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Temperature Trend Predictive IoT Sensor Design for Precise Industrial Automation

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Abstract

Predictive IoT Sensor Algorithm is a technique of data science that helps computers learn from existing data to predict future behaviors, outcomes, and trends. This algorithm is a cloud predictive analytics service that makes it possible to quickly create and deploy predictive models as analytics solutions. Sensors and computers collect and analyze data. Using the time series prediction algorithm helps to predict future temperature. The application of this IoT in industrial environments like power plants and factories will allow organizations to process much larger data sets much faster and precisely. This rich source of sensor data can be networked, gathered and analyzed by super smart software which will help to detect problems, work more productively. Using predictive IoT technology - sensors and real-time monitoring - can help organizations exactly where and when equipment needs to be adjusted, replaced or how to act in a given situation.

Keywords: *IoT Sensors, Weather Prediction, Temperature, Industrial Automation, IIoT Algorithm*

1. Introduction

In the Internet of Things many of the objects that around us will be connected to the Internet to provide new services and increase the efficiency [1, 2]. Sensors will be one of the key drivers of IoT expansion [3]. Sensors measure physical inputs and transform them into raw data, which is then digitally storable for access and analysis [4]. Miniaturization has enabled sensors to integrate into smart devices, expanding their capacity beyond data measurement and analytics to transmitting information via the internet. In today's context, sensors can measure anything from temperature, force, pressure, flow and position, to light intensity. And they are being embedded into everything, from electricity networks, roads and other infrastructure, to mobile, wearable, home automation and security devices [5]. Among the most discussed applications for sensors are all things smart: cities, environment, water, metering, security and emergency services, retail, logistics, industrial control, agriculture, farming, domestic and home automation, and e-health [6].

Changes of climate and climate conditions have been watched for centuries. Particularly in that countries where the climate is changeable fast. Watching the climate parameters varieties is basic to decide the

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environment changes. There had been continuously a huge significance of climate impacting on human life and industry which had propelled to the improvement of entirety logical zones on the climate and climate perception. These days, there are numerous automated temperature measuring systems all over the world collecting the natural parameters continuously for a few or the other applications which appears the significance of the climate on the day to day life. The temperature forecasted information can be utilized for the fields like agriculture, transportation, industry, especially in the factories and etc. [7].

Internet of Things is fast emerging and becoming an almost necessity in life especially in the industrial sphere. The concepts of using technology in industrial is not new, but with the improvements in technology, the impact of technology in daily industrial activities can be seen in almost all the aspects. Today, all aspects of our industry can be monitored and analyzed using information captured from different connected devices [8].

These days, industry tries various ways to support maintenance to decrease costs and get more efficiency using smart devices and software. The IoT stages donate a great bolster for forecast because it can coordinate information from different gadgets and manufacturing systems [9].

This paper deals with the weather forecasting system developed for the industrial automation system. Using Arduino, sensors and applied algorithm the system will predict the future temperature based on the previous data that was collected for the previous time. It will be used in the industry for the temperature monitoring and forecasting the data to the server which could be viewed and used for the periodical statistical analysis of the data.

The paper consists of some parts as follows. In section II IoT system for industrial automation is given. Section III has the System implementation. Time series prediction algorithm is described in section IV. And section V on the experimental results. Conclusion and future work are given in section VI.

