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Augmenting Structure for Noise Reduction in UAV

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ABSTRACT

Unmanned Aerial Vehicles (UAV) or drones are used in various fields from capturing live events to surveying dangerous areas. Building a UAV with stealth capability is quite important in some areas, such as broadcasting or military operations. As the standard size or power requirements of the UAV increases, the noise level of the UAV is known to increase. The primary cause of the noise is the vibration of the main body (the hanging payload of T-Lion UAV below the UAV central region). Noise reduction of UAVs is essential to build stealth drones. In this paper, we propose an additional structure to cover the propeller to control the noise. To reduce noise caused by vibration, the main body of the UAV is equipped with a dampener that uses various materials to reduce vibration and shock. Both Sorbothane and Styrofoam are materials that can absorb shock and vibration. We suggest two kinds of drone covers: one was made of Sorbothane (type A) and the other was Styrofoam (type B) in a slightly different shape. Type A has the top and bottom cover of the propellers, but type B does not use a cover to reduce the impact of low airflow on the propellers. In addition, type B tested with one leg (type B-1) and three legs (type B-3). The experiment used an IRIS+ drone of 3D Robotics Inc. We could reduce propeller noise by an average of 5.34, 1.54, and 3.78 dB using type A, type B-1 and type B-3, respectively.

1. INTRODUCTION

These days, Unmanned Aerial Vehicle (UAV), or drones, are used for commercial and military purposes with the advantage of the remote pilot control (Nonami 2010). Making a UAV stealthier is important in areas such as human health, military and

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broadcasting systems (Li 2017). However, noise levels of UAV's increase as the UAV standard size become larger. Noise reduction of UAVs is essential to build stealth drones. The primary cause of the noise is the vibration of the main body, the hanging payload of T-Lion UAV below the UAV central region (Gavrilets 2000, Li 2017). There are two ways of reducing the noise of a UAV. One is active noise control (ANC), and the other is passive noise control (PNC).

ANC, also known as noise cancellation or active noise reduction, is a method in which a second sound wave is used in order to cancel an original sound wave. This method reduces noise by creating additional sound waves to cancel the original sound wave. The process by which these two sound waves cancel each other is called 'destructive interference' (Elliott 1993). These days, ANC is already used in headphones and cars to reduce noise and best suited for low frequency noises (Castro 2017). It can be applied to reduce UAV noise.

PNC is a method using physical things, like extra padding on a headset to eliminate external noise. PNC can reduce noise by modifying the shape or using noise-isolating materials (Oh 2019). Some ways to modify the shape of UAV's is to change the variety of the number of blades and to adjust blade length, width, shape, and angles (Pechan 2015, Marino 2010). Also, adjusting infill percentage and covering the drone with shrouds have been found to be effective (Penkov 2017).

In this paper, we will look at state-of-the-art methods of noise reduction and show our suggested structure and experimental results. Finally, we will end our paper with the conclusions.

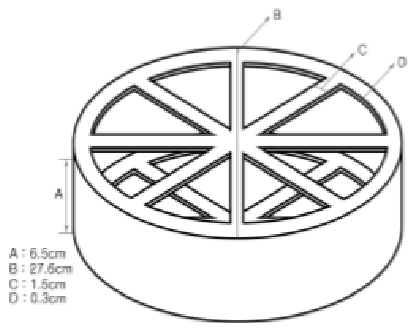

Fig. 1 Concept for type A

Fig. 2 Type A realized

2. SUGGESTED STRUCTURE

To reduce the vibration of UAVs, the main body of the UAV is equipped with a dampener. The dampener is a device that use a variety of materials to reduce vibration and shock. Dampeners play a very important role in reducing vibration. There are many different types of dampeners such as silicon balls, silicon foams, Sorbothane sheets, and kyosho zeal sheets (Li 2017, Uragun 2014, Rao 2002). We recommend two different types of Drone covers.

2.1 Type A

Using a Sorbothane sheet, we made a drum-like cover (shown in Fig. 1 and Fig. 2). The Sorbothane sheet is a material that can absorb shock and vibration. After making our initial cover, we found that the material is too soft for what we wanted. To solve this problem, we put paper to harden the cover.

2.2 Type B

Type B in Fig. 3 and Fig. 4 was made of Styrofoam. Styrofoam as a material is also good at absorbing vibration. We made another cover but unlike Type A, we didn't make a top or bottom cover for the propellers. We only made a side cover.

When we tested our Type B, we came to an unexpected result. At first, we used three legs to support the Styrofoam, but the results showed the opposite of what we wanted. Noise was increased by more than 5dB. We thought the reason for this was because the of air flow going pass our cell phone sensor. So, we change the direction of our cell phone, we managed to get some good results. But the three legs blocked the air flow to the propellers. To reduce the effects of lack of air flow had on the propellers, we removed two legs from our design. We called our three legs design 'Type B-3' and our one leg design 'Type B-1' shown in Fig. 5 and Fig. 6.

