

A Survey on Thermal Image Processing Using GA, ANN and Fuzzy C-Means Algorithm

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ABSTRACT: Use of thermal imaging in medical application is the best method for premature detection of breast cancer. Analysis of thermographs helps in identifying the absurdness in the region. Several image detection policies are developed to access the abnormal sector and different quantitative factors are used for describing it among them ANNs are used for classifying absurdness depending upon the severity. ANN is also used to analyse the chance of predicting nitrogenous content in grass level using thermal techniques, based on the rule that plant harvesting with a higher Nitrogen content would be absorbing more optical energy for direct photosynthesis, therefore releasing extra energy as heat into the atmosphere. Advanced method is used to perform the diagnosis of arthritis using thermal images of diseased zones. Thermal Image analysis can be used to populate charts that could be used as input generators to fuzzy network which assume the presence of arthritis. Next up come the application of genetic algorithm in the field of thermal image processing. Here authors have shown how to use CGA (continuous Genetic Algorithm) in place of typical GA which actually works with real numbered outcomes instead of binary strings. Next, concept of printed circuit board and application of deconvolution in case of GA have been shown. In the following papers innovative and interesting techniques of segmenting an image have been cited which have used the concept of genetic algorithms for that purpose.

KEYWORDS: CGA, Deconvolution, Rheumatoid arthritis, Aerospace, Mutation.

I. INTRODUCTION

Thermal image processing is the processing of image which involves detecting the infrared radiation of dark objects (i.e. objects emitting less light) and assigning appropriate colours as per their temperature to form the final image. It is a very significant topic and for this purpose latest algorithms have been used. Evolutionary algorithms such as Genetic algorithm, artificial neural network, Fuzzy C means, and ant colony optimization are the most popular ones. Here we have chosen ANN, GA and Fuzzy C means for the concerned purpose. We have picked up recent and relevant papers on this topic and have tried to write reviews on those. Let us start with ANN. In the first paper related to ANN and thermal image processing the author has mentioned the use of thermal images for estimating the nitrogen content. He has also used a neural network for this purpose. Secondly, application of ANN and thermal image for aeronautic purposes have been shown. In the third paper comes its application oriented study in case of medicinal implementation. Lastly, it has been discussed how ANN and thermal image processing can be used for breast cancer screening. Pathological applications are also cited. In the next part Fuzzy c means c comes into the picture. In its first paper how it is useful in detecting Rheumatoid arthritis, has been discussed. Next using adaptive fuzzy c means technique of detecting footpath walkers has been discussed. Lastly, an application oriented example of breast cancer detection has been cited. Lastly, comes GA which is mostly used and hugely successful in the field of thermal image processing. The authors came up with an interesting concept of Continuous Genetic Algorithm which works with real numbers instead of binary strings. It actually introduces the computational part of the algorithm regarding our topic. In the next paper GA has been explained with the help of deconvolution theorem. There we get to know about Printed circuit boards and ICs. The energy dissipated by each IC of the PCB has been tracked to get the desired results. In the third paper, a new term known as segmented contour is introduced. Contour is a boundary or an outline generally of curved shape.

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Traditional GA is applied on each of the contours and the outputs are integrated to get the optimized final output for the whole test set. In the final paper of GA, high resolution infrared imaging has been introduced in order to successfully detect tumours. Heat transmission techniques along with application of GA have also been discussed in this paper. In the next part of this review paper we will discuss each of the papers in detail.

II. REVIEW

1. Thermal image processing using ANN:

M.Safa et al in [1], have found first stated an ANN model to estimate nitrogen content and possibility of predicting nitro amount. The conclusion measured environment to separate the amount of manure supply on leaf surface temperature. A multi-layered model, consisting of several inputs, hidden layers and an outer layer trained by back proliferation learning technique. In the dispensation of inputs by the system, each neuron in the procedures the slanted inputs through a transmission function to produce an output. The transfer is a linear or nonlinear function. The output of a neuron depends on the specific transfer function used. This output is then sent to the neurons in the following layer through networks and these neurons complete their outputs by the sum of the estimated inputs through their transfer functions. When this layer becomes the output layer, the neuron output becomes the forecasted output. This is one of the most relevant methods of applying ANN in case of thermal image processing. The nitrogen content in soil can play a pivotal role can determine the quality of crops produced hence it can found an important application in modern day implementation of ANN. A specific neural network has been used for this purpose.

