Civil Drone Ethics and Sustainability

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Abstract

In order to solve the largely ignored issues of civil drones it is imperative to develop a framework that assures an ethical and sustainable practice. This paper analyses continuing ethical and sustainable issues, then reviews existing literature focused on these issues and their recommended solutions. Highlighted while reviewing literature was the common shortcoming of not considering that sensors other than cameras can breach privacy. Furthermore, a revised code of ethics/sustainability is developed and divided into the following principles: flying zones, data acquisition, data processing, and sustainable practice. To evaluate the code of ethics/sustainability it was applied to a case study of inspecting a solar farm in New Zealand. The case study showed the code created a non-invasive and sustainable drone practice. Rapid civil drone development calls for further development of this paper and related studies.

Keywords: Code of ethics; Civil drone; Ethical and sustainable issues; Privacy.

1. Introduction

Drone use is proliferating rapidly due to the obvious advantages in various applications. Drones are capable of performing tasks more effectively than humans and without any risk. They achieve this through fast movement and height controllability which can be accomplished with a manned aircraft but at a greater risk and cost. Drones are defined as unmanned aircraft systems that either operate by a remote operator or autonomously.

Drone technology was originally developed for military use and over recent years there has been widespread development of civil drones [1]. As civil drone use is growing rapidly, they are becoming increasingly integrated with personal and professional practices. Many industries are adapting their approaches to problems by incorporating drones to reduce expenditures [2]. These drones are equipped with various sensors dependent on the application it is being used for. Majority contain an optical camera to assist in operation of the drone, but many other sensors are commonly used. Typical applications of drones include aerial photography and film, delivery, surveying, inspections, and surveillance.

While there has been significant debates regarding the ethics and sustainability for military drones, non-military drones have been largely ignored [3]. Drones can pose a significant privacy threat dependant on the application and sensors equipped. Drones that contain sensors can potentially breach personal privacy. These sensors can invade people's privacy intentionally or unintentionally by capturing private information. This privacy breach can occur at two main stages; whilst the drone is in flight and during post flight data analysis.

Drones can perform operations faster and more efficiently than other methods, but not always in a more sustainable manner. Although, in some applications drones are significantly more sustainable. One study proved that over a 1-kilometre delivery drone used a sixth of the power required by a motorcycle delivery [4].

With the rise in civil drone production we must ensure they are being produced and operated in a sustainable matter. This will impact the drones materials and production methods. These problems cause the question to arise: how do we respect privacy and produce drones in a sustainable matter? Many attempts have been made to restrict drones, but it is difficult to create a framework that applies to all drone applications without removing or reducing the efficiency of the device.

1.1. Objective

The objective of this paper is to analyse ethical issues that arise from using drones, then review existing codes of ethics to produce a new revised code of ethics. The aim is to ensure people's privacy is protected when drones are operating. To determine if the code of ethics holds this aim, it is analysed against a specific case. This code of ethics is targeted at governments, the drone industry, and drone users.

2. Literature Review

This section begin analyses the general ethical and sustainability issues that arise when operating and producing drones. Additionally, it outlines and analyses existing ethical frameworks and principles. This allows for a revised code of ethics that ensures privacy and sustainability to be produced.

2.1. Ethical Issues

The direct ethical issues are difficult to pin down due to the diversity in applications. In privacy, the information that will be recorded depends on the multiple factors. These factors consist of the location of the drone, the operator of the drone, the sensors it is equipped with, and the height the drone is flown at. The sustainability issues we are mainly focused on are the drone materials and production methods.

Drones are capable of significantly infringing on people's privacy intentionally and unintentionally. For example, a drone equipped with an optical camera can determine a person or vehicle location in private or public space. It also has the capacity to reveal who a person associates with, their body language, and behaviour. If there are multiple still images or a video it can reveal movement through space. An optical camera is not the only sensor that can infringe on people's privacy. A temperature sensor or a thermal camera can reveal people's temperatures. A global positioning sensor (GPS) can capture precise locations of people or vehicles. A camera with audio capabilities can infringe on private conversations. Distance sensors such as LIDAR systems can create 3D models, producing similar data to optical cameras. These considerations are amplified when flying at lower altitudes as drones can see into offices, homes or other private spaces. These situations, and others where subjects are being covertly recorded, are particularly problematic.

In some applications drones are employed on their stealthy abilities. In 2017, a drone operated by a news organisation flew over the current Kentucky Governors home to capture footage for a story on the suspiciously low tax assessment of his property [5]. The Kentucky Governor criticised the news organisation for their inappropriate approach to covering a new story. The news organisation responded saying they were flying according to federal regulations [5].

