

Heatmap System with Predictions*

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Abstract—Temperature plays an important role in chemical laboratories, food safety compliances, warehouse inventory management, patient's health, climate temperature monitor, room fireplace predictions and in many areas. This paper provides about implementation of Heatmap System with temperature predictions which accurately predicts using latest Technologies and algorithms and therefore the product would advantage for everybody where temperature observation is needed. Polynomial regression algorithm is planned to implement this Heatmap System for precise temperature predictions. The sensors facilitate to verify and validate the temperature in indoors at several locations. Data on the sensing elements are often will provide through cloud facilities. Polynomial regression algorithm is going to be accurately predict the temperature and it will help in temperature analysis according to system deployment at things, environment, patients and industries. It is likewise single system for everybody and everything to evaluate data of current temperature and future temperature that is for analysis. This Heatmap System also raises alerts which are based on given temperature thresholds. Alerts by Alarm, notifications through Mobile SMS, sending messages through Telegram APP, receiving emails automatically and online visualization reports are also available.

Index Terms—Temperature, Sensor, polynomial regression, Prediction, Predictive Analysis, Monitor, Alert.

I. INTRODUCTION

Throughout our daily lives, the increasing phenomenon of the age has supposed that the world around us is also getting smarter. Virtual devices and sensors are not just in our pocket or workplaces, but in our houses, schools and many locations and cities increasingly. Taking a key role in supporting collect, observe and monitor statistics and these statistics about their surroundings, these devices are in a function to talk with every other thru a large scope of network called the Internet of Things. In addition, the polynomial relationship help in analyze accurately fit according to the collected data points on the plot. We refer this as polynomial regression. This is turning into a critical player in a growing range of tool regions that include picture recognition, natural language processing, forecasting, prediction and optimization of procedures accurately in Machine Learning. Machine Learning is growing into the element of being capable of draw interesting patterns and inferences from these assets of real-time data and making the consequences available to analysts in addition to at once embedding them into commercial enterprise processes accurately. The intersection between machine mastering and internet of things is creating a desire for new approaches of thinking about knowledge sensors, citizen information scientists and a bunch of various issues. Machine mastering at the side of internet of things will play an increasingly vital feature in our lives because the days pass by, as each are fields of laptop technology which may be presently in a fast country of development.

This paper gives a usage of internet of things and polynomial algorithm strategies for temperature monitoring for the scope of everything that are for example, food safety compliances, warehouse inventory management, while transit goods, chemical laboratories, patient's health, climate temperature

monitoring, etc. Temperature plays a vital role in shaping the chemical composition or integrity of volatile compounds and biological samples severally. They will render useless and have an effect on experimental conclusions or perhaps worse, the patient's health, if not kept under a strict temperature range. It is, therefore, very important for laboratories and check clinics to take care of a controlled atmosphere for successful testing on these samples. With sensors temperature monitoring solution, a laboratory will conduct tests and store samples during a controlled atmosphere, to work out correct results using latest technology learnings.

Developing and maintaining a uniform batch of food items that stands true in keeping with the standards set by food restrictive authorities is vital for the food and food business. However, for sustenance corporations with the franchise in numerous corners of the globe, maintaining these quality and safety standards will be a significant challenge. The food business therefore uses heater/freezer fitted chambers to develop a manageable atmosphere for his or her product. Sensor's temperature observance resolution permits the food business to watch the temperature of those chambers permitting them to make sure that the restrictive compliances are met. They will remotely monitor the temperature of the things and ensure the standard of their product.

Some product is sensitive to humidness and temperature. Storing them during a traditional warehouse may result in their corrosion and are so needed to be keep in temperature-controlled surroundings. By mistreatment heaters or freezers, the temperature and humidness of the warehouses is maintained to make sure the standard of a particular variety of product. By mistreatment device based mostly temperature watching resolution, a storage and inventory manager will track and remotely amendment the

temperature of the warehouse. This reduces review prices and helps firms to make sure the standard of their product.

