Military Vehicles Tracking with Blockchain in Low-FPS UAV Videos

Sium Bin Noor, Mohtasin Golam, Subroto Kumar Ghosh,
Md Mehedi Hasan Somrat, Jae-Min Lee, Dong-Seong Kim
Networked Systems Laboratory, Department of IT Convergence Engineering,
Kumoh National Institute of Technology, Gumi, South Korea.
(siumbinmoor, golam248, subroto, mehedi, ljmpaul, dskim)@kumoh.ac.kr

***Abstract*—This paper proposes a robust framework for tracking military vehicles in low frame rate Unmanned aerial vehicle (UAV) videos, combining a lightweight YOLOv11n object detection model, self-supervised tracking and secure data management using Pure Chain [1], a permissioned blockchain. The YOLOv11n model, trained on annotated UAV datasets, achieves high accuracy above 96% enabling real-time and accurate detection under challenging conditions such as low resolution and rapid viewpoint changes. The framework ensures secure and tamper-proof storage of tracking data through Pure Chain, achieving low latency of 4.55 ms and high throughput of 17.27 transactions per second, surpassing typical blockchain networks. Experimental results demonstrate the integrated framework's reliability and efficiency for secure military vehicles monitoring.**

***Index Terms*—Military Vehicles, Low-FPS Videos, Tracking, Pure Chain**

I. Introduction

UAVs are now widely used in military operations to keep an eye on vehicles and activities from the sky [2]. These UAVs often capture videos at low frame rates which makes it harder to follow moving military vehicles smoothly. At the same time, blockchain technology is becoming important in military systems because it keeps data safe and prevents others from changing it. Using blockchain can help protect the information collected by UAVs and make sure it can be trusted [3]. Combining UAV surveillance with blockchain can improve how well military forces track vehicles and share secure and reliable information.

Tracking military vehicles in low frame rate UAV footage is very difficult because the video only shows a few frames per second. This causes big jumps in where vehicles appear from one frame to the next, making it hard to follow them precisely. The moving camera on UAVs also changes viewpoints quickly, adding more challenges. Traditional tracking methods that expect small movements between frames do not work well in this low-FPS setting. Additionally, images are often low quality [4] because of video compression and cloud streaming, making vehicles harder to identify. Vehicles of the same type also look very similar, so tracking them accurately requires more than just appearance. These problems create gaps in reliable, real-time monitoring of military assets from UAVs.

To solve these problems, this paper proposes a new tracking method that uses self-supervised learning on single-frame data to recognize and follow military vehicles in low-FPS UAV videos. The approach learns to link vehicles across frames using both detailed object features and the overall scene context, even when video quality is low or vehicles look similar. The tracking model is designed to work efficiently with smaller image sizes and feature representations, making it suitable for real-time use on UAVs. Pure Chain is integrated to keep tracking data secure, trustworthy, and tamper-proof that enable safe sharing and better accountability in military operations [5].

II. Methedology

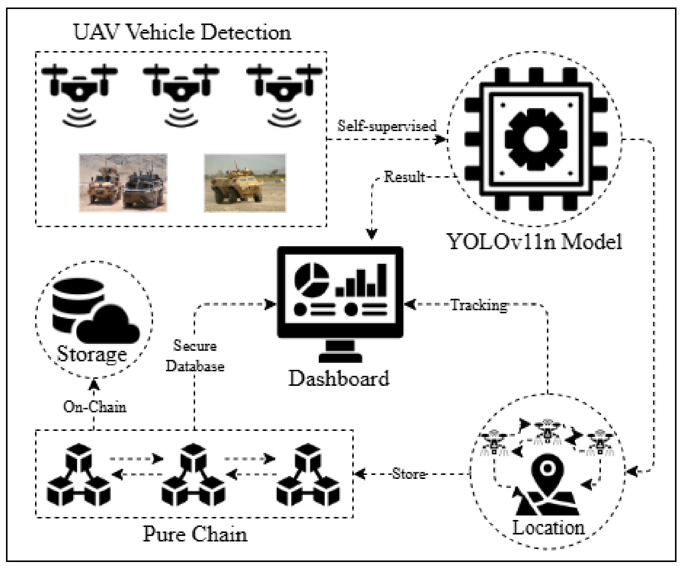

Fig. 1: Proposed Framework for Military Vehicles Tracking

In Figure 1, the proposed military vehicle tracking framework illustrates the YOLOv11n model, a lightweight and efficient object detector optimized for real-time applications on edge devices such as UAVs. YOLOv11n is selected for its balance of accuracy and computational speed, which enables it to detect military vehicles effectively even when processing power is limited. The model is trained on a large-scale general dataset and subsequently fine-tuned using a curated dataset of low frame rate UAV footage annotated with bounding boxes for various classes of military vehicles. This training approach allows the model to accurately localize vehicles under challenging conditions such as low resolution, occlusions, and varying environmental factors. A self-supervised framework is used. Unlike traditional methods that require dense frame-to-frame annotations, this approach learns robust instance-level feature representations from single-frame-labeled data. For secure management and verification of tracking information, the framework incorporates Pure Chain, a permissioned blockchain platform tailored for military applications. Pure Chain's decentralized ledger ensures the immutability and integrity of tracking records, mitigating risks of data tampering or unauthorized access. The integration of YOLOv11n's lightweight detection capabilities with self-supervised tracking and blockchain-based data security forms a comprehensive and scalable framework for reliable, real-time monitoring of military vehicles in complex aerial environments.

