International Journal of Management, IT & Engineering
Vol. 8 Issue 1, January 2018,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

VISION BASED CONTROL AND MONITORING OF SPEED IN POWER STATIONS

A.Thirumurthi Raja*

S.P.Victor*

Keywords:

Sensors

DIP

VHDL

FPGA

Abstract

In power station electricity is generated by coupling the turbine with the generator. The turbine is rotated through steam/water in thermal power station /Hydraulic Power station. In atomic power station heat is generated through nuclear fusion and water is heated and steam is generated to run the turbine. It is essential to maintain constant speed N to maintain the frequency F. Increase/Decrease of frequency affect the domestic set up. This paper is to replace the sensor with a digital camera. This paper is focused on the measurement of speed of turbine-generator coupling at power station. Not only measuring the speed of turbine- Generator coupling is essential but also to control the speed of turbine – Generator coupling if it exceeds the rated speed of 1500 RPM. To maintain constant speed the DIP technique is suggested here.The coupling between the turbine and Generator is photographed for rated constant speed and stored inside the computer as standard image in terms of its texture feature value using local tetra pattern. When the speed of the turbine varies due to less/ excess steam/water which ultimately affect the generator speed , a digital camera which is installed near the coupling takes photograph at every 10 minutes and forward the image to the computer. When the current image does not match the

* Research and Development Centre[1], Bharathiar University, Coimbatore,Tamilnadu,India

standard image control signal is generated and control action is taken accordingly. To support speedy comparison of images, it has been implemented in Very Large Scale Integration. Even though, comparison algorithms are successful at software level, better results can be achieved by implementing in hardware.

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1. Introduction)

Most industrial plants are hazardous in nature. The technical development in Electronics, Information technology, Image processing and industrial computers resulted in the development of remote control and monitoring the plants [1]. Remote operation field needs quite a good amount of instrumentation support for control as well as monitoring purposes.[2] Nowadays plant size has grown bigger which needs control of many parameters like flow, level, pressure, speed, temperature, displacement, vibration [3]etc., Sensors like RTDs, Thermocouple, strain gauges, tachometers, LVDT's etc generates analog signals[4]. Here encoder tachometer is used to measure the turbine speed. A relative encoder tachometer is attached to the turbine shaft which can activate a F to V converter. Then the voltage value is read by a proper range of voltmeter [5]. When analog sensors are used to measure physical parameters, once in every six month it has to be calibrated properly [6]. After the calibration only it gives error free measurement. Due to the changes in the properties of the components used in the sensors the sensors cannot be calibrated properly [7]. Another problem which is encountered by the usage of analog sensor is hysteresis effect. It is due to the ageing of the components in the sensors, as input increases output decreases. Measurement using sensors is not full proof method due to the errors gross error, systematic error and random error in sensors [8]. Errors in these sensors are prone to happen which are discussed below. Hence getting accurate results are not possible [9]. So many correcting methods are to be employed [10]. A new technique to solve these problems is to use Digital Cameras in place of analog sensors. The digital images are taken and continuously transmitted to computer which is available in the operator station. Texture Feature value is extracted from the digital image speed of the turbine is measured based on the feature value [11]. It is not only measuring speed of the turbine but also controlling the speed if it increases or decreases. The control action is done through the Program Logic Controller. Digital image processing paves way for generating control signals by comparing the just received image with the standard image already stored inside the computer. For comparing the two images i.e current image with already stored standard image, two methods are used. They are: 1. C Environment 2. In Matlab Environment 3.VLSI environment. The image comparison speed is high in VLSI environment as compared with the other two environments. For hardware implementation FPGA Spartan 3E starter Kit is used. The projected method is an enhancement over established software tool based approach in comparison of images.

2. Errors in reading Analog Sensors

.A digital tachometer is an instrument which is used measure the rotation speed of electrical machines. It reads the speed of electrical machines in terms of RPM (Revolution Per Minute). When sensors are used to measure the physical parameter (Speed), yearly twice the sensor must be calibrated properly[12]. After the calibration only it gives error free measurement. Due to changes in the properties of the components used in the sensor, the sensor cannot be calibrated properly. Another problem which is encountered by the usage of analog sensor is hysteresis effect. (i.e due to ageing of the components in sensor as input increases output decreases). Measurement using sensors is not full proof method due to errors such as gross error, systematic error and random error in sensors. Now due to the new invent of digital camera, this sensor is replaced by digital camera which is directly integrated into computer.

