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A Study on Temperature Analysis for Smart Electrical Power Devices

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ABSTRACT

An electrical power utility, like an electrical power pole, includes various kinds of sensors for smart services. Temperature data is considered one of the important factors that can influence the smart operations of this utility. This study suggests a method for temperature data analysis for deciding the status of the smart electrical power utilities by using Kalman Filter and Ensemble Model. The suggested approach separates the temperature data according to the different positions of the temperature sensors of a utility, then uses Kalman Filter and Ensemble Model to analyse the characteristics of the temperature variation. With detailed processes, method explains the variation between an external temperature factor like weather temperature data and the sensed temperature data, and then, analysis the temperature data from each position of electrical power utilities. In this process, the suggested method uses Kalman Filter to remove error data and the ensemble model to find out mean value of every hour of electrical data. The result and discussion of temperature analysis were described clearly with the analysed results of electrical data. Finally, we were able to check the working condition of the power devices and the range of the temperature data foe each devices, which may help to indicate any causalities with respect to the devices in the utility pole.

Keywords : Electrical Data Analysis, IoT, Electrical Utility

스마트 전력 기기의 온도 분석에 관한 연구

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요 약

전신주와 같은 전력 설비에는 스마트한 서비스를 위한 다양한 종류의 센서가 포함되어 있으며, 온도 정보는 전력 설비의 정상 동작 상태를 판단하는 중요한 요소 중 하나이다. 본 연구에서는 칼만 필터(Kalman Filter)와 앙상블 모델(Ensemble Model)을 이용해 스마트 전력 장치의 상태를 판단할 수 있도록 장치의 온도 분석 방법을 제안했다. 제안 된 접근 방식은 서로 다른 위치에 설치된 센서로 부터 수집된 정보 중 온도 데이터를 분류하고 칼만필터 및 앙상블 모델을 사용하여 온도 변화의 특성을 분석했다. 세부적으로 수집된 온도 데이터로부터 기상 온도 데이터와 같은 외부 인자를 제거하고 전력 장치의 각 위치로부터의 실제 장치의 온도값만을 분석했으며, 이 과정에서 칼만필터를 사용하여 오류 데이터를 제거하고 앙상블 모델을 사용하여 매 시간 정상 동작하는 전력 설비의 온도 평균값을 산출했다. 온도 분석에 대한 결과와 논의는 전력 데이터에 분석 결과에 명확하게 설명되어 있다. 마지막으로, 분석된 데이터를 통해 전력 장치가 정확히 동작하는지를 판단할 수 있는 온도값의 정상범위를 확인하였다.

키워드 : 전력데이터분석, IoT, 전력설비

1. Introduction

All over the world, from rurals to urban, low to high altitudes, electric utility poles plays a important role for the safe delivery of electricity. Especially, the developed countries have the advanced and high technologies involved with the electricity pole which advances in both high security and safety. The electricity pole has many electrical power devices that used for the transportation of the

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electricity. As the power devices are continuously working, there may be a chance to radiate high temperature which may affect the devices attached to the electric pole. So, in this paper, we have discussed the temperature related factor that may affect the power devices, that may leads serious damages for the electricity pole devices and the electricity transmission.

The main objective of the study is based on the temperature analysis based on the time series of temperature on each power devices attached to the electric pole. In this process, first, we fetch data from information storage database and then categorize the data as DateTime, Position, and Temperature. In this data, there is a different type of positions based on electrical power devices, which can be separated into each position of electrical data. Later, two important models namely Kalman Filter and Ensemble Model were used. The purpose of Kalman Filter is to remove the unrelated data such as error or unwanted data and the Ensemble Model is used to find out the mean value of data based on time series.

Depending on Kalman Filter and Ensemble Model, the result has been extracted from the electrical data. Using the filtered data, the difference of the temperature analysis is used to identify the cause and safety towards the electric pole.

