1 OBJECTIVE

To give the student an awareness of the decomposition process of a body, and to make the student aware that the body can be detected through the use of thermal imaging and Unmanned Aerial Vehicles (Drones)

Bodies for the purpose of this paper will be those of livestock (cattle, horses, pigs etc) and human. Some of the images contained in this paper could be confronting and suggest consideration prior to continuing.

2 DESCRIPTION

Using a thermal imaging camera mounted upon a UAV (Drone), a wide area of land can be scanned for heat signatures. Heat signatures are the heat given off from an object, either as internal heat or reflected heat, being detected through the lens of a thermal imaging camera.

These heat signatures can be useful tools for finding people, animals and vegetation changes.

People and animals can be identified through heat signatures whether they are alive or recently (4-5 months depending on external factors) deceased.

Vegetation can be scanned for stress or poisoning, and they also give a heat signature that is related to the health of the plant.

A combination of this knowledge gives us an ability to scan for persons or animals that have died, for a much longer time span than has previously thought to be possible.

Why?

The dead body will give off a heat signature for up to 4-5 months depending on the atmospheric conditions, environmental conditions and the possibility of animal scavenging. The surrounding vegetation will be poisoned by the release of lactic acid from the body during decomposition. This acid will kill the surrounding grasses immediately surrounding the body, and stress the grasses in the outer perimeter of the dead and dying grasses. Depending on the physical size of the body, some small shrubs and trees may also become sick or stressed. This gives us the heat signature that can be compared to the surrounding vegetation, identifying the location of an event.

Even if a body has completely decomposed to the skeletal stage, by using the vegetation heat signatures, we can extend the timeframe for finding the signs of death and decomposition enabling us to locate the body.

Bodies that have been buried in shallow graves, can be located in the same manner. The body on decomposition will generate heat as bacteria builds in the body. In shallow graves, this heat rises and from the air the heat signatures will be distinguished from the ambient temperatures of the surrounding soil due to this heat generation.

Early morning is the best time to detect heat signatures by thermal imaging as the ambient temperatures of the surrounding environment is lower.

Understanding of the decomposition of a mammal, gives us an understanding of what we can look for with thermal imagery to identify where remains may be located and possible indications of TOD (time of death) in relative time, not to be confused with exact time. Exact time indications and causes of death are not to be considered as part of this paper.

3 THE STAGES OF DECOMPOSITION

A body is considered "fresh" during the first twenty-four to forty-eight hours after death (Galloway et al., 1989). After this time, a body moves into the "decomposed" stage, marked by signs such as distinct colour changes and skin slippage

(Galloway et al., 1989). The third and final stage, the "dry" stage, manifests itself through significant tissue loss and subsequent bone exposure (Galloway et al., 1989).

3.1 The "Fresh" Stage

3.1.1 Rigor mortis

Rigor mortis refers to the process of muscle stiffening which results from a build-up of lactic acid in the tissues following death (Janaway, 1996). The muscles will begin to seize up.

3.1.2 Livor mortis

The second process that is sometimes used to determine post mortem interval is livor mortis (Kaatsch et al., 1994). When the cells break down and circulatory activity ceases, blood responds to gravity and settles in the lowest points of the body, creating visible red areas on the skin (Baden and Hennessee, 1989). This process, although affected by other variables, generally begins within an hour post mortem and takes around eight hours to complete (Baden and Hennessee, 1989).

3.1.3 Algor mortis

The third process, algor mortis, refers to the lowering of the body temperature post mortem. Typically, temperature drops two degrees within the first twelve hours after death, and then continues to decrease at a rate of about one degree per hour (Perper, 1993). Simple calculations are then needed to determine the time since death. However, this temperature can be affected by ambient temperature and bacterial activity.

Then the changes begin, and one of the most important is the bacterial decomposition of sugars and proteins in the tissues, mainly coliforms, Clostridium, Psedomonas and Proteus species.

These are anaerobic bacteria that normally live inside the large intestine, though they may come from an infected wound, such as gangrene.

As they feed on the decaying flesh, the bacteria excrete gases, carbon dioxide and sulphur dioxide, which inflate some body parts, mainly the face, abdomen and male genitals.

Blowflies are the first carrion insects to arrive, and seek a suitable oviposition site (site to deposit or lay eggs).

3.2 Bloat

The bloat stage provides the first clear visual sign that microbial proliferation is underway. In this stage, anaerobic metabolism takes place, leading to the accumulation of gases, such as hydrogen sulphide, carbon dioxide, methane, and nitrogen. The accumulation of gases within the bodily cavity causes the distention of the abdomen and gives a cadaver its overall bloated appearance. The gases produced also cause natural liquids and liquefying tissues to become

frothy. As the pressure of the gases within the body increases, fluids are forced to escape from natural orifices, such as the nose, mouth, and anus, and enter the surrounding environment. The build-up of pressure combined with the loss of integrity of the skin may also cause the body to rupture.

