2021 Research Report

Analysis on Spectrum Monitoring System Data for Auto Detection Interference Application

Final Report

Grantor: National Yunlin University of Science and Technology

Abstract

Keywords: Radio interference, Radio monitoring, Spectrum management system

The "Radio Frequency Monitoring Project" of ex-Directorate General of Telecommunications, Ministry of Transportation and Communications(ex-MOTC), established the monitoring energy technology of the relevant radio wave monitoring network and formed a 24/7, real-time and automatic nationwide radio wave power monitoring network via monitoring network and spectrum management system. In 2006, National Communications Committee (NCC) was organized, and set "Continuously Banning Illegal Channels in Accordance with The Law, and Actively Opening up Channels" as policy for solving problem of illegal radio stations. They used the Radio Wave Power Monitoring System of ex-MOTC to keep the order of radio wave. A new generation of radio monitoring systems have been built, with the aim of improving the future flight, shortness, low-power radio equipment and the special interference problems in metropolitan areas in 2018.

In recent years, the economy of Taiwan has been flourishing. A lot of buildings lead to rapid changing of surrounding terrain and increasing the difficulty of interference forbidden, coupled with the opening up of new businesses, a large number of spectrums are released. For this reason, this project intends to propose an interference detection system to identify the frequency bands suspected of interference in various services.

The final report of this project is organized as eight chapters: Chapter I is the introduction; Chapter II is collection and analysis of radio wave monitoring interference early warning methods; Chapter III is collection of monitoring data generated by the monitoring system; Chapter IV is interference calculation and monitoring data analysis; Chapter V is the interference cases study; Chapter VI is analysis and discussion on the causes of interference; Chapter VII analyzes the interference of airline channel communication by broadcasting channel signals; Chapter VIII is future improvement measures and early warning mechanism planning recommendations and conclusions of the radio wave monitoring system.

For the system aspect, we analyzed the radio wave detection data provided by NCC, and made analysis results visualized for conveniently observing the change of spectrum. For the theory aspect, we referred to previous relative project reports and relative books. We illustrated the factors of various interference, and explained factors and types of suspected interference frequency band based on the output images of proposed system. In chapter VII of this report, the expected benefits of this project are described, and the future prospects are put forward so that researchers in the future can have a clear research direction.

Chapter 1 Introduction

The " Analysis on Spectrum Monitoring System Data for Auto Detection Interference Application" baseon Spectrum Monitoring System. For Spectrum Monitoring System data processing and analysis, establishment of automated interference analysis. This automated system provides spectrum efficient resource management.

Section 1.1 Background

The new-generation Spectrum Monitoring System was completed and has been in use since 2018. Its performance surpasses terms include width frequency range, irregular signals, direction locating, and digital demodulation. However, there has yet to be any in-depth analysis of the monitoring data. Our research is essential in order to swiftly detect and eliminate radio interference.

Section 1.2 Purpose

This research Auto Detection Interference Application project goals as follows:

1.2.1 Strengthening the application of the new-generation Spectrum Monitoring System

This project's comprehensive research analysis can help with grasping how interference cases are handled, strengthen the current new-generation radio wave monitoring system, and use the foundation to develop and apply the latest prevention technologies and methods.

1.2.2 Establish a protection profile for Spectrum interfering

This research's actual radio wave monitoring data can be used as a reference for future optimization of the radio wave monitoring network, improving the ability to deal with related interference cases.

Section 1.3 Scope of Research

The main research categories are as follows:

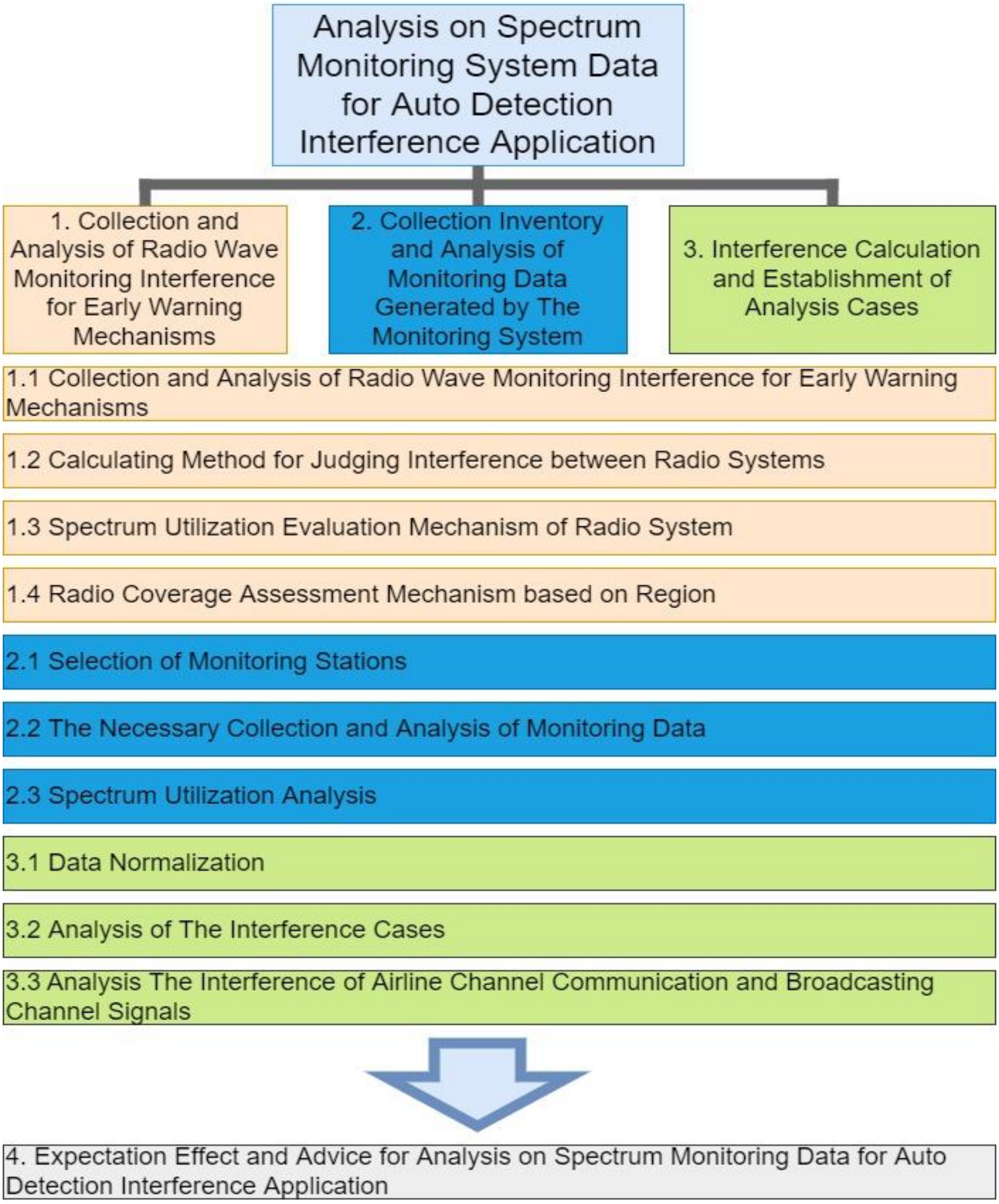


Figure 1 Research Project Chart

Source: The team finishing

Section 1.4 Research Methods and Procedure

In order to achieve the required four major research components set forth for this project, and based upon the aforementioned research content characteristics and categories, the work can be roughly divided between two research methods: literary research and experimental research.

Table 1 Research projects and reports description

Research projects	Report generation	Requirements of researching
1. Collection and analysis of radio wave monitoring interference for early warning mechanisms	(1) Classification method of interference signal in HF/VHF/UHF	Technical documents of international organizations
	(2) Calculating method for judging interference between radio systems	
	(3) Spectrum utilization evaluation mechanism of radio system	
	(4) Radio coverage assessment mechanism based on regions	
2. Collection, inventory and analysis of monitoring data generated by the monitoring system	(5) Selection of monitoring stations	In addition to solving the background noise of the monitoring station, it also collects the occurrence of special abnormal signals
	(6) The necessary collection and processing of monitoring data	1.Radio wave data collection and analysis 2. Understand the current use of radio frequency bands 3. Abnormal signal interference situation
	(7) Spectrum utilization analysis	
3. Interference calculation and establishment of analysis cases	(8) Data normalization	Data analysis and search for interference identification situation
	(9) Analysis of the interference cases	
	(10) Analysis the interference of airline channel communication and broadcasting channel signals	

Research projects	Report generation	Requirements of researching
4. Expectation effect and advice for analysis on spectrum monitoring data for auto detection interference application	(11) Expectation effect of qualitative benefits analysis	Benefit analysis
	(12) Schedule and Funding evaluation	

Source: The team finishing

Chapter 2 Spectrum Monitoring System Data collection and Analysis for interference detection

This chapter conducts research and analysis on radio wave monitoring interference early warning methods through literature and analysis methods. The evaluations are including: the classification method of interference signals in different frequency bands; the calculation method of interference discrimination between radio systems; the spectrum utilization evaluation mechanism of radio systems and the radio coverage assessment mechanism's regional implementation.

Section 2.1 Calculating Method for Judging Interference between Radio Systems

2.1.1 Co-channel interference

Co-channel interference is when useful signals and interference signals are working in the same channel. The major reason for this interference is that a proper distance separation was not maintained, causing the interference to exceed the tolerance level of the allocated frequency band, or the occupation or misuse of the bandwidth.

2.1.2 Adjacent channel interference

Adjacent channel interference is caused by frequency offset due to a bad transmitter or a bad receiver unable to filter out signals aside from the allocated bandwidth. The transmit power of the allocated channel of the interference source falls into the adjacent channel of the receiver.

2.1.3 Harmonic interference

Harmonic interference refers to two signals are not located in adjacent frequency bands. This interference may be caused by non-linear components of the system.

2.1.4 Intermodulation interference

Intermodulation distortion is caused by non-linearities at the transmitter or receiver. This interference may be caused by multiple or added different frequencies. For example: $f = \mathrm{n}f_1 \pm mf_2$, where the f is the intermodulation frequency, f_1,f_2 are two signals frequencies, n, m are integers. The order of intermodulation is $|n| + |m|$ (positive integer). Since third order intermodulation distortion has higher power, as follows: $2f_1 + f_2$, $2f_1 - f_2$, $f_1 + 2f_2$, $-f_1 + 2f_2$), it's easier to create interference. With $2f_1 - f_2$ and $-f_1 + 2f_2$ being closer to the transmit frequency, the two signals have a lesser likelihood to be filtered out.

Section 2.2 Radio Coverage Assessment Mechanism based on Region

Evaluation of the following models: free space propagation loss model, Cost-231 Hata Model, ITU-R P.370-7, ITU-R P.1546-6 and the ITM Model. Here, we give the comparing table The ITM model is used in this project. It was selected to simulate radio wave coverage for the following reasons:

1. There are two working modes to choose, among which the regional model can be used for uncertain terrain environments.
2. Wide frequency range.
3. A larger simulated distance range.
4. Calculations take into account various environmental materials.
5. Environmental factors in varying climates are considered.

