Coastal Surveillance and Detection of Intruder – A Mechanism using Antenna Arrays

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Abstract.

In this paper the Intrusion Detection over a wide coastal line is tested using the developed Antenna Arrays on a Laboratory Setup as well as the live coastal region. The foundation of implementation methodology is laid on the Microwave Detection mechanism where Microwave beams are used in the sensor technology, where a transmit antenna generates the beams to form a spot on the receiver. If the receiver detects a difference in the received power, the system immediately begins to analyse the intrusion possibilities and, if the predetermined conditions for an incursion are met, an alarm is sounded to alert the control room. The system is capable of working even in non-favourable weather conditions. The entire system was implemented and tested at Laboratory in a simulated environment as well as live on the river site in Ahmedabad. As a result the data obtained from the simulated laboratory environment and river site were deeply analysed through 'Digital Signal Processing Techniques". The outcomes obtained are encouraging, where human and non-human intrusions were detected, after 'Digital Signal Processing' with an existing 'Edge Gateway Electronic System' located near the receiver antenna at the coastal site .

Keywords. Microwave Technology, Device free localization, Transmission and Receiver, Gain and Power

1. INTRODUCTION

India has a long coastline with a thriving fishing sector that relies on the resources of the sea. As previous occurrences have demonstrated, effective surveillance with tracking of the coast is very important to maintain the nation's security and economic strength. The paper referred [1] presents two radio frequency sensors with different directivities designed and tested for device-free localization in an indoor environment. Mostly, in smart homes and smart offices, people may be irritated by wearing the device on them all the time. As compared with device-based localization, the proposed sensors can localise dynamic targets without affecting the privacy of the people around. Both sensors are tested to detect the change in received signal strength (ΔRSS) due to the presence of an obstacle. RF sensors operate in the ISM band of 2.4–2.5 GHz frequencies.. Experimentation shows that the higher directivity provides better ΔRSS [1]. The designed Microwave imaging system is based on Microwave Object Detection Algorithms that will be able to detect human and other 'intrusive' objects without human intervention. [2] The sensor node will efficiently send the sensor data to the hub through wireless link. The prototype model is set up in the simulated lab to address the detection of intrusion sensing, alarm communication and assessment. The algorithm based on correlation method is employed for intrusion detection in long, flat, narrow geometrical zones/border areas [3]. Advancements in 'Microwave image processing' have been recently proved as promising imaging tools, which could play a fundamental role to efficiently manage emergencies related to stroke and haemorrhages. This paper focuses on the radar imaging (through microwave sensors) approach and in particular on the processing algorithms of the backscattered signals. [4] Assuming the use of Microwave Imaging Space-Time beamforming algorithm, Artefacts removal is an essential step of any microwave radar imaging system and currently considered artefact removal algorithms have been shown not to be effective in the specific scenario of brain imaging [5]. The reliable prediction of coverage footprint resulting from an airborne wireless radio base station, is of utmost importance, when it comes to the new emerging applications of air-to-ground wireless services. [6] These applications include the rapid recovery of damaged terrestrial wireless infrastructure due to a natural disaster, as well as the fulfilment of sudden wireless traffic overload in certain spots due to massive movement of crowds. In this paper, we propose a statistical propagation model for predicting the air-to-ground path loss between a low altitude platform and a terrestrial terminal.[7] A fast microwave imaging method for brain stroke detection is presented. The method estimates the power distribution of the scattering waves inside the head based on the measured multistatic scattered signals around the head. [8] In that regard, Average Trace Subtraction (ATS) and Bessel function are used to remove the background reflections and calculate the scattering electromagnetic waves in the frequency domain. [9] The imaging algorithm is verified using a round-shaped 8-element antenna array which surrounds a realistic head model in the simulation environment. The obtained images using the presented technique demonstrate its ability in brain stroke detection and localization. [10]

2. Test setup and Data collection

Figure 1 illustrates the Lab setup for capturing the experimental data. The input signal (0 dB) of 10 GHz is fed to the RF amplifier. The transmitting gain is set to 20 dB. The RF amplifier power is fed to the transmit antenna.

