Application of Drone Technology in Spectrum Monitoring to Detect Radio Interference

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Abstract. With the advent of the fourth industrial revolution, new technologies such as AI, Big Data, Cloud computing, and IoT have been introduced. In the process of innovation, the significance of frequency resources has become more important, and as the amount of frequency bandwidth used increases, problems such as radio interference have also increased. Therefore, new methods of spectrum monitoring have become increasingly essential. The efficiency and flexibility of drones combined with the merging of various industries through Industry 4.0 have dramatically expanded the market and technology of drones with potential applications in spectrum monitoring. This paper examines the possibility of the utilization of drones in spectrum monitoring and radio interference detecting.

Introduction

The emergence of new technologies such as AI, Big Data, Cloud, and IoT has created new value via the converging of existing industries and new technologies. In the information-based society of the 21st century, radio frequency resources have become recognized as valuable public assets along with the likes of oil, steel, gas and coal. Similar to the fields related to the economic development of a nation, such as security, disaster relief, and exploration of new sciences and technology, the applications of radio frequency resources in particular are very diverse. Developed nations such as the United States and the United Kingdom are actively promoting the development of policies and technologies related to radio frequency resources in order to utilize relevant applications in a systematic and efficient manner. Therefore, the utilization of radio frequency resources has expanded rapidly, resulting in the significance of frequency allocation, interference detection and radio frequency manage becoming more important.

However, an increase in the usage of frequencies has also led to an increase in the occurrence of radio interference, resulting in required spectrum monitoring in areas where it is difficult to monitor with conventional equipment. In Korea, the spectrum monitoring range is only 35%, and 65% of frequency blind areas still exist [1]. In addition, it is difficult to find a source of radio interference when a source of radio interference is encountered in a valley or a canyon where it is difficult to access a monitoring vehicle. As a result of this dilemma, there is a need for the development of new mobile spectrum monitoring equipment.
The remote-control capabilities and mobility of drones is currently attracting attention in various fields, and as a result, attempts to deploy drones in environments that are difficult to access with existing equipment are currently underway. Drones are capable of being operated with the addition of various equipment, therefore, efforts are being made to create new value and initiate applications into various fields such as disaster relief, agriculture, transportation logistics and security. In the field of radio spectrum monitoring, the remote-control capabilities and the mobility of drones are suitable countermeasures to the inherent mobility limitations that exist in traditional spectrum monitoring equipment.

**Theoretical Background**

**Frequency Monitoring**

According to central radio management service wave monitoring system refers to a system that measures waves or detects the direction of waves. In Korea, the frequency of waves within the range of 9KHz ~ 275GHz is measured. The method of work is largely divided into monitoring and investigation. In the case of monitoring, it is monitored for illegal use of the frequency, including satellite wave monitoring. The investigation is conducted to prevent the distribution of illegal equipment and equipment, and to prevent victims from arising.

Radio waves emitted from illegally modified radio equipment, or unlicensed equipment, can cause TV reception and radio signal problems, or obstruct radio signals used by the fire department, ambulances, and trains, which could result in serious threat to human safety concerns. With increasing importance being placed on environmental protection relevant to radio wave use, more efficient and effective means of spectrum monitoring is needed to prevent and strengthen controls on a rising number of unlicensed radio stations. For important stations related to national security and safety of life, preemptive measures are needed to remove the causes of harmful waves beforehand or to change stations that cause radio interference to other frequency bands [3].

On March 2011, instances of GPS signal disturbances were observed in the northern sections of metropolitan areas of Seoul, Incheon and Paju. In the private sector, a slight level of disturbance has occurred, such as a lack of a mobile phone clock that meets GPS signals or poor call quality. However, in the military sector, an incident occurred where a coast guard patrol ship belonging to the Navy Incheon Coast Guard Command disappeared from radar systems; consequently, severe obstacles such as the stoppage of GPS related equipment during the mission of the US military reconnaissance aircraft RC-7B, transpired during this incident [4]. Another incident took place on May 22, 2015, during the International Alpine Skiing Competition held in Italy, where large drones carrying the TV relay cameras suffered radio interference in control, causing the malfunctioning drone to crash in the vicinity of a contestant [5]. GPS disturbance, radio interference and other damage occur on a yearly basis, and the size and type of damage are increasing. Radio interference refers to a disturbance phenomenon in which a signal other than a desired signal is superimposed on a signal as an external radio interference wave.

In Korea, the spectrum monitoring range is only 35%, and 65% of frequency blind areas still exist [1]. In addition, it is difficult to find a source of radio interference when a source of radio interference is encountered in a valley or a canyon where it is difficult to access a monitoring vehicle. In the coastal waters, many Chinese boats are crossed, and military communications are made using military frequencies, resulting in complaints from the army that cause difficulty to find radio interference to military communications. In the high-density apartment complex in the urban area, the user is searching for a source of radio interference using a portable detector. However, due to the privacy issue, there is a limit to the monitoring of the proximity access approach. As a result, the problems of mobility and accessibility of existing monitoring equipment are constantly mentioned, and new monitoring methods are needed in preparation for new innovation using intelligent information technology of the 4th Industrial Revolution.
Drones were initially developed in the early 2000s and were intended to be utilized as unmanned military aerial vehicles. The early drone prototypes were used for aerial missile bombing exercises and were gradually expanded to include reconnaissance functions and were later deployed as offensive weapons. In recent years, multinational corporations and national agencies have been expanding their deployment of drones into various other fields such as mass media, disaster prevention, broadcasting production, construction, security, aviation measurements, and transportation logistics [6]. The global commercial drone market size was valued at USD 500 million in 2014 and is expected to grow at a CAGR of approximately 17% over the forecast period. Surging application in government and retail industry sector is expected to drive the global market for the next seven years [7].