Tretout et al. [2], have discussed about the technique of using ANN as a means of reviewing compound aeronautics related or in other words air transport structure based on use of multi based neural networks. The arithmetic transposal is obtained and a complimentary model developed has been used to comprehend a software program. The Neural Network just classifies thermal signs that are thermal performance curves. The attainment spreads asset of inputs. Each image is the longitudinal, latitudinal and altitudinal combined representation of the examined part at a given time. A pixel value in an image resembles to the temperature of a certain and fixed parameter in the measured object. The first step of processing is the detection of a defect. More perfect outputs that would provide help for the detection of the defect. Several neurons are put in the output layer, each one is responsible for one characteristic of the defect among the ones that define the thermal behaviour of a material, for example depth or contact resistance. This technique is a way of allocating the final result on several structures. It can be applied in modern days to improve quality of service in aerospace industry.

In [3] by Wiecek et al we get to know about that one of the principles of thermal imaging in medical application.. ANN can have hidden layers which allow nonlinear processing of input structures. Number of neurons involved in the first layer can be equal or lower than the number of input ones. As the algorithm of artificial neural network is the not a linear system, such method allows the added scheme relating and data lessening, what finally increases the scope of classification. It is well known that the training of ANN is a very vital step in the entire procedure. It is a multivariable optimization problem typically based on back-propagation technique. One needs enough data during erudition stage to obtain the standards of neuron weight constants. The efficiency of image arrangement directly depends on quality of ANN erudition process. In medical applications, one of the main features of the thermal image is its maintenance of uniformity and evenness of temperature patterns across the places and areas of diagnosis. But in pathological cases the images derived from thermal imaging is equally uneven and disturbance associated. Any significant unevenness or ununiformed distribution can designate a physiologic irregularity.

Strzelecki et al in [4] have cited pathological cases which have been selected for breast cancer screening. Few restrictions were used for coming to the conclusion making and further classification. Sensitivity and resolution of these thermographs are high and hence asymmetric examination can be performed more easily on these thermographs. According to the authors, the sensitivity of the structures as a function of distance and size of the subject should be as low as possible. In addition, to compare the results obtained, choosing the less reliant on thermal catalogue from no. of pixels in the considered region of interest is recommended by the author. ANN is used for classifications and the selected image is used as inputs and then numerical technique is used to compute features of the images, and medical instances were presented where breast with tumour has indeed higher temperature on the surface.

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2. Thermal image processing using Fuzzy C Means:

Nizami Mohiyuddin et al in [5] segmented the thermal images for evaluation of Rheumatoid Arthritis disease. In this section Mohiyuddin described that patients with no Arthritis and also who have Arthritis person chosen for this study. The average age of the patient was thirty five years. In this method the imaging is performed using an infrared camera. Air temperature and the humidity of the imaging room were stable, with maximum temperature of $+2$ degree C. The thermal images are captured in the same room at approx. same time of the body. In Non-Rheumatoid Arthritis person, the graphical record displayed homogeneous and well organised temperature variations. In case of abnormal condition, there was a certain variations in the temperature in the abnormal region. Actually, the certain change of temperature is examined for predicting the concerned disease. By applying this algorithm the output images after segmentation are overlapped by the original image. Fuzzy-c-mean output overlapped with original image is used for plotting the heat distribution index from the supplied values of the heat distribution index comparison graph. The fuzzy-c-means algorithm is relevant enough in this scenario to produce an optimal result related to our topic.