Intestinal anaerobic bacteria transform haemoglobin into sulfhemoglobin and other coloured pigments. The associated gases which accumulate within the body at this time aid in the transport of sulfhemoglobin throughout the body via the circulatory and lymphatic systems, giving the body an overall marbled appearance.

If insects have access, maggots hatch and begin to feed on the body's tissues. Maggot activity, typically confined to natural orifices and masses under the skin, causes the skin to slip and hair to detach from the skin. Maggot feeding, and the accumulation of gases within the body, eventually leads to post-mortem skin ruptures which will then further allow purging of gases and fluids into the surrounding environment. Ruptures in the skin allow oxygen to re-enter the body and provide more surface area for the development of fly larvae and the activity of aerobic microorganisms. The purging of gases and fluids results in the strong distinctive odours associated with decay.

3.3 Active decay

Active decay is characterised by the period of greatest mass loss. This loss occurs as a result of both the voracious feeding of maggots and the purging of decomposition fluids into the surrounding environment. The purged fluids accumulate around the body and create a cadaver decomposition island (CDI). Liquefaction of tissues and disintegration become apparent during this time and strong odours persist. The end of active decay is signalled by the migration of maggots away from the body to pupate.

3.4 Advanced decay

Decomposition is largely inhibited during advanced decay due to the loss of readily available cadaveric material. Insect activity is also reduced during this stage. When the carcass is located on soil, the area surrounding it will show evidence of vegetation death. The CDI surrounding the carcass will display an increase in soil carbon and nutrients, such as phosphorus, potassium, calcium, and magnesium; changes in pH; and a significant increase in soil nitrogen.

3.5 Dry/remains

During the dry/remains stage, the resurgence of plant growth around the CDI may occur and is a sign that the nutrients present in the surrounding soil have not yet returned to their normal levels. All that remains of the cadaver at this stage is dry skin, cartilage, and bones, which will become dry and bleached if exposed to the elements. If all soft tissue is removed from the cadaver, it is referred to as completely skeletonised, but if only portions of the bones are exposed, it is referred to be partially skeletonised.

4 BODY TEMPERATURE ON DECOMPOSITION

The bodies of six individuals were placed at the Anthropological Research Facility and subjected to one of three experimental conditions for study. Two bodies were placed on the surface, two were wrapped in cotton thermal blankets, and two were shrouded in plastic tarps.

The bodies were allowed to decompose naturally for thirty days while daily temperature measurements were collected and were then uncovered on Day 31 and scored for decomposition.

The temperature differences between bodies under different treatments were then compared, as were the accumulated degree days calculated by different methods. No statistically significant differences were found in temperature between bodies with different coverings, however noticeable differences were observed in decomposition. Covering a body in a cotton thermal blanket appeared to heavily influence the mummification of the body, while encasing a body in a plastic tarp led to moist decomposition and prolonged insect activity, in contrast with the bodies placed on the surface.

This study was conducted at the Anthropological Research Facility at the University of Tennessee, Knoxville. The facility consists of approximately 1.3 acres of wooded area, with minimal ground cover and primarily deciduous tree cover. A wooden fence surrounds the entire perimeter in order to prevent large scavengers such as canines from disturbing the remains contained within the research area.

Six fresh human cadavers were used in this research. Four of the cadavers were covered; two in plastic tarps and two in cotton thermal blankets. The purpose of covering the bodies was to create an intact internal shroud environment to compare to the external, ambient environment.

To achieve this internal environment, the body was first laid face up on the tarp or blanket, and the ends of the coverings were folded over the head and feet. The body was then rolled in the coverings to create a tightly wrapped shroud. Two bodies were placed uncovered on the ground surface as controls. The selection of materials was based on case reports of cadavers wrapped in plastic and blankets (Komar, 2003, Derrick 2007 personal communication). The cadavers were placed at the Anthropological Research Facility on May 29, 2008, at the same time to ensure that all were exposed to similar environmental conditions. The bodies were also placed as close to one another as possible to try and limit the amount of environmental variation between test subjects. Subjects were not protected by screening or wire mesh. This type of covering has traditionally been used to discourage animal scavengers. Part of the data collected discerned whether any of the coverings inhibited animal or insect activity, and therefore any barrier designed to protect the remains would have hindered this part of the study.



Figure 1: Graph of mean daily under body temperatures for Individual 1.



Figure 2: Graph of mean daily under body temperatures for Individual 2.



Figure 3: Graph of mean daily under body temperatures for Individual 3.



Figure 4: Graph of mean daily under body temperatures for Individual 4.



Figure 5: Graph of mean daily under body temperatures for Individual 5.



Figure 6: Graph of mean daily under body temperatures for Individual 6.



Figure 7: Graph of mean daily inside shroud/under body temperatures for Individuals 1-6.