3. Proposed System

In this system the speed of the turbine is monitored and controlled efficiently by the following experimental set up shown in fig.1. In power station, by combining turbine with generator, electrical energy is produced. In thermal power station through steam the turbine is revolved. In Hydraulic power station, through water the turbine is revolved. In nuclear power station, water is heated by heat which is generated through nuclear fusion. This will cause the generation of steam to run the turbine. It is known that

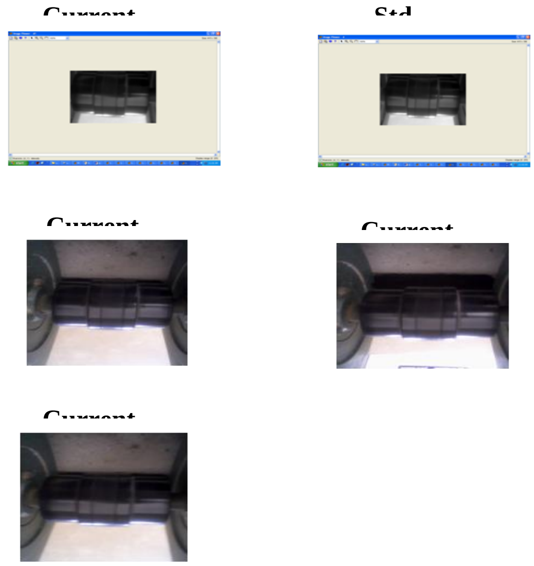
$$N = F * P/120$$

N – Speed of turbine which is ultimately linked to generator.

F – Frequency

P – Number of poles in the Generator

Figure 1 shows the various current images and Standard Image respectively



It is necessary to keep stable speed N (1500 RPM) to uphold the frequency F. Any increase in frequency or decrease in frequency changes the household arrangement. To keep up steady speed the Digital image processing technique is recommended.

Texture analysis has been extensively used in a variety of applications such as remote sensing and computer and machine vision due to its capability in extracting the prominent features. It is proposed that a second order Local Tetra Pattern (LTrP) has been calculated based on the direction of pixels using horizontal and vertical derivatives. The procedures which are followed to monitor and controlling of vibration, critical speed, whirling of shaft and speed of the machine are explained as follows:

1Standard image is loaded and it is converted into gray scale.

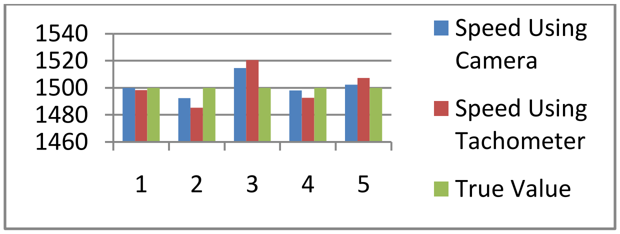
2. First –order derivates are applied in horizontal and vertical axis.

3. The direction for every pixel has been calculated.

4. Based on the direction of the center pixel, the patterns are divided into four parts.
5. The tetra patterns are calculated, and they are separated into three binary patterns.
6. Calculate the magnitudes of center pixels have been calculated.
7. The binary patterns have been calculated.
8. Construct the feature value (using local tetra pattern) of standard image and store it.
9. Find the feature value of current image by using the above said procedures.
10. Compare the current image with the standard image in the computer.
11. If both images match, no control action will be taken.
12. If both images do not match, control signal will be generated for control action

Table.1 – Texture feature values of incoming and standard images and its mean absolute Error

Sl. no	**Type of Image**	**Texture feature value using Local Tetra Pattern**	**Actual Speed to be maintained (RPM)**	**Speed of Machine measured by Digital Camera**	**% Error using Camera**	**Speed of Machine measured By Sensor (Tachometer) in RPM**	**% Error using Camera**
1	Standard Image	203	1500	1500	0	1498.32	0.11
2	Current Image 1	201	1500	1492.45	0.5	1485.22	-0.99
3	Current Image 2	205	1500	1514.78	-0.99	1520.56	-1.37
4	Current Image 3	202	1500	1498.12	0.13	1492.61	0.49
5	Current Image 4	204	1500	1502.33	-0.16	1507.39	-0.49
Mean Absolute Error					0.356		0.69



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X –Axis : 1- Standard Image

2. Current Image1

3. Current Image2

4. Current Image3

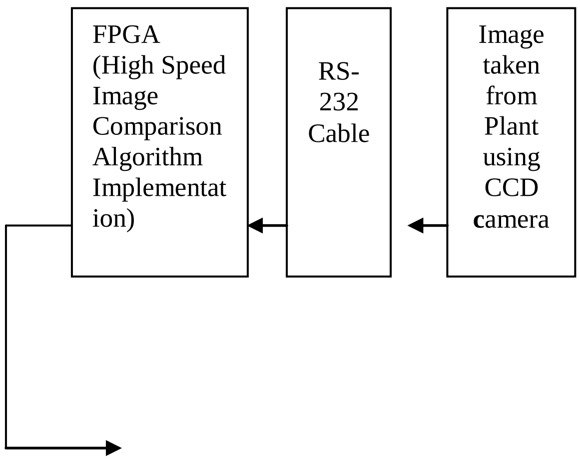
5. Current Image4

Y-Axis: Speed in Revolution Per Minute.

