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THE COMPARATIVE STUDY OF POLLUTION DETECTION ON SATELLITE IMAGES OR DIGITAL CAMERA IMAGES USING THERMAL IMAGE PROCESSING

Prof. Prashant D. Londhe[1], Prof. Truptee A. Dhamnaskar[2]
[1, 2]Assistant Professor, Department of Computer Science, Gogate-Jogalekar College, University of Mumbai, Ratnagiri, Maharashtra, India

ABSTRACT
Pollution is adverse changes in environment that can make living being to suffer many problems. It is important to find amount of pollution factors to do remedy. Image processing is nothing but analysis of image. Thermal Image processing is recent trend in image processing which is improved image processing technique. In this paper researcher is trying to do comparative study of thermal image processing. As an application in this paper, the use of thermal image processing is defined to detect the pollution in city from satellite images or digital camera images.
Keywords: Thermal Image Processing, Pollution Factors

INTRODUCTION

The paper is focusing mainly on two types of pollutions viz. Air Pollution and Water Pollution. As Air and Water directly affects human life cycle, therefor air and water are considered as major parameter for human to survive in a nature. Several Software systems, EcoMapper, Robotic Fish, Tadpole, Microbial Source Tracking are traditional and recent techniques for detecting water pollution. Environmental monitoring data management system is commercial software system used to define water quality in the case of water pollution. It is simple monitoring software which put commands from one place. EcoMapper is underwater vehicle. It is purely autonomous. It gives water quality, the currents of the water and bathymetry as an output. EcoMapper works by mapping out the bottoms of the seas. EcoMapper is provided with side scanner sonar system. The advantage is it gives result consistently by moving under the water[1]. The disadvantage is this system can be manipulated by single person and it has a 8-14hour life span at the speed of 2-4knots. A robotic fish has cost is $3.6million. This is used to detect amount of oxygen levels of the water, Oil slicks and other contaminant. The data retrieved from this fish is of utmost important because it implicates with global warming and the state of water resources. The fish about 5 feet long and can move at a speed of 1m/s, with an on-board guidance system will prevent them from bumping into rocks, other fishes and even ships. They have a form of sonar attach to them, allowing them to communicate in the water. With enough data collected, it will come to the surface and transmit to the control center, wireless. Tadpole is also used to detect water pollution. African clawed frog tadpoles, in response to a pollutant can light up and will indicate the presence of several chemical species at the same time. This method is easy to use, less time consuming and less labor intensive than traditional detection methods for heavy metal detection in water. Microbial source tracking (MST) is another method used to determine the various host that contributes to faecal pollution in water bodies. The concept that the origin of faecal pollution can be traced using microbiological, genotypic, phenotypic, and chemical methods has been termed microbial source tracking. The application of MST is to provide a tool for identifying the source of pollution and allowing proper remediation and preventive measures. Water contaminated with human faeces are generally regarded as more hazardous to human

health. For MST to be done, indicator microorganisms are introduced to predict and detect the presence of pathogenic microbes. Indicator organisms are very useful in as they function the need to assay for every pathogen that may be present and detected in water. Many advantages of using this method is that indicators are non-pathogenic, rapidly detected, easily enumerated, have survival characteristics that are similar to those of the pathogens of concern, and can be strongly associated with the presence of pathogenic microorganisms. Some examples of indicators microbes are E.coli, Enterococcus spp, C. perfringens. Swimming Behavioural Spectrophotometer (SBS) method is the method of detecting pollution through the behaviour of a protozoa in water called genus Tetrahymena. This method was awarded as 2010 "Better World" technology by the Association of University technology Mangers[16]. By comparing the movement of the protozoa which is placed in a control and the movement of the protozoa which is placed in the sampling water allow the digital camera along with specialized software which stored over 50 behaviour of protozoan in 3D motion to identify the pollutants. Algae detection method is new and faster method was developed in Israel by Dr. YuliaPinchasov. Traditional method is a time consuming and costly method. However, this method is faster, more cost efficient and accurate. By Shining laser beam onto the algae allows researcher to determine the amount of contamination from the sound waves emitted under the water. As the laser beam encourages photosynthesizing of algae, the rate at which it photosynthesize and the condition of the algae determines the amount of heat shot back into the water which creates the sound waves. Underwater microphones are used to capture the sound waves which are analyzed to determine the health of the algae as well as status of the water. Different kinds of pollution affecting the algae will emit different sound[2][16].