4.1 Temperature Trends

Some of the treatments appeared to have constantly shifting daily temperatures, while other treatments appeared to maintain more stable temperatures. Maximum and minimum temperatures also varied between treatments. (See Figures 1-6 for mean daily temperatures taken from inside the shroud or under the body for each individual.) The difference in temperature pattern can be seen most clearly in Figure 7, which shows the mean daily temperatures for all of the individuals superimposed together for comparison.

From these finding, we can note that each of the bodies had a rise in temperature above ambient, within the first 5 days and remained above for the full 30 day period. The exception to this was the body as depicted in Table 5 which remained above ambient temperature although the rise and fall of temperature was not as dramatic as the other test subjects.

4.2 How This Can Be Useful To Investigation

These figures show that a body's temperature will rise during decomposition giving us a significant heat signature to scan for. Setting the thermal imaging camera to scan between ambient of 22 degrees Celsius and 45 degrees Celsius would have identified these bodies as definite heat signatures.



Figure 8: Aerial image of a cow. Dead for 3 days.



Figure 9: Thermal image of cow in Figure 8.

Although the temperature of the cow in figures 8 & 9 are significantly higher than those in the previous figures, as mentioned previously, the atmospheric conditions such as temperature and humidity will change the heat signatures accordingly. The ambient temperature the Figures 1 to 6 was 22-25 degrees Celsius while the ambient ground temperature in Figure 9 was 33.3 degrees Celsius.

4.3 Effect on Localised Vegetation



Figure 10: Pig carcass in the different stages of decomposition: Fresh > Bloat > Active decay > Advanced decay > Dry remains



Figure 11: Grasses effected by body fluids being expelled through orifices.

5 OTHER EFFECTS ON DECOMPOSITION

Apart from the effects of temperature, humidity and wind on the decomposition of bodies, flies, maggots and wild animals and birds can hasten the decomposition process by exposing the body to the elements more rapidly than if left intact.

5.1 Flies



Figure 12: Flies attack the openings in the body.

5.2 Maggots



Figure 13: Maggots bury into the skin and flesh.

5.3 Wild Dogs, Pigs and Birds

Wild Dogs, pigs and carrion eating birds speed up decomposition by eating large parts of the body leaving little but bone fragments in some cases.



Figure 13: Wild Dog

Figure 15: Feral Pigs



Figure 16: Carrion Birds (Wedge Tailed Eagle)

6 AREAS OF OPERATION

Most rural, semi-rural and large town blocks can be scanned with the use of thermal imaging and UAV's. This is also dependent on local bylaws and CASA restrictions within the UAV use guidelines.

7 ADVANTAGES



Figure 17: SES Land Search

7.1 Time

The UAV can be utilised to cover large areas of land at short notice and take images that can be analysed by searchers without the need to send land searchers into inhospitable areas unless required.

Under normal conditions it is more time efficient to get one operator to a site, set up and operate than it is to get a group of persons together, give them an operational, brief and start a search of an area.

Land searchers can be bought into an area after detailed aerial images have been taken so that trace evidence is still captured prior to inadvertent disruption.

7.2 Trace Evidence

Sometimes the advance of land searchers obliterate trace evidence that may be photographed in high resolution from the air without disturbing any of the surrounding area.



Figure 18: High definition image without ground disturbance.

7.3 Flexibility

The use of the thermal imaging camera and the digital SLR camera is not limited to the UAV application. The cameras can be used in conventional rotary wing aircraft (Helicopters) and planes.

As the cameras are both adaptions to the UAV, they are not limited to that use.

If a large area of land needs to be scanned for the detection of a body, either a living lost person or the body of an animal or person, the camera can be used by qualified personnel from the helicopter or plane.

8 LIMITATIONS

8.1 Weather

No rain fog cloud or wind conditions

8.2 Aviation

Not within 5.5 km of an airport and a ceiling height of flight of 400 ft. or 120 m Other Aircraft responding to the same operation

8.3 Space and Crowd Limitations

Available areas for take-off and landing need to be clear of obstacles, buildings and personnel. Only those persons directly associated with the air operations should be within a 30 m radius of the take-off and landing site.

8.4 Flight Time

Time, based on the conditions of wind combined with the payload being used on the UAV, can vary from 15 to 20 minutes carrying either the thermal imaging camera or the DSLR cameras.

8.5 Training

UAV Training Thermography

9 FUNCTION SECTORS

The Sectors that this technology can be applied to are endless. However for this paper the applications can be applied to the following:-

- Department of Agriculture and Water Resources Livestock welfare
- Private property owners stud cattle search
- Private investigations of livestock losses
- Public and Private Investigators
- State and Federal Police Homicide and Forensic Investigations
- Defence Department

10 GLOSSARY

CASA - Civil Aviation Safety Authority

Cadaver - term used to refer to the dead person or animal

CDI - cadaver decomposition island

FARF- Forensic Anthropology Research Facility

FPV - First Person View (Camera)

QPS – Queensland Police Service

UAV – Unmanned Aerial Vehicle

RPA – Remotely Piloted Aircraft

TOD- time of death

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