CNN-based Unwanted UAV Detection System

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***Abstract*—Applications using Unmanned Aerial Vehicles (UAV)s are growing rapidly because of its easy-availability and is in trend, but with this growth, people also became creative in using it for doing unlawful things. To mitigate this, a lot of UAV detection systems emerged using different technologies. This paper proposes a UAV detection system exploiting a Convolutional Neural Network (CNN) for detection and show its advantage compared with other Deep Learning (DL) algorithms.**

***Index Terms*—Convolutional neural network, deep learning, unmanned aerial vehicle (UAV) detection.**

I. Introduction

Fast rising fleet of Unmanned Aerial Vehicles (UAV)s started since 2015 and a lot of open-source database has also been available to the public to analyze and research because of the wide applications and innovation that people can do with UAVs to help people in their daily lives.

With these emerging technologies, people also became creative in using it for illegally observing other people, attacks, transporting drugs, etc., and that's when anti-drone systems are created. Using different technologies, UAVs can be detected as listed in Table I together with its tracking methods used and challenges [1].

These technologies have its strength and weaknesses and combining all of these into a single system can deal with multiple scenarios but of course, there will be features that will be sacrificed such as the system's processing time and it will be more complex. However, the performance of these current technologies is also out of date and is used for deployment. Therefore, the recommended solution is upgrading these systems and follow today's trends. The author's proposed an innovated anti-drone system where Deep Learning (DL) for detection is exploited for easier implementation.

TABLE I
ANTI-DRONE TECHNOLOGIES

Surveillance Technology	Drone Signature	Tracking Method	Challenges
Audio	Time-frequency feature	DOA	High ambient noise
Video	Motion or appearance features	Motion-based	Small objects, occlusion
RF	RF signal	RSS-based	RF noise
Radar	Micro-Doppler signal	Doppler-based	Low radar cross-section

Fig. 1 illustrates a block diagram of a radar-based anti-drone system as an example. In the figure, it shows that the area is being observed by drones equipped with cameras and is being identified using micro-Doppler signal signature detector with radar technology.

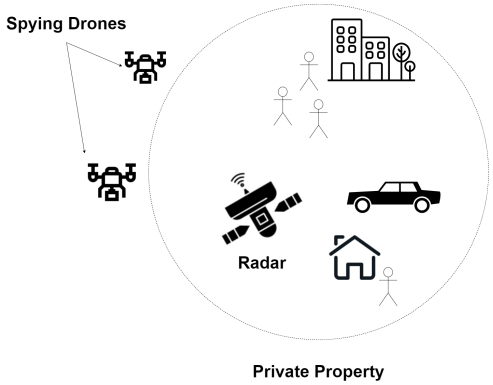

Fig. 1. Radar-based anti-drone system block diagram.

II. Proposed System Model

TABLE II
FINAL PROPOSED NETWORK PARAMETERS

Layer	Function and Parameters	Values
Input Layer	Input Size	11 x 61
Convolutional layers	Number of Filters	32
	kernel size	3x3, 5x5, 7x7
	Stride	(1,1)
	Activation Function	ReLU
	Pooling	MaxPooling
MaxPooling	Stride	(1,1)

Showed in Fig. 2 in the next page the proposed network that is used in this system. It is based in Convolutional Neural Network (CNN) which are mostly used in classification, detection or recognition projects [2], [3], and its parameters are listed in Table II. Connected to the input layer are the feature detection layers or hidden layer. This layer is responsible for pooling, convolution, and activation [4].

The signal enters the feature detection layer that is comprised of the convolution layer, pooling technique, and an activation function, it will down-sample the input, simplify the network by lessening the features that needs to be learned by the network, and speed up the processing time of the network then combine all of it together using a combination technique.

III. Results

Using an open-source dataset, SafeShore dataset is accessible in http://safeshore.eu/dataset/ with the creator's permission that is sent through email. This database of drones is officially

