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Research Article

Smart IOT and ML Based Vaccine Storage System

Bhushan S Kumbhar[1], Mayuri R Pawar[2], Dipam S Kakade[3], Avesahemad SN Husainy[4]

[1,2,3,4]Sharad Institute of Technology College of Engineering,Yadrav.
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I N F O

Corresponding Author:
Bhushan S Kumbhar, Sharad Institute of Technology College of Engineering, Yadrav.
Orcid Id:
https://orcid.org/0000-0001-8440-611X
E-mail Id:
bhushankumbhar2903@gmail.com
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A B S T R A C T

In this system, we employ IOT and ML as much as they can monitor the storage system. A smart ML and IOT based vaccine storage system is designed to monitor all parameters which are required to store the vaccines. The real-time data, plotted graphs, and predicted data are all displayed on smartphones and desktops. The GPS technology is offered to pinpoint the system's exact location. Every characteristic, including temperature and humidity, is monitored by a sensor. The PCM is used to store vaccines for prolong cooling when power is cut-off. According to a WHO report, the majority of vaccinations, including those for Diphtheria, Tetanus, Pertussis, Hepatitis A, Hepatitis B, Hib, Influenza, Meningococcal, and Pneumococcus, must be stored at temperatures between 2 and 8 degrees Celsius.[1] Because vaccines are expensive and scarce, their effectiveness is lost when they are stored above or below the appropriate temperature. This results in financial loss. Vaccines are extremely sensitive to the humidity and temperature of their environment. Therefore, even a small change in the ambient temperature has a significant impact on the shelf life and effectiveness of vaccines.

Keywords: IoT , ML Algorithms ,VCR

Introduction

According to the Researchers, viruses spread promptly across the globe and the implications of this is the death of millions in a short span of time. Also, these pandemics result in destroying the economy. Vaccination is the most crucial medical precaution for curing patients. WHO states that most of the vaccines need to be stored in (2-8 degrees). Moreover, the U.S. Department of Health and human services proposed that for storing and handling vaccines there should be an adaptable system.[2] One of the fundamental aspects that we can improve in vaccine storage is by getting more data from temperature, Humidity, Location accurately. By collecting more data, we can apply machine learning and prediction for the same. In our system, the implemented sensors will allow the vaccine provider to monitor the vaccine temperature, humidity, location whenever necessary. So that the system can safely store and transport the vaccines to the recipient.[3] The temperature and humidity sensor that is the DHT11C recorder is installed inside the cold box where the vaccines are to be stored. The GPS module that is implemented with the cold storage box will monitor the precise location of the vaccines which will help in easily tracking the transportation status.[4] The data including the temperature, humidity values, its fluctuation if any, the location of the cold box in terms of latitude and longitude will be collected to the NODEMCU which is nothing but ESP8266 that acts as a Wi-Fi module that conveys all the information to the cloud storage and then data can go through ML algorithms which will predict the data so user can be aware of the probability of an outcome thus we can create an opportunity to override any circumstances before any damage happens. So that the system can safely store and transport the vaccines to the recipient.[5]

Predictive Model for Vaccine Storage System

Ascertainment of Input Values

In this case, regression is used to forecast the temperature and humidity rise in the box. Among the many readings we have generated for the model building, some were sorted out to be used as input for the linear regression model. It predicts the value of one variable contingenton the value of another. The variable you desire to predict is referred to as the dependent variable. The variable applied to predict the value of the other variable is known as the independent variable.This type of analysis calculates the coefficients of a linear equation that includes one or more independent variables that best predict the value of the dependent variable. Linear regression is used to fit a straight hypothesis between predicted and actual output values. Simple linear regression calculators that use the "least squares" method to find the best-fit line for a set of paired data are available. The value of X (dependent variable) is then estimated from Y (independent variable). The VCRS system implemented in the setup maintains the optimum temperature of -5 to 8 degree Celsius inside the cold storage box, when there is availability of power. The Phase Change Materials are maintained at their particular freezing point so that they can be implemented during the power outage conditions. The data including the temperature, humidity values, its fluctuation if any, the location of the cold box in terms of latitude and longitude will be collected to the NODEMCU which is nothing but ESP8266 that acts as Wi-Fi module conveys all the information to the cloud storage for further process. For the best output, constant input is selected as shown in Table 1. All of the null values and missing values are filled in data cleaning and pre-processing.

temperature and humidity. Initially, two main parameters are set for predictive graph plotting. The dependent variables are set to temperature and humidity and independent variable as Timestamp. In MATLABfor predicting data in real time using linear regression algorithm. The MATLAB Basic Fitting UI assists you in fitting your data by calculating model coefficients and plotting the model on top of the data. See Example: Using Basic Fitting UI for more information. You can also use the MATLAB polyfit and polyval functions to fit your data to a linear model with coefficients.

