TEMPERATURE MEASUREMENT OF VISIBLEHEAT SOURCES USING NEURAL NETWORK

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ABSTRACT

In any industrial processes, the temperature measurement is an important requirement. Presently thermocouples, pyrometers and contact type sensors etc. devices and techniques are used for temperature measurement of several heat sources. Temperature measurement of furnace, boiler,burner etc. is a very difficult and tedious task also breakage of sensors occurs due to such high temperature so it requires daily maintenance. In this proposed system image processing and neural network technique is used to estimate the temperature of visible heat sources. System uses camera to take the images of heat source. Thermocouple will be used to measure the actual temperature. Various analytical techniques can be applied to estimate the color temperature correlation. Artificial neural network (ANN) is used to create the database of captured images and measured temperature so that approximate temperature is estimated.

KEYWORDS

Image processing, Artificial Neural Network, Furnace and Thermocouple

1.INTRODUCTION

Temperature is the most frequently measured physical quantity, second only to time. Temperature gives the very important information in industry as it acts as the indicator which provides condition of the machinery parts, output products etc. In any industrial processes, the temperature measurement is an important requirement. Presently thermocouples, pyrometers and contact type sensors etc. devices and techniques are used for temperature measurement of several heat sources. The pyrometers are under the category of non contact temperature measurement used to detect temperature of the aimed locations only. With the help of sensors it is very difficult and risky to measure the temperature of visible sources of heat includes furnace, boilers, burner, incandescent lamps etc. also installation of sensors is very difficult near to high temperature heat sources. In industry conventional sensors such as thermocouples, resistance temperature detector (RTD) are used to measure the temperature of heat sources. In case of fast temperature readings as required in welding process these conventional sensors fails, they can’t provide fast and exact measurement.

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Thermocouples are used to monitor the temperature of aimed locations i.e to identify hot spots in furnaces, ovens, boilers and other heat sources etc. Thermocouples can only be used for 2 to 3 times at such high temperature, so there is need to replace the thermocouple in periodic manner due to its breakage. For replacement of thermocouple inside the boiler or furnace requires shutting down the whole unit. The shut down process is very time consuming and complicated so it reduces the efficiency of system and follows the maintenance process. Non contact method like optical pyrometer is used to get the overall temperature distribution of furnace, so for that surface area is scanned using optical pyrometer but it is not recommended that to keep the furnace or boiler door open for a long duration. Thus there is requirement to design a low cost, reliable, efficient and more accurate system useful in giving non contacttype of temperature estimation which gives point source temperature as well as temperature distribution.

2. LITERATURE ON RELATED WORKS

Presently there are several methods available for temperature measurement. Non contact temperature measurement system which uses the infrared computer vision to calculate the temperature of the melted cast iron.Temperature measurement by using formal methods e.g. thermocouples, pyrometers etc. gives several disadvantages also has less accuracy over this proposed method. The infrared images of the melted iron during pouring are taken by using camera and with the help of image processing technique the temperature is measured. In this system the Flir thermo vision camera is used which has very high cost [1]. Digital photographic images and image processing technique used to estimate temperature of visible heat sources. With the help of color dominance technique several equations are formulated and correlation between color temperatures is determined for multiple zones in captured images. Using thermocouple the real temperature is measured and same used for calibration [2]. The concept of image processing includes segmentation techniques, edge detection algorithms, texture and color representation, concept of neural networks etc. is explained in [3]. The noncontact temperature measurement system using fluorescence thermometer in presence of electromagnetic or microwave field is discussed, It is a two dimensional system includes sensors having photoluminescence property which linked with the temperature.

The photoluminescence image has brightness level which depends on temperature. So by using video image processing technique the temperature is measured [4]. It [5] has given the temperature monitoring of pulverized coal flame using imaging based multicolour pyrometer. In this a filter is designed which splits the light of flame in to three different beams at three selected wavelength used in multicolour theorem. The high resolution Charge Coupled Device (CCD) camera and beam filtering is used to detect the coal-fired flame and gives the three images of different wavelength further this is used to determine two color temperatures and true color temperature is estimated using two color temperature. The survey regarding digital camera processing is discussed in [6]; the camera manufacturer adds their intellectual characteristics in to the camera, which responsible for change of resulting image. The properties include sensor size, filter sensitivity, auto-focus, white balance algorithm, colour transformation, post processing, image reproduction techniques. The three dimensional temperature measurement of a combustion flame is addressed in [7]; they combined image processing technique and two color pyrometry for continuous estimation of temperature distribution in a combustion flame. In that [8] has discussed two-color principal for the measurement of temperature and soot concentration of pulverized coal flames. System combines optical sensing and digital image processing techniques to operate on two-color principle. Images are taken for specific wavelength. The spectral radiance of the soot particles in the flame and the spectral sensitivity of the imaging system are considered to be proportional to grey level which is used as output of the developed imaging system. The ratio between the grey-levels of corresponding pixels within two images captured is used to calculate the temperature and its distribution over flame.