2. Related Works

Ghil et al and Vautard et al explains the interdecadal oscillations and the warming trend in global temperature time series [1], which is analyzed using the time series of global surface air temperatures for the past 135 years of data [1]. Richard et al has examined a real-time global sea surface temperature analysis [2] and Anton et al, analysis the outdoor air temperature and mortality in the Netherlands based on time series analysis [3]. Mohit Bhatnagar and B. Jayant Baliga analysised and comparison of 6H-SiC, 3C-SiC, and Si for power devices [4]. Richard J. T. Simms and et al. analyzed channel Temperature Determination in High-Power AlGaN/GaN HFETs Using Electrical Methods and Raman Spectroscopy[5]. Similarly, we analysis the temperature based on time series in electrical power devices using Kalman filter and ensemble models.

2.1 Kalman Filter

Kalman filter is an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone, by using Bayesian inference and estimating a joint probability distribution over the variables for each timeframe [6]. It is also known as Linear Quadratic Estimation (LQE) [6]. The Dynamic Linear Model is one of the most important in Kalman Filter. First, we need to estimate the Maximum Likelihood Estimation (MLE). Afterward, based on MLE we can estimate the Kalman filter values. The MLE and Kalman filter functions namely 'dlmMLE()' and 'dlmFilter()' which are executed in R language. The main purpose of Kalman filter is used to filter the error of unwanted data and then produce an accuracy of electrical data.

2.2 Ensemble Model

The Ensemble Model is defined as the process of running two or more related but different analytical models and then synthesizing the results into a single score [7]. Another, the mean value of all data at the particular time which is known as Ensemble Model [8].

The Fig. 1 diagram shows for ensemble model of monthly temperature data. In this diagram, X-axis has time (hours) from 0 to 23 hours and Y-axis has monthly temperature data from January to December. Every month has an average of temperature data. The blue dotted line explains the ensemble mean, which represents mean value of all monthly temperature data at a particular time (15th hour).

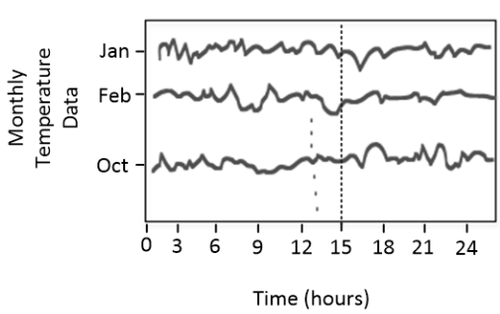

Fig. 1. Diagram Show for Ensemble Model of Monthly Temperature Data

3. Materials and Methods

Fig. 2 shows overview of the electricity pole with electrical power devices and other supported materials which is used for transmissions of electric power from one place to another place with thick cable wires. There are different types of electrical power devices which are represented by position-0, position-12, position-18, and etc.

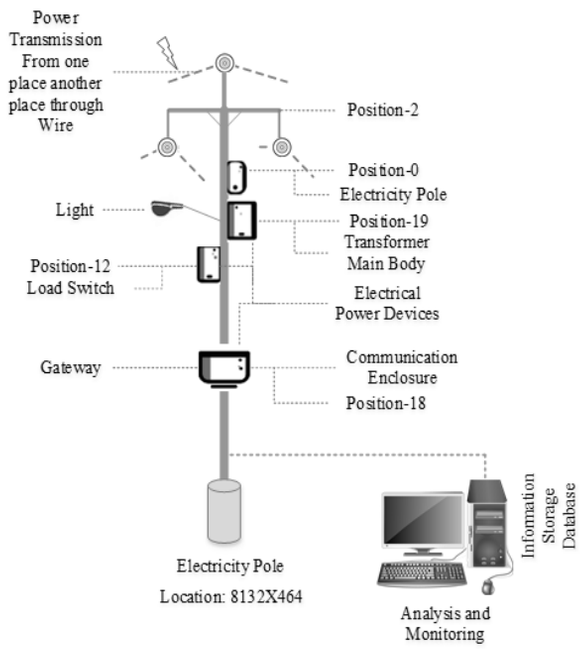

Fig. 2. Diagram Shows for Electrical Power Devices Placed in Electricity Pole

The device of the position-18 is gateway and communication enclosure, position-12 is load switch and position-0 represents pole temperature.