Steps

1. Load data into MATLAB framework. The "load" function is used to get dataset for a file. The data which is pre-processed and cleaned for better model prediction and accuracy.
2. Assigning the data attributes in forms of variables of the model, the data is split into X and Y for training and testing. For training 70% data is given to model and 30% for testing. X is determined as prediction variable and Y as response variable. Here "regress" function is used to build the model.
3. To visualization the graph and hypothesis line, "plot" function is used and to analyse "scatter" function is used.

Working Methodology

When there is electricity, the setup's Smart refrigeration system keeps the cold box at the ideal temperature of -5 to 8 degrees Celsius. In order to be utilised during a power outage, the Phase Change Materials are kept at their specific freezing point. When there is a power outage, the PCM containers are retained in the cold box so that

	A	B	C	D	E	F	G
1	created_at	entry_id	field1	field2	field3	field4	field5
982	2021-12-21T10:51:04+00:00	981	27.2	54.6	16.68483	74.47332	12.83333
983	2021-12-21T10:51:25+00:00	982	27.3	54.6	16.68483	74.47331	12.83333
984	2021-12-21T10:55:17+00:00	983	27.3	54.5	16.68477	74.47321	12.83333
985	2021-12-21T10:55:38+00:00	984	27.3	54.5	16.68482	74.47331	12.83333
986	2021-12-21T10:55:59+00:00	985	27.3	54.5	16.68483	74.47332	12.83333
987	2021-12-21T10:56:20+00:00	986	27.3	54.4	16.68482	74.47331	12.83333
988	2021-12-21T10:56:41+00:00	987	27.3	54.4	16.68485	74.47327	12.83333
989	2021-12-21T10:57:01+00:00	988	27.3	54.4	16.68485	74.47327	12.83333
990	2021-12-21T10:57:22+00:00	989	27.3	54.4	16.68489	74.47331	12.83333

Figure 1.Input Values

Development of Predictive model of Vaccine Storage system using Linear Regression

A linear regression model giv0es us continuous values so that prediction and analysis is comparatively easier. PCM error detection can be determined using fluctuations in they may impart the chilling effect to the vaccines, which are thus continuously held at a temperature of 2 to 8 degrees Celsius. With the help of the installed sensors, the vaccine supplier will be able to keep an eye on the temperature, humidity, position of the vaccine as needed.

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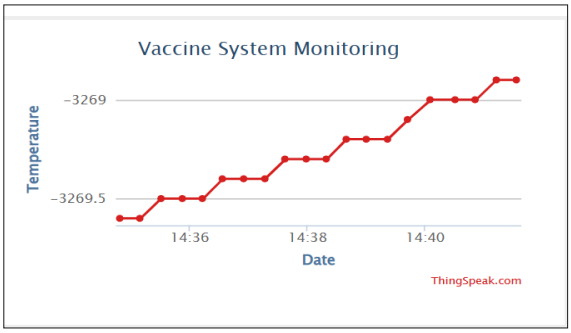
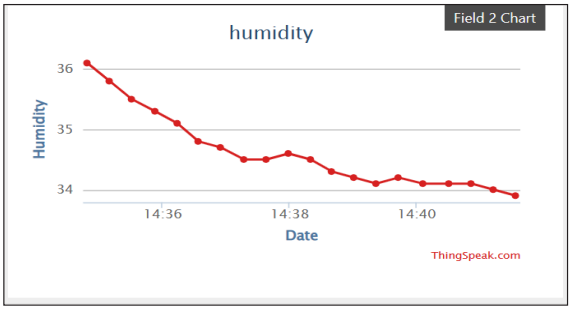
so that the vaccinations may be safely stored and delivered to the recipient via the system. The benefit of a monitoring system with worldwide access is that a user may check the controlled environment's characteristics, such as temperature, humidity, GPS position, remotely from any point in the globe. Regardless of the operating system, the user can access the monitoring system through a PC, laptop, or smartphone. The Node MCU ESP Controller, DHT 22 Temperature & Humidity Sensor, Neo 6 GPS Module ,[3,4] 4 Digit 7-Segment Display, any pertinent cloud system that can be accessed by a laptop or a PC make up a parameter monitoring system with worldwide access. DHT 22 sensor measures the temperature and humidity of the controlled environment (refrigerator evaporator). The NEO 6 GPS module acquires GPS location information, the Node MCU ESP controller receives this information. Two recipients get this information from the Node MCU ESP controller. The first is cloud storage, which allows for remote access to this data, the second is a 4-digit, 7-segment display. You may examine the humidity and temperature of the regulated environment on the 7-segment display that is physically mounted with the IoT monitoring device. This 7-segment display may be used to examine the parameters if the cloud system is not accessible. Regardless of the operating system on the device, a smartphone, laptop, or PC may use the internet to access the cloud storage. Therefore, it has the advantage of allowing remote access to these real-time parameters. Additionally, the cloud storage hosts archived data that may be retrieved. The Local Access features an SD card storage that stores the parameters with respect to time and allows for subsequent access to the data. But since there is no option for remote access to the storage system, real-time data monitoring is not feasible. Through a 4-digit, 7-segment display, real-time temperature and humidity data may be read locally as well as remotely. The node MCU ESP controller and display are directly coupled. Through this display, you can only see temperature and humidity information. Real-time data is constantly changing in relation to time. The rate at which the parameter is measured by the DHT 22 sensor and sent to the node MCU ESP controller is similar to the change in real-time data. Their data may be put via machine learning (ML) algorithms, which will forecast the data and inform the user of the likelihood of a result. By doing this, we can offer a chance to change any situations before any harm is done. so that the vaccinations may be safely stored and delivered to the recipient via the system. Machine Learning algorithms like: regression and classification are used to identify the similarities and discovering unusual data patterns for predicting aspects for cooling on the pre-existing/labelled data, which will be displayed on web-app.