Figure 2 shows the comparison between the true speed, speed measured by digital Camera and the Speed measured by digital Tachometer.

4.**VLSI implementation of Speed monitoring and control of turbine**

The coupling between the turbine and Generator is photographed at 10 minute interval for rated constant speed and stored inside the FPGA as standard image. When the speed of the turbine varies due to less/ excess steam/water which ultimately affect the generator speed , a digitalcamera which is installed near the coupling takes continuous photograph and forward the images to the FPGA. When the current image matches the standard image control signal is generated and control action is taken accordingly. Figure.3shows the general block diagram of proposed system.



Control Signal from FPGA to plant

Fig 3. General Block Diagram of proposed System

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4.1 Distance Matrix Algorithm

$$\delta = \sqrt{\sum_{i=1}^{N}(yi - fi)^2} \qquad (1)$$

Where

δ=Difference,

Y_i=Standard Image,

F_i=Field Image.

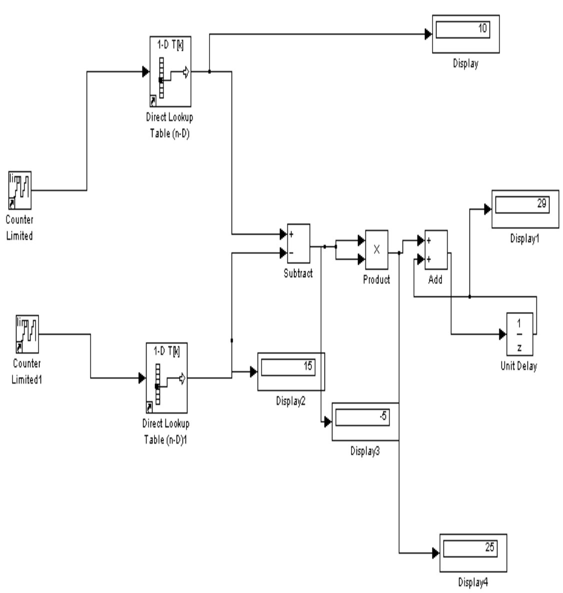

Fig.4. Proposed System Architecture

Fig.4shows the proposed architecture.Fig5 shows the corresponding VHDL output of proposed system

Simulated Environment:

Family: Spartan 3

Device: XC3S400

Synthesis Tool: XST (Verilog/VHDL)

Package: TQ144

Simulator: Modelsim SE-VHDL

Image Size: 256*256

RAM size: 4 GB

Processor: Dual Core

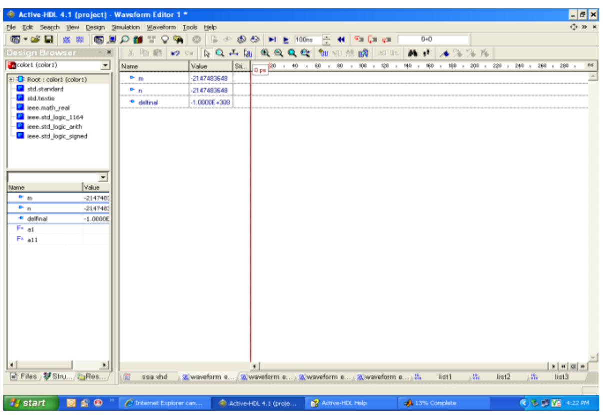

Fig.5. VHDL Output of Proposed System

5. Conclusion

Thus it is concluded that a total eradication of this type of sensor (Digital Tachometer) is possible with the new advent of digital image processing technology. Signals from transducer are replaced by field images capturing and processing .This is more accurate and reliable than signals from sensors. By the usage of digital cameras, the problem of calibration and hysteresis effect has been completely removed. This paper presents a new methodology for designing high speed image comparison by using FPGA and reduced the comparison time. If we comparing the image by based on threshold value in MATLAB and other technique it will take more time but our methodology guarantees to reduced the time by comparing the image.

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