All the electric pole data and the corresponding device data are stored in the database by parsing the raw data obtained from the sensors. As the pole consists of different devices, temperature is analysed for each devices separately.

For each devices, electrical data consists of different information namely, Place, Latitude_Longitude, Facility, Date_Time, Date, Time, Pole, Position, Temperature, Alarm_Temperature, Accelerator_pitch, Roll, Alarm_Accelerator, Battery, Alarm_Battery and Period, etc. In this study, we only require few electrical data such as Date_Time, Position, and Temperature. As mentioned earlier, there are three position such as position-0, position-12, and position-18 based on electrical power devices. First, we split the positions and then analysis the temperature based on time series. Before analysis, the Kalman filter is used to remove the unwanted data that are unnecessary for the analysis.

The purpose of Kalman Filter is used to remove error data, already mentioned in section 2.1 and then Ensemble Model has been adopted in electrical data. The mean value of all temperature data corresponding to each and every hour of time in electrical data is calculated.

4. Result and Discussion

In this paper, the electrical power data are used to analysis the temperature with the help of Kalman Filter and Ensemble Model. We have used 2 months of electrical data. This data has many categories and different positions, the required categories are Date_Time, Position, and Temperature. First, we separate each position and generate the result for each position of electrical data. The data is plotted with time (hours) from 0 to 23 hours X-axis and Y-axis has the temperature in degree Celsius.

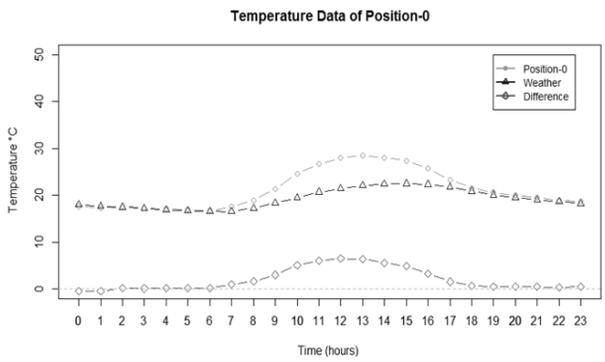

Fig. 3. Result Shows for Position-0 of Temperature in Electrical Data

Fig. 3 result shows the position-0 of temperature in electrical data. In the plot of position-0, the green line indicates an average of temperature (position-0) data plotted from 0 to 23 hours, the blue line indicates an average of weather data for that particular place and the red line indicates the difference between position-0 and weather data. The grey dotted lines indicate baseline of temperature.

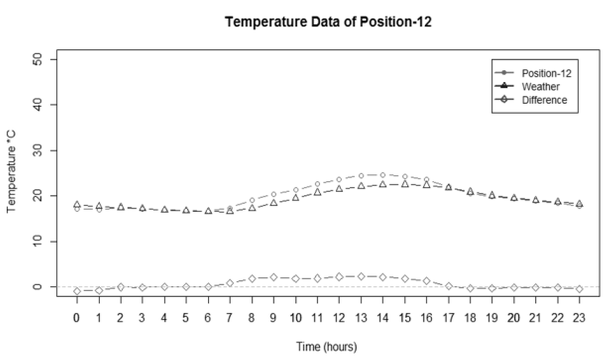

Fig. 4. The Result Shows for Position-12 of Temperature in Electrical Data

In this position, the maximum range of temperature is approximately 28℃ and the temperature increases from

morning 8'o clock to evening 5'o clock, when compared to the remaining hours.

Fig. 4 result shows the position-12 of temperature in electrical data. In this plot, the pink line refers to the average of temperature data of position-12 plotted from 0 to 23 hours, blue line refers to the average of weather data, and the red line shows the difference between position-12 and weather data. In position-12, the maximum range of temperature is approximately 24℃ from 8 am to 4 pm. So, the result shows that the Load Switch device of position-12 of temperature has been analysed in electrical data.