2. IoT System for Industrial Automation

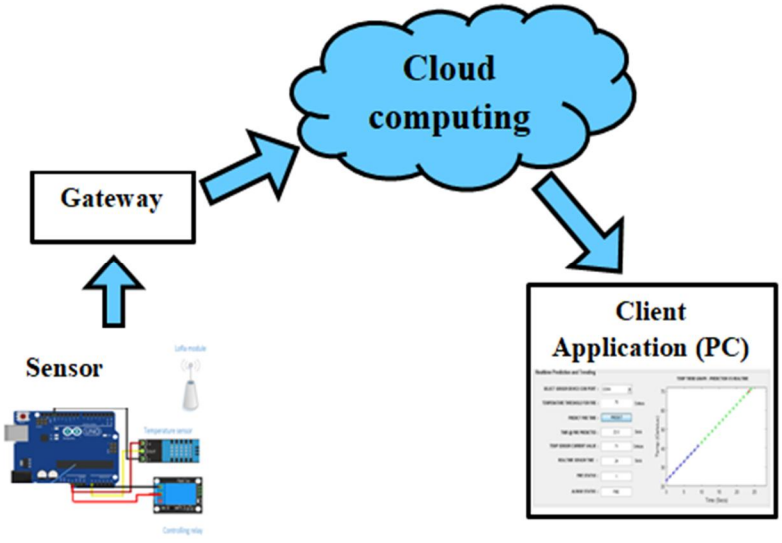

Figure 1. IoT System Usage Model

Internet of things is rapidly increasing innovation. IoT is the network of physical objects or things integrated with hardware, computer program, sensors, which empowers these objects to gather and exchange data. For this proposed idea, we are developing a framework which is able consequently to monitor the

mechanical applications and create alerts utilizing the concept of IoT as shown in Figure 1. This necessity needs process engineering systems, automated manufacturing, and industrial automation. Therefore, industrial automation plays a key part in solving the requirements, safety and stability of industry. A primary concept of this is that it summarizes employments of IoT in industries to monitor and control the industry automatically.

The proposed IoT empowered detecting and observing framework comprises of a sensor that collects data, Gateway, Cloud Computing and Client Application as appeared in Figure 2.

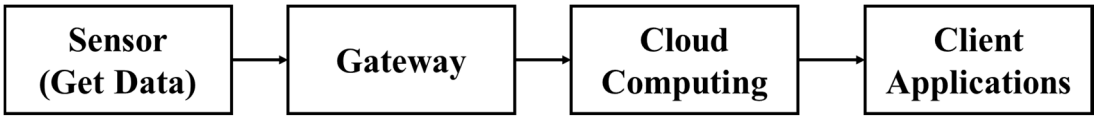

Figure 2. Block Diagram

The sensor connected with Arduino microcontroller detects temperature and send the electrical signal to cloud computing. The information gotten at the sensor part being send to Gateway that direct to cloud computing, where prediction process starts to analyze data and predict future temperature. In order to predict the future temperature, there was suggested using the time series prediction algorithm that will provide future estimated temperature based on the previous data. The analyzed and predicted information by cloud computing using MatLab program is transmitted to Client Application terminal. The sensed data is delineated graphically and recorded in an exceed expectations sheet, which is created in MatLab program. This information is transmitted to a database by internet. Lora module plays role of wireless communication.

3. Necessity of IoT Predictive Sensor

The Internet of Things has become more than a vision. As more organizations put in place sensor-enabled devices and intelligent systems that connect things with people and processes - to help drive efficiencies and unlock new opportunities.

Predictive maintenance might be constrained if the employees must rely on measurements that are not precise, if the batteries in measuring equipment fail, or if data communications are limited. Today, such constraints are being overcome. New predictive sensors and data analysis software is simplifying condition monitoring and streamlining the process of predictive maintenance.

Using predictive sensors to detect when a critical piece of machinery is close to failing saves an industry. The small wireless sensors directly monitor the machine. Data indicates whether the bearing is about to fail and predicts critical points of temperature. The sensors are used to detect the impending failure. The sensors use low-energy. The sensor technology is critical because it is small enough and doesn't interfere with the performance. The sensors also have the potential for applications in harsh manufacturing environments as well as transportation, distribution and warehouse fleet management and etc.