Vijay John et al in [6] proposed a pedestrian detection algorithm for infrared images using adaptive fuzzy-c-means algorithm. Footpath walker detection is the most important for advanced driver assistant system. It is a main technology in computer vision. It also finds many other applications, for example security. The Infrared image footpath walker detection algorithm, typically consists of three components candidate footpath walker detection, feature extraction, and feature classification. In general, footpath walker detection is conducted for images in visible spectrum but it is not suitable for detection during night. Infrared or thermal imaging then used for at the time of night due to its capability of capturing the energy which is emitted from the footpath walker. The above algorithm is basically engaged to segment the Infrared images and find out the candidate footpath walker. Unlike, the original fuzzy-c-means algorithm we adaptively estimate the required number of clusters and fuse various or multiple clusters to retrieve the candidate pedestrians. In this section we are using the human pose's features of walking uprightly. Secondly, the central moment ellipse is used to remove the set of candidate walkers. The performance of the proposed algorithm is compared to different algorithm on publicly available data set. By comparing and analysing with the other algorithms we can conclude that this pedestrian detection using fuzzy-c-means algorithm are very efficient and effective to use. It has found relevance in modern day science's application relating fuzzy c means involving thermal image processing.

Dr.S.Ravi et al in [7] proposed breast cancer detection on thermogram at preliminary stage by using fuzzy interference system. Thermogram and mammogram is used for detecting breast cancer but thermogram is considered as one of the most important and effective methods for early detection of breast cancer. Early detection of breast cancer is the way to improve the survival rate of patients life. Thermogram is a convincing front line screening tool. Infrared thermography is used to detect or the diagnosis of the above disease. The main idea of the Infrared Thermography is that, it detects infrared light which released by an object. Say, for example the body's heat mainly caused by the abnormalities in the blood flow existed in the surface of the disease area. Infrared Thermography is not a method for detecting the anatomical retarders, it is a method showing the physiological changes. Fuzzy c means algorithm is applied for segmenting the images. Fuzzy-c-means is approved to be good for image segmentation as they keep more data than that of other processing models. However, from various report we conclude that indeterminacy of element in FCM could not be assessed and described in some application .i.e. expert application. It is applicable for women of any age as it uses temperature dependent means of scanning the affected region or the concerned area. This is certainly a step towards revolution in medical science and diagnosis of breast cancer.

3. Thermal image processing using Genetic algorithm:

Sertan Erkanli et al in [8] have proposed a means to develop computational methods for obtaining efficiently improved images. It is achieved by combining visual images with infrared Images with the help of Genetic Algorithm. It can be done at three parts— pixel, feature and decision. A database for images is created by the publishers and several techniques were developed to improve image quality as an effort to address the challenge in the concerned field. There are several parameters to evaluation criteria. Sharpness varies with the frequency. Image fusion can be divided into three levels: pixel, feature and decision. In the enhancement part, the proposed algorithm works for dark and bright images. In the contrast part, it can be shown that the transfer functions that could be barely seen features in low contrast images clearly visible. A temporal transformation matrix was determined depending on chosen corners and the transformation matrix was used for the registration. Finally, a continuous genetic algorithm was developed for image

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fusion. The continuous GA has the advantage of less storage requirements than the binary GA and is inherently faster than the original binary GA because the chromosomes do not have to be decoded prior to the evaluation of the cost function. It has been seen that the CGA is much more convenient with respect to traditional GA as it takes into consideration real numbers for its functioning. There is also a part related to parameter selection and determining the ending condition of the fitness function. The selection of parameter and the ending criteria play a vital role in determining the final outcome of the full algorithm. The population at an initial stage is chosen randomly to be operated on. It proceeds to the next generation as the representative of the previous generation. It goes on recursively until a satisfying ending criteria is encountered.

In [9] by Marcu et al we come across the concept of PCB (printed circuit board). Here thermal image analysis relies on energy dissipation of each IC of the PCB. The energy dissipation associated with the passage of electrons through the junctions in a semiconductor device gives rise to thermal characteristic of each IC. Thermal images are constrained by infrared camera position and sensitivity. Therefore, the observed image results from the convolution of the heat sources f and the heat dissipation function g and blurring function g' , plus noise due to image acquisition process. Function g'' in is $g''(x, y) = g(x, y) \circ g'(x, y)$. The steps of GA are image coding, initial population, fitness measure, selection, crossover, and mutation and exit condition. In the selection process the best chromosomes are selected for the new generation of population. The others are randomly selected for the new population according to the fitness function and the corresponding condition. The mutation step adds some extra features into the new set of population. In order to add new type of solutions, a randomly selected chromosome item is increased or decreased by a random value. Deconvolution of thermal images is useful in eliminating infrared image acquisition errors and reducing the influences between integrated circuits on the PCB. The main drawback of this approach, as told by the authors, is the time of solution achievement, therefore further work will try to reduce the time and cost of calculations.