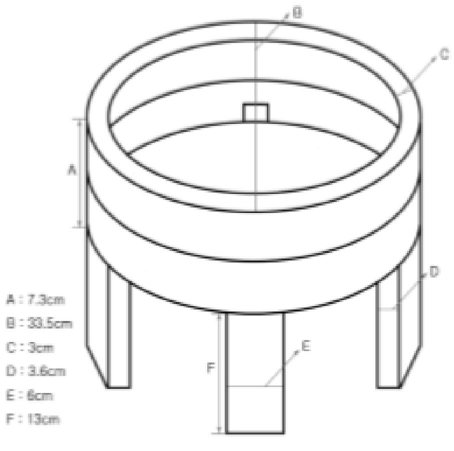

Fig. 3 Concept for type B-3

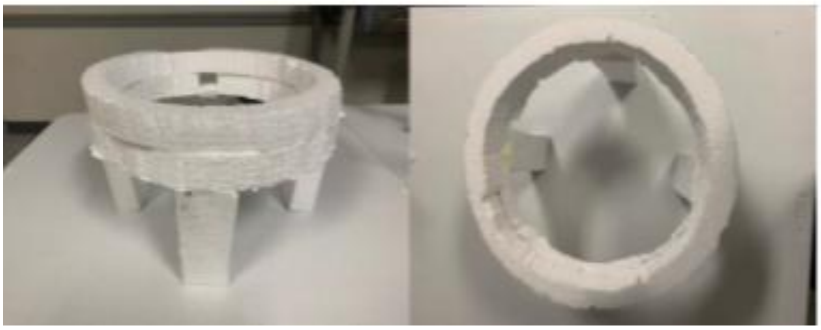

Fig. 4 Type B-3 realized

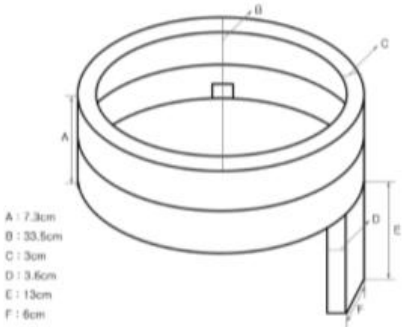

Fig. 5 Concept for type B-1

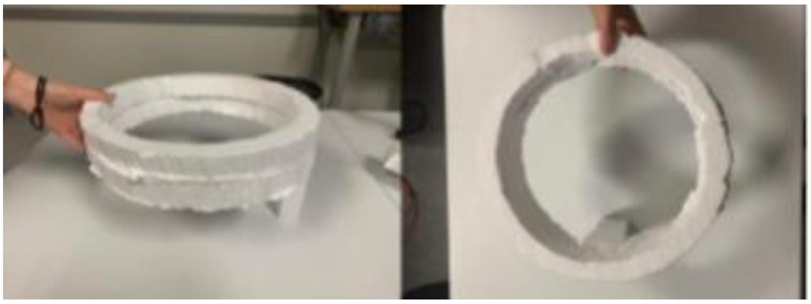

Fig. 6 Type B-1 realized

3. EXPERIMENT SETUP

We used a 3D Robotics Inc.’s IRIS+ Drone for the experiments. The following Table 1 describes the motor and propeller specifications used in the 3DR IRIS+ Drone. Fig. 7 shows the experimental environment which was tested indoors. We experimented to operate only one propeller. After removing three different propellers, only one propeller was used in the experiment and a smartphone application called 'Decibel X' was used to measure decibels. The length between the Drone and the cell phone was 50 cm. The yellow thread represents the length.

Table 1 Specification

Motor	Model	MN2213
	KV	950(rpm/V)
	Stator Size	(D)22x(H)13mm, 4mm(Shaft)
	Thrust	280g@3S, 400g@4S
	Motor line	80mm (20 AWG)
Propeller	Model	T9545
	Size	24.13*11.43mm

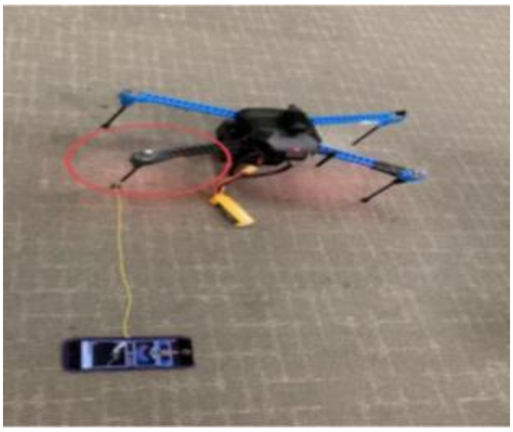

Fig. 7 Indoor Testing

Table 2 Noise by the Cover Types (in dB)

