Design and Analysis of Airborne Thermo Graphic Cameras for Night Vision in Maritime Surveillance Applications

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Abstract:- **In this paper, we endeavour to discuss and analyse the operation of a thermographic camera embedded in an airborne vessel (surveillance aircraft) for maritime surveillance applications subject to properties such as response time, range, imaging time, suitability of material for infrared detection, resolution and contrast enhancement, operating temperatures, etc for given wavelengths, to work towards an optimal design.**

Keywords **– Night Vision Imaging, Thermal Imaging, Heat signatures, Target Detection, Surveillance, Infrared Detection, Airborne Target Acquisition devices**

I. INTRODUCTION

To ensure complete maritime security, surveillance and reconnaissance operations are required to be conducted round the clock for keeping a check on intrusions into territorial boundaries as well as for Search and Rescue (SAR) operations. But how does one effectively achieve the same during night, in near-absolute darkness? A reliable technique is the use of thermographic cameras1 that can sense and detect surrounding information despite the lack of visible light and other obscurities like dense fog, smoke, rain, etc2. These cameras, that sense infrared radiation, function quite differently from other Night Vision Devices (NVDs) in principle3. For example, these generate pictures from ambient heat, not light. As all objects radiate some amount of heat, the technique can be used to produce real-time images of the object viewed through the camera from the heat that it emits. This is essentially the infrared signature4 of the object and can be used to analyse its features such as shape, size, temperature, position, etc using different modeling techniques5. The images formed can be monochromatic or pseudo-coloured (with a temperature scale), with every colour corresponding to a specific temperature of the body. That is, hotter objects appear brighter in monochrome than cooler objects (that appear dark). The temperature pattern or thermogram7 can be used to see in the dark through a forward or side looking infrared detector and locate targets that pose a threat to coastal security.

II. METHOD

It was endeavoured to analyse thermographic cameras for use in maritime surveillance applications and the research component was divided into three sections – first, literature study, that is to understand the operating principle of this type of vision devices to be able to study their design better. Second, a basic block diagram, devised to delineate the aforementioned principle, especially for use in maritime security and surveillance. Third, design description and performance which includes the overall performance of this system when placed on an aircraft. The following section explains the methodology adopted for the same:

1. Literature Study

The global market of Infrared Imaging and Near-Infrared Imaging is expected to reach USD 471.2 Million by 20208. The increasing popularity and productivity is evidently implied from the various applications9 of the technique. Thermal imagers are used for search and rescue operations10 in remote areas, warning drivers during night-time driving, monitoring active volcanoes11, forest fires, maritime patrol and many more. They have recently also been exploited for medical diagnosis applications in cancer12 detection, burns analysis, etc. The diversity in the way these cameras can be used not only makes one wonder the enormous potential that rests in this technique but also provides greater incentive to try and apply it to different situations.

Thermographic or night vision cameras on aircrafts are used to help pilots see in near-absolute darkness, when little or no light is available for amplification. These cameras use infrared detection and temperature mapping to create a picture in order to detect warmer targets against a relatively cooler background. They can also be used to steer the aircraft at night and in inclement weather, thus enabling pilots to detect and react to unfore„seen" circumstances while patrolling over maritime sea lanes.

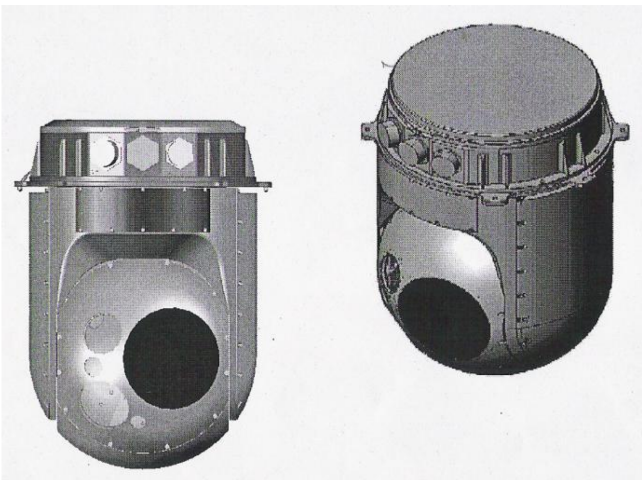

Fig. 1. Forward Looking Infrared System used in Maritime surveillance.

For maritime surveillance14, they are deployed as Forward Looking Infrared devices in an isolated chamber (gimbal-mounted structure) that allow a wider field of view while also keeping the uncooled thermographic camera in near operational temperature for imaging in visible light and near-infrared ranges (0.4 to 1.0 µm).