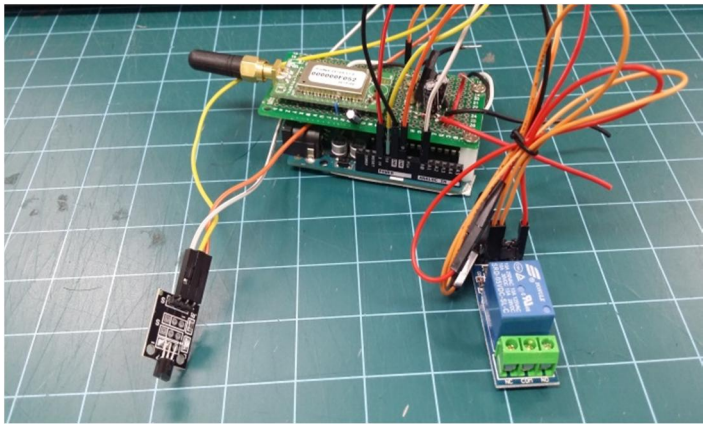

Figure 3. System Implementation

The proposed concept is emulated using Arduino microcontroller with connected LoRa module, temperature sensor and relay module to control system and shown in Figure 3. The temperature sensor detects the temperature of its environment and converts the reading into an electrical signal and sends data to microcontroller. After microcontroller sends this data to cloud computing to analyze data for prediction future temperature and then transmit data to client application. A relay is an electrically operated switch. It is necessary to control a microcontroller by a separate low-power signal. With our solution memory of 2 KB is sufficient memory for handling information to forecast the future temperature.

In case gotten data of the prediction of the critical temperature, system automatically will be switched off, to prevent any accidents that usually occur because of overheating. This also has a feature to configure alert at multiple levels of temperature for different cases.

4. Time Series Prediction Algorithm

In equation (1), time Series Prediction algorithm represents the use of a model to foresee future occasions based on known past occasions, before they are measured. In other words, given to begin with t measured information focuses of time series a_{t+1}, the point of prediction is to create a demonstrate able to advance the value

$$a_{t+1} = f(a_1, a_2,...,a_t). \quad (1)$$

The main point of time series data prediction is to find function to provide an accurate future value of the series. Some research directions indicate as important the immediate future value whereas other problems may indicate a further interval of interest. In equation (2), the prediction of the following m values of time series:

$$a_m = f(a_1, a_2,...,a_n), m \in [n + 1, n + k], k > 0 (5) \quad (2)$$

Time Series Analysis and Prediction face a continuously rising interest and have been widely applied in different circles of industry [10]. This approaches focus on a number of data collections of the previous collected data, using mathematic modeling, time-frequency analysis, statistics methods, to process and make a prediction on the next most probable data. This paper proposed to use time series algorithm using gotten past data to predict the next term for time series. The proposed time series prediction algorithm for

temperature prediction is shown in Figure 4.