This private data can negatively impact people. For example, an inspection drone could provide information revealing workers behaviour and place of work. The company could then use this information as reason for disciplinary actions.

Private property surveillance is viewed as unethical, but in public spaces it is commonly recognised that we are being watched and recorded by CCTV. This leads to the question, would drone footage of a public space cause reason for concern? A study that explored this question states, “*some participants pointed out that surveillance from civil drones is different to more traditional forms of surveillance because it may not be clear who is conducting the surveillance or why*” [6]. Although this is important to consider, many participants thought of this as an “simple extension of CCTV technology” [6].

A commonly used sustainability definition from the United Nations Brundtland Commission will be used to determine if the process is not sustainable. This being, “meeting the needs of the present without compromising the ability of future generations to meet their own needs”
[7]. Materials could be made from a non-renewable source that is harmful to the environment. The manufacturing processes could release pollution into the atmosphere. These reasons are harmful to future generations, therefore unethical. It was decided not to investigate the sustainability of drone operations. As multiple studies highlighted that operating the drone had insignificant environmental impacts in comparison to the material selection and the production method [8] [9].

2.2. Review

To compare different codes of ethics and various literature, each principle has been divided into subsections based on typical approaches to the problem: flying zones, data acquisition, and data processing, and sustainable practice. Flying locations will specify where a drone can operate and the restrictions to follow in specific areas. The Data Acquisition principle will entail a methodical plan of collecting data to ensure privacy is kept. Data processing shows how data is processed in a private manner which occurs after data is captured. Sustainable practice consists of analysing the environmental impact of material selection and production methods. Splitting these principles enables me to compare, contrast, and easily identity common issues and shortcomings.

2.2.1. Flying Locations

It is important to restrict where drones can fly to limit the data they can potentially capture. The Tianjin University framework suggests employing no fly zones as it eliminates concerns of the public as the drones would no longer be able to fly in potential privacy breaching areas [10]. An approach from the UK’s governments framework is to not allow drones fitted with a camera to fly closer than 50 meters to a building, vehicle, or a person without permission [11]. The UK framework also states drones must be flown in line of sight [11]. The current approach from the New Zealand Civil Aviation states drones must be flown in line of site and it does not allow flying over people’s property without prior permission [12]. Whilst in America it is legal to fly over property, a law was passed in 2021 that allowed drones to fly over people and vehicles at night [13].

2.2.2. Flying Locations Analysis

Tianjin University no fly zones recommendation in practice was well liked by the public. In 2015, NoFlyZone.org allowed users to submit home addresses to create no fly zones above their properties. They received 10,000 submissions within 24 hours [10]. Their technique to protect privacy is excellent but it does require users to register manually [10]. Registering manually would potentially limit the successfulness of this framework. The UK’s approach of enforcing minimum distances between drones and people, vehicles, and buildings is not a well thought out approach to protect people’s privacy. Cameras, particularly with zooming features, can capture high resolution images or videos at greater distances than 50 meters. Only applying this rule to cameras instead of all sensors is another major limitation of this framework as other sensors are capable of infringing privacy. Flying the drone in line of sight significantly reduces potentially privacy breaches.

New Zealand's approach is simple, hence easy to implement. Although you cannot fly over private property, it is still possible to breach privacy with cameras or other sensors, which is why this approach needs adjustment. Americas approach allows for full privacy breaches.

2.2.3. Data Acquisition

As discussed in section 2.1 optical cameras and sensors can expose private information. Cameras are essential to many drones as they provide the current position to the operator, making it difficult to regulate. Many attempts have been made to solve this issue.

Sweden approached the issue by banning all camera drones unless a surveillance permit was acquired [14]. Tianjin University's framework recommends using prohibiting data acquisition techniques [10]. They suggest using the cameras focusing capabilities to disorientate prohibited objects. Software will identify if the area is restricted, and if this is true then it would defocus the camera. If the process couldn't be completed live or the camera doesn't have zooming capabilities, they suggest using data processing software onboard to automatically delete footage of prohibited objects. Bassi recommends incorporating data retention by design [15]. Bassi states they should be capable of turning on and off sensors during the flight, masking private areas, and automatic pixelation of faces.

2.2.4. Data Acquisition Analysis

Sweden's approach of banning camera drones was overly strict with cameras being essential on majority of drones. Hence, Sweden's Unmanned Aerial System argued that the ruling could put 5000 jobs in danger [14].

