Mobile system of decision-making on road threats," Procedia Computer Science, vol. 112, pp. 1737–1746, 2017.

[15] A. Ahmadi and S. G. Machiani, "Drivers' performance examination using a personalized adaptive curve speed warning: Driving simulator study," International Journal of Human- Computer Interaction, vol. 35, no. 11, pp. 996–1007, 2019. [Online]. Available: https://doi.org/10. 1080/10447318.2018.1561785.

[16] K. Reinmueller and M. Steinhauser, "Adaptive forward collision warnings: the impact of imperfect technology on behavioral adaptation, warning effectiveness and acceptance," Accident Analysis & Prevention, vol. 128, pp. 217–229, 2019.

[17] A. Nowosielski, K. Małecki, P. Forczmanski, and A. Smoli ´ nski, "Pedes- ´ trian detection in severe lighting conditions: Comparative study of human performance vs thermal-imaging- based automatic system," in Progress in Computer Recognition Systems, R. Burduk, M. Kurzynski, and M. Wozniak, Eds. Cham: Springer International Publishing, 2020, pp. 174–183.

[18] I. Feldstein, A. Guentner, and K. Bengler, "Infrared-based in-vehicle head-tracking," Procedia Manufacturing, vol. 3, pp. 829–836, 2015.

[19] N. Ragesh and R. Rajesh, "Pedestrian detection in automotive safety: Understanding state- of-the-art," IEEE Access, vol. 7, pp. 47 864–47 890, 2019.

[20] Y. Shao, Y. Mei, H. Chu, Z. Chang, Y. He, and H. Zhan, "Using infrared HOG-based pedestrian detection for outdoor autonomous searching UAV with embedded system," in Ninth International Conference on Graphic and Image Processing (ICGIP 2017), H. Yu and J. Dong, Eds., vol. 10615, International Society for Optics and Photonics. SPIE, 2018, pp. 1143 – 1147. [Online]. Available: https://doi.org/10.1117/12.2304530

[21] H. Nanda and L. Davis, "Probabilistic template based pedestrian detection in infrared videos," in Intelligent Vehicle Symposium, 2002. IEEE, vol. 1. IEEE, 2002, pp. 15–20. [22] K. Piniarski, P. Pawłowski, and A. D ˛abrowski, "Video processing algorithms for detection of pedestrians," Computational Methods in Science and Technology (CMST), vol. 21, no. 3, pp. 141–150,2015.