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Drone Classification Model Using AI Algorithm

JunSung Park*(1), SeongOok Park(2)
(1) KAIST, Daejeon, KOREA; e-mail: kirasnip@kaist.ac.kr
(1) KAIST, Daejeon, KOREA; e-mail: soparky@kaist.ac.kr

Abstract

Classifying drone and bird is a hot issue for drone detecting radar system. From a radar point of view, the most representative technology for distinguishing birds from drones is the method using a micro-doppler. In this paper, we introduce a classification model that distinguishes different micro-doppler aspects generated by drones. And also, we present a method for obtaining training data which has difference doppler aspects. To verify the performance of our proposed scheme, we process the practical experiments at conventional outdoor fields using our own radar. In addition, the proposed method shows a final classification rate of 96% for the 24 class datasets which is based on the actual data.

1 Introduction

As the technology of drones gradually develops, commercialized drones are becoming smaller and being advanced. Due to the technical development of drones, abuse cases are gradually increasing. To prevent this phenomenon, drone detection radars are being developed worldwide. The hot-issue in drone detection radar is the classification between drones and birds. It is hard to classify two objects due to the similar range cross section (RCS) of the two objects. Among the proposed methods for distinguishing two objects a representative method is using a micro-Doppler [1], [2]. The difference between the Doppler aspect that occurs in birds and in drones is utilized to classify. From this concept, in this paper, we propose a method to obtain data sets with a different Doppler aspect. Moreover, we introduce a model which can classify different Doppler aspects.

In order to verify the proposed data sets and classification model, we obtained raw data in a practical experiment by using our own made Ku-band 4-channel radar system. And also, the proposed classification model is trained and tested based on obtained data.

The remainder of this paper is organized as follows: Section II introduces the data collection concept and radar system for obtaining different doppler aspect data. Section III provides our proposed classification model for distinguishing different doppler aspects. Section IV shows the results to verify the reliability of our proposed method. Finally, in section V, we summarize the conclusion of the manuscript.

2 Data Collection

In order to secure datasets with different Doppler aspects, experimental settings are made as shown in Fig 1.

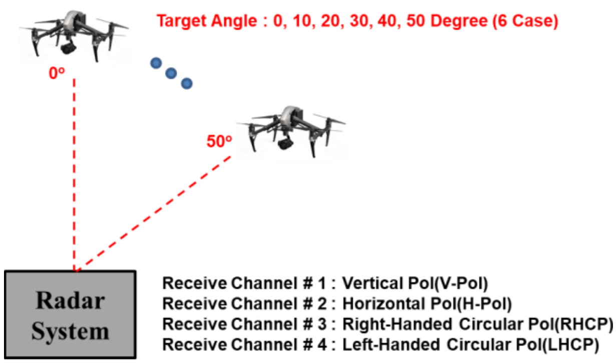
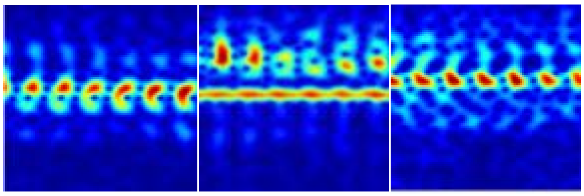


Figure 1. Data collection geometry of obtaining datasets with various Doppler aspects using multi-polarization Ku-band radar system.

Table 1. Ku-band Radar System Specification

Parameters	Values
Frequency Band	Ku-Band
Bandwidth	150 MHz
Chirp Duration	200 us
LFM Waveform	Sawtooth
Transmit Power	1W(30dBm)
Sampling Frequency	2 MHz
Tx Ch. Pol.	Vertical
Rx Ch. Pol.	V/H/RHCP/LHCP
Classification Class Num.	24 Cases

Depending on the angle of the radar and the target drone, different Doppler aspect occurs. Moreover, different Doppler aspect is generated according to the polarization of the radar RX channel. Using these characteristics, we configured the radar RX channel with 4 polarizations (V/H/RHCP/LHCP) and set the angle of the target drone to 6 types (0/10/20/30/40/50 degree) as shown in Fig 1. The detailed specifications of the Ku-Band FMCW radar system are listed in Table 1. Data sets with 24 different Doppler aspects (24 Class) are obtained. Three cases of the obtained raw data set are shown in Fig 2. Fig. 2 (a) is Micro Doppler Signature (MDS) for a drone at 0 degrees using a V-Pol RX channel, Fig. 2 (b) is MDS for a drone at 10 degrees using a V-Pol RX channel, and Fig. 2 (c) is MDS for a drone at 0 degrees using a H-Pol RX channel. It can be seen that different Doppler aspects are observed depending on the angle as shown in Fig. 2 (a) and Fig. 2 (b) [3]. And also, it can be seen that different Doppler aspects



(a) *(b)* *(c)*

Figure 2. *(a)* Micro Doppler Signature of 0 degree (V-V), *(b)* Micro Doppler Signature of 10 degree (V-V), and *(c)* Micro Doppler Signature of 0 degree (V-H)

Table 2. Classification Model Specification

Parameters	Values
Input Channel	3
Output Channel	24
Base Model	VGG11
FC Layer	512//256, 256//24
Activation Ft.	ReLU
Loss Ft.	Cross Entropy
Optimizer	Adam
Batch Norm.	Used
L2 Regularization	Used

are observed depending on the polarization as shown in Fig. 2 (a) and Fig. 2 (c) [4].

3 Classification Model

The proposed classification model is based on Convolution Neural Network (CNN), which shows good performance for 2D images task [5]. The specifications of the proposed classification model are presented in Table 2.

4 Experiment & Results

The secured training data size is 6190 per class, and the data size is 64x64x3. 10% of the entire data set is randomly extracted for a test set. The computer used was equipped with an Intel i9-11900 CPU, 64-GB RAM, and NVIDIA GeForce RTX 3080 Ti. The CNN algorithm is implemented with Pytorch 1.11.0 version with Anaconda 3.9 and Pycharm community edition platform. And, the epoch was set to 200, and the batch size is set to 128. It took about 330s for each epoch to train. The classification rate of 24 class was 96.1% as shown in Table 3.

Table 3. Classification Rate Results of 24 Class Dataset

Class Number	Rate	Class Number	Rate	Class Number	Rate
1	100%	**9**	95.4%	**17**	98.4%
2	99.2%	**10**	85.1%	**18**	94.5%
3	95.2%	**11**	93.4%	**19**	100%
4	98.6%	**12**	100%	**20**	99.1%
5	98.4%	**13**	99.1%	**21**	84.2%
6	99.2%	**14**	95.1%	**22**	99.2%
7	96.6%	**15**	98.4%	**23**	93.2%
8	98.4%	**16**	94.5%	**24**	97.1%
Total Classification Rate: 96.1%					

5 Conclusion

We introduce a method to obtain data sets with a different Doppler aspect. And also, we introduce a model which can classify different Doppler aspects. To verify the proposed method of collecting the various Doppler aspect data set, we did a practical experiment using a multi-polarization Ku-band radar system. The proposed model was trained using collected data, and the performance of the model was verified using a test set. As a result, a classification rate of 96.2% was achieved for 24 classes and proved the effectiveness of the proposed scheme. In the future, the proposed method in this paper, which can classify different Doppler aspects, could support the problem of distinguishing drone and bird.

Acknowledgements

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