Both of Tianjin University's approaches would force privacy disclosure which is not appealing to most people or companies. This approach assumes every drone can perform data processing live where many drones would lack the processing power. Nevertheless, disorientating images is an interesting approach to camera prohibiting data acquisition as it allows for normal use of the drone while ensuring privacy. Furthermore, not all cameras on drones have zooming capabilities so the other approach must be used. These frameworks are both majorly limited as they don't consider other sensors aside from optical cameras.

Bassi's approach focuses on cameras but addresses other sensors briefly. Along with Tiajins approach, drones may lack the processing power to achieve this data acquisition live. One potential shortcoming arises if the operator is relying on camera footage to control the drone. If that footage is blurred or masked, the operator could lose control of the device.

2.2.5. Data Processing

In some applications, footage is recorded or still images are captured. This data is handled at two stages either during or after the flight. This data should be protected at these stages to ensure privacy is protected.

To protect the onboard data, one paper suggests using blockchain technology as a form of encryption [16]. Another paper suggests homomorphically encrypting camera data then storing it in the cloud when real-time video streaming [17]. A typical problem with encrypting data is that there are third party platforms that need to decrypt this data causing a reduction in the security. This paper uses a homomorphic encryption which does not encounter this issue.

2.2.6. Data Processing Analysis

Encrypting videos that will be stored on devices or transmitted should be extended to include all sensor data recorded rather than solely video. Blockchain technology is the most secure method as it uses a decentralized network that is tamper-proof and traceable. Although blockchain uses a low amount of processing power, it requires drones to be connected to the internet which is not common. By using homomorphically encrypted data we can perform actions to the data without decrypting it. This has the potential to be a good solution for when data is recorded as we can filter the data before decrypting inhibiting the possibility of others interpreting the private data.

2.2.7. Sustainable Practice

The production method and materials depict the environmental footprint of the process, therefore the sustainability. An older but renowned framework adapted from the Lowell Centre for sustainable Production (LCSP) suggests reducing or eliminating hazardous materials inducing batteries as well as minimising energy used in production [18]. LCSP defines sustainable production as "*the creation of goods and services using processes and systems that are non-polluting; conserving of energy and natural resources*" [18]. Koiwanit recommends reducing the amount of carbon fibre materials and either increasing battery efficiency or using more sustainable batteries [9]. Another paper suggests reducing the complexity of some parts including the frame as the complexity of the part was found to increase the environmental impact significantly [19].

2.2.8. Sustainable Practice Analysis

The framework adapted from LCSP agrees with Koiwanits recommendation on batteries and carbon fibre as it is an energy expensive material [9]. LCSP's definition of sustainable production follows the sustainability definition from the United Nations Brundtland Commission. Limiting the amount of material that is made from carbon fibre and using more sustainable batteries is a good approach as these are the materials that have the largest environmental impact [9]. The complexity of the structure of drone parts gives strength and rigidity. This approach is not applicable as these advantages cannot be lost, leaving the option of using a different material. Using a material with better strength and sustainability could be worth investigating. These frameworks and papers do not address if the drone is going to be used for a positive environmental impact which should be a consideration. Additionally, these frameworks are limited by focusing on specific parts rather than the drone as a whole.

3. Code of ethics/sustainability

Through reviewing existing frameworks, recommendations, and other literature, a revised code of ethics/sustainability was developed. The code of ethics will be divided into the same principles as the previous section.

3.1. Flying Locations

Drones must not fly over any private property without given permission. Drones equipped with any with sensors must not fly closer than 10 meters to no-fly zones. No-fly zones will be automatically implemented, mainly covering private property. Further specific requests of no-fly zones can be made on the appropriate website.

3.2. Data Acquisition

All drone's firmware must be updated with filtering software to restrict data acquisition. The new firmware will control sensors depending on the type:

- Optical cameras will automatically heavily pixelate prohibited scenes: people, private property, and vehicles. Thermal cameras will pixelate and not record radiometric data (the corresponding temperature value of each pixel) of prohibited scenes.

- Distance sensors such as LIDAR devices will be switched off if pointed at prohibited scenes.
- Audio devices will discontinue recording if the drone is closer than 50 meters of a prohibited scene.

Drones that are unable to install the firmware must follow section 3.3 accordingly.

3.3. Data Processing

All flight data must be homomorphically encrypted if it is stored online. Flight data that did not go through the above data acquisition stage must be run through the same filtering software where it can then be decrypted for personal use.

