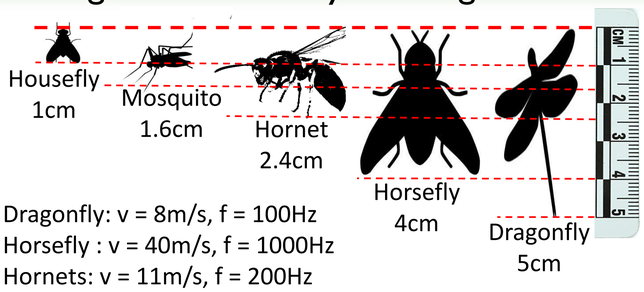
Algorithm for Micro-Size Target Detection with Frequency Modulated Continuous Wave (FMCW) Radar

INTRODUCTION

There is a widespread usage of the micro-UAVs and rise of the insect drones. The smaller the MAV, the harder it is to be detected by conventional radar. Hence, FMCW radar is simulated in order to detect a micro-size target which is less than 5cm size.

METHOD

Since, the MAV is an insect size. So it is assumed that the target being simulated is the size of an insects which is bee, mosquito and fly. Each of these insects have different flapping frequency which will then help us to distinguish and classify the target.



Dragonfly: v = 8m/s, f = 100Hz
Horsefly : v = 40m/s, f = 1000Hz
Hornets: v = 11m/s, f = 200Hz
Mosquitoes: v = 0.5m/s, f = 500Hz
Housefly: v = 2m/s, f = 300Hz

RESULTS

Measurement taken within 50ms integration time. The bandwidth of radar is 30MHz, and the ramp duration is 1ms with initial target is 300m away.

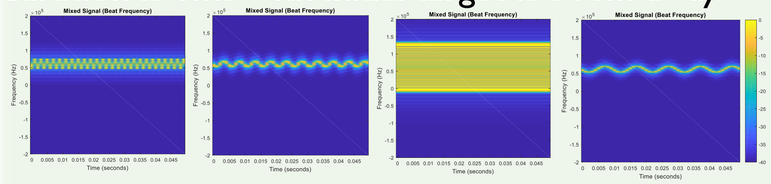


Figure 1: Beat Frequency of (a) Mosquito, 500Hz, (b) Hornet, 200Hz, (c) Horsefly, 1kHz, (d) Dragonfly, 100Hz

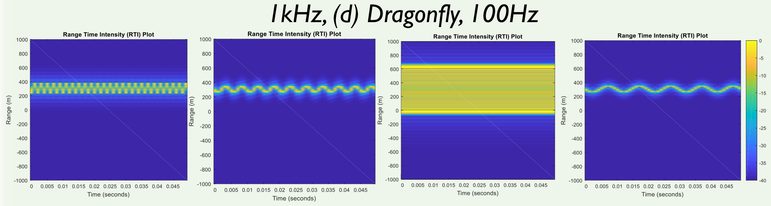


Figure 2: Range Time Intensity (RTI) of (a) Mosquito, 500Hz, (b) Hornet, 200Hz, (c) Horsefly, 1kHz, (d) Dragonfly, 100Hz

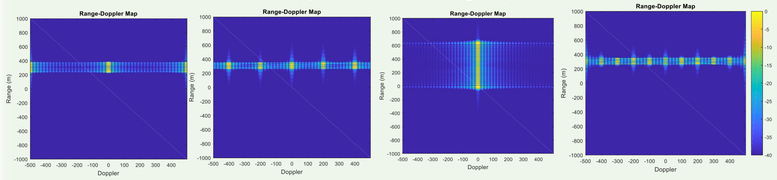


Figure 3: Range-Doppler Map of (a) Mosquito, 500Hz, (b) Hornet, 200Hz, (c) Horsefly, 1kHz, (d) Dragonfly, 100Hz

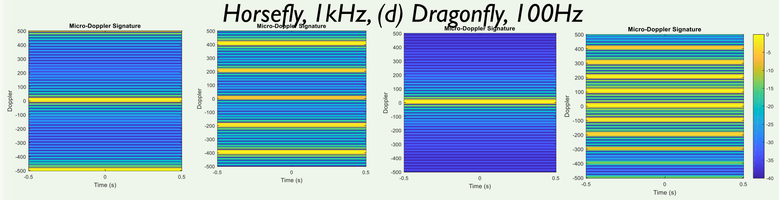
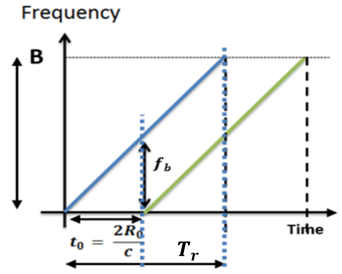


Figure 4: Micro-Doppler of (a) Mosquito, 500Hz, (b) Hornet, 200Hz, (c) Horsefly, 1kHz, (d) Dragonfly, 100Hz

DISCUSSION

There will be two types of Doppler that will be taken into account Beat frequency is caused by runtime speed (as a carrier of distance information) and Doppler frequency is caused by the speed (as a carrier of velocity information).

The bulk translation velocity describes the motion of the target. Where as micro-motions like wingbeat frequency from insects offer micro-Doppler signature.



$$f_b = \frac{B}{T_r}(t_0)$$

$$f_b = \frac{B}{T_r}\left(\frac{2R_0}{c}\right)$$

CONCLUSION

There is a huge potential to classify small targets as well by using the micro-Doppler signature. This feature enables to recognize target, where each of them will have different flapping wing and pattern.

Safiah Binti Zulkifli and Dr. Alessio Balleri
Signals & Autonomy Group. Centre for Electronic Warfare, Information and Cyber (EWIC)
Cranfield University. Defence Academy of the United Kingdom. Shrivenham, SN6 8LA
Safiah.Binti-zulkifli@cranfield.ac.uk and a.balleri@cranfield.ac.uk
www.cranfield.ac.uk/cds

Ministry of Higher Education
Putrajaya, Malaysia

Universiti Sains Malaysia
Pulau Pinang, Malaysia