LITERATURE SURVEY

For many industrial applications thermal imaging technology become more valuable diagnostic tool for detecting abnormality that are not visible to naked eye. Thermal imaging cameras are small, light weight, reliable and easy to use. To produce visible images the thermal camera records intensity of radiation in infrared part.

Infrared energy (A) coming from an object is focused by the optics (B) onto an infrared detector (C). The detector sends the information to sensor electronics (D) for image processing. The electronics translate the data coming from the detector into an image (E) that can be viewed in the viewfinder or on a standard video monitor or LCD screen[1]

Because of the capacity of making invisible visible many industries have combined their predictive maintenance programs with thermal image cameras to keep their plants operational at all times. One tremendous tool for monitoring motors, pumps, high voltage and high temperature equipments, low voltage cabinets and many more is thermal camera. Fire related problems in industry can also be avoided because of thermal camera.

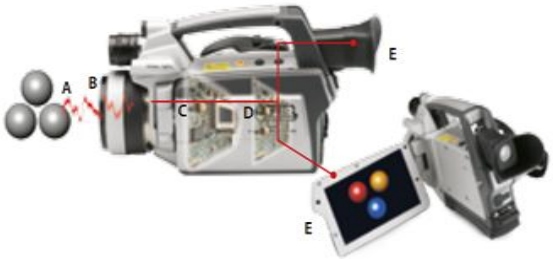

Fig.1 Camera used to take pictures for Thermal Image Processing.

In agriculture related issues after harvesting cleaning and grading plays an important role for improving quality of paddy seeds. Different machineries are also not able to fully sort husk and paddy seed though the use of thermal imaging becomes more advantageous over traditional methods in agriculture. Thermal image technique converts the invisible radiation produced by an object into visible image without building any contact with object. Observing temperature variations is possible because the amount of radiation emitted by an object increases with temperature[2].

Here researcher stated that because of low thermal conductivity paddy husk can act as insulator

or heat resistance material. Because of the higher temperature paddy seeds are brighter than husk. Thermal image method can detect husk because of temperature difference between husk and paddy seeds.

Thermal bridging is used to improve efficiency of building envelopes. Major source of heat loss through wall systems is thermal bridging. To improve future design of wall system researcher suggests integration of infrared imaging into LEED certification process. For sustainable environmental balance builders are now adapting new techniques and technologies with social and economic affordability. Researcher suggests permanent use of infrared imaging for improving efficiency of energy of building envelops[3].

In this paper researcher stated that satellite data is useful in current applications like tracking pollution from agricultural and wild fires, air quality forecasting, evidence for exceptional events, by providing input evaluating output of model and many more. Satellite data come in different levels. Low level data is raw data which is processed by higher levels to obtain spatial grid data[4]. The strength of satellite data is spatial coverage. Because of challenges in accessing, processing and interpreting data many users are not taking full advantage of satellite data. To develop improved quality satellite instruments stakeholders involved in air quality management and other agencies engaged in decision support should express their suggestion and needs to scientist involved in satellite instruments development[5].

Researcher stated that image captured by digital camera is very simple and inexpensive way by which we can analyze air quality or air pollution[6]. Because of RGB encoding technique colors are visible to human eye. RGB stands for Red, Green and Blue colors coded between 0 to 255 allows any image a total of 256 X 256 X 256=16.8 millions of different colors. The atmosphere is mixture of different gases and many small solid particles. To capture visual impact of pollution camera can work as a effective tool. In this paper researcher invented atmosphere pollution detection method to analyze hidden information with the help of digital image processing technique. This method include following steps:

I. Generation of histogram of an image with RGB.
II. Compare image with unpolluted image
III. Using Haar wavelet transform analyze frequency bands in image
IV. Again compare with unpolluted image by analyzing standard deviation of energies

As the civilians spend most of the time in indoor the researcher tried to develop an automatic system for detection of indoor thermal pollution with the help of thermal image processing. Wet or moist wall, poor maintenance of air conditioner, home dust, tobacco smoke, pesticides and household products are treated as major sources of indoor air pollution. These problems are recognized as risk factors for human health also[7].