K. Ito, H. Ihara [9] proposed that with the help of chromaticity coordinates (x, y) the quantitative characterization of propane premixed flame color is done and use of the same in several applications. Flame colors and flame spectra are related with each other in the specific range of air/fuel ratio. As air ratio changes the flame colors are accurately expressed using chromaticity coordinates. Air ratio and relative spectral intensity can be estimated by using flame color. In that [10] has explored a new indirect method, which estimates the temperature from respective color of light sources. They use color video camera having fixed white balance, set of color chips and microcomputer for experimental setup. Color camera and color chips detect the light from light sources and from this color temperature is calculated. The video camera used has chrominance property as well as fixed white balance. From this technique the estimation accuracy is about 0.1-1.4% is achieved. To summarize, this paper presents the noncontact temperature measurement using image processing and neural network technique. This system is very reliable, efficient, low cost and more accurate system useful in giving non contact type of temperature estimation which gives point source temperature as well as temperature distribution.

3. PROPOSED SYSTEM ARCHITECTURE

In this proposed system the non contact temperature measurement of visible heat sources is carried out with the help of image processing and neural network algorithm in MATLAB.

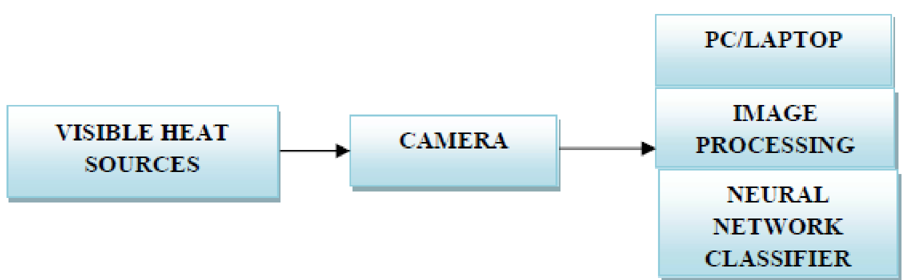


Figure 1. General System

With the help of camera, images of visible heat sources, wax candle, furnace etc. will be taken. The images and respective temperature will be record and this is used as database for further processing. Temperature will be measured using thermocouple and other instruments. Next step is pre-processing of image and creating the color transformation structure using Red, Green, Blue (RGB) or Hue, Saturation, Value (HSV) structure. The next part is image segmentation, in this image will be segmented into different parts according to the temperature similarity.

Image segmentation means to separate the object from background. Then by using color dominance techniques the temperature is assigned to the available segments. Neural Network (NN) is chosen as a classifier tool due to its well-known technique as a successful classifier for many real applications. Neural Network is selected as classifier because it gives high accuracy and basically used for nonlinearity detection. Hence, by using image processing and neural network technique temperature will be estimated from visible heat sources.

4. ARTIFICIAL NEURAL NETWORK

Neural network is a network structure consisting of a number of nodes connected through directional links. Each node represents a process unit, and the links between nodes specify the causal relationship between the connected nodes. The nodes in the network are adaptive which means that output of these nodes depends on parameters which are modifiable and are related to nodes. The learning rule specifies how these parameters should be updated to minimize a prescribed error measure which is a mathematical expression that measures difference between networks actual output and desired output.

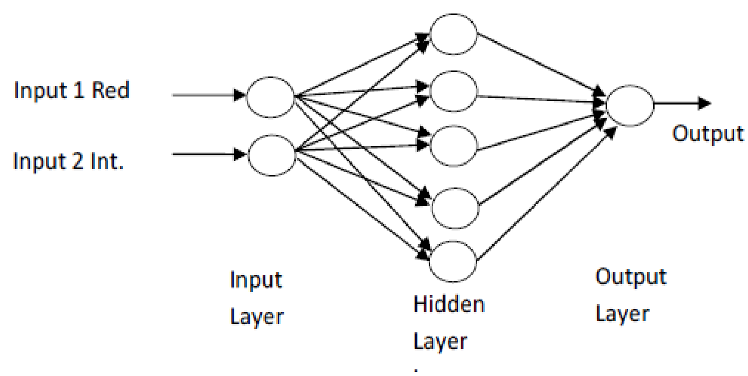


Figure 2. Structure of a Multilayer Neural Network

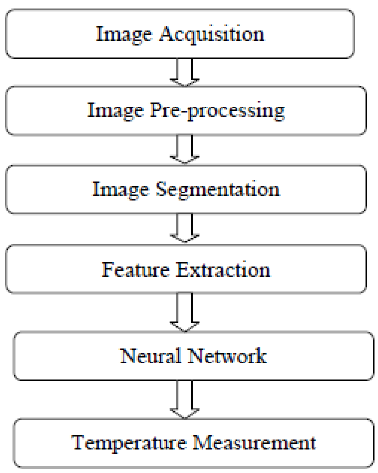
The training data is an intensity of pixels on image and the actual temperature measured. Once the training is completed on this data set, the network is ready to be used on the image where the intensity of pixels is measured and temperature is estimated. The neural network is trained for limited data set for instance, temperature calculation for few sets of pixels is known to it. The temperature calculation for any in between pixel will be estimated by neural network.