The reason why drones have become so widely utilized across various fields is due to the fact that they can be remotely controlled and be operated with various additional equipment. Additional devices can be mounted on the drones as needed such as cameras, ultrasonic equipment, and sensors for temperature, oxygen, and carbon dioxide measurements, allowing for full customization and versatile usage. Via wireless communication, drones can transmit the results of various tasks by means photo captures or video recording directly to the user in addition to the ability to remotely check or adjust sensor value measurements through the drone’s control system [8]. Drones are becoming more popular and widely used in various fields due to their flexibility of use and efficiency of operation, and as a result further research is being actively carried out in attempts to expand the drone’s versatility and field of operations.

One such example of drone research is their applications in the field of disaster information network systems that utilize drones to track and monitor natural disasters such as earthquakes, volcanic eruptions, and tsunamis [9]. This research is based on disaster information network system that uses the drone as a remote controlled autonomous flight node with the following functions: 1) search for transmittable radio stations via autonomous flight, 2) receiving transmissions from wireless stations while hovering, 3) returning to base of operations after successfully receiving data transmissions, 4) flying to a power supply station capable of recharging its battery in the case of insufficient power. Figure 1 showcases the drone’s ability to search for possible wireless nodes in a disaster information network system. In the event where a drone detects a remote signal, it searches for the source of the signal based on the GPS location information collected from three stations. Additionally, as depicted in figure 2, studies are being conducted in various fields for innovating drone usage, such as research on a drone’s ability to provide communication services to users while maintaining flight and providing a network of operations in a specific area.

Method
In this study, we conducted interviews with experts and literature studies to confirm the feasibility of frequency monitoring using drone. Expert interviews were divided into two parts (drones, spectrum monitoring plan), which consisted of common questions about spectrum monitoring improvement measures and questions on the possibility of spectrum monitoring of drones. The subject and duration of the investigation were conducted by a written interview from October 10, 2017 to November 25,
2017. As a result, the respondents in the frequency domain were six professors, three academics, one researcher, and two experts.

**Frequency Monitoring Using Drone**

In order to construct spectrum monitoring using a drone, an antenna, a frequency analyzer, a storage device, and a communication modem should be installed. The performance of the spectrum monitoring drones is expected to depend on the performance of the frequency analyzer and requires equipment capable of analyzing the range from 9KHz to 6GHz and a lightweight frequency analyzer. In addition to the advantages of mobility when conducting spectrum monitoring work using drones, it is possible to more precisely search the point causing interference by creating 3D map [10]. In case of spectrum monitoring using drone, it can be solved in terms of spectrum monitoring for areas that are difficult to detect with existing spectrum monitoring equipment such as an inter-mountainous base station, EIRP measurement, and canyon intrusion detection. Especially, it will be possible to replace the drones in the high-density apartment complexes in the downtown area by using portable detectors, and it will be more cost-effective and time-reduced. There are two ways of using the drones as a monitoring method: the receiver is placed in the vehicle, the antenna is installed in the drones, and the is used completely. The advantages and disadvantages of each are shown in the table below [1,11].

| Advantages | Disadvantages |
|------------|---------------|
| Long duration flights | Limit of flights |
| Risk of loss is relatively little. | Limitation of terrain such as mountains |
| Low cost of establishing a measurement/detection system | Limitations of frequency monitoring. |
| Most realistic alternative. | Available only for special purposes |

Table 1. Characteristics of spectrum monitoring system using wired drones.

| Advantages | Disadvantages |
|------------|---------------|
| A wide range of flights in a short time. | Impossible long duration flights |
| A wider range of measurements / detection | Risk of loss is relatively large. |
| periodically measure / detect through autonomous flights | Many technological issues to be solved such as the weight |
| regardless of terrain such as mountain | of the frequency analyzer and the antenna |
| various fields for frequency monitoring | |

Table 2. Characteristics of spectrum monitoring system using wireless drones.

Figure 4. Spectrum monitoring scenario using drones.  
Figure 5. Spectrum monitoring system using wired drones.

**Conclusion**

Based on the interviews with experts and the literature review, this study examined the possibility and advantage of spectrum monitoring using drone for frequency management. There are still technical and limitations to be solved in terms of battery problems, frequency analyzer and antenna weight and privacy issue. However, the rapid development of the drone technology makes it possible to use the drone in terms of spectrum monitoring. When combined with existing spectrum monitoring vehicles and antennas, efficiency is expected to increase in terms of a wider range and frequency control. According to National Radio Research Agency, spectrum monitoring using a drone can be used to identify the characteristics of frequency that are currently not actively used and to establish a
frequency utilization base without causing communication disruption between terrestrial terminals and public terminals.

In the aspect of socio-economic resource conservation, consideration must be made toward the precise recognition of frequency users and limited resources in the frequency bandwidth; as a result, it is necessary initiate efforts into efficiently allocating frequency resources whilst optimizing usage of waves regarding noise and occupied frequency bandwidth. On a final note, in an effort to prepare for a future society where the value of resources in frequency bandwidth will continuously increase, society must take measures to optimize the utilization of frequency via investment and development of technological advancements as well as research on relevant policies and regulations [2].

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