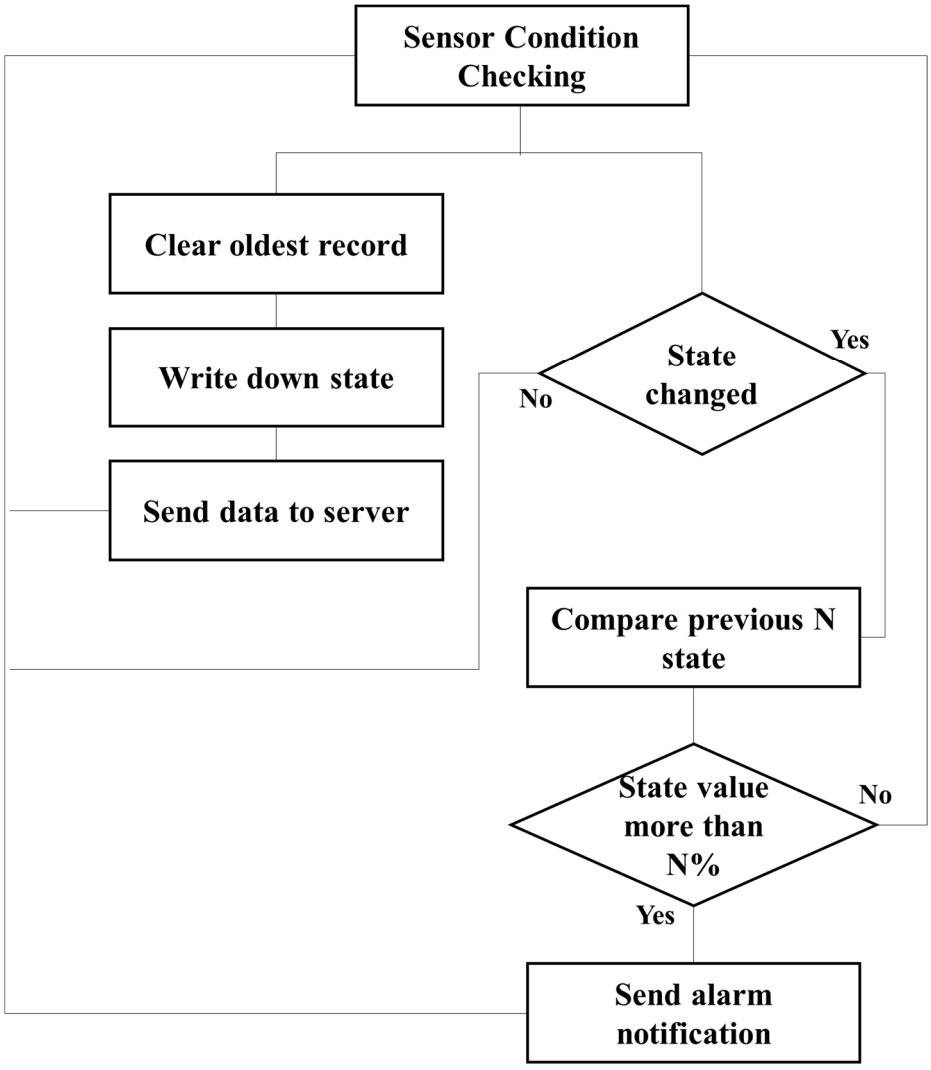

Figure 4. Time Series Prediction Algorithm

4.1 Algorithm Explanation

At first sensor starts checking condition of the environment. The received data starts being analyzed in parallel. Algorithm memorizes previous 20 seconds. So more previous data go to state of clearing oldest record and then writing down state and send data to server. If state not changed then algorithm goes to sensor condition checking. If state changed it goes to compare previous N state. Then there are also two cases. If state increased more than N% from nominal it sends alarm notification. If state was not increased it goes to sensor condition checking again.

4.2 Graph

Figure 5 expressed in graphical form of Time series temperature prediction. There are three levels of measuring temperature. First one predicted, second is major and third one critical. Time Series Prediction Algorithm takes previous time of data for analyzing data to predict next data of time series. Time-series

forecasting is a quantitative forecasting technique. It measures data gathered over time to identify trends. The data is taken previous 20 seconds interval.

The trend component refers to the gradual data shifting over time. It is often shown as an upward and downward sloping line to represent increasing or decreasing trends. The Time Series Algorithm is generally used when historical data plays an important role in predictive forecasting. The trend increases or decreases over a period of time. This can be caused due to upward or downward pattern. The process is shown in the next graph:

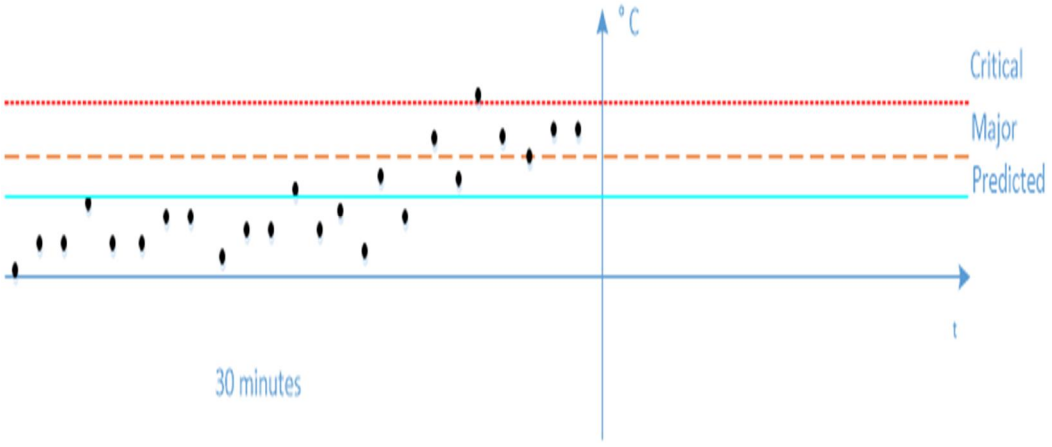

Figure 5. Diagram of Time Series Prediction

5. Result Analysis

For proposed algorithm simulation to get accurate prediction is used MatLab program. Using MatLab program based on mathematical tools and the time series algorithm it will output accurate prediction. Figure 6 is IoT sensor based environment temperature trend window.