A sigmoid function is used as transfer function defined on each unit in order to construct a nonlinear mapping between the inputs and the outputs. The parameters to be adapted or updated during the training procedure are connection weights, threshold values and the gradients of sigmoid functions on each unit. The input and output layer of neural network for distance determination consists of single neuron and hidden layer consists of 20 neurons. The number of neurons in hidden layer and training time are related to each other. The training time increases for lesser number of neurons in hidden layer. Conventional back propagation algorithm is used for updating the parameters. The general structure of multilayer neural network is shown in Figure 2.

5. SYSTEM FLOW CHART

5.1 IMAGE ACQUISITION

Using digital camera various images of the visible heat sources like wax candle, burner, oil lamp etc. are taken. For initial experimentation selected the wax candle image which is captured in a dark room as shown in fig.4



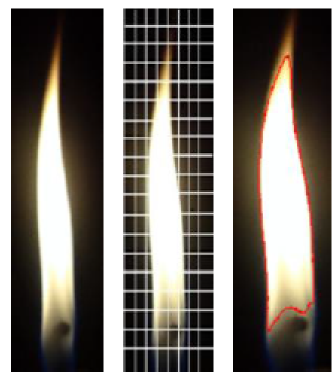


Figure 3. System Flow Chart Figure 4. Original flame & segmentation

5.2 TEMPERATURE MEASUREMENT

Using thermocouple, RTD etc. the temperature of the flame is measured. The temperature is measured by creating different sectors of the flame. The sensor is moved in to different positions in the flame and temperature is recorded.

As shown in fig.4 the entire candle flame is divided in to several zones. Using thermocouple the temperature is measured at each zone. With the help of image segmentation technique several zones are differentiate and observed colour dominance. The RGB and HSI model is used for colour-temperature correlation. In that main focus is given to red, blue and intensity parameters. As temperature increases the intensity and red component also increases shown in table I.

5.3 TRAINING NEURAL NETWORK WITH INPUT IMAGES

Input images are trained using Back Propagation feed forward method of Artificial Neural Network. The computed images are fed to the neural networks. Table I contains selected parameters for the Neural Network. After setting the parameters of neural networks, the network is trained with input images via input layer, hidden layer and output layer.

Here the red component value, X Y coordinates and corresponding measured temperature is used as database. This work includes use of the mathematical function Log-sigmoid which is mentioned in the Table I. To minimize the errors, the output layers are sent back to hidden layer and update the weights of these layers which are the previous layers. The momentum and learning rate parameters counts the updates from previous iterations and recalculates the new updated output. 1000 iteration are used and the error value is minimized to 0.001.

5.4 TESTING THE ANN WITH TESTED IMAGE

Neural Network is trained with red component of image and its respective temperature data. Neural network is fed with these data. Log-sigmoid function values are used to compare the images with images of trained neural network to get finest match. The nonlinearity is removed using the neural network.

Table I. Measured Temperature & Pixel Intensity

X	Y	Actual Temperature	Pixel (Red) Intensity	Estimated Temperature
2505	1364	220	23	216
1614	1793	260	47	252
3564	1940	375	77	368
2606	2094	416	100	405
1757	1833	450	151	447
1848	1853	480	221	473
1883	1853	500	249	498
3197	1862	545	252	530
1970	1876	610	255	605

6. EXPERIMENTAL APPROACH

Here, we have used the database of images. Fig. 7 shows the segmented image and histogram of intensity value. MATLAB2010 software coding is used to complete the simulation method.

Training part includes use of input images with red component of pixel and corresponding temperature to train the Artificial Neural Networks, the following table gives neural network parameters like input, output layer and hidden layer used for complete training and testing purpose.