Results and Discussion

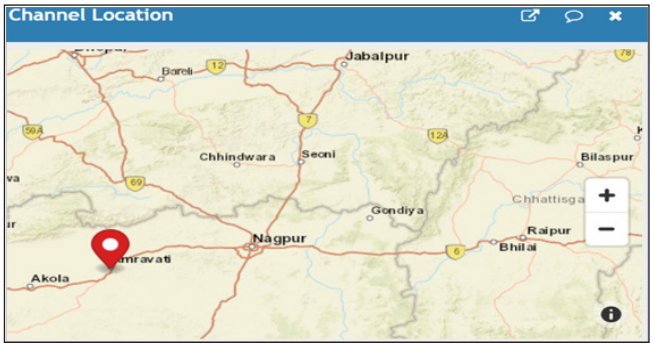
The accuracy of results demonstrated that the linear regression model successfully captured the relationship between temperature/humidity and Timestamp, allowing for accurate predictions of PCM error detection. Real-time monitoring and analysis of temperature and humidity fluctuations using this model can provide valuable insights into potential errors or deviations in the PCM system.The predictive graph plotted using the linear regression model can serve as a visual representation of the predicted data. This graph can aid in identifying patterns, trends, potential anomalies, allowing for proactive measures to be taken to address PCM errors promptly. Following are results of the real time analysis and prediction.



Graph 1.Shows Real Time temperature in the cold storage box



Graph 2.Shows Real Time Humidity in the cold storage box



Graph 3.Shows Real Time Temperature in the cold storage box

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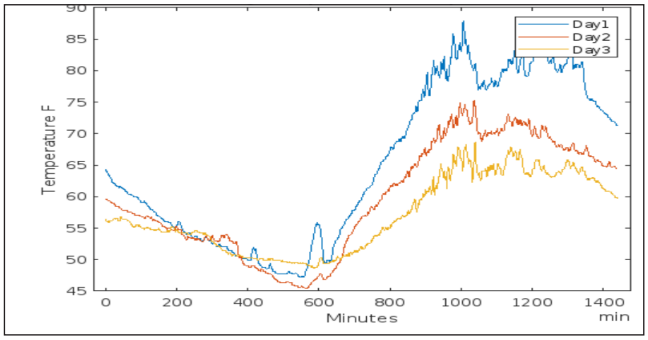
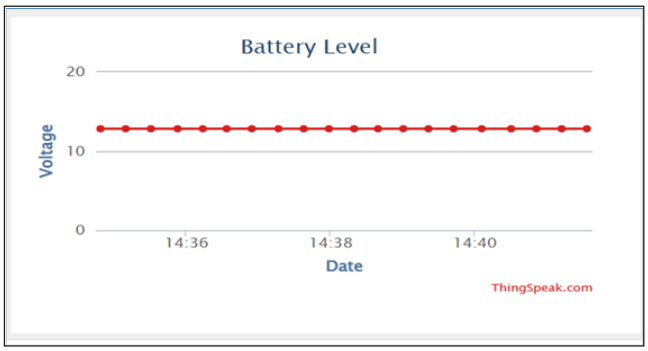
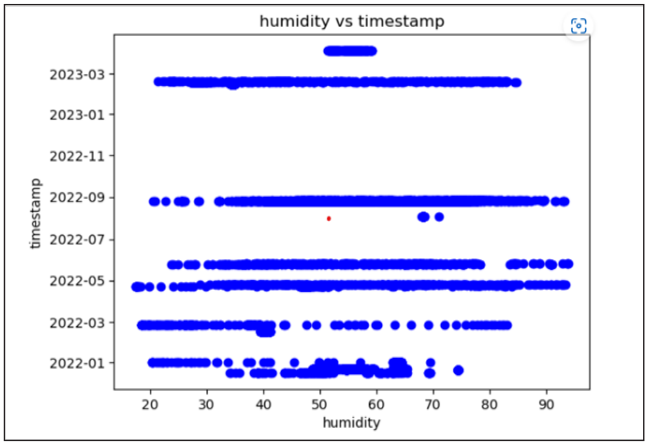