In Table 2, we compare the effective propagation distance and path length in the frequency band used by different propagation modes such as free space propagation loss model, Cost-231 Hata Model, ITU-R P.370-7, ITU-R P.1546-6 and the ITM Model.

Table 2 Propagation model comparison table

Propagation Model	frequency	Effective Launch Propagation Model	Path length
free space propagation loss model	N/A	N/A	N/A
Cost-231 Hate model	1.5GHz~ 2GHz	30m~200m	N/A
ITU-R P.370-7 model	30MHz~ 1,000MHz	＜ 1,200m	10km~ 1,000km
ITU-R P.1546-6 model	30MHz~ 4,000MHz	＜ 3,000m	1km~1,000km
ITM model	20MHz~ 20GHz	< 3,000m	1km~2,000km

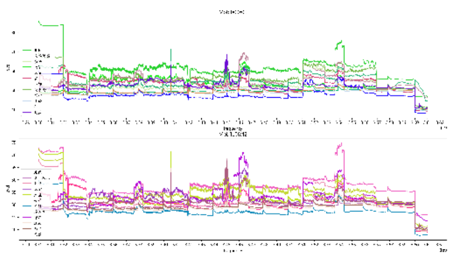
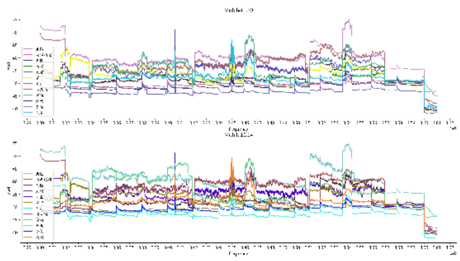
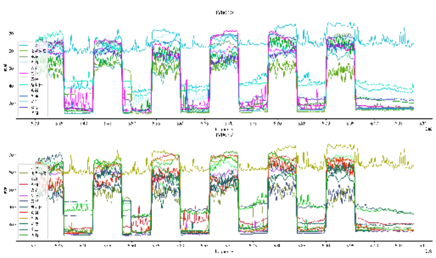
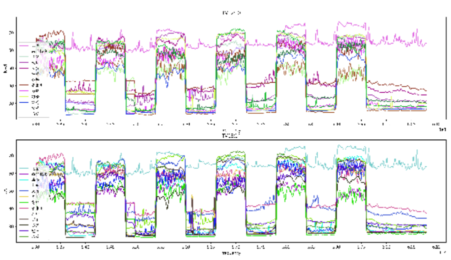
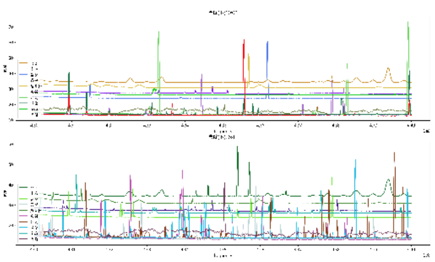
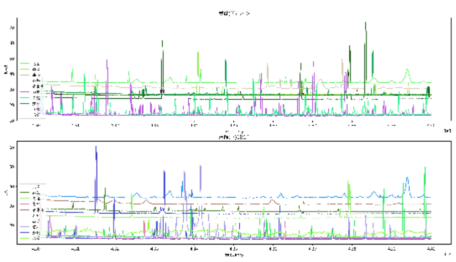
Source: The team finishing

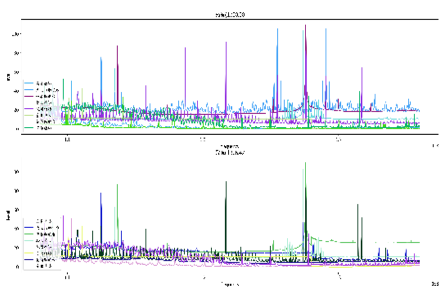
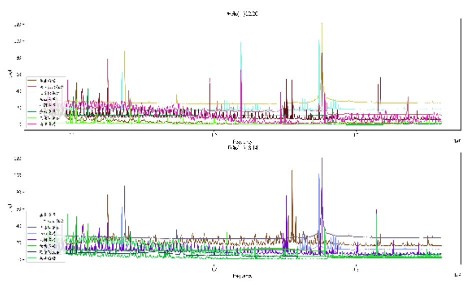
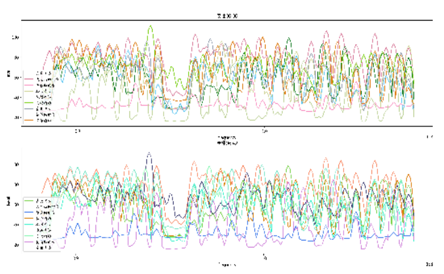
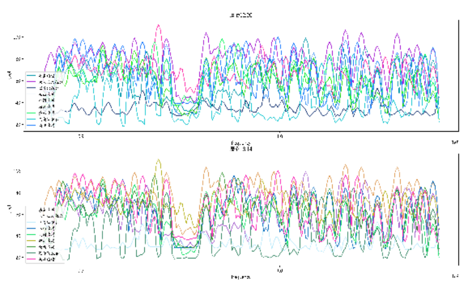
Chapter 3 Spectrum Monitoring System Data Normalization and standardization Process

Section 3.1 Selection of Monitoring Stations

The research team discussed and analyzed the field strength data obtained by the radio wave monitoring stations. Table 3 shows the basis for consideration by each monitoring station.