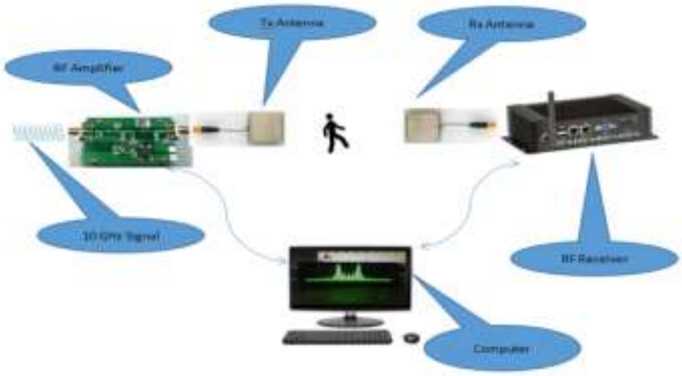

Figure 1. Schematic block of Test setup to capture intruder data.

A receiving antenna is connected to an RF receiver on the receiver side. The computer is connected to an RF receiver to collect the signal of the receiving antenna. The data was captured at every step of the intrusion and were recorded on the computer.

The detailed functioning of receiver and transmitter are illustrated in terms of block diagram as shown in Figure 2 and Figure 3 respectively.

As an intruder moves from top to bottom at different distances from Tx-antenna, the power drop pattern changes as tabulated in Table 1. The scale of the model is scalable by controlling the transmit power for desired distance from 1 to 10 kilometers. The developed patch antenna framework is designed to work under the scale factor of 1:100 under the Lab framework.

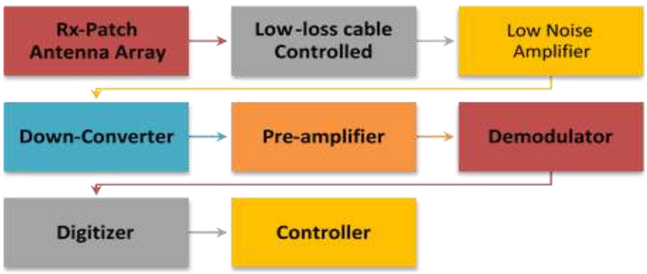

Figure 1.2. Block diagram illustrating the functioning of Transmitter

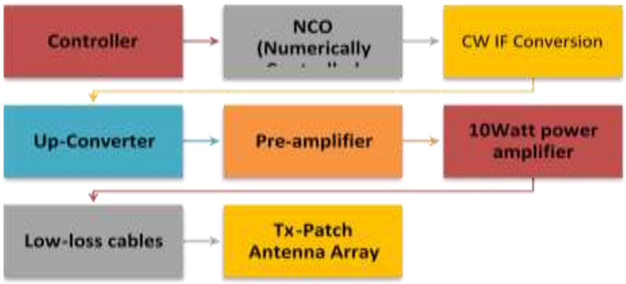

Figure 1.3. Block diagram illustrating the functioning of Receiver

3. Results and Discussion

Under the research the target parameters of power drop 20 to 22 dB, distance of 8 to 10 km. Through the adopted methodology, the target achieved as 19 to 22 dB attenuation with human intrusion, and 10 km and with enhanced parameters of Rx-receiver, it can be achieved as high as 25 km.

The reasons for the difference are environmental conditions, inaccuracies in sensor fabrications and instrument errors. The excellent data were received in the Lab condition which are tabulated in Table 1. Considering safety against the high power RF radiations, the transmitter power is kept at a safe level of less than 10dBm.

For calculating the scalability of the model used in the Lab, the following equation, which will calculate the Free Space Path Loss at given frequency.

$$FSPL = 20\log d + 20\ lof\ f + 20\ lof\ (4\pi c) - G\ (T_x) - G(R_x) \qquad (1)$$

Here, G(Tx) and G(Rx) are the gain of the transmitting and receiving antenna respectively, whereas d is the distance between the antennas.