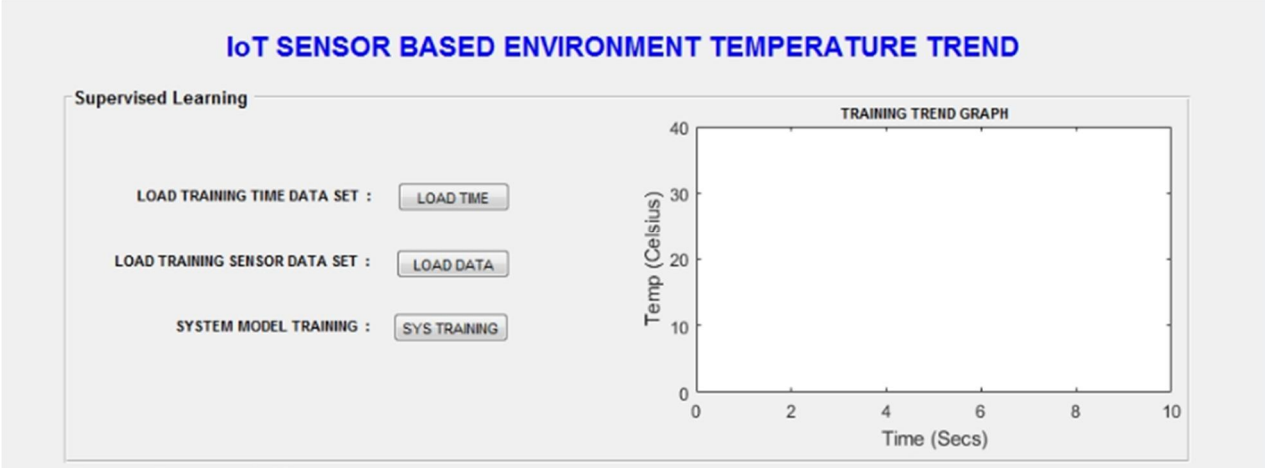

Figure 6. IoT Sensor Based Environment Temperature Trend

First window is supervised training trend graph. That consists of Load training time data set, Load training sensor data set and System model training. Second window is Real time Prediction and Trending

(temperature trend graph). That consists of value such as Temperature threshold for fire, predict fire time, time fire predicted, temp sensor current value, real time sensor time , fire status , alarm status. Here time interval is expressed in seconds.

The time series temperature prediction algorithm training process is shown in Figure 7. At first this algorithm gets some data and starts to analyze data based on the previous data. As it shown on the graph prior to predict some data at first it analyze this data and then output some prediction. On the next figure will be shown results and prediction value that was implemented in real environment.