Table 3 Spectrogram of at a single point in time

Mobile business 5/9	
	
(a). 00：00、06：00	(b). 12：00、18：14
Digital TV business 5/9	
	
(a). 00：00、06：00	(a). 12：00、18：14
Amateur Radio business 5/20	
	
(a). 00：00、06：00	(b). 12：00、18：00

Airline channel 5/20	
	
(a). 00：00、06：00	(b). 12：00、18：14
Airline channel 5/20	
	
(a). 00：00、06：00	(b). 12：00、18：14

Based upon the radio signal field strength data collected by the research team and the recommended simulation results in accordance with the spectrum management system manual, it will divide into five categories based upon type of business: mobile, digital TV, amateur radio, airline channel and broadcasting channel's needs. According to the requirements, the four directions of Taiwan's north, central, south and east are used as the basis for selecting monitoring stations. Table 4 lists the various business stations selected for monitoring.

Table 4 Monitoring stations

Business	Monitoring Station 1	Monitoring Station 2	Monitoring Station 3	Monitoring Station 4	Monitoring Station 5	Monitoring Station 6	Monitoring Station 7
Mobile business	Keelung City Keelung Station	Taipei City North District Station	Hualien City Guangdong Street Station	Taichung City Fengyuan Station	Kinmen Counrty Jincheng Station	Kaohsiung City Qieding Station	
Digital TV business	Keelung City Keelung Station	Taipei City North District Station	Hualien City Guangdong Street Station	Taichung City Fengyuan Station	Kinmen Counrty Jincheng Station	Kaohsiung City Qieding Station	

Business	Monitoring Station 1	Monitoring Station 2	Monitoring Station 3	Monitoring Station 4	Monitoring Station 5	Monitoring Station 6	Monitoring Station 7
Amateur Radio business	Keelung City Keelung Station	Taipei City North District Station	New Taipei City Dadongshan Station	Hualien City Guangdong Street Station	Taichung City Fengyuan Station	Kinmen Country Jincheng Station	Kaohsiung City Qieding Station
Airline channel	Songshan Airport Station	Taoyuan Airport Station	Kaohsiung Airport Station	Tainan Airport Station	Penghu Airport Station	Hualien Navigation Station	
Broadcasting channel	Songshan Airport Station	Taoyuan Airport Station	Kaohsiung Airport Station	Tainan Airport Station	Penghu Airport Station	Hualien Navigation Station	

Section 3.2 Analysis Scheme

In this project, the proposed analysis mechanism and detection process are shown in Fig.2.

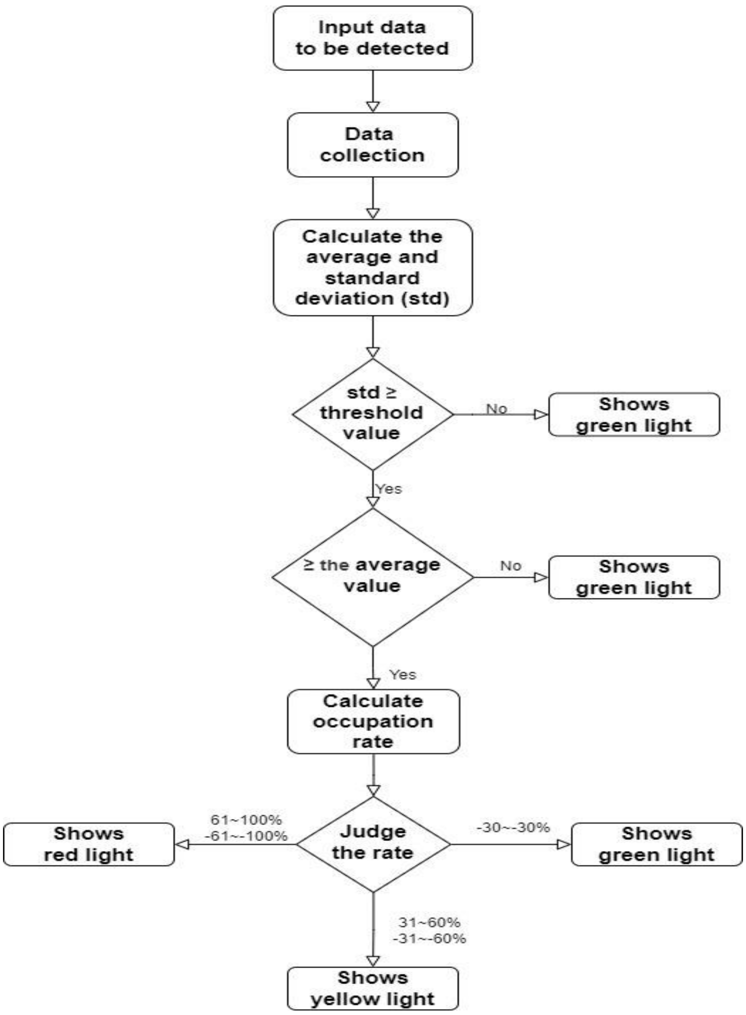


Figure 2 Flow chart of the detection system

Chapter 4 Interference Calculation

Section 4.1 Data Analysis

Step 1：Receiving the inspection data

Prior to the system performing detection, the operator must upload the monitoring data file (the number of files here may be one week or more). Then, he sets the radio wave detection data (such as: site name, business type, dates of the detection file, detection frequency band and time period, etc.) after receiving it.

Step 2：Verify the inspect data

After the test file is properly prepared, the system will automatically classify it according to date, time and frequency band. We will store it through a data structure of comparison type for future internal usage in the system.