In actual site conditions, d = 10 km. f = 10 GHz, G(Tx) = 14, G(Rx) = 14. Transmitter amplifier gain = 2, Receiver amplifier gain = 60. Free space path loss = 71 dB.

The distance between transmitting and receiving antennae of 10 km are comfortably detectable with the sensitivity of the receiver of -60 dBm. The distance can be increased 25 km by increasing the sensitivity of the Rx-receiver by 10 more dB.

Table-1 shows the statistics of the received power based on the intruder entering tangential to the ‘beam’ and the distance from the Tx sensor.

Table-1 data received against the movement of intruder

	Distance from Transmitting sensor in Meters (m)								
Step No	**1m**	**3m**	**5m**	**7m**	**9m**	**11m**	**13m**	**15m**	**17m**
Step 1	1.3	1.2	1.1	1	0.9	0.75	0.5	0.3	0.15
Step 2	1.4	1.3	1.2	1.1	1	0.9	0.6	0.45	0.3
Step 3	1.5	1.4	1.3	1.2	1.1	1	0.75	0.55	0.4
Step 4	1.6	1.5	1.4	1.3	1.2	1.1	0.85	0.62	0.46
Step 5	1.7	1.6	1.5	1.4	1.3	1.2	0.95	0.75	0.55
Step 6	1.9	1.8	1.7	1.69	1.63	1.23	1.09	1.04	0.8
Step 7	2.8	2.5	2.43	2.05	2.01	1.98	1.87	1.54	1.38
Step 8	3.6	3.45	3.37	3.2	3.08	2.5	2.03	1.6	1.4
Step 9	5.58	5.15	4.72	4.05	3.7	2.8	2.23	2.03	1.9
Step 10	11.66	11.2	10.74	9.8	8.9	8.44	7.96	7.5	7.04
Step 11	16.32	15.9	15.45	14.93	13.8	13.38	12.96	12.5	12.08
Step 12	22.1	21.1	20.11	19.11	18.11	17.11	17.62	17.14	16.66

Step 13	22.5	21.5	20.5	19.4	18.4	17.4	20.42	19.92	19.44
Step 14	22	21.2	20.21	19.21	18.21	17.96	17.54	17.11	16.69
Step 15	15.94	15.5	15.05	14.3	13.3	12.86	12.42	11.98	11.54
Step 16	10.3	9.9	9.5	8.89	7.9	7.5	7.1	6.7	6.3
Step 17	4.88	4.5	4.12	3.46	2.87	2.66	2.28	1.87	1.49
Step 18	3.7	3.56	3.43	3.21	2.63	2.39	2.16	1.76	1.34
Step 19	2.9	2.76	2.64	2.57	2.38	2.27	2.05	1.63	1.21
Step 20	1.8	1.68	1.53	1.42	1.35	1.26	1.17	1.04	0.85

To eliminate the noise and interferences, the received signal was sampled at 100 times in the second and was averaged on 100 datasets. So, one sample is connected at every second. The noise and interference is further reduced by applying 6^{th} order polynomials, and the detection ability increases and falls alarms get reduced significantly. To remove static background, multiple backgrounds have been generated. One will be a master background, which will be derived from several backgrounds under different light and tide conditions. Besides, floating vegetation, leaves, etc has been removed to detect the target efficiently.

Through the experiments, it is found that the received power fluctuates within 1 to 2 dB. If human or human sized objects intrude between the transmit and receive sensors, the power received on the receive sensor falls down by 7 to 10dB than nominal power received at the receiving sensor under “no intrusion” conditions. . Based on the geographical and environmental conditions of the site, the “Alert threshold” is set between 3 to 5dB. Drop in received power is the function of the object size and the distance from the transmitting sensor.

The Microwave Imaging can be optimized for many more use cases. Microwave imaging approach enhances to detect and identify unknown objects and security threat level detection as well.

4. CONCLUSION

This paper provides a method of the end application of the customised patch antenna arrays fabricated using highly customised dielectric material. The effect of the intruder is tabulated, which numeracies as the drop of the received power as function of the size and speed of the intruder.

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Biographies

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