

Contriving State of the Art Strategies to Aid Armed Forces by Applying RF 3D Imaging Techniques in Real Time

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Abstract - Military power is an inexorable consideration for any nation that wants to project itself as a strong and developed country. With technological advancements, there have been subsequent advancements in various fields, but not much of an improvement in the gears used by the military. There are situations that demand the execution of rescue operations such as terrorist attacks and fire accidents. The objective of this project is to make a remarkable enhancement in the subsisting military defence techniques using RF 3D imaging sensors. It would enable soldiers to visualize objects existing around them which are hidden from their sight. The details of a concealed location can be obtained by collecting outputs from multiple sensors placed in different perspectives of the region. The outputs are combined to create an abstraction of the inside which enables the military personnel to take an informed decision and devise strategies accordingly. The live movements inside the area can be tracked by increasing the RF which can help the soldiers to calculate the time and direction to strike. So, incorporating artificial intelligence techniques to such sensors can aid the armed forces to defend better by helping them to derive precise inferences.

Key Words: Radio Frequency (RF); Imaging; Sensors; Internet of Things; Range

1. INTRODUCTION

The RF 3D Imaging sensor is a System on Chip (SoC) that is an integrated circuit that provides high-resolution images for a wide variety of machine vision applications, including robotics, transportation, smart buildings, security, and retail. RF 3D imaging SoC accommodates an emitter and a receiver. The emitter emits radio waves and the receiver detects the reflection. To obtain an accurate view, these sensors use transceivers that emit RF signals of various frequencies - low frequencies to penetrate materials and high frequencies to detect slight movements and provide angular resolution. Since low frequencies pass through materials, the sensor can scan through solid surfaces, creating a 3D image of what's behind. Unlike X-Ray vision, where the wavelengths are about four million times shorter than that of radio waves, the RF waves do the job much more effectively. While the distance to a material's surface can be calculated based on the amount of time the receiver takes to pick up the reflected waves. A method known as frequency sweeping is used to determine the composition of different materials based on the attenuation of the reflected

waves. The RF imaging sensor network takes multiple measurements and estimates whether a particular zone is safe based upon the distance between the sensor and the object. The output fetched from the sensors are compiled together.

2. EXISTING SYSTEM

Night-vision and thermal imaging are the two commonly used technologies on the battlefield. Soldiers make use of night vision to illuminate darkened surroundings while thermal imaging is used to illuminate darkened targets. But until very recently, soldiers have had to carry separate imaging systems for each, which has a counter positive impact on how swiftly they can switch optics and acquire their targets. These two optic approaches are therefore prone to compromising on the soldiers' safety and reducing the overall effectiveness of the mission.

2.1 T-7 Thermal Goggles / Binoculars

The T-7 thermal imaging binocular/ goggles take an intelligent approach to individual military imaging systems. Innovative engineering allows the user to realize the complete potential of thermal imaging performance while maintaining a familiar form factor that easily mounts to most existing night vision helmets and head mounts. Head mounted to standard military or law enforcement helmets, the T-7 thermal binocular is a potent thermal goggle system capable of hands-free thermal imaging during dismounted scenarios. The T-7 thermal binocular is a rugged thermal imager when hand-held. By adding one of several long-range telephoto thermal imager optics, the T-7 thermal binocular converts into a futuristic thermal binocular system for intelligence gathering at a safe stand-off distance.

2.2 Enhanced Night Vision Goggle III and Family of Weapon Sight-Individual (ENVG III/FWS-I) program

BAE Systems has recently announced a new kind of optic that encompasses the functionality of both, night vision as well as thermal imaging, into a single package. With the optic itself being mounted on the soldier's rifle, what it detects is transmitted via a Bluetooth connection to a head-mounted display. This allows the war fighter to quickly switch between the two modes with just the press of a button. It features a Rapid Target Acquisition (RTA) Module to exponentially reduce target engagement time. This

innovative solution uses a wireless connection to channel the weapon sight's aim point and surrounding imagery directly into the soldier's goggle. This enables soldiers to quickly locate and engage targets from any carry position, without having to shoulder the weapon itself. This capability also allows soldiers to accurately engage targets while still maintaining full cover for heightened survivability.

