Improving night vision system by implementing thermal imaging cameras

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Abstract

Safety and security of life are the two most booming words in the field of transport and manufacturing. The safety of the people both inside and outside the vehicle is of prime concern in the automotive manufacturing industry. Driving at night can be very different from driving during the day. Night driving increases crash risk for all drivers. Thus, after dark, chances of being in a fatal vehicle crash go up sharply, though the traffic is way down. In view of this, in this paper, one of the possible ways of improving the night vision system in automotive is supported through various data. An Automotive night vision system is system to increase the vehicle driver's perception and seeing distance in darkness or poor weather beyond the reach of vehicles head light. Currently, the night vision system is offered as optional equipment on certain premium vehicles the camera is connected to the front grill of automotive. It senses the images in the form of electronic signal and then sends it via cable to the LCD screen which helps the driver for his convenience. Therefore, implementing thermo-graphic camera/Infrared camera in the automotive industry can help to avoid or minimize the accidents, mainly during night.

Literature survey

Pre 1940's flares and spot lights were used for operations at night. Due to the nature of this early night vision device (NVD), they gave away tactical positions. Military scientists began to think of improve night vision to gain a strategic advantage. The first night vision device (NVD) was created during the world war-2 by placing an infrared filter over a search light. Fighters were use special binoculars to see using the light from this night vision method. This way infrared light was used to visualize the things in the dark.

Several accidents showed that driving at the night represents a significant potential danger. In Germany, ~50 % of the fatal car accidents happen at night, although an average of the 75 % of all driving is during a day. A similar situation is found in USA. About 28 % share of all driving, 55 % of all fatal accidents occur at night. Accidental statistics throughout Europe as a whole also justify intensive consideration of the issue of nocturnal driving. According to estimates, ~ 560,000 people injured in the dark and ~23,000 are killed. Over 25,000 accidents per year involving pedestrians and cyclists occur during the night in Germany. The reason are obvious as poor or significantly limited sight conditions on highways and country roads, obstacles or narrow bends which are recognized too late with low beam, inappropriate judgement of the speed or distance due to lack of the orientation for the eye, driving into the “black hole” of the head lights of oncoming traffic. These challenges were overcome by using night vision system which uses thermal detection method to detect heat on objects and there by alerts the rider.

1. Introduction

The accidents that occur on roads during night times mainly owe to the poor visibility and make the drivers rather than driving ahead, predict their way ahead. But this is not just the case of drunken drivers but also sensible drivers who find very bad visibility during the early morning or the odd evenings. That makes the use of night vision systems which uses infra-red sensors or headlights to provide a clear view of the road ahead.

Before knowing about the night vision systems it is necessary to understand about light, the electromagnetic spectrum and the infrared radiation. Light or visible light is electromagnetic radiation within the portion of the electromagnetic spectrum that is perceived by the human eye. Visible light is usually defined as having wavelengths in the range of 400–700 nanometres, between the infrared and the ultraviolet. The electromagnetic spectrum is the range of frequencies of electromagnetic radiation and their respective wavelengths and photon energies. Infrared radiation (IR), sometimes referred to simply as infrared, is a region of the electromagnetic radiation spectrum where wavelengths range from about 700 nanometers (nm) to 1 millimeter (mm). Infrared waves are longer than those of visible light, but shorter than those of radio waves.

Humans are visible only to the rays falling under the visible region of electromagnetic spectrum and are invisible to both the infra-red as well as the ultra violet region of the electromagnetic spectrum. But night vision technology makes it possible for the humans to view the rays felling in the infra-red region of the electromagnetic spectrum, that is generally the night vision systems used in automobiles captures the infra-red image of distant obstacles on road as every object emits infra-red rays (heat rays) even during night. This image is viewed in a screen and the driver can thus apply the brakes as required.

1.2. INFRARED RADIATION

Infrared radiation (IR), sometimes known as infrared light,is electromagnetic radiation (EMR) with wavelengths longer than those of visible light. Hence, it is undetectable by the human eye, although IR of wavelengths up to 1050 nanometers (nm) from specially pulsed lasers can be seen by humans under certain conditions. Most of the thermal radiation emitted by objects near room temperature is infrared. As with all EMR, IR carries radiant energy and behaves both like a wave and like its quantum particle, the photon. Depending on the wavelength and frequency, infrared is commonly divided into five categories as near-wavelength, short-wavelength, mid-wavelength, long-wavelength and far-infrared. Some of the applications of Infrared waves are -Heat Source, Infrared Communication, Infrared Photography, Massage Therapy, Astronomy and cosmetology Applications.