Step 3：Calculate the average and standard deviation of specific time

The proposed system will calculate the standard deviation and average value of the field strength values of each frequency band on different days through the previously uploaded multiple spectrum monitoring data. And then, we will use the standard deviation of each frequency band to determine the threshold judgement.

Step 4：Analyze the radio wave data

Upload a single radio wave detection data and perform the compilation of the detection data according to Step 2.

Step 5：Judge the field strength of the detection data

After comparing the average value and standard deviation value obtained from the Step 3 with the field strength value of the interesting frequency band in the test data, we can judge whether the field strength value has exceeded the average value. If it is higher than the average, we will increase the weight value of the interesting frequency band. Here, the weight value is used to indicate its severity and to classify the hazards. Therefore, the frequency band of concern that exceeds the average value is determined to be level 2.

Step 6：Analyze the occupation rate of unusual spectrum

In order to confirm the correctness of the above data. The system takes the time that exceeds the average value for the frequency band of level 2 within one day and divides it by the time of one day to obtain the occupancy rate of the frequency band for each day. Therefore, we can this value to determine the usage behavior of the abnormal frequency band.

Step 7：Construct images

After calculating the utilization rate of the interesting frequency band, we can draw the following images including the radio wave detection data spectrogram, standard deviation and average value spectrogram, the frequency spectrum of the current period, and the utilization rate of the interesting frequency band at each point in time.

Step 8：Define the aberrant signal

The utilization rate of the frequency band of concern obtained by using the above method to determine whether the utilization rate of the frequency band is gradually improving or deteriorating. At the same time, we can get the hazard classification according to the trend and level of its usage rate. In order to express the degree of hazard results clearly, we use the three lights such as green, yellow and red to represent the degree of hazard from low to high.

Step 9：Provide detection mechanism

After the system detection is completed, a warning signal will be generated for the irregular result of the detection.

Step 10：Data backup and record

After the warning signal is issued, the system will store the results and graphics into the system database. The operator will decide whether it’s interference or not and then the results will be recorded back into the system.

Section 4.2 System Restrictions

In this project, we propose a detection mechanism to analyze the receiving spectrum information. By using the above-mentioned steps, we can successfully detect the abnormal field strength of the interesting frequency band and then generate an alarm signal for operator to make subsequent judgments. However, there are three system restrictions as following.

4.2.1 Decide the temple interference judgement

Our proposed system can currently only analyze a certain frequency band and time and provide an abnormal data as a reference because the provided information only includes time, frequency, and field strength values in this project. However, it cannot completely ensure that the frequency band is the interference band.

4.2.2 Multiple interference sources

It only uses the parameters such as time, frequency, and field strength. Therefore, it cannot decide the interference is a single interference source or multiple interference sources in our proposed scheme. In order to improve this restriction, it must be evaluated through other relevant parameters (such as azimuth).

4.2.3 Interference signal hidden in normal signal

Since our proposed system conducts interference detection from the perspective of statistical analysis, it must need to use a large amount of data collected from the monitoring stations as a reference background signal. Therefore, regardless of the type of service, the standard deviation of the interfered frequency band cannot be judged when the interference signal is hidden in the normal signal or background signal. So, the system will treat this interference as a normal signal.

4.2.4 Variety amplitude of behavior judgement

For our system, the occurrence of misjudgments can only be minimized through the rising/falling trend of the occupancy rate. However, it is unable to determine the changes in the frequency spectrum of the intermediate days.

Section 4.3 Conclusion

In the section 4.1, it describes how to obtain available information from the known radio wave detection raw data and then analyze the data through our proposed method to determine whether it is an abnormal signal or not. In the section 4.2, it points out the shortcomings of our proposed system. The main reason is that our proposed system analyzes and judges by using the field strength value of the frequency band. Therefore, it can only find out the single interference and fails to bring the situation of multiple interferences in this system. In the future, we can make diligent improvements to overcome this shortcoming.

Chapter 5 Analysis of The Interference Cases

In this chapter, we will introduce the interference analysis case for the mobile communications, amateur radio and broadcasting channel. The major method is to use the field strength map generated by the interference early warning system to analyze suspicious frequency bands, and then compare the collected data. After analysis, we can find that the cause of mobile communications interference may be that the frequency bands used between the two telecommunications are too close, which results in overlap of frequency bands for co-frequency interference. The cause of amateur radio interference may be adjacent frequency interference caused by strong signals in adjacent frequency bands. Here, the Taipei North District Station is used as an example to provide further explanation.

Section 5.1 Mobile Communication Interference

This section describes a mobile communication interference case. In this case, we use the Taipei North District Station as the detection station. The analysis dates are from April 23, 2021 to May 9, 2021; the duration is 24 hours. We will do the following four steps to get the abnormal signal.

Step 1: We calculate the standard deviation and average value of each frequency band according to the different data such as date, time, frequency and field strength.

Step 2: It is performed to filter out the frequency band with a higher standard deviation, and then we cannot only add the frequency band to the list of concerns but also set it is the Level one.

Step 3: If the frequency band of Level one in the concern list exceeds the average value, it will be set Level two.

Step 4: The system will calculate the frequency band of level 2 for analysis and the occupancy rate during the date.

The results of this simulation are shown in Fig. 3. According to our proposed system, the results are displayed as three warning indicators of green, yellow, and red. The frequency band is recognized as a normal use range or an abnormal use range through the system analysis mechanism. According to our analysis, from April 23, 2021 to May 9, 2021, it was found that the abnormal frequency because it is not only changed greatly and exceeded the threshold, but also the daily occupancy rate grew rapidly. Therefore, we will list this frequency band as a red alarm.