3.4. Sustainable Practice

Ninety percent of the materials used in parts must be recyclable. Production methods should be optimised to decrease the energy used. No manufacturing processes should release toxic or harmful waste. If the application of the drone produces a positive global impact, this principle can be flexible upon further discussion.

4. Case Study Discussion

The inspection industry exploits drones. Typical inspections consist of technicians walking around and observing the site rather than flying a drone overhead and inspecting it from this footage or using software. The code of ethics will be analysed with the specific case of a drone inspecting the 2.1MW solar farm in Kapuni, Taranaki. The drone used will be a DJI Matrice 300RTK paired with a H20T thermal camera as this a typical drone used to inspect solar farms [20]. The sensors the drone is equipped with include an optical camera, thermal camera, and a laser rangefinder.

4.1. Flying Locations

The operator will have to gain prior consent to fly on this section of private property. Once the drone is flying it must not get closer than 10 meters of the neighbouring private property.

4.2. Data Acquisition

This drone will have the latest firmware on board filtering prohibited data. Whilst flying, the distance sensor will be off majority of the time as it will be pointing onto private property. The optical camera will operate fine whilst looking at the private property, however it will pixelate the neighbouring private property. The farm is adjacent to a public road which will not be pixelated, however if vehicles or people are present on this road they will be pixelated. The thermal camera will operate in the same manner as well as not recording radiometric data of the pixelated areas. If a person or vehicle came into the view of the drone they would be pixelated.

4.3. Data Processing

Since the data was filtered on board, the only requirement is that the data is homomorphically encrypted when it is stored.

4.4. Sustainable Practice

DJI drones use lithium-ion batteries which can be recycled but the production is harmful for the environment. The rest of the drone can also be recycled [21]. Although the battery manufacturing method needs adjustment, the drone is being used to increase power production for a renewable energy source so this drone can be flexible with the sustainability principle.

5. Code of ethics Evaluation

This section will evaluate how the code of ethics performed in the specific case study and in general.

5.1. Code of Ethics Case Evaluation

Since this case study takes place in New Zealand, it will be analysed to determine if the code respects privacy as stipulated in the New Zealand Privacy Act [22]:

- you know when your information is being collected
- your information is used and shared appropriately
- your information is kept safe and secure
- you can get access to your information

The code does not allow for personal information to be collected; therefore, the first two points are fine. Information is kept using a secure encryption method. There is no personal information stored so no access is required. The code of ethics handled this case well in terms of privacy as it followed the New Zealand privacy act.

The time of the inspection would be slightly longer than a normal operation as the operator would need to adjust the flight path. Additionally, the flight path would be altered due to the 10-meter requirement from the neighbouring private property. The most significant difference would be the pixelated sections when flying. This has the potential to disorientate operators if they become too close to an edge enforcing a 10-meter gap to the edges, therefore minimising this risk. Since the drone is being used to increase the efficiency in renewable energy systems, it upholds our suitability definition even if the production method is not one hundred percent sustainable.

5.2. General Evaluation

The framework was developed after reviewing existing literature. This allowed me to build a framework without common issues and potential shortcomings identified in the literature. The two main privacy issues not addressed in these papers were not considering how sensors, other than an optical, could breach privacy, and how adapting changes in a hardware manner is more difficult. The main sustainability issue that was overlooked was if the drone had a positive impact for the environment in its application. Our sustainability definition requires a positive impact for the future, therefore if the positive impact of the application outweighs the negative production impact it can still be developed. The code of ethics identifies and address all the above issues.

The code respects the Treaty of Waitangi principles of partnership, participation, and protection [23]. Partnership is reflected in the cooperation between the drone operator and the public. Participation is demonstrated by taking into consideration the publics opinion and providing mutual benefit. Protection is established by respecting everyone's rights to privacy.

6. Conclusion and Recommendations

In this paper potential ethical and sustainability issues that are present were understood. Existing literature was reviewed before developing the code. To evaluate the code, it was analysed on how it would affect a common drone application of inspecting a solar farm. Building on existing frameworks and other literature allowed me to identity common faults to address within the code of ethics. Analysing existing literature highlighted areas that lack research. Literature on the sustainability in the production of drones was largely unexplored. Without significant research it is difficult to formulate a framework that ensures a low environmental impact. Further development should be invested into the methods stated in the code, particularly pixelating private property and objects as well as detecting drones. In general, further research should be employed on the privacy and sustainability of drones as the rapid growth into technology will cause constant limitations to the current code.

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