An investigation into the effect of surveillance drones on textile evidence at crime scenes

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Abstract

With increasing numbers of Police forces using drones for crime scene surveillance, the effect of the drones on trace evidence present needs evaluation. In this investigation the effect of flying a quadcopter drone at different heights over a controlled scene and taking off at different distances from the scene were measured. Yarn was placed on a range of floor surfaces and the number lost or moved from their original position was recorded.

It was possible to estimate "safe" distances above and take off distance from the bath mat (2 m and 1 m respectively), and carpet tile (3 m and 1 m) which were the roughest surfaces. The maximum distances tested of 5 m above and 2 m from was not far enough to prevent significant disturbance with the other floor surfaces. This report illustrates the importance of considering the impact of new technologies into a forensic workflow on established forensic evidence prior to implementation.

Key Words

Trace evidence, drone, fibres, crime scene, forensic science

1. Introduction

With increasing numbers of Police forces using drones for crime scene surveillance, the effect of the drones on trace evidence present needs evaluation.[1] Trace evidence is defined by the FBI as *"... materials that could be transferred during the commission of a violent crime."* [2] It is inferred from this definition that if the evidence is small enough in size to be transferred into a scene, then it is also small enough to be removed, intentionally or otherwise, by similar momentary contact with other objects. Trace evidence has provided valuable forensic evidence in some high profile legal cases such as the Soham murders [3] and the murder of Sarah Payne [4]. Trace evidence still holds a high value in the current legal system, and emphasis is still put on the recovery and recording of trace evidence collection in CSI protocol.[5] A crime scene's integrity needs to be maintained in order for these volatile fibre traces to be preserved and collected by investigative staff. The meticulous recording of where the trace evidence was recovered from is essential, if the location of recovery is unknown (or altered by investigative staff) the evidence may be inadmissible to court because it cannot be proven to relate to the case.[6]

Police forces around the world are increasingly using quadcopter drones for use in remote surveillance of crime scenes.[1,7] It is possible that a drone may be used indoors in large industrial units or scenarios where it is deemed a danger for first responders to enter the building as well as outdoors. Drone developers have been quoted saying that the use of drones will help to preserve a scene better than having crime scene investigators physically at the scene, as the drone will not disturb the evidence.[1] This statement is certainly true for larger and heavier pieces of evidence such as tools or vehicles, however there seems to have been little consideration for the effect on any trace evidence in a scene. Quadcopters force air underneath them in order to remain airborne, in the same way a helicopter does. This area of forced air is known as a downwash and has been shown to cause disturbance of the area immediately under a helicopter [8]. Fibre trace evidence, due to its small size, may be more likely to be displaced or removed altogether by the downwash produced by a quadcopter passing over it. The effect of fibre evidence retention at outdoor scenes, therefore subject to more air movement than indoor scenes, has been examined. Palmer and Polworth [9] reported that fibres may be retained on a naked pig carcass for more than 12 days when left in the open. They report that 67 to 74 % of fibres are lost in the first two days in the open and by day five between 93 and 95% are lost. They argue that in open scenes rain may play a bigger part in fibre loss than wind.

In this project the effect of the downwash of a quadcopter has been investigated to determine if it affected the retention of textile evidence in crime scenes. Yarn retention on a range of floor types was recorded after a drone flypast at differing heights and also having taken off at set distances from the evidence area. The aim of this work was to help Police forces wishing use quadcopter drone surveillance in the future in maintaining the integrity of scenes by adhering to or flying above any minimum “safe height” and “safe distance” determined.