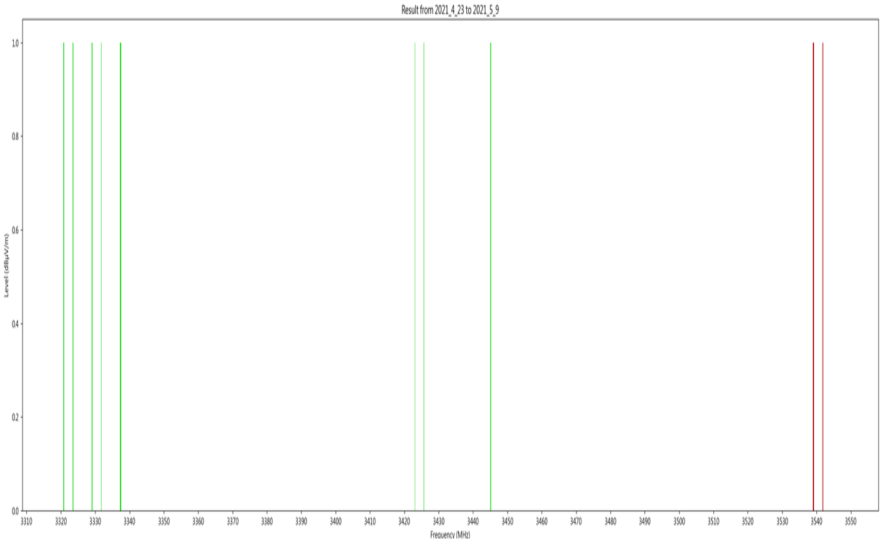


Figure 3 Mobile communication alarm classification at the North District Station

Section 5.2 Amateur Radio Interference

In this section, we will analyze the amateur radio interference cases by using our proposed method. Here, the detection data is collected from the North District Monitoring Station, date is from May 15 to May 23, 2021 and the frequency is from 143.9MHz to 146.1MHz. It will do the following four steps to get the abnormal signal.

Step 1: We calculate the standard deviation and average value of each frequency band according to the different data such as date, time, frequency and field strength.

Step 2: It is performed to filter out the frequency band with a higher standard deviation where the threshold value is 75% of the highest field strength), and then we cannot only add the frequency band to the list of concerns but also set it is the level 1

Step 3: If the frequency band of Level one in the concern list exceeds the average value, it will be set level 2.

Step 4: The system will calculate the frequency band of level 2 for analysis and the occupancy rate during the date.

The results of this simulation are shown in Fig. 4.

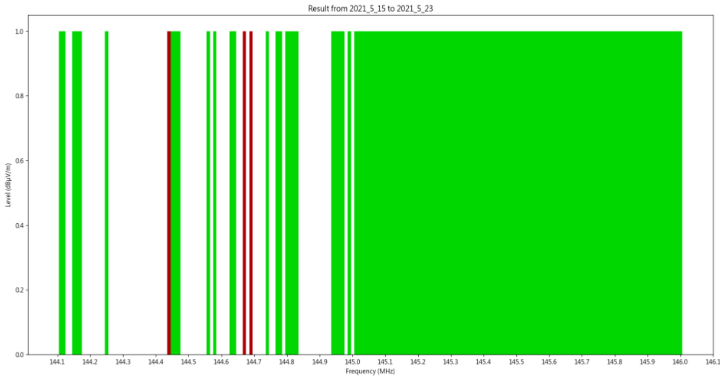


Figure 4 Amateur radio warning classification at North District Station

Section 5.3 Broadcasting Channel Interference

The test station for broadcasting analysis is Taipei Songshan Airport and date is from May 3-22, 2021. Firstly, we are to filter out the frequency bands with higher standard deviations and added it to the list of concerns. If the frequency bands in the list of concerns exceed the average value, we will continue to analyze the occupancy rate of this frequency band, and divide it into three warning indicators: green, yellow, and red. Green to red, indicates the degree of harm from low to high.

Past research has focused on analyzing the protection bandwidth between the two channels to avoid the interference caused by frequency offset. At the same time, NCC continue to ban and actively open channels in accordance with the law to solve the problem of illegal broadcasting. Thus, in recent years the problem of broadcasting station interference has been significantly improved.

From Fig.5, the green warning label, the analysis factor is that the broadcast station is not used continuously for 24 hours, which causes the standard deviation to be too large. The red warning mark in Figure 5 shows that the analysis factor is irregular and deliberately transmitting high-power signals, which affects the communication quality of the original radio station.

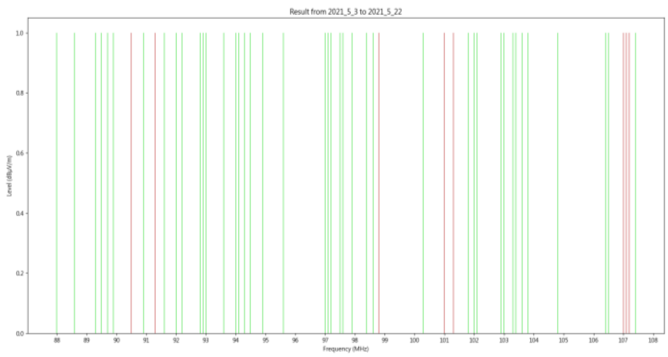


Figure 5 Broadcasting station-Songshan Airport warning classification result map

Chapter 6 Analysis The Interference of Airline Channel Communication and Broadcasting Channel Signals

According to the field strength waves generated by using our proposed system, the suspected frequency band is identified by comparing the radio frequency assigned by the flight. We can find that the cause of the interference is more likely to be that the radio station's interactive modulation falls into the flight frequency band. Therefore, when a suspicious frequency band is found, it can be calculated to fall into the suspicious frequency band based on the interactive modulation product of the frequency assigned by the broadcasting station. Here, the Songshan Airport is used for interference analysis case.