2. THERMAL IMAGING CAMERA

Thermal imaging cameras are handheld electronic devices with an integrated visual display, designed for detecting heat energy.The key component of a thermal camera is a heat sensor attached to a special type of lens, which is then adapted to work alongside standard image-capture technologies. This allows engineers to quickly identify regions of excessive temperature or sources of wasted heat energy, such as overheating components or potential thermal insulation gaps in building inspection.

Visible light forms only a small part of the electromagnetic spectrum, and the only part we can actually see. When pointed at an object or area, the sensor on a thermal detection camera allows the user to view the otherwise invisible infrared spectrum, which exists at wavelengths between visible light and microwaves.

This is often rendered as a color map in modern IR cameras, although black-and-white displays are still preferred for certain applications due to their reduced visual 'busyness' and improved capture of fine detail.

On a color thermographic display, warmer components or regions will show up as reds, oranges and yellows, while cooler parts will typically be shown as purples and blues, while green usually indicates areas that are roughly at room temperature. Because they measure infrared radiation, and not visible light, thermal cameras are also useful for identifying heat sources in very dark or otherwise obscured environments. Quality thermal imaging cameras are often sold in the UK in a selection of user-friendly ergonomic designs and offer temperature detection capabilities spanning a broad range of heat sensitivities. This makes them a valuable companion to emergency response units, medics, product manufacturers, engineers and maintenance workers across a wide variety of industries as well as an increasingly affordable option for many different types of hobbyists and enthusiasts at home.

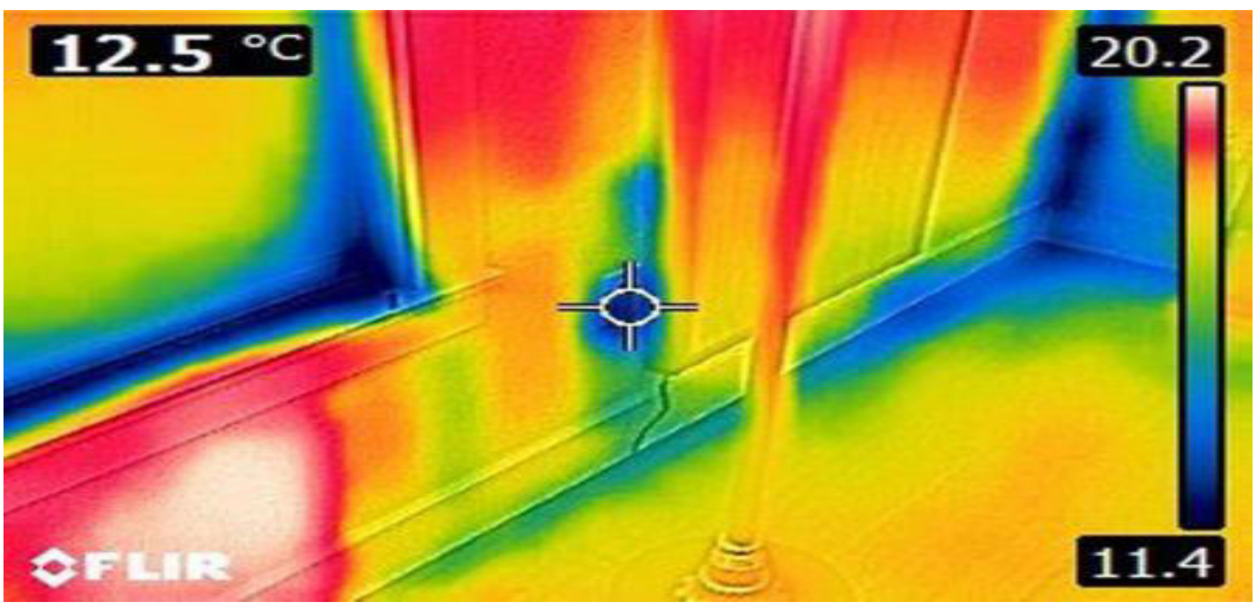

Figure 1: Uses of thermal imaging cameras

Beyond basic engineering applications, the emergency services are among the more familiar users of thermal detection cameras today. The technology is deployed regularly in scenarios including firefighting, night-time police pursuits, and disaster response search and rescue. Some of the other applications are as follows:

-Thermal security cameras

-Thermal imaging cameras for wildlife

-Thermal imaging cameras for Apple & Android devices

-Thermal imaging cameras for fire detection

-Thermal cameras for drones

3. The history of thermal imaging cameras

It is only in the past few years that the mass production of thermal imaging technologies has reached a point where handheld thermographic cameras (also known as heat cameras, thermal detection or infrared cameras) are now an accessible option for most civil applications and/or hobbyist use. However, viewing heat energy as an infrared spectrum display is not actually a new concept by any means; in fact, the roots of the basic thermography principle were established more than 200 years ago by the German-British astronomer William Herschel.