2. Materials and Methods

The five floor types used in the investigation were a heavy duty carpet tile, a bath mat, two linoleum cuttings and a hard vinyl tile. The surfaces were all trimmed to 306 mm x 306 mm to match the size of the hard vinyl tile.
These surfaces, found in different environments around the home and workplace, were chosen because they have different properties such as texture, which could affect the way the fibres and textile evidence are retained. Small pieces of blue-tack were attached to the corners of the tiles to anchor them to the floor. Floor material was chosen as it could be the location for a sexual assault, the location of a body that may be moved or other such scenarios were fibres and textile evidence would be transferred onto a floor surface.
Hard vinyl floor tile (Wickes, Manchester, UK)
Smooth wood effect linoleum (Carpetright, Thurrock, UK)
Rough granite effect linoleum (Stephen Fretwell floor coverings, Doncaster, UK)
Heavy duty carpet tile (Wilson’s carpets, Doncaster, UK)
Chenille bath mat (Adore home, Accrington, UK)
The yarn evidence was taken from a single ball of 100% acrylic double knitting wool, dye colour 357, batch number 810 (Crafty knit, East Lothian, Scotland)
A model AR2.0 power edition quadcopter drone, with 195 mm rotor (Parrot, Paris) was flown controlled by a Nexus 7 touchscreen tablet (Google product, Asus, China)

On each tile 25 points were marked using a marker pen of a contrasting colour as shown in Figure 1. Yarn of 25mm length and 2mm width was taken from the acrylic wool and placed on these points for each analysis to ensure comparable results based on the starting location. The yarn was placed with forceps to ensure a consistent pressure was applied, to avoid any possible effect on persistence.

The tests were undertaken in the centre of a large sports hall to remove any influence of external factors such as wind or rain. In a smaller room, such as in a house, the effect of the downwash bouncing off the walls would have to be considered.

The height of the drone was ascertained using the integral altimeter and was deemed acceptable within 0.02 m either side of the desired testing height.

2.1 Height Test Method

Heights of 0.5 to 3.0 m, in 0.5 m increments, were used. The drone took off 5.70 m from the floor tiles.

The approach speed was standardised to the slowest constant speed available and the flight over the area lasted around 10 seconds. After the fly past the pieces of yarn were recorded as either having been removed from the tile, moved a small distance or remaining in the same position. Each test was repeated seven times.

Figure 1. Floor surface sample tiles. (Left to right) top: smooth linoleum, rough linoleum and hard vinyl tile. Bottom: carpet tile and bath mat. The carpet tile is set up in the "before exposure" format with evidence placed on each marked point. The carpet tile's marked points were crosses to improve visual contrast with the tile’s spotted pattern. All other tiles were marked with dots.

2.2 Take off Distance Tests Method

The same floor surfaces and yarns as the "Height" tests were used to test the effect of the drone taking off a set distance from the evidence.

The drone was set to take-off from predetermined distances from the evidence tile of 0.5 m, 1.0 m and 2.0 m. When it reached a height of 0.75 m, it was immediately flown away from the evidence tile to a point 5.70 m from the evidence tile to land. This was to ensure the landing did not affect the evidence. The same slow speed was used as in the "Height" tests to ensure consistent results. After take-off the yarn was recorded as either having been removed from the tile, moved a small distance or remaining in the same position.

3. Results

All yarn evidence was completely removed from the smoother surfaces (smooth linoleum, rough linoleum and hard vinyl tile) at all of the heights tested. There was one exception at 2.0 m for the rough linoleum, where 1 piece (out of a total 175) remained on the tile but not in its original position. The mean value for the loss at each surface at each height increment is shown in Table 1. The bath matt held the evidence well at most heights, with no recorded losses over 2 m and very small loses at 1.5 m. The carpet tile was similarly good at retaining evidence with one or two lost over 2 m.

Table 1. Evidence lost (%) per height test for each floor tile (mean of 7 tests).

	Mean Loss of Evidence %				
Height (m)	**Bath Mat**	**Carpet Tile**	**Smooth Linoleum**	**Rough Linoleum**	**Hard Vinyl Tile**
0.5	16	18.3	100	100	100
1.0	5.7	6.3	100	100	100
1.5	0.1	7.4	100	100	100
2.0	0	1.2	100	100	100
2.5	0	1.2	100	100	100
3.0	0	1.7	100	100	100

When the movement of evidence was considered the bath matt showed some yarns being disturbed up to 1.5 m above but not above that. This combined with the removal data show that above 1.5 m there was no affect on the evidence on a bathmat. The carpet tile showed some movement evidence at all heights. This is summarized in Table 2.