Now, for different time, the diagrams shown in Fig.6 and 7 when it compares the frequencies of the radio communication facilities of Songshan Airline Services with the assigned frequencies of Songshan radio-assisted navigation facilities. We can find that the unused frequency bands have abnormally raised field strength values, namely 112.5MHz and 117.7MHz and 125.3MHz. So, we can compute the interactive modulation frequency of the Taipei New Taipei broadcast channels to distinguish the main frequency band or the interactive modulation frequency band. There are multiple abnormal field strength values in the 126MHz-129MHz frequency band.

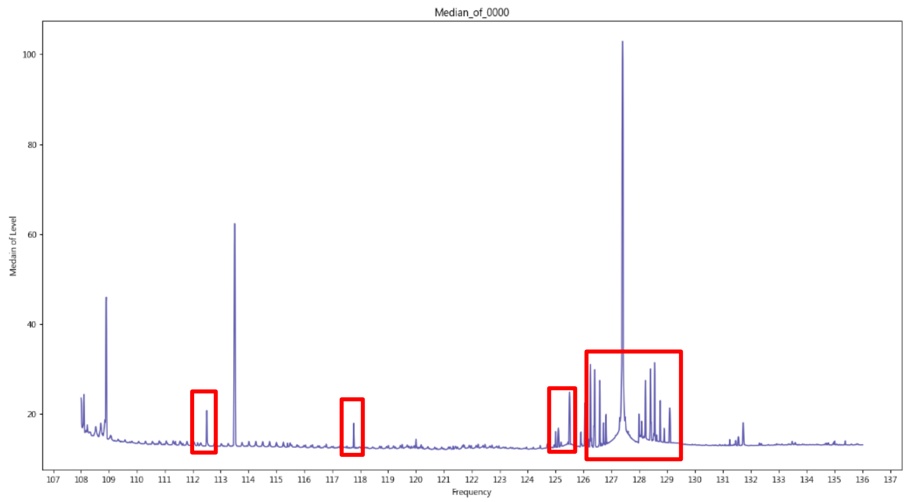


Figure 6 Multi-day average frequency spectrum of Songshan Airport at 00:00

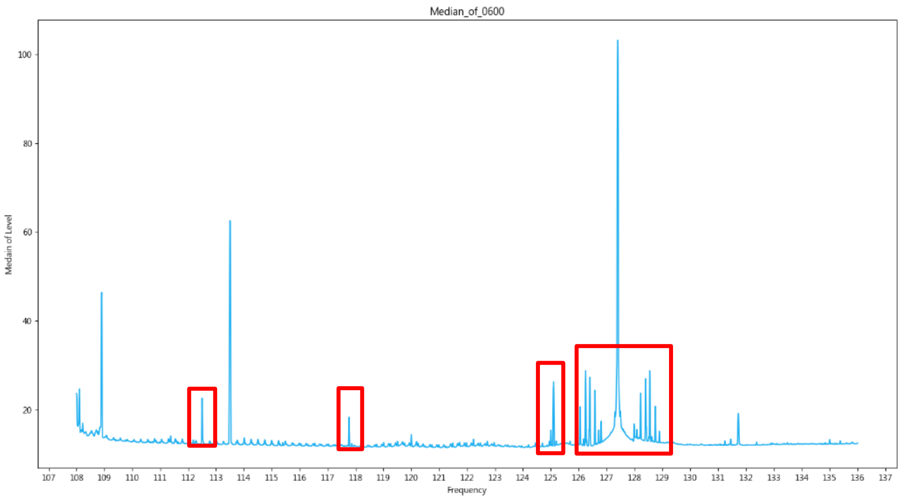


Figure 7 Multi-day average frequency spectrum of Songshan Airport at 06:00

Irregular Frequency Analysis

In 112.5MHz frequency analysis：this frequency might be affected by the cross modulation of Stations A (101.7), B (90.9), C (104.9) and D (97.3): $2f_1 - f_2$, $2 \times 101.7 - 90.9 = 112.5$ and $2 \times 104.9 - 97.3 = 112.5$.

In 117.7MHz frequency analysis：this frequency might be affected by the cross modulation of Stations A (104.9) and B (92.1): $2f_1 - f_2$, $2 \times 104.9 - 92.1 = 117.7$

In 125.3MHz frequency analysis：this frequency might be affected by the cross modulation of Stations A (107.7) and B (90.1): $2f_1 - f_2$, $2 \times 107.7 - 90.1 = 125.3$

In 126MHz-129MHz frequency analysis: this frequency may be due to the strong signal of 127.4MHz, which may cause multiple intermodulation products in the internal intermodulation of the monitoring station.

Chapter 7 Expectation Effect and Advice for Analysis on Spectrum Monitoring System Data for Auto Detection Interference Application

Section 7.1 Expectation Effect of Qualitative Benefits Analysis

7.1.1 Possible undetected interference

The early warning system is proposed which can sort data in advance, strengthen data collection, information processing and analysis capabilities. It is expected to optimize the system to actively detect abnormal interference and improve the efficiency of processing interference.