Table II: SELECTED PARAMETERS FOR ANN TRANNING

Sr.No	ANN Parameters	Description
1	Artificial Neural Network Layers	3
2	Input Layer	Contains pixel intensity values of the image
3	Output Layers	Gives the temperature value corresponding to the intensity of pixel
4	Neurons in Input Layer	30
5	Neurons in Output Layer	1
6	Number of Iterations	500
7	Gradient Value	1e-25
8	Learning Rate	0.03
9	Performance goal	0.001
10	Mathematical function used	Sigmoid function

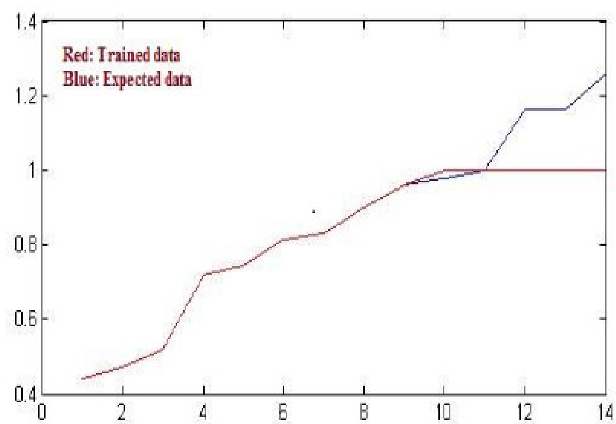


Figure 5. Graph of actual data and trained data

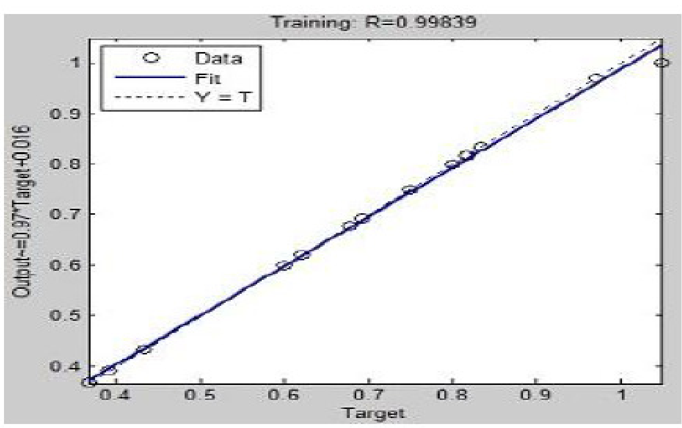


Figure 6. Regression Plot for training state

Correlation between Target and actual output is shown by Regression plot which is depicted in Figure 9.

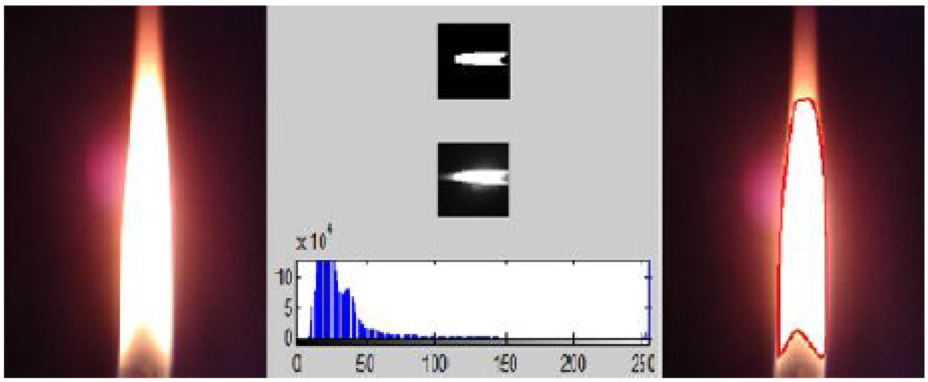


Figure 7. Tested candle flame image and its histogram

7. RESULTS & OBSERVATIONS

With this system the temperature is estimated which is close to the actual temperature. The neural network is used to train the database and for non linear application. As the flame contains several zones so it gives non linear characteristics hence with the help of neural network we get the better results as compared to other methods. The three images of flame and related data are used to train the neural network so that accurate temperature will be estimated by this system. The red colour in the image is used to get the actual temperature correlation as well as intensity of the pixel. According to the colour of the flame the temperature changes, as colour is darker it indicates higher the temperature. This proposed system will be used for temperature measurement of various visible heat sources as furnace, boiler, molten metal etc. The image is captured and processing techniques are applied on to it so that colour pixel intensity information available also related temperature is measured with the help of sensors and hence this database is used to train the neural network so that actual temperature is estimated.

8. CONCLUSION

The proposed system is a non contact temperature measurement system using image processing and neural network. Using neural network the non-linearity characteristics are easily and efficiently evaluated. This system uses normal digital camera so it is very low cost, reliable and efficient temperature measurement system over contact type measurement system. RGB & HSI models are used for colour-temperature correlation. This system is used to temperature measurement of various types of furnace, boilers contains molten metal, stoves, industrial flames etc. System gives point source temperature as well as temperature distributions of selected application.

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