Table 2. Mean % of evidence moving position per test (mean of 7 tests).

	Evidence moved position (%)				
Height (m)	**Bath Mat**	**Carpet Tile**	**Smooth Linoleum**	**Rough Linoleum**	**Hard Vinyl Tile**
0.5	21.7	50.8	100	100	100
1.0	11.4	43.4	100	100	100
1.5	9.0	19.44	100	100	100
2.0	0	11.4	100	100	100
2.5	0	5.0	100	100	100
3.0	0	10.8	100	100	100

A summary of the data for the take-off distance test is shown in Table 3. For the bath matt and the carpet tile the yarns remained on the tile for all tests. The other surfaces lost all evidence at all heights tested. After take-off there was some movement on the two rougher surfaces without yarns being totally removed from the area, shown in Table 4.

Table 3. Mean % of evidence lost following take off tests at varying distances.

	Mean loss of evidence (%)				
Distance (m)	**Bath Mat**	**Carpet Tile**	**Smooth Linoleum**	**Rough Linoleum**	**Hard Vinyl Tile**
0.5	0	12	100	100	100
1.0	0	0	100	100	100
2.0	0	0	100	100	100

Table 4. Mean % of evidence moving position per take off test at varying distances.

	Evidence moved position (%)				
Distance (m)	**Bath Mat**	**Carpet Tile**	**Smooth Linoleum**	**Rough Linoleum**	**Hard Vinyl Tile**
0.5	12.6	45.2	100	100	100
1.0	0.6	0.6	100	100	100
2.0	0	0	100	100	100

4. Discussion

The quadcopter's downwash was too powerful for smooth surfaces such as the hard vinyl tile, smooth or textured linoleum to retain any evidenc at the heights tested. This would likely apply to other smoother surfaces such as level-set concrete or marble flooring. The amount of downwash produced is dependent on multiple factors, but the main one being the weight of the drone. With the battery and the indoor shroud installed, the AR2.0 had a mass of 430 g, which means 4214 N of force is required to keep it hovering (as the downwash needs to equal the weight to maintain equilibrium). For outdoor crime scene surveillance the size of the drone is likely to be bigger and therefore heavier, meaning a stronger draft. There are smaller commercially available camera drones that could be used to survey indoor scenes however until tested should be used with caution in flying close to an unexamined scene. The results show a drone of the AR2.0's size is too powerful for maintaining scene integrity with indoor use as Gray had mentioned in his explanation of potential forensic drone applications;[1] and on smoother surfaces would have to fly above 3.0 m (although the actual safe height is currently unknown) in scenes permitting such a height. At the present time, there have been no recorded instances of drone use on indoor scenes, but investigations in warehouses or similar buildings could be suitable, particularly if it is thought unsafe for humans to enter.

Only one sized rotor (195 mm) was used in this investigation, however other models of quadcopter use different sized rotors.[10] Using a different sized rotor would change the rate of air moved by the quadcopter, therefore changing the effect (and perhaps the size) of the drone's downwash.

This investigation looked into a narrow range of floor surfaces with only one type of yarn; future investigations could monitor the dispersal of different types of yarn and fibres with the same drone height on a wider range of floor types, or alternatively add to this investigation by using the same test conditions but different flooring types such as the wider varieties of household carpet. The use of microscopic fibres as transferred in an actual case would be a good addition to the test. Fibres are not the only type of trace evidence, fragments of glass and tiny particles such as gunshot residue will likely be affected in a similar way to fibres [11].

5. Conclusion

The investigation confirmed there was a significant change in the retention of textile evidence on a range of floor types after a drone flypast. It has also shown that not only did the individual factors of floor surface type and the drone's height influenced the number removed, but the interaction between them did also.

The distance between the take-off point and the evidence has been shown to affect the number evidence, with similar observations as the "Height" tests.

There were no previous published works on the investigation of quadcopter drones' effects on trace evidence, and whilst this project may be one of the first of its kind, it is not exhaustive or extensive enough to cover the many variables associated with drone use. There is much more research required before the bigger question of "are drones safe to use in crime scene surveillance?" can be answered.

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