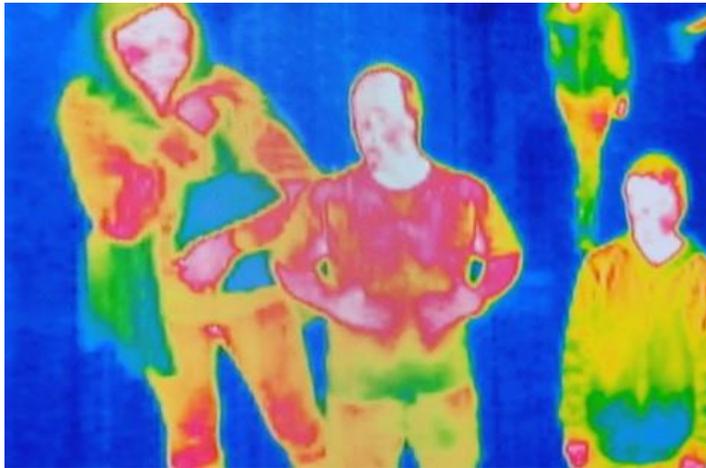


Fig -1: Thermal Image

2.3 Limitations

1. Soldiers cannot see through solid surfaces and detect what's present behind them.
2. Soldiers cannot see through fire flames.
3. Motion identification, beyond the human sight, isn't possible.
4. It is not possible to calculate the exact distance of objects or people from a particular region and so determining whether a particular zone is safe or dangerous becomes a difficult task.

3. PROPOSED SYSTEM

A System is built by incorporating multiple RF 3D imaging sensors using IoT (Internet of Things) techniques. Each sensor has a range of 10 m. The sensors are placed in such a way that they capture a location from different perspectives. To obtain an accurate 3D view, these sensors use 72 transceivers that emit RF signals of various frequencies - low frequencies (~ 3 GHz) to penetrate materials and high frequencies (~ 81 GHz) to detect even the slightest movements and provide angular resolution. Since low frequencies pass through materials, the sensors can efficiently scan through solid surfaces, and use image processing techniques to create an image of what's behind them. Image stitching algorithms are then used to create an image combining all the images obtained by each individual sensor. Thus, it is possible to determine the opponents'

strength which enables the military personnel to take informed decisions and devise strategies accordingly.

A method called frequency sweeping is used to determine the composition of different materials based on the attenuation of the reflected waves. Each material absorbs and reflects various frequencies in distinct ways which allows observers to distinguish between them, much like an object that reflects red light is discerned by the observers as a red coloured object. By measuring the reflected waves at each frequency, the sensor can identify the composition of substances. For instance, the percentage of metal and plastic in a firearm can be determined using this method. Therefore, the veterans can determine the damage factor of the weapons that are likely to be used against them by learning their compositions and studying them further based on the acquired information.

The RF imaging systems work in a highly precise manner. They take multiple measurements and estimates whether the particular zone is safe. To take a measurement, each transceiver sends radio waves in unique sweeping pattern of frequencies. As the reflected waves are received one at a time, the chip's integrated digital signal processor (DSP) uses a sophisticated algorithm to calculate distances and generates a image based on hundreds of individual measurements. The sensor is accurate enough that it can detect a person's position and movements and even breathing patterns, using a combination of Doppler shift and positional changes, based on which the soldiers on field can accordingly determine the exact moment to strike.

3.1 Sensor Specification

- 72 Transceivers.
- Frequency Range: ~3 GHz to ~81 GHz.
- Range of Coverage: 10m.



Fig-2: Vayyar RF 3D Imaging Sensor

3.2 System Architecture

The System is built by combining multiple RF 3D Imaging sensor through IoT (Internet of Things) techniques. The output from these sensors are stored for performing the required image processing operations. These outputs are fetched from the storage and stitched together to generate a single image. The Safe zone identification algorithm is then used to determine whether the specific zone is safe or dangerous by calculating the distance of the opponents and their weaponry from it.

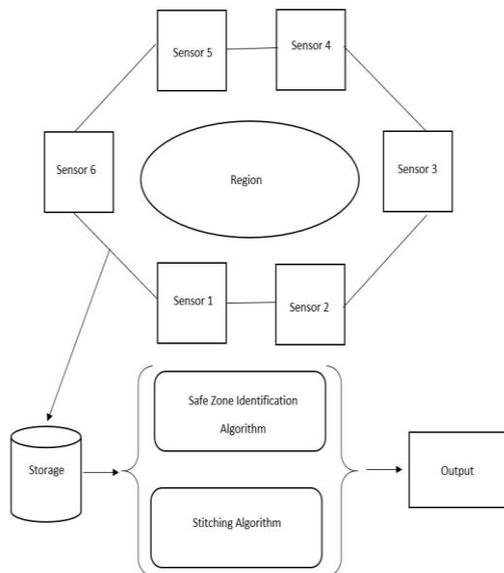


Fig-3: System Architecture

4. CONCLUSION

There are lots of limitations in the subsisting methods such as being unable to see through solid surfaces and calculating distances of objects from the target point. It requires lot of time to manually overcome these limitations. The proposed system eliminates all the curbs of the subsisting systems. By using multiple 3D RF imaging sensors to obtain images of an area from different perspectives, an overall combined image of the region can then be obtained by using image stitching algorithms. The opponent's power can thus be determined. Along with this, the distance of a specific zone from the opponents and their weaponry can also be obtained, based on which it can be determined whether the zone is safe or dangerous. Depending on these conclusions, the workforce can strategize accordingly and strike at the perfectly apt moment, giving them a hidden advantage over the opponent.

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