Fig. 5 result shows the position-18 of temperature in electrical data. This position is relatively important when compared to others because position-18 is the gateway of all positions. In this plot, the cyan line specifies an average of temperature data of position-18 plotted in X-axis, blue lines for weather data and red lines for the difference between position-18 and weather data. The maximum range of temperature was approximately 33℃ in position-18 of electrical data. Compared to position-0 and position-12, position-18 was exposed high temperature in the electrical power device. Therefore, the gateway of position-18 reveals more temperature difference during the analysis in electrical data.

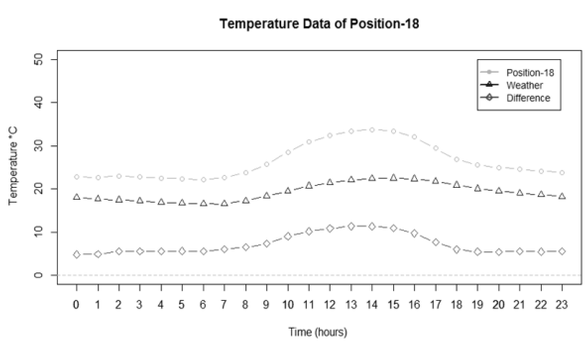

Fig. 5. The Result Shows for Position-18 of Temperature in Electrical Data

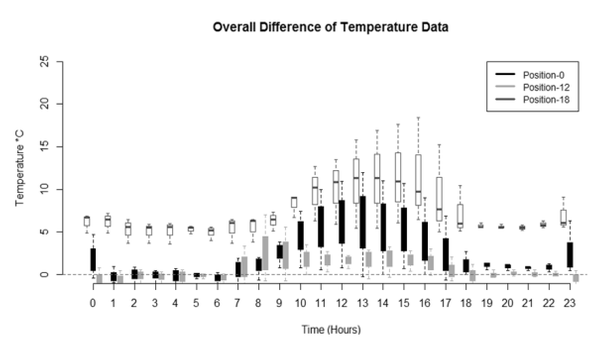

Fig. 6. Result Show for all Positions of Temperature in Electrical Data

Fig. 6 result shows the difference of all positions, which is presented in a single plot for the purpose of comparing the range of temperature from one to other and also identifies the limits of temperature in electrical devices. The dark rectangular color box shows the standard range of temperature and dashed lines shows the possible ranges of temperature. The standard range of temperature is based on past data that occurred many times in between range. So, we conclude this range is normal range for temperature. If the temperature is beyond the limit (abnoraml range) then i.e., maybe some problem has occured in that particular devices. According to seasons change, the range of weather temperature also change. So, based on this, the range of temperature changes in electrical data. The blue, green, and red colors are referred to temperature data with respect to position-0, position-12, and position-18. In general, particular hours from 8 am to 5 pm, all the position of temperature data are very high. For the reason of industries and factories get more power to run machinery. Therefore, all the positions of temperature have been analysed in electrical data.

5. Conclusion

This paper introduced a time series-based method to analyse temperature data sensed from electrical devices with Kalman Filter and Ensemble Model. In the analysis, we obtained identification of the maximum range of temperature at particular hours. And, we found that all the electrical power devices worked properly but the maximum range of temperature in electricity poles of a particular region was different with each region.

For that reason, the electrical data were collected from September to October months, which is autumn season in South Korea. Generally, in this season, the climate is supposed to be cool or pleasant, but, during day-time it produces high temperature, which may result in the usage of other electric devices. In industrials and factories using more power to run machinery. Example, if everyone uses Air cooler (air cooler takes high electric power) during these hours then the electric power will pass highly in electrical power devices. Therefore, this may be reason for electrical power devices to reveals more temperature in electricity pole. Therefore, based on this study we analysed temperature data and the devices are working properly in the electricity pole. Future research depends on forecasting the energy consumption on the major part of electricity data.

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