Chapter 17
Quaternion Based Machine Condition Monitoring System

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ABSTRACT

In this chapter, a new and effective quaternion based machine condition monitoring system using log-polar mapper, quaternion based thermal image correlator and max-product fuzzy neural network classifier is discussed. Two classification characteristics namely: peak to sidelobe ratio (PSR) and real to complex ratio of the discrete quaternion correlation output (ρ-value) are applied in the quaternion based machine condition monitoring system. Large PSR and ρ-value are observed in case of a good match among correlation of the input thermal image with a particular reference image, while small PSR and ρ-value are observed in case of a bad/not match among correlation of the input thermal image with a particular reference image. Some simulation results show that log-polar mapping actually help solving rotation and scaling invariant problems in quaternion based thermal image correlation. Log-polar mapping can help in smoothing the output correlation plane, and hence it provides a better way for measuring PSR and ρ-values. Results also show that quaternion based machine condition monitoring system is an efficient machine condition monitoring system with accuracy more than 98%.

INTRODUCTION

Thermal imaging machine condition monitoring system is a monitoring system that using thermal imaging camera to capture in infrared images for the machines to be monitored, process them and monitor the machines' condition. The main merit of thermal imaging machine condition monitoring system as compare to conventional machine condition monitoring system is that, in conventional machine condition

DOI: 10.4018/978-1-61520-849-4.ch017

monitoring system, site staffs used to check and monitor every single item on machines and electrical equipments by hand. This was time consuming and quite risky, because heat will be generated by a device that undetectable by human eye easily, especially in dark condition. As for thermal imaging machine condition monitoring system, thermal camera is in place of hands on monitoring since thermal camera uses infra-red sensors that captures infra-red coming from different objects in the surrounding and forms a thermal(infra-red) image. Since infra-red radiation from an object is due to the thermal radiation, the image formation will depend on the object temperature and not on the light reflected from the object.

Nowadays, most factories rely on machines to help boost up their production and process. Therefore an effective and thermal imaging machine condition monitoring system play an important role in those factories to ensure that their production and process are running smoothly all the time. Thermal monitoring can reveal some serious electrical problem in a factory that usually goes undetected until serious breakdowns occur. In factories, there are various types of functioning machines to be monitored. When there is any malfunctioning of a machine, there will be extra heat generated which can be picked up by thermal camera. With the algorithm proposed in this chapter, it is simple to detect and monitor the conditions (overheat or not) of more than one machines in a single view captured by thermal camera. These monitoring and subsequent analyses of the images from the inspection can alert maintenance personnel to take corrective action and/or repair the overheat/fault machine.

Machine condition monitoring can be applied to many conditions. Condition monitoring of temperature, analysis of machine vibration, over voltage or current are the most common. In effect any condition that can be detected by a sensor can be monitored. An example of famous condition monitoring systems' manufacturer is National Instruments (National Inst. Corp., 2009). National Instruments condition monitoring systems have been successfully implemented on a variety of turbines, compressors, generators, and other devices, offering simple connectivity to vibration sensors such as radial and axial proximity probes, integrated electronic piezoelectric (IEPE) accelerometers, and tachometers including laser tachs and keyphasors. However, for monitor different types of machines/devices in networking, it has to interconnect the sensors and interpret the sensors' data which are different for varieties of sensors use. This sometimes complicated the network. Hence one solution to solve this is by using image-based approach, whereby thermal (infra-red) imaging is appropriate in this manner. Thermal imaging can help monitor temperature of machines/devices. The amount of infrared radiation emitted by a machine/device increases with temperature. Therefore image captured through thermal imaging sensor (thermal camera) allows one to see variations in temperature and monitor accordingly. Rolling element bearings are critical components in induction motors and monitoring their vibrating condition is important to avoid failures. When there is a fault bearing, extra heat will be generated by motor. It can be captured by thermal camera and alert maintenance personal. By doing so, thermal imaging can help in the analysis of machine vibration too. In the case of over voltage or current of a device, extra heat will also be generated at source portion. This can be captured by thermal camera as well and alert maintenance personal. Therefore, image-based condition monitoring system using thermal camera can replace those using specific sensors (thermometer, vibration sensor, over voltage /current sensor etc.) and it can standardized measurement in a single type of output data (temperature reading in color data form) for a networked condition monitoring system.

A new and effective quaternion based machine condition monitoring system using log-polar mapper, quaternion based thermal image correlator and max-product fuzzy neural network classifier is discussed in this chapter. Log-polar mapping method is applied because it helps in solving rotation and scaling invariant, data compression problems and also helps in smoothing the output correlation plane. In con-