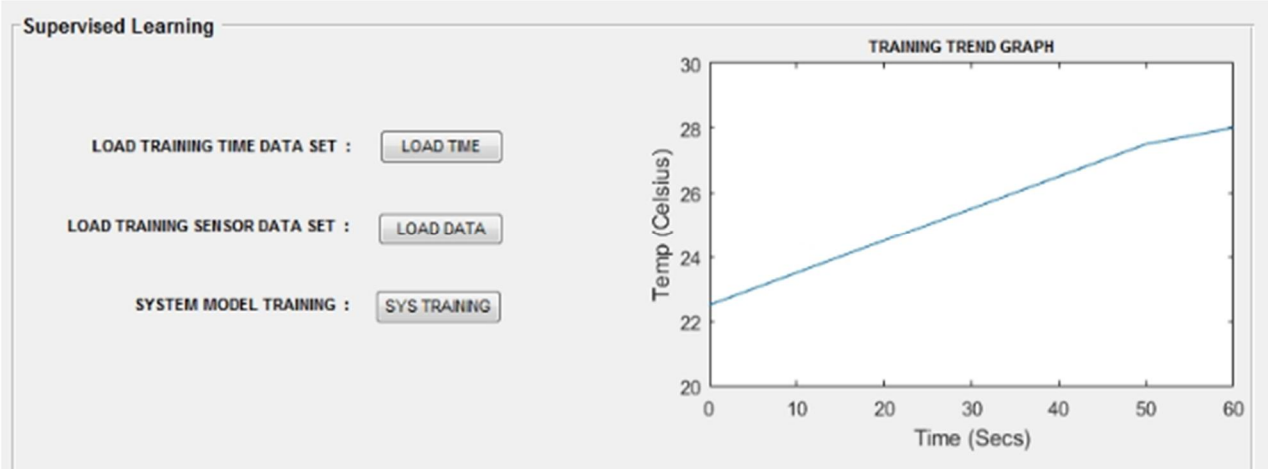

Figure 7. Training Trend Graph

In the Real time prediction and Trending window there are parameters (Figure 8) as follows:

(i) Select sensor device COM port: COM4
(ii) Temperature threshold for fire: 70 Celsius
(iii) Predict fire time: Predict
(iv) Time fire predicted: 23.5 secs
(v) Temp sensor current value: 71 Celsius
(vi) Real time sensor time: 24 secs
(vii) Fire status: 1
(viii) Alarm status: FIRE

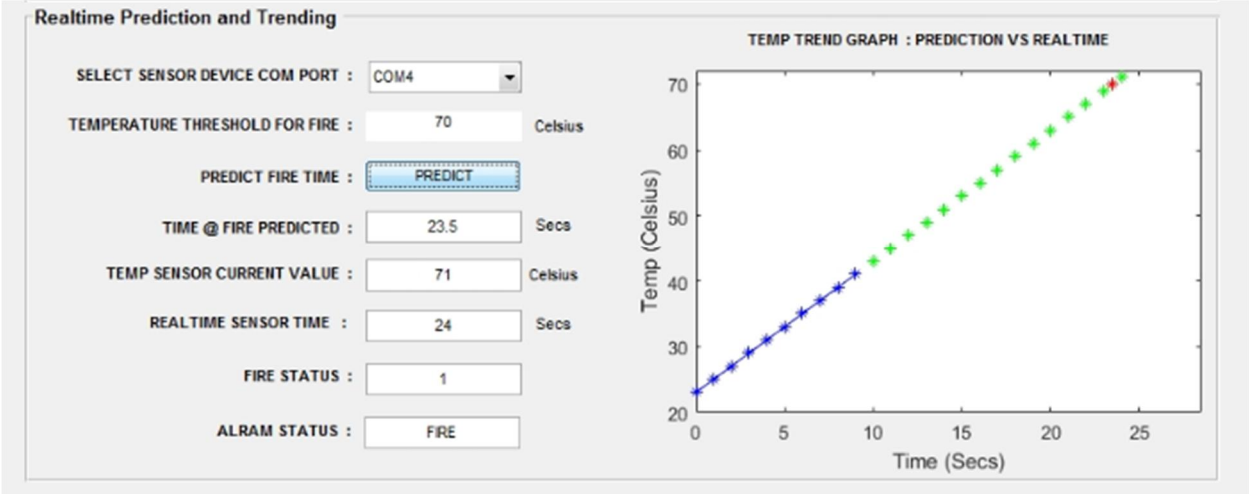

Figure 8. Real Time Prediction and Trending Window

Figure 8 shows the result of analysis of Real time temperature prediction using time series algorithm. In the time interval from 0 to 10 seconds was learning process. And using real time prediction algorithm based on the previous data it was analyzed using mathematical method to output prediction data. So on the point from 10 to 23.5 seconds the green line is prediction of data. And critical point is red point on 23.5th second. So if system predicts some critical temperature of environment, it can prevent automatically any accidents that occur in the industry before.

6. Conclusion

Using IoT sensors such as the low cost, low power wireless communication LoRa module, temperature sensor, relay module, Arduino microcontroller and time series prediction algorithm provide a simple approach to determine the range of values necessary for a good prediction of the time series terms that is useable for industry. The time series prediction algorithm uses the actual collected values of a previous data. So using MatLab program to analyze data generates an accurate prediction of expecting temperature to prevent some accidents or give some alert to host of some industry. It improves the operational efficiency and system application flexibility by using the IoT based prediction algorithm instead of the traditional analog systems, and at the same time reduces the manpower cost. This system can be applied in many types of industries to prevent any accidents because of overheating.

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