Key features of digital image processing like Image enhancement, color conversion and morphological operation are used in this paper for pollution detection. As indoor air pollutants are invisible to eye, researcher suggests use of thermal imaging camera for moisture detection problem in buildings. The defect is detected in short duration because of capacity of rapid scanning of a surface[8].

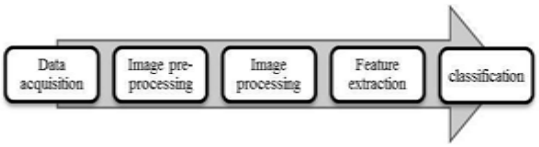

Fig. Detailed Process of Image Processing

In this paper, researcher captured images for indoor pollution detection with thermal image camera and then preprocessed that images to improve quality. To obtain region of interest apply thresholding. The feature extraction process calculate quantitative measurements and image is classified as polluted or non- polluted.

THERMAL IMAGE PROCESSING

It is well believed that[9][10][11][12] all the objects whether they are human made or nature made, they emit heat in a nature. Objects emits heat in the form of infrared energy. According to wikipedia, infrared (ir) is invisible radiant energy, electromagnetic radiation with longer wavelengths

than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nanometers (frequency 430 thz) to 1 mm (300 ghz). Generally infrared energy is divided into three categories viz. Near-infrared (near-ir), mid-infrared (mid-ir), thermal-infrared (thermal-ir). First category, near-infrared (near-ir) is closet to visible light having wavelength in the range from 0.7 to 1.3 microns, or 700 billionths to 1,300 billionths of a meter. They are used by variety of electronic devices such as remote controls. Second category, mid-infrared (mid-ir) has wavelengths ranging from 1.3 to 3 microns. They are used by variety of electronic devices such as remote controls. Third category, thermal-infrared (thermal-ir) occupies the largest part of the infrared spectrum, thermal-ir has wavelengths ranging from 3 microns to over 30 microns[17].

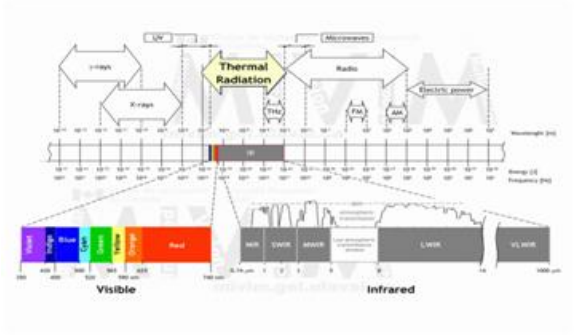

Fig : infrared spectrum

The heat produced by an object can be detected and studied for various types of applications. This technology is refers as thermal imaging technology. In thermal imaging technology very subtle temperature differences is taken to detect the change of the state of the object. even in complete darkness and challenging weather conditions, thermal imaging gives users the ability to see the unseen. Thermal image processing technique was initially developed for military purpose. Later on many security, law enforcement applications used this techniques for getting better results. Thermal imaging detects suspicious activity for long distances in total darkness and through fog, smoke, dust, foliage, and many other obscurants. In security or surveillance systems, thermal imaging cameras used to provide comprehensive threat detection and integrate with larger networks. The focused light is scanned by a set of infrared-detector elements. The detector elements creates a very detailed output pattern in the form of temperature called a thermogram.

Thermal imaging can be seen as a method of improving visibility of objects in a dark environment by detecting the objects' infrared radiation and creating an image based on that information. Here's an explanation of how thermal imaging works: all objects emit infrared energy (heat) as a function of their temperature. The infrared energy emitted fig by an object is known as its heat signature. In general, the hotter an object is, the more radiation it emits. A thermal imager (also known as a thermal camera) is essentially a heat sensor that is capable of detecting tiny differences in temperature. The device collects the infrared radiation from objects in the scene and creates an electronic image based on information about the temperature differences. Because objects are rarely precisely the same temperature as other objects around them, a thermal camera can detect them and they will appear as distinct in a thermal image. Thermal images are normally grayscale in nature: black objects are cold, white objects are hot and the depth of gray indicates variations between the two (see fig. 2, left). Some thermal cameras, however, add color to images to help users identify objects at different temperatures (see fig. 2, right). Nowadays this technology has contributed in many areas and in this paper an investigation about its contribution in the field of pedestrians' detection and crowd counting[17].