	Simple	Type A	Type B-1	Type B-3
1	63.8	58.9	63.5	60.6
2	63.7	59.0	63.2	60.2
3	64.5	59.4	62.9	61.1
4	64.9	58.9	63.0	61.0
5	65.5	59.5	62.1	60.6
Average	64.48	59.14	62.94	60.7

4. RESULTS

The noise of the simple propeller was measured first. We measured the average dB per minute and repeated it five times. Next, we measured noise using the Type A drone cover, followed by the Type B drone cover. Table 2 provides the noise by the different cover types. Even though Type B had a better result than the basic propeller, Type A did the best results among them. The average noise of the basic propeller was

64.48dB. We reduced noise 5.34dB by using Type A, 1.54dB by using Type B-1, and 3.78dB by using Type B-3. The materials such as Sorbothane and Styrofoam absorbed vibrations of the air. Although actual vibration is not reduced, the materials had eased amplitude.

5. CONCLUSIONS

In this study, we found the best way to reduce noise for a UAV is vibration reduction. Thus, based on the previous studies, our experiment dealt with noise reduction by using shrouds made of different materials. We proposed two types of drone covers. One was made of Sorbothane (type A), and the other was Styrofoam (type B-1 and type B-3) in a slightly different shape. Type A has the top and bottom covers of the propeller, but type B does not use the cover to reduce the impact of low airflow on the propeller. In addition, Type B was also tested on one leg (type B-1) and three legs (Type B-3). The result showed the effects of materials that absorb vibration. The three proposed covers reduced noise, with the Sorbonne (type A) covering showing the best results. As we used appropriate materials like Sorbothane, noise reduction could be improved. However, type A was a little heavy so we couldn't fix it well. Type B had a lot of volume because of its low durability. In further studies, the cover should be made much lighter and smaller.

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REFERENCES

Castro, V., Contreras, V. M., Cea, G. A., Collado, G. A. and García, L. (2017), “Active Noise Cancellation System for UAVs,” [online] Available: https://pdfs.semanticscholar.org/d737/03bc3b24f7155b1f279b37dff406cb9561cb.pdf

Elliott, S. J. and Nelson, P. A. (1993), “Active noise control,” IEEE Signal Processing Magazine, **Vol 10**, 12–35.

Gavrilets, V., Shterenberg, A., Dahleh, M. A. and Feron, E. (2000), "Avionics system for a small unmanned helicopter performing aggressive maneuvers," 19th DASC. 19th Digital Avionics Systems Conference, Philadelphia, PA, USA, **2000**, 1E2/1-1E2/7, doi: 10.1109/DASC.2000.886895

Li, Z., Lao, M., Phang, S. K. and Hamid, M. R. A. (2017), “Development and Design Methodology of an Anti-Vibration System on Micro-UAVs,” International Micro Air Vehicle Conference and Flight Competition (IMAV).

Marino, L. (2010), “Experimental analysis of UAV-propellers noise”, 16th AIAA/CEAS Aeroacoustics Conference, June **2010**, Stockholm, Sweden, [online] Available: https://doi.org/10.2514/6.2010-3854

Nonami, K., Kendoul, F., Suzuki, Wang, W. and Nakazawa, D. (2010), “Autonomous Flying Robots”, Springer, Tokyo, **2010**.

Oh, J., Choe, D., Yun, C., Kim, J. and Hopmeier, M. (2019), "Towards the Development and Realization of an Undetectable Stealth UAV," 2019 Third IEEE International Conference on Robotic Computing (IRC), Naples, Italy, **2019**, 459-464.

Pechan, T. and Sescu, A. (2015), "Experimental study of noise emitted by propeller's surface imperfections," Applied Acoustics, Vol. **92**, May 2015, 12-17.

Penkov, I. and Aleksandrov, D. (2017), "Propeller shrouding influence on lift force of mini unmanned quadcopter," International Journal of Automotive and Mechanical Engineering, **14(3),** Sep. 2017, 4486-4495.

Rao, A. G. and Mahulikar, S. (2002), "Integrated review of stealth technology and its role in airpower," Aeronautical Journal, **106**, 629-642.

Uragun, B. and Tansel, I. N. (2014), "The noise reduction techniques for unmanned air vehicles," 2014 International Conference on Unmanned Aircraft Systems (ICUAS), Orlando, FL, **2014**, 800-807. doi: 10.1109/ICUAS.2014.6842325