Connecting makers, distributors, and shoppers are one among the numerous crucial applications of a supply chain. Throughout the distribution section, the standard of the product being shipped is affected adversely because of dynamic environmental conditions. Hence, corporations develop special containers to take care of an acceptable surroundings for his or her product whereas they are shipped from one location to a different. Exploitation temperature observance sensors permits corporations to trace environmental parameters of a trailer end-route even from a foreign location. The present technological solution at the side of advanced measure establish transparency during a cold provide chain and permit corporations to take care of the standard of their product.

Manufacturing primarily based firms rely tons on the standard and potency of their machines. Fast instrumentation breakdown may end up in bottlenecks that more affects the performance of the full plant. As rise in temperature is one in every of the implications of the machines' wear and tear, temperature observation sensors is accustomed observe problems touching the performance of the machines. This helps the businesses to cut back instrumentation time period and conduct effective condition-based maintenance (CBM) on them whenever they endure a sudden malfunction or breakdown.

The applications of temperature observation systems are quite versatile. They provide exemplary advantages in terms of keeping the environmental conditions stable and controlled as per specific needs. Below are the highest five advantages that this resolution offers:

Save time with instant notifications and alerts:

An internet of things system offers instant notifications in time period. Hence, a temperature observation system permits a corporation to trace the environmental parameters on a secure web/mobile-based platform. This eliminates redundant tasks like taking manual readings, therefore saving time and elevating fast deciding.

Productivity improvement with advanced analytics:

The data gathered from the temperature sensors may be accustomed produce applied mathematics insights. These insights can embody the time period throughout that product deteriorate and details related to the temperature readings. This may facilitate the businesses to enhance the responsibility of their warehouse and cold storage.

Maintaining regulatory compliance:

Companies should maintain the standard of their product within the entire cycle of the provision chain. The product ought to meet the protection and quality standards set by the authoritative restrictive bodies. Temperature observation permits firms to guard their merchandise from the adverse effects of adjusting weather and so meet regulative compliance.

Accessibility from remote locations:

As internet of things [4] encompasses advanced telemetry capabilities, remote temperature monitoring from distant locations is also. The data gathered through temperature monitoring sensors [11,20] can be accessed from faraway places on a web application or a mobile app.

Creating transparency in the supply chain:

With advanced telematics capabilities, a temperature observation system will transfer the information to multiple profiles at the same time in time period. This will increase the visibility between the provider and carrier sanctioning them to observe the parameters through remote locations.

This temperature sensors collected information may be keep exploitation cloud technology and can be used for correct prognosticative analysis with the assistance of polynomial regression. The employment of temperature observation sensors is enabled the monitoring of modification in temperature touching in several areas. This can be conjointly enabling corporations to make sure the standard of their merchandise whereas they are in transit.

II. LITERATURE REVIEW

In the proposal "[1] Hotspot Temperature Monitoring of Fully Insulated Busbar Taped Joint" by Liezheng Tang ; Jiangjun Ruan ; Zhifei Yang ; Rou Chen ; Guannan Li ; Xuefeng Yin[1], a temperature increase checked on a sensible insulated busbar during warm summer time season. This is to validate and for improving the condition monitor the temperature.

In the proposal "A 0.065-mm 3 Monolithically-Integrated Ultrasonic Wireless Sensing Mote for Real-Time Physiological Temperature Monitoring" by Chen Shi, Tiago Costa, Jeffrey Elloian, Yihan Zhang, Kenneth L Shepard [2], human body temperature monitored and this is for the biomedical applications. They also detected the tissue pathologies for the treatment of thermal.

In the proposal "Design and Experimental Study of the Wireless Online Monitoring System of a High-Temperature Superconducting Machine" by Guangkun Lian ; Jiahe Zhang ; Biao Chen ; Fei Ban ; Zhe Hou ; Huitao Li [3], detected the environment temperature along with volate and others. They used wireless facility to monitor the system online and they developed the system for high-temperature superconducting machines.

In the proposal "Hybrid Approach for Securing the IoT Devices" by Sai Prasanthi, M., Katragadda, V. B., Perumalla, H., & Sowmya, B [6], they used security algorithms to protect the information and data has been collected from the sources using sensors.