In simplified terms, Herschel was the first to discover the presence of infrared, all the way back in February 1800, while using a prism to study the visible light spectrum. Herschel could place a thermometer just beyond the red light end of the spectrum to detect the existence of a hitherto unknown invisible band, warmer than any of those in visible light. Today, we refer to this invisible band as 'infrared' radiation, which lies between visible light and microwave frequencies on the electromagnetic spectrum.

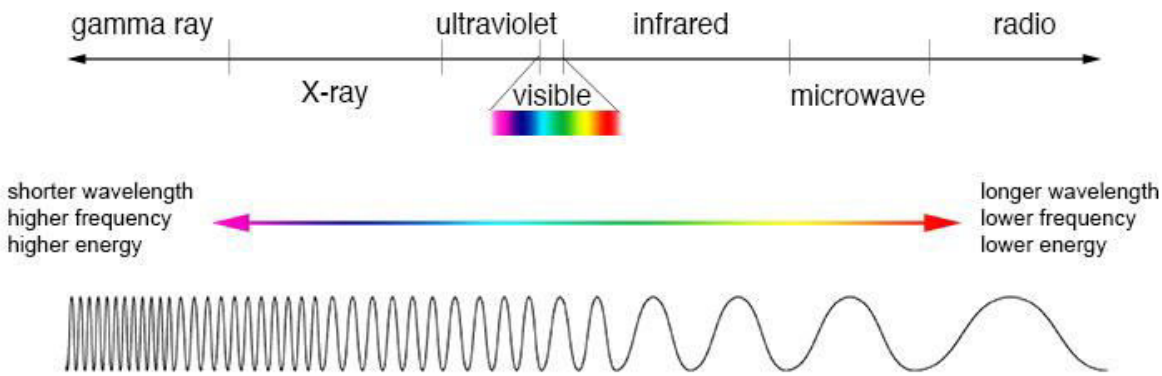

Figure 2: Electromagnetic spectrum

Although thermal imaging camcorders were still a long way off, Herschel's findings were quickly used to produce a number of early thermocouple-type modules, which could detect the unseen heat emanating from warm bodies at a considerable distance. His initial discovery was further developed by many other physicists, engineers and inventors in subsequent years.

4. Thermal Detection

Thermal, or infrared, detection systems utilize sensors to pick up radiation in the infrared part of the electromagnetic spectrum. An infrared camera detects the thermal energy or heat emitted by the scene being observed and converts it into an electronic signal. This signal is then processed to produce an image. The heat captured by an infrared camera can be measured with a high degree of precision. This means that infrared cameras can be used for things like checking thermal performance and determining the relative seriousness of problems associated with heat. The higher the temperature of a body or object, the more radiation it emits.

Contrary to popular belief, infrared cameras cannot see through walls or other solid objects. They can only measure the heat emitted by the scene being observed. A thermal image of a wall, for example, will show the flow of heat through the wall if there is a heat source behind it, but it cannot "see" the heat source itself.

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However, in the part of the electromagnetic spectrum from 0.7 µm to 4 µm, infrared radiation is measured according to the light reflected off of the material or scene being observed.