III. Performance Evaluation

TABLE I: Military vehicles detection model comparison

Model	Precision (%)	Recall (%)	F-1 Score (%)	Accuracy (%)
MobileNet SSD	82.5	84.3	86.5	85.5
YOLOv4	92.2	91.7	94.5	92.0
YOLOv5	93.5	92.5	93.6	94.2
YOLOv8	94.5	93.5	94.3	93.7
YOLOv11n (this paper)	96.7	96.6	96.7	96.5

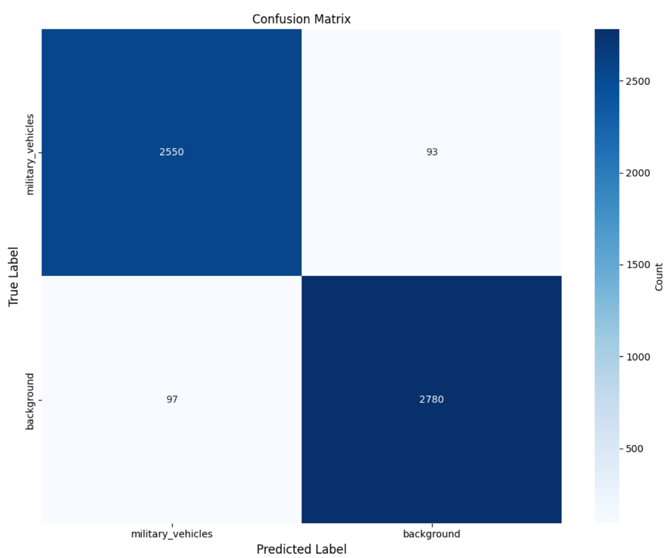

Fig. 2: Confusion Matrix

In Figure 2, the proposed military vehicle tracking framework was evaluated on a dataset of 5,520 low-FPS UAV video frame samples. The Table I illustrates YOLOv11n-based detection comparison with other models. YOLOv11n achieved an accuracy of 96.56%, precision of 96.76%, recall of 96.63%, specificity of 96.48%, and an F1-score of 96.70%. These results demonstrate the model's robust ability to accurately detect and track military vehicles despite challenges such as low frame rates, occlusions, and similar vehicle appearances. The Pure Chain was also assessed for securely storing detection images and tracking data, showing average transaction latency between 3 to 5 milliseconds and average throughput of 17 transactions per second, supporting real-time and reliable data updates for mission needs. In Figure 3, when compared to Sepolia, Pure Chain provided much lower latency (4.55 ms vs 11.42 ms) and higher throughput (17.27 vs 9.23 transactions per second), as shown in the accompanying comparison chart, demonstrating its superior efficiency and suitability for high-performance field operations.

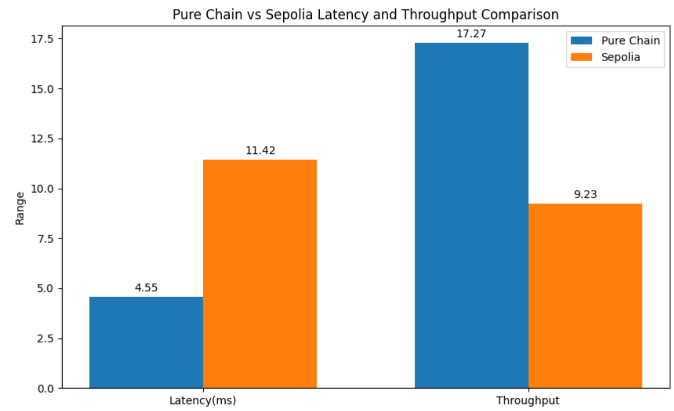

Fig. 3: Pure Chain vs Sepolia Comparison

IV. Conclusion and Future Work

This study introduced an efficient framework for tracking military vehicles in low-FPS UAV footage using YOLOv11n detection, self-supervised tracking and secure storage with Pure Chain. The framework achieved high accuracy and reliable performance. Future work will focus on improving long-term tracking and advancing multi-UAV data fusion.

Acknowledgment

This work was partly supported by Innovative Human Resource Development for Local Intellectualization program through the IITP grant funded by the Korea government (MSIT) (IITP-2025-RS-2020-II201612, 33%) and by Priority Research Centers Program through the NRF funded by the MEST (2018R1A6A1A03024003, 33%) and by the MSIT, Korea, under the ITRC support program (IITP-2025-RS-2024-00438430, 34%).

References

[1] D.-S. Kim, I. S. Igboanusi, L. A. C. Ahakonye, and G. O. Anyanwu, "Proof-of-authority-and-association consensus algorithm for iot blockchain networks," in *2025 IEEE International Conference on Consumer Electronics (ICCE)*. IEEE, 2025, pp. 1–6.

[2] P. Gupta, B. Pareek, G. Singal, and D. V. Rao, "Edge device based military vehicle detection and classification from uav," *Multimedia Tools and Applications*, vol. 81, no. 14, pp. 19 813–19 834, 2022.

[3] M. Golam, J.-M. Lee, and D.-S. Kim, "A uav-assisted blockchain based secure device-to-device communication in internet of military things," in *2020 International Conference on Information and Communication Technology Convergence (ICTC)*. IEEE, 2020, pp. 1896–1898.

[4] N. A. Almujally, A. M. Qureshi, A. Alazeb, H. Rahman, T. Sadiq, M. Alonazi, A. Algarni, and A. Jalal, "A novel framework for vehicle detection and tracking in night ware surveillance systems," *Ieee Access*, vol. 12, pp. 88 075–88 085, 2024.

[5] D.-S. Kim and R. Syamsul, "Integrating machine learning with proof-of-authority-and-association for dynamic signer selection in blockchain networks," *ICT Express*, vol. 11, no. 2, pp. 258–263, 2025.