INFRARED BANDS AND THERMAL SPECTRUM

Spectrum In Latin 'infra' means "below" and hence the name 'Infrared' means below red. 'Red' is the color of the longest wavelengths of visible light. Infrared light has a longer wavelength (and so a lower frequency) than that of red light visible to humans, hence the literal meaning of below red.' Infrared' (IR) light is electromagnetic radiation with a wavelength between 0.7 and 300 m, which equates to a frequency range between approximately 1 and 430 THz. IR wavelengths are longer than that of visible light, but shorter than

that of terahertz radiation microwaves (Bhowmik et al., 2012).Objects generally emit infrared radiation across a spectrum of wavelengths, but only a specific region of the spectrum is of interest because sensors are usually designed only to collect radiation within a specific bandwidth. As a result, the infrared band is often subdivided into smaller sections. The International Commission on Illumination (CIE) recommended the division of infrared radiation into three bands namely[13], IR-A that ranges from 700 nm to 1400 nm (0.7–1.4 m), IR-B that ranges from 1400 nm to 3000 nm(1.4–3 m) and IR-C that ranges from 3000 nm to 1 mm (3–1000 m). A commonly used sub-division scheme can be given as follows: Near-infrared (NIR, IR-A DIN): This is of 0.7–1.0 m in wavelength, defined by the water absorption, and commonly used in fiber optic telecommunication because of low attenuation losses in the SiO2glass(silica) medium. Image intensifiers are sensitive to this area of the spectrum. Examples include night vision devices such as night vision camera. Short-wavelength infrared (SWIR, IR-B DIN): This is of 13 m. Water absorption increases significantly at 1450 nm. The 1530–1560 nm range is the dominant spectral region for long-distance telecommunications. Mid-wavelength infrared (MWIR, IR-C DIN) or Intermediate Infrared (IIR): It is of 3–5 m. In guided missile technology the 3–5 m portion of this band is the atmospheric window in which the homing heads of passive IR 'heat seeking' missiles are designed to work, homing on to the IR signature of the target aircraft, typically the jet engine exhaust plume. Long-wavelength infrared (LWIR, IR-C DIN): This infrared radiation band is of 8–14 m. This is the "thermal imaging" region in which sensors can obtain a completely passive picture of the outside world based on thermal.[14][17]

IMAGE DENOISING

Image Denoising technique is used to remove all noise particles from the image to make suit for image processing. The Various image noising models are Guassian Filter, linear PDE model, second order PDE model. Images are two types viz. linear and non-linear. Linear PDE model has fast processing. Total Variation filter is best Image Denoising technique for non-linear images. The [15]Convolution Kernel HK,J gives an output AM,N by moving all rows and coloumns of images. The formula is given as follows :-

$$B\left(m+\frac{K}{2}, n+\frac{J}{2}\right) = \sum_{k=1}^{K}\sum_{j=1}^{J} H(k,J)A(m-k.n-j)$$

In the most simple cases, the mean value of certain subimage matrix moving through the whole image is computed for every point in the image by using same value of convolution kernal evaluated as reciprocal values of the number of kernel values.

The Image Spectral Component is given by,

$$\left|Dft\left(H(k,j)\right)\right| = \begin{cases} e^{-j\omega 1\alpha 1}e^{-j\omega 2\alpha 2} \\ 0 \end{cases} \quad if\ range\ in\ w1$$

CONCLUSION

In this paper, researcher is trying to implement thermal image processing technique for detection of pollution. Researcher has concluded that colour thresholding and morphological operations are image processing techniques that can be applied for detection of pollution. The change in environment can be computed by analyzing histogram of RGB channel and frequency bands.

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