4.1. The Schema

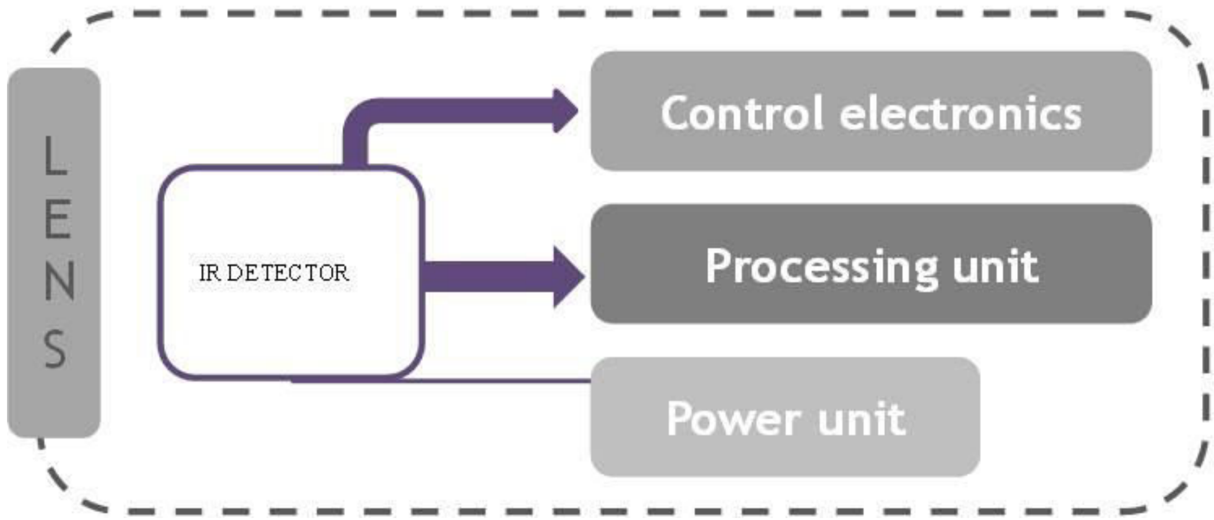

Figure 3: Schematic representation of thermal cameras

Thermal cameras are made with either cooled or uncooled infrared detectors. Cooled detectors deliver better image quality and precision, while uncooled detectors are less precise but also less expensive. Cooled infrared detectors must be coupled with cryogenic coolers to lower the detector temperature to cryogenic temperatures and reduce the heat-induced noise to a level lower than that of the signal emitted by the scene. Uncooled image detectors do not require cryogenic cooling. They are designed using a device called a microbolometer - a special type of bolometer that is sensitive to infrared radiation.

When the camera's sensor picks up infrared radiation, the data is converted into a colored representation of the scene. The camera's settings can be adjusted before an image is taken to show different temperature gradients. Depending on the degree of precision required, resolution can also be an important factor. In industrial maintenance, for example, where the parts to inspect may be large and the thermal contrast high, a thermal camera with low spatial resolution (from 60x60 pixels) is sufficient. For more detailed inspections or to observe small details with equally small differences in temperature, a higher spatial resolution (from 640x480 pixels) is a must.

5. How thermal imaging cameras work?

An infrared, IR or thermal imaging camera works by detecting and measuring the infrared radiation emanating from objects, in other words, their heat signature. In order to do so, the camera must first be fitted with a lens that allows IR frequencies to pass through, focusing them on to a special sensor array which can, in turn, detect and read them. The sensor array is constructed as a grid of pixels, each of which reacts to the infrared wavelengths hitting it by converting them into an electronic signal. Those signals are then sent to a processor within the main body of the camera, which converts those using algorithms into a color map of different temperature values. It is this map which is sent on to be rendered by the display screen.

Many types of thermal imaging camera will also include a standard shooting mode that works with the visible light spectrum, much like any other point and click digital camera. This allows for easy comparison of two identical shots, one in IR and another in normal mode to help quickly identify specific problem areas once the user steps out from behind the lens.

6. Why do thermal Imaging cameras work better at night?

Thermal imaging cameras tend to work better at night, but it has nothing to do with the state of the surrounding environment being light or dark. Rather, because the ambient temperature - and, more importantly, the core temperature of otherwise unheated objects and environments is nearly always significantly lower at night than during sunlight hours. Thus, thermal imaging sensors are able to display warm areas at higher contrast.

Even on relatively cool days, heat energy from the sun will be gradually absorbed by buildings, roads, vegetation, construction materials and more while ever it’s daylight outside. In addition, for every degree these sorts of objects gain in ambient temperature over the course of the day, they become less clearly distinguishable from other warm objects the camera’s sensor is being used to detect and highlight. For the same reason, the most thermal imaging cameras will display warm objects in sharper contrast after several hours of darkness, rather than just after the sun sets - and, even during full daylight hours, they are usually be more effective in the early morning than in the middle of the afternoon.

7. Conclusion

To sum up it has become the need of the hour to have these kinds of hybrid safety systems on the latest automobiles that could save the lives of many. All the automobile giants should divert their R & D work towards such innovative technologies and make this world a safer world to live in. Many such ideas are yet to come and developing such techniques one of which being the night vision sensors used in cars and other automobiles which can increase the safety of the driver as well as people in the car. Implementing this on Indian terrain can reduce the catastrophic incidents that occur on the roads especially during the night times. Thus, implementing THERMAL IMAGING CAMERA is one the possible way to improve safety and visibility during night times.

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