The operating principle of thermal imaging includes the fundamental principles of radiation, convection and conduction2. Every object radiates energy by the constituent black body radiation. The infrared sensors sense this radiation in the infrared range by focusing the same though the same and create a very detailed temperature pattern also known as thermogram. This pattern is then used to distinguish between the heat signatures of the objects in the scene focused by the thermal imager, using a special signal processing unit13 which runs the scene on a dedicated display. Sometimes temperature mappings are done to add pseudo-colour or false colour into the captured pictures that allow better visibility and detection. In Maritime surveillance, these cameras help in law enforcement through information on enemy intrusions and infiltrations through the sea, particularly during night. A real time image of scenery is generated in the infrared spectrum radiation at night by the following steps: The IR detector captures the thermal image; the output electrical signal gets converted to a video signal; the processed signals is translated to a TV picture on which the various temperature and emissivies appear as different brightness. Cooler objects are translated to darker colours, while brighter objects get converted to light colours, mostly white1.

The advantage of thermal imaging15 over night vision, that makes it suitable for covert surveillance operations, is predominantly that infrared images are difficult to camouflage. Additionally, infrared sensing is difficult to intercept by the enemy as, unlike radars, no energy is radiated by the device itself. The camera can also see through inclement weather conditions like fog, rain, dense clouds, etc.

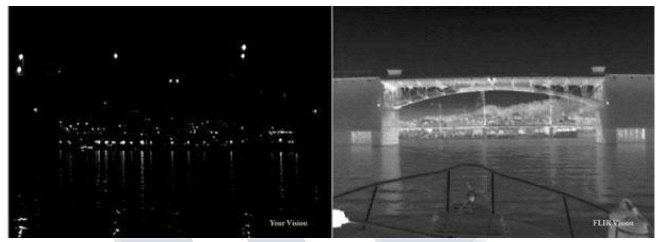

Fig. 216. Naked eye night vision versus thermal imaging using forward looking infrared imaging

2. Block Diagram

A descriptive diagram of the aforementioned principle can be illustrated as

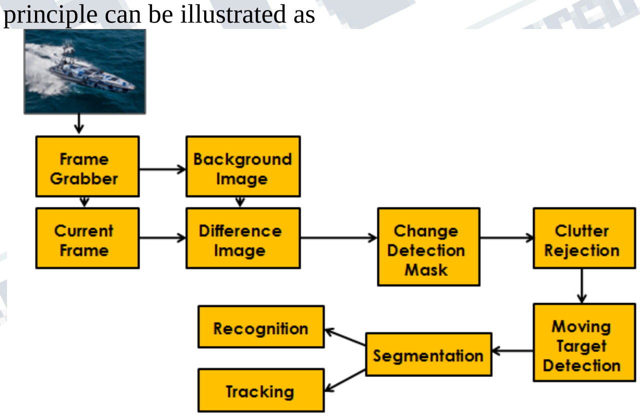

Fig. 3. Block Diagram of Infrared Imaging using Thermographic Camera

3. Design Description and Performance

For efficient aerial scanning, thermographic cameras are deployed on aircrafts for maritime surveillance. Endeavours are made to analyse the design of these cameras, as a trademark of FLIR™ systems3 used in coast guard patrol.

The basic design makes provisions for Detection and Recognition ranges based on the lens used. In the device used for analysis:

Detection range is approximately 30 km while recognition is possible for upto 22 kms, with the required target discrimination range as 50m between 2 targets. The parameters for camera rotation are 70° to -90° elevation and 360° azimuth, therefore no restriction.

Performance metrics that are considered in this study for the camera sensors include response time subject to the signal processing unit, device stability, efficiency, imaging time, suitability of material for infrared detection, resolution and contrast enhancement. These metrics will be analysed in the course of the study in order to work towards and optimal design17.

Fig. 43,6. Indicative image of infrared detection and imaging by FLIR during night.

III. CONCLUSION

In conclusion, it can be reported that airborne thermographic cameras provide an efficient means of ensuring maritime surveillance by the principle of infrared detection over the seas for search and rescue operations as well as reconnaissance. Maritime patrol and law enforcements can be achieved by aerial scanning using these cameras to keep a check on ingress and infiltration. The camera can also be interfaced with encoding altimeters, GPS and other flight path aiding devices. An optimal design of the camera will further assist through better, swifter performance, thus enabling to perceive potential threats and take informed decisions to counter the same.

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