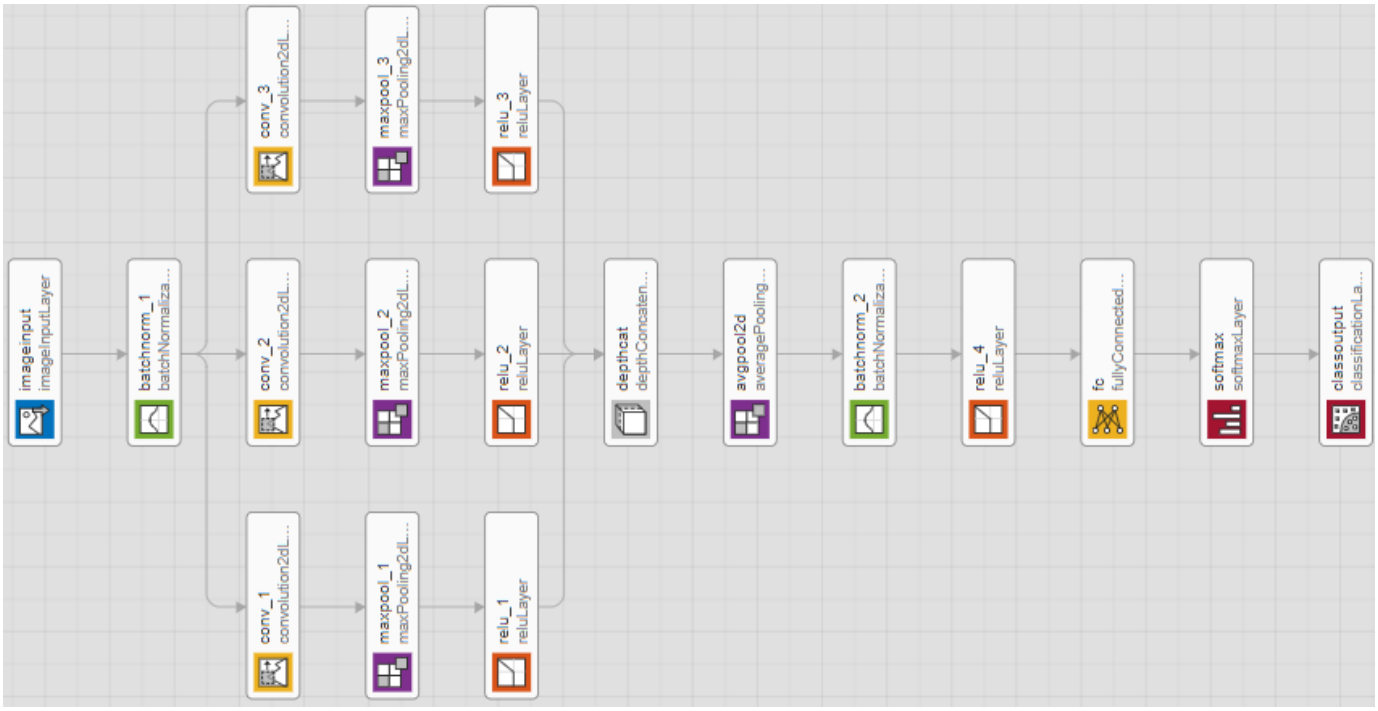

Fig. 2. CNN-based proposed network structure.

used by the European Commission to prevent human trafficking, smuggling or any crimes within the coastal border.

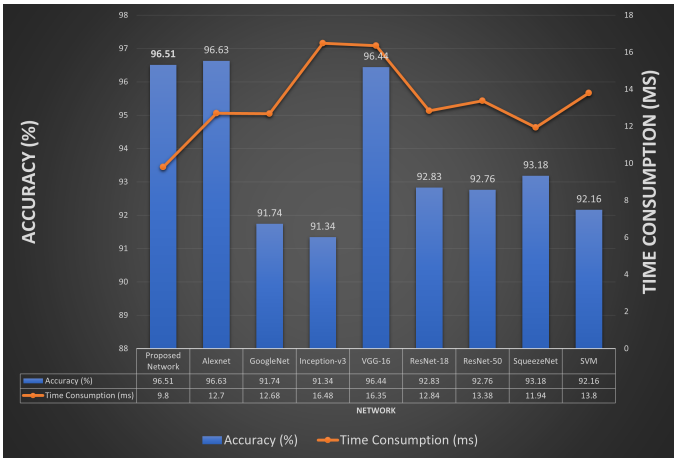

Fig. 3. Validation Accuracy Comparison Results.

Fig. 3 shows the comparison of the validation accuracy of the proposed networks together with various CNN models and their processing time consumption.

IV. Conclusion

The CNN-based proposed network showed that its accuracy may not be the highest but if it will be considered to be implemented in real-life, its low processing time will be more efficient to use. This is the time spent in processing one frame. Consequently, a shorter processing time signifies how fast the network is even with the AlexNet having 96.63% which is .12% higher that the proposed network.

For future works, the authors are looking into combining two or more surveillance technologies and apply it into multiple scenarios since one technology actually addresses the gaps or challenges of another.

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References

[1] X. Shi, C. Yang, W. Xie, C. Liang, Z. Shi and J. Chen, "Anti-Drone System with Multiple Surveillance Technologies: Architecture, Implementation, and Challenges," in IEEE Communications Magazine, vol. 56, no. 4, pp. 68-74, April 2018, doi: 10.1109/MCOM.2018.1700430.

[2] A. Aouto, T. Huynh-The, J. Lee and D. Kim, "Pose-Based Identification Using Deep Learning for Military Surveillance Systems," 2019 International Conference on Information and Communication Technology Convergence (ICTC), Jeju Island, Korea (South), 2019, pp. 626-629, doi: 10.1109/ICTC46691.2019.8939983.

[3] C. Aker and S. Kalkan, "Using deep networks for drone detection," 2017 14th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS), Lecce, 2017, pp. 1-6, doi: 10.1109/AVSS.2017.8078539.

[4] A. P. Hermawan, R. R. Ginanjar, D.S. Kim and J. M. Lee "CNN-Based automatic modulation classification for beyond 5G communication", IEER Communication letters vol 24, no 5, pp 2020