7.1.2 Long-term monitoring of irregular signals

Since the system's initial detection of irregular signals is only from one day, its accuracy is not ideal. In order to ensure that the data is correct, the system monitors irregularities on a long term basis and evaluations are made using the occupancy rate. To get the correct answer, check whether there is a decrease or increase trend and determine whether the time proportion is too high.

7.1.3 Identifying non-random interference signals

By Calculating the link budget of signal, we can know whether the receiver can fit the signal from the transmitter. In this project, the regression tracking or big data analysis method is performed on the signal intensity collected daily to determine whether a certain frequency band has been interfered with by irregular signals, which can improve the efficiency of judging interference.

7.1.4 Establishing various signal detection processes and judgment case summaries

In this project, the degree of spectrum interference has been divided into three levels and uses the colors green, yellow, and red as the distinction. This screening result can be used as a basis for judging whether it is true interference and improve the efficiency of interference judgment.

7.1.5 Graphical data

Our proposed system cannot only integrate each piece of data and display it as a continuous waveband graph but also superimpose and compare the frequency band conditions of multiple days. Therefore, the abnormal signal judgement can be made more accurately and quickly for the operator.

Section 7.2 Expectation Effect of Quantitative Benefits Analysis

7.2.1 Reduce database collation

In this project, the proposed system can turn spectrum information into visualized information, it will make the real-time processing more efficient in the future. It is expected to save 40% to 50% of data processing time.

7.2.2 Decrease case interpretation time

When interference occurs or it wants to understand the current spectrum utilization status, you can use the picture information processed as the basis for judgment. It is expected to increase efficiency by 25%.

Section 7.3 Financial Evaluation

For the future research schedule, it will take about half a year to implement. The tasks include data analysis, procuring equipment and system establishment, system integration, modifying system parameters, and post-operation adjustments. The time needed to complete each of the five tasks is shown in Tables 5.

Table 5 Work items and estimated time

Item	Expect time
Data analysis	1 month
Procuring equipment and system establishment	3 months
System integration	1 month
Modifying system parameters	1 month
Post-operation adjustments	1 month

Chapter 8 Conclusion

8.1 Classification Method of Interference Signal in HF/VHF/UHF

Interference signals are mainly divided into four types in HF/VHF/UHF: co-channel interference, adjacent channel interference, Harmonic interference and Intermodulation interference.

8.2 Calculation Method for Judging Interference between Radio Systems

Until now, the most radio wave interferences are caused by excessive transmitter power or improper frequency separation. By calculating the link budget of the signal, we can figure out whether the receiver can receive the signal from the transmitter. Therefore, the link budget estimated from the difference between the link budget and the background noise, and the upper limit of the attenuated power value is used as the basis for judging interference. Similarly, in the estimated formula, it can be known that the higher power, the stronger signal strength will be received at the receiver, the higher probability that it will interfere with other useful signals. However, these calculation methods often require parameter values related to the propagation path to determine whether it is an interference event caused by an abnormal signal.

8.3 Radio Coverage Assessment Mechanism Based on Region

The radio wave coverage simulation model is used in this project is the ITM model. Our simulation tool is radio mobile online and its simulation frequency range covers from 20MHz to 20GHz. At the same time, it also incorporates parameters such as antenna type, polarization direction, refraction, dielectric constant of different materials, various climate zones and path parameters. In other words, this model has an important advantage in that it can take into account more different parameters to allow that users can modify the adaptive adjustments when their needs and also make it more widely usable in various places.

8.4 Selection of Monitoring Stations and Analysis Scheme

We select the detection sites for the amateur radio and flying channels is based on the following four criteria: (1) the range of monitoring site includes a significant signal source, (2) it has the special function or the location of the monitoring station is close to the airport or a representative metropolitan area, (3) the particularity of the possible signal sources is covered by the monitoring station's geography such as the wide range of monitoring coverage and (4) the collected monitoring station data has special or abnormal information.

8.5 Data of Monitoring System Collection and Analysis Scheme

In Chapter 2, it describes the process of collecting and processing monitoring data via flowchart. Then, the signal calculations in our system can be used as a preliminary interference early warning mechanism to reduce the chance of mutual interference between services.

8.6 Spectrum Utilization Analysis

In chapter 2, it calculates the spectrum usage rate in one day. Since the spectrum is a limited resource, the spectrum utilization evaluation mechanism can determine whether there are any available frequencies based on its spectrum utilization.

8.7 Spectrum Monitoring Data Normalization

In Chapter 4, it describes how the system is used and its operational analysis principles. Through actual case analyses, it has also successfully obtained the suspicious interference frequency band. It further explains the flaws of the system as well as restrictions on its use.

8.8 Analysis of Interference Cases

In Chapter 5, it introduces with the analysis of the causes of interference from mobile communications, amateur radio, and broadcasting stations. Then, we analyze the causes of interference through the alarm classification result map of Taipei North District Station. Finally, the suspected interference frequency bands are found.

8.9 Analysis of The Interference of Airline Channel Communication and Broadcasting Channel Signals

In this project, we select the Songshan Airport as an analysis case. The analysis of the cause of the flying channel communication interference by the broadcast station signal can compare the frequency spectrum and the assigned frequency to distinguish the main frequency and possible interactive modulation signals. Then, in the abnormal continuous waveform, we will discuss the influence of different radio frequency modes on the background noise.

8.10 Expectation Effect

According to project research, this early warning mechanism system has been effective in data processing. If it is successfully integrated with existing systems and implemented in the future, then it can effectively improve the effective use and the management of spectrum resources. In addition, it also can quickly detect and eliminate overseas and domestic radio interference to improve Taiwan’s capabilities in spectrum management and interference processing.