In [10] Payel Ghosh et al, present an innovative and interesting technique for processing thermographic images using a genetic algorithm (GA). The fundamental aspect of the GA is chromosome and it consists of a set of factors. A contour is nothing but a boundary or an outline. The whole sample space is broken into several contours and each contour is worked upon separately. At the end of all operations the results of the individual and isolated contours are integrated to form the final output. Contour method of segmentation can be defined as a shape-dependent method where an entropy function is permanently employed to perform selection. The energy function is composed of parameters like edges, pixel intensity, object-level terms such as curvature of the object and size. In these methods the initial contour is usually placed randomly in the region of interest. During the image estimation method, derivation of entropy condition drives the curve towards the boundary of the object. The GA is composed of: the training stage and the segmentation stage. In the training stage, shape, variability and texture information of the region of interest are derived from gradually segmented images. During the segmentation procedure the genetic algorithm assesses contours for segmenting the input image using a fitness function, and loops over consecutive generations until the fitness value surpasses limiting condition or the threshold.

In [11] by Mital Manu, the author presents a review of thermal imaging which reveals that the development of high-resolution digital infrared imaging, computerized image storage and comparison, and sophisticated technologies for image enhancement and analysis, offer potential in the use of thermography. It tells us about characteristics of cancer and how it can vary skin surface temperature. A heater was placed in agar to record and display the heat produced by a tumor in the living tissue. The temperature distribution on the skin surface was filmed with the help of an infrared camera. To find the position and heat rate of the source a genetic algorithm was used as the evaluation method to an optimization technique to find a probable set of candidate solutions. It still remains an adjunct technique since it cannot detect micro-calcifications in the breast that can be seen only by mammography (i.e. X-ray examination of the breasts for diagnosing and locating abnormalities, especially tumors).By completing a clinically applicable algorithm that can be used to recognize tumors and pinpoint their locations, authors have taken a huge step forward in the field of cancer detection. The genetic algorithm used as the estimation method in the mentioned research uses mutation and simple crossover operators. Skin temperatures are really sensitive to the heat exchange factor and coefficient. Though the imaging phase is performed inside thermally conducive environment, obtaining precise estimates for the heat transfer coefficient during the process remains an area of challenge, as told by the authors. The heat transfer coefficient takes

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into account the effects of convection, radiation and evaporation i.e. the common methods of heat transmission for altering temperature of the surface.

III. CONCLUSION

In this review paper we have tried to write the steps of implementing thermal image processing, which is a vital part of modern day image processing. It is a burning topic and a lot of work has been done on it on the global front. For this very purpose we have tried to use three of the most efficient and effective evolutionary algorithms. Namely, Artificial neural network, fuzzy C means and genetic algorithm. Using ANN how we can estimate the nitrogen content in the soil, or be it detecting a tumour, or controlling aerospace modules following the neural network norms have been discussed along with its application in case of thermal image processing. The same has been done for Fuzzy C Means as well where early detection of Rheumatoid arthritis using thermal procedures has been cited as a relevant example. Other than that, detection of breast cancer is also discussed. Last but not the least, we have discussed about GA(genetic algorithm) and how it is actually applicable in case of thermal image processing. Several case studies have been cited. A modified approach in the name of continuous GA has also been discussed in the corresponding part of this review paper. Further discussion were there regarding thermal image processing using GA while deconvolution theorem was applied on it. Here each of the algorithms has its individual shortcomings. Like when we are using GA we are not guaranteed to obtain the desired output as the algorithm will terminate after reaching the final iteration or when the maximum number of generation has been reached. Then again algorithms like ANN and Fuzzy C Means are not always certain to produce desired outcomes. An optimal model can be developed consisting of several algorithms to cover each other's drawback in order to reach a near perfect desired output. Though we tried our level best, many other things can be added to this review paper. It was a great learning curve for us and we are keen to further work on this topic and take this experience forward and convert it to something bigger and better in the times to come.

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