In the proposal "A Survey on the Role of IoT in Agriculture for the Implementation of Smart Farming" by Muhammad Shoaib Farooq ; Shamyra Riaz ; Adnan Abid ; Kamran Abid ; Muhammad Azhar Naeem [8], they developed IoT solutions which helped to monitor agricultural farms automatically and

it has been reduced the human intervention. They technologies they used network topologies, phone based, etc. and developed applications which are based on sensors for various aspects of managing the farm.

In the proposal of "Development of an IoT-Driven Building Environment for Prediction of Electric Energy Consumption" by Guneet Bedi ; Ganesh Kumar Venayagamoorthy ; Rajendra Singh [15], they developed a system for predicting high energy consumption in electric loads and they controlled to optimize the electric loads. They given this system for effective management of energy and making sure the energy is generating sufficiently.

In the proposal of "IoT based smart and flexible lightning in streets" by Anitha, R., Nishitha, M., Akhila, K., Sai Anusha, K., & Srilekha, G [20], they used different climate parameters for temperature forecast and they considered the data for forecast the dengue. This approach and procedure to help in decreasing the spreading of dengue, etc.

In the proposal of "An optimal multitier resource allocation of cloud RAN in 5G using machine learning" by Bashir, AK; Arul, R; Basheer, S; Raja, G; Jayaraman, R; Qureshi [24], modified C-RAN architecture to multitier Heterogeneous Cloud Radio Access Networks in a 5G networks. This modification is for improving control unit of network management and also to optimize it. They implemented this with the help of Machine Learning.

III. ARCHITECTURE OF HEAT MAP SYSTEM

As part of voltage regulator connections, Vin pin on the voltage regulator to the 5.V pin on the Bolt device, Vout pin on the voltage regulator to a node on breadboard, GND pin on the voltage regulator to the GND pin on the Arduino or form a GND node similar.

As part of wifi module connections, Tx or TxD pin to the Rx3 pin on the Bolt device, EN or CH_PD pin to the 3.3-V power node, IO16 or RST pin to the 3.3-V power node, 3V3 or VCC pin to the 3.3-V power node, GND pin to the ground pin or node and finally Rx or RxD pin to pin Bo. Below is the diagram for the architecture.

Hardware and Software:

- Smart Phone
- Bolt microcontroller
- 5- to 3.3-V step-down voltage regulator
- Logic level converter from 5 to 3.3 V
- ESP-01 Wi-Fi module
- One desktop or a notebook
- Breadboard
- TMP36 temperature sensor
- Package of wires male-to-male to connect the components
- Package of wires female-to-male to connect the components

- Digital Ocean Droplet (Cloud Platform)
- Python Libraries
- Twilio
- Mailgun
- Telegram APP

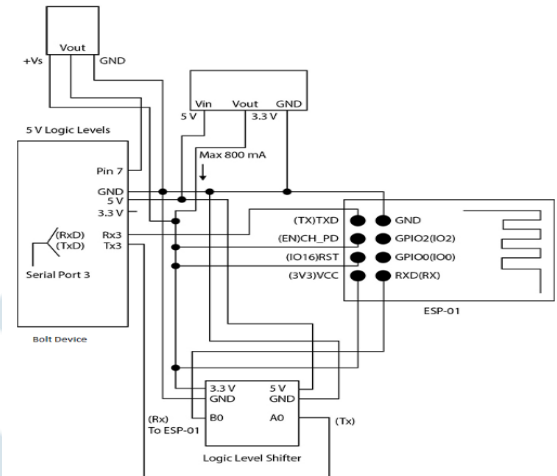


Fig. 1 Heatmap System Architecture

Bolt Cloud:

The Bolt Cloud is one amongst the main part in providing the internet of things capabilities to the Bolt device. All the Bolt devices hook up with the Bolt Cloud out of the box. The Bolt devices are shipped with a computer code that helps it perceive a way to hook up with the Bolt Cloud over the net. Bolt cloud could be a server for communicate along with the Bolt Wi-Fi module over the internet. It is the options like receiving and storing the information collected by Bolt Modules, Storing the information, analyzing it via knowledge visualization and polynomial regression algorithm.

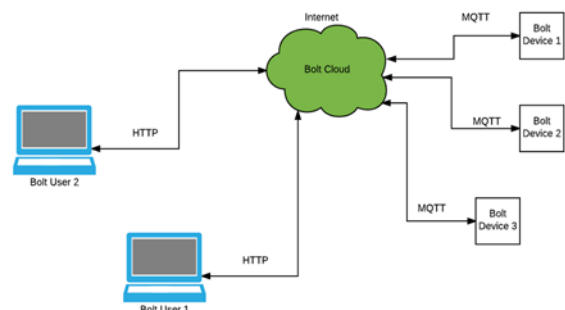


Fig. 2 Bolt Cloud

The communication of Bolt devices with Bolt Cloud happens over the MQTT communication protocol. MQTT stands for Message Queue mensuration Transport. however why will we have to be compelled to have a protocol reminiscent of

MQTT for communication once protocol & HTTPS protocols are therefore in style and wide used for communication? Though these protocols are popular, the number of overhead knowledge that's sent over the net for managing the communication is kind of plenty. Overhead knowledge is that the data that is distributed together with the particular message/data which conveys the additional data needed to grasp the message and data sent. The overhead information varies from protocol to protocol. This is often fine just in case of systems corresponding to mobile phones, laptops, desktop computers that have the hardware capabilities and therefore the network capabilities to send the additional overhead information.

Most internet of things services and sensors contain restricted process capabilities and affected net information measure. Because of these limitations, they send knowledge over the net only needed and therefore the data sent is incredibly low in terms of information measure usage. Therefore, exploitation protocols like HTTP, HTTPS does not become possible wherever the overhead knowledge is over the particular data itself. MQTT contains terribly low overhead and therefore becomes ideal for net of things communication.

MQTT may be a pub-sub electronic messaging protocol. Tap house refers to business enterprise and sub refers to subscribing. There is a central entity, in our case it's the Bolt Cloud. All the Bolt devices hook up with the Bolt Cloud and send the information to numerous channels by business enterprise the data on their distinctive channels. The Bolt device conjointly purchase channels in order that they will receive commands coming back from the Bolt users. The Bolt Cloud users, i.e., individuals like United States communicate with the Bolt Cloud exploitation the HTTPS communication protocol. The Bolt Cloud dashboard is useful to regulate and monitor the Bolt devices or can be used the Bolt Cloud genus Apis just in case a wish to by-pass the dashboard and access the Bolt devices via programs that written by developers.

Bolt Cloud receives all the commands to regulate or request for sensing element information from Bolt devices and sends the commands to the Bolt device. The Bolt device executes the commands, and sends a response back to the Bolt Cloud that successively forwards it to the user who initiated the command.

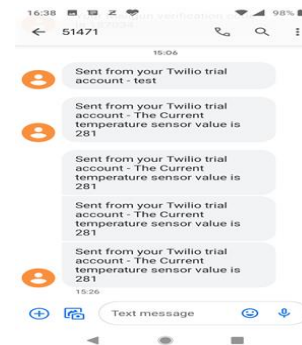


Fig. 3 Mobile SMS Alert Screen Shot

Digital Ocean Droplet with Software:

Digital Ocean calls its cloud servers Droplets that accounts to an equivalent issue as Instances by AWS (Amazon internet services). Actually, droplets are simply an elaborate term for software package. It may be numerous versions of Ubuntu, fedora or CentOS. This analysis used the suitable image (version and sort of OS) of droplet. At the time of this writing, the 64-bit Ubuntu sixteen.04.6 image is chosen. The foremost common software package for ssh in windows is Putty. Putty could be a free Telnet and SSH terminal software package for Windows and operating system platforms that alter users to remotely access computers over the net. In Ubuntu sixteen.04 that is that the version of Ubuntu put in on your Digital Ocean droplet, solely Python-3 is accessible. Pip3 could be a package manager for python3 won't to install and manage packages and python libraries. It is system freelance.

Twilio:

Twilio could be a third-party SMS practicality supplier. it is a cloud communications platform as a service (PaaS) company. Twilio allows software developers to programmatically make and receive phone calls and also send and receive text messages using its web service APIs. Created the account on Twilio and it is used Bolt Python library to create SMS Alert system.

The given code incessantly fetches the temperature price mistreatment `analogRead` operate. Since the device is connected to A0 pin of the Bolt, we are going to execute the analogRead() operate on the pin. The response from the Bolt Cloud mistreatment the analogRead() operate is in an exceedingly JSON format, thus we are going to have to be compelled to load the JSON knowledge sent by the cloud mistreatment Python's json library. The temperature price is within a field tagged as "value" within the response. we will access the JSON values mistreatment the statement `sensor_value = int(data['value'])`. This line additionally converts the device reading to whole number knowledge kind for comparison the temperature vary. this is often boxed in within a try-except block to handle any error that will occur within the code. If the temperature reading is on top of the most limit or below the minimum limit. If it exceeds, then the

SMS are going to be sent. The SMS to be sent can contain the text "The Current temperature device price is" followed by the temperature value. The response from Twilio are going to be keep within the `response` variable. Once the temperature reading has been sent, have to be compelled to watch for ten seconds to induce ensuing reading and therefore the program to sleep once each loop iteration. The statement `time.sleep(10)` puts the program execution on hold for ten seconds. this implies that the program wouldn't execute for a amount of ten seconds.

Mailgun:

Mailgun is associate degree Email automation service. It is a really powerful set of intrinsic functions for causing emails. Developers will method their email with the assistance of Mailgun API. Created the account on Mailgun and it's used the Bolt Python library to make Email Alert system.

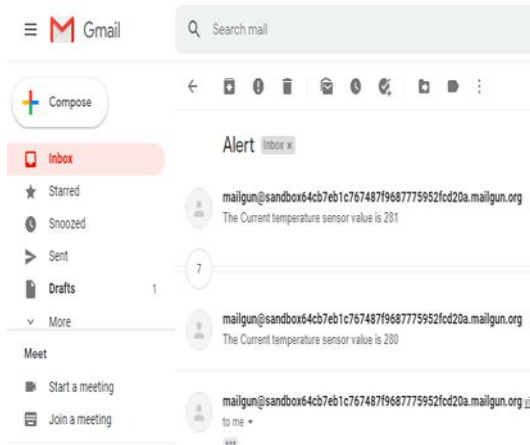


Fig. 4 Mail Alert Screen Shot

The code unceasingly fetches the temperature worth victimization `analogRead` operate. Since the detector is connected to a pin of the Bolt, we'll execute the analogRead() operate on the pin. The response from the Bolt Cloud victimization the analogRead() operate is in an exceedingly JSON format, therefore we'll ought to load the JSON knowledge sent by the cloud victimization Python's json library. The temperature worth is within a field tagged as "value" within the response. It will access the JSON values victimization the statement `sensor_value = int(data['value'])`. This line conjointly converts the detector reading to whole number knowledge kind for comparison the temperature vary. This is often boxed within a try-except block to handle any error which will occur within the code. Additional rationalization of try-except code block is given here. Subsequent line of code checks if the temperature reading is on top of the most limit or below the minimum limit. If it exceeds, then the e-mail are sent. The send_email operate takes 2 parameters. Initial one is Subject of the Mail and therefore the different one is Message content.

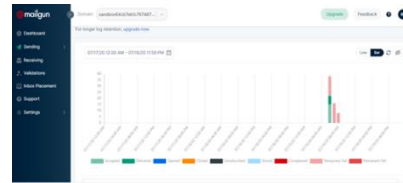


Fig. 5 Mailgun Logs Screen Shot

The Email to be sent can have the topic "Alert" and contain the text "The Current temperature device price is" followed by the temperature value as outlined the send_email() operate. The response from Mailgun are keep within the `response` variable. The text parameter from the response extracted and regenerate to json and therefore the message from it's written. Once the temperature reading has been sent, we'll ought to stay up for ten seconds to induce successive reading. For this, we'll place the program to sleep once each loop iteration. The statement `time.sleep(10)` puts the program execution on hold for ten seconds. this implies that the program wouldn't execute for a amount of ten seconds.

Telegram:

Telegram could be an electronic communication app the same as Whatsapp. This will be able to send and receive messages together with files conjointly. It's liberal to use. This will be able to access the platform via your Android/iOS/Windows phone and conjointly your laptop or mack. A channel is to message what teams are to Whatsapp.

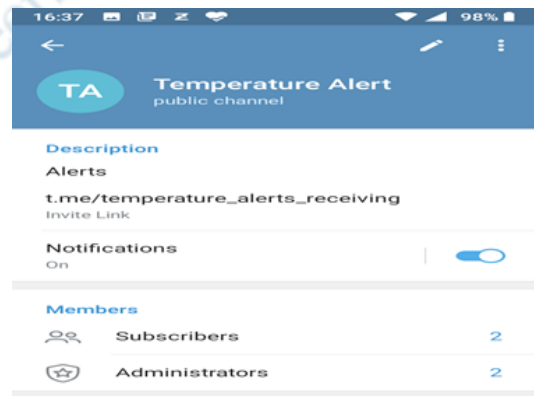


Fig. 5 Telegram APP Configurations

Channels are a tool for broadcasting your messages to giant audiences. They can have an unlimited number of subscribers, they can be public with a permanent URL and each post in a channel has its own view counter. Bots are third-party applications that run within message. Users will act with bots by causation them messages, commands and requests. it's used Bots to send alerts on channel. The Bolt Cloud returns a standing of one if the request was created with success and the rest aside from 1

means the request has failing. The road `if data["success"] != "1":` checks for a sound response. The operate is sheathed within a try-except block to handle any exceptions and errors. Just in case of any error or exception within the attempt block, the except block is dead. This can come back a response of -999 just in case of any error. The info variable may be a wordbook that holds the chat ID(Channel ID) in order that the larva is aware of which channel it's to post the message to. It additionally contains the text message to be sent as a message.

Sensors:

A detector may be a tool that detects and responds to some form of enter from the bodily surroundings. Any detector is employed to live a property, which incorporates pressure, position, temperature, or acceleration, and reply with feedback. the actual input are light-weight, heat, motion, moisture, pressure, or somebody of a amazing wide range of different environmental phenomena. The output is typically a proof this is often remodeled to human-readable show on the detector place or transmitted electronically over a community for reading or equally process. Here are some samples of the varied totally different sorts of sensors.

An element detector in an exceedingly car's emission management machine detects the gasoline/oxygen quantitative relation, typically through a chemical process that generates a voltage. A laptop within the engine reads the voltage and, if the mixture isn't best, readjusts the balance. Motion sensors in various structures as well as domestic safety lights, automatic doors and toilet fixtures unremarkably ship out some kind of strength, inclusive of microwaves, unhearable waves or delicate beams and unearth while the glide of energy is interrupted by one thing coming back into its path.

A photo sensor detects the presence of visible light, infrared transmission (IR), and/or ultraviolet (UV) energy. Retro-reflective detectors are the foremost unremarkably used LED-primarily based mostly photoelectrical sensor in clean item detection applications. Every detector homes associate degree electrode and a receiver. Retro-reflective photoelectrical sensors with a homocentric optical style emit and receive light-weight aboard a widowed slender axis. This optimizes the detection of clear gadgets by dramatically decreasing the threat of false detection from mirrored delicate. Sensors the usage of this generation might have a tiny low bright spot that simplifies detector alignment and allows terribly precise forefront detection.

These sensors use a solid-state technique to work out the temperature. That's to mention, they don't use mercury (like recent thermometers), bimetallic strips (like in some home thermometers or stoves), nor do they use thermistors (temperature sensitive resistors). Instead, they use the very fact as temperature will increase, the voltage across a diode will increase at a famed rate. (Technically, this can be truly the fall between the bottom and electrode - the V_{be} - of an

electronic transistor.) By exactly amplifying the voltage amendment, it's straightforward to get associate degree analog signal that's directly proportional to temperature. There are some enhancements on the technique however, primarily that's however temperature is measured. The good news is all that complicated calculation is completed within the chip - it simply spits out the temperature, prepared for you to use!

Because these sensors haven't any moving components, they're precise, ne'er wear out, don't want standardization, work beneath several environmental conditions, and are consistent between sensors and readings. What is more they're terribly cheap and quite straightforward to use?



Fig. 6 TMP36 Sensor

The basic statistics are for the temperature device within the Adafruit look, the Analog Devices TMP36 (-40 to 150C). It's terribly the same as the LM35/TMP35 (Celsius output) and LM34/TMP34 (Fahrenheit output). the explanation we have a tendency to went with the '36 rather than the '35 or '34 is that this device features a terribly big selection and doesn't need a negative voltage to browse sub-zero temperatures. Otherwise, the practicality is largely constant.

- Size: TO-92 package (about 0.2" x 0.2" x 0.2") with three leads
- Temperature range: -40°C to 150°C / -40°F to 302°F
- Output range: 0.1V (-40°C) to 2.0V (150°C) but accuracy decreases after 125°C
- Power supply: 2.7V to 5.5V only, 0.05 mA current draw

Predicting Temperature using Polynomial Regression

Step 1: Hardware connections for temperature monitor screen, in the interfacing sensor over VPS of the Cloud, API and Alerts module.

Step 2: Powered up the circuit and waited for the connection to the Bolt Cloud. (The Green LED of the Bolt should be on)

Step 3: On cloud.bolttiot.com and created a new product. While creating the product, chosen product type as Input Device and interface type as GPIO. After creating the product, selected the recently created product and then configured.

Step 4: In the hardware tab, select the radio button next to the pin. Given the pin the name 'temp' and saved the configuration using the 'Save' icon.

Step 5: Moved to the code tab, give the product code and written the code.

Step 6: Written the code to plot the temperature data and ran the polynomial regression algorithm on the data and saved the product configurations.

Step 7: In the products tab, selected the product created. Selected the Bolt device in the popup and then clicked the 'Done' button.

Step 8: Clicked on 'deploy configuration' button and then the 'view this device' icon to view the page that given the design.

Step 9: Waited for about 24 hours for the device to upload enough data point to the Cloud. On the predict option to view the prediction graph based on polynomial regression algorithm as per the parameters of the algorithm.

Results:

Prediction points: This number tells the Visualizer how many future data points need to be predicted. By default, the Visualizer spaces the points with the data collection time in the hardware configuration of the product. So, changed the product to collect data every 5 minutes, and selected 6 prediction points, the Visualizer will predict the trend and showed 6 points up to 30 minutes in further.



Fig. 7 Predictions Graph

The prediction history graph helps for tune the machine learning model. It has to change the parameters below, to make it so that this graph most closely resembles the actual data. When this happens the predicted data or the predicted future temperature will be most accurate.

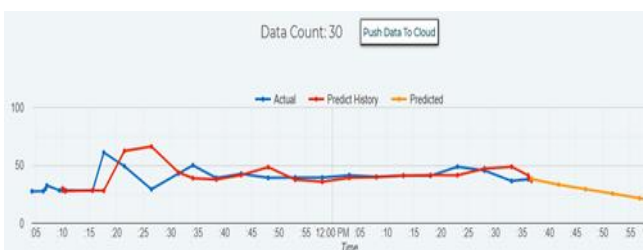


Fig. 8 Predictions Graph

IV. CONCLUSION

IoT and Machine Learning are specifically creative technological know-how in which software people create new developments and discover the gaps in the present developed applications. There are many applications, developments in the form of apps and software for improving the use cases of IoT with ML. But, I did not find an effective system with sensors and ML for quality studying about temperature. This Heatmap System is for accurately monitoring the current temperature and predictive analysis of temperature for forecast. This Heatmap System will extremely useful for enabling in indoors, industries and many more. This will be a one system for all the area to monitor temperature based on sensors. In the analog approaches people are spending lots of their time on gathering temperature information and visualizing the situations for taking any decisions. This Heatmap System for better monitoring and predictive analysis for forecasting as well with the help of IoT and Machine Learning. Even this system gives a usage of IoT and Machine Learning strategies for monitoring and predicting the temperature, making plans for extending this support by providing audio announcements with recommendations based upon current monitoring of temperature and this could for anyone in real-life. Also, this Heatmap System can be extended up to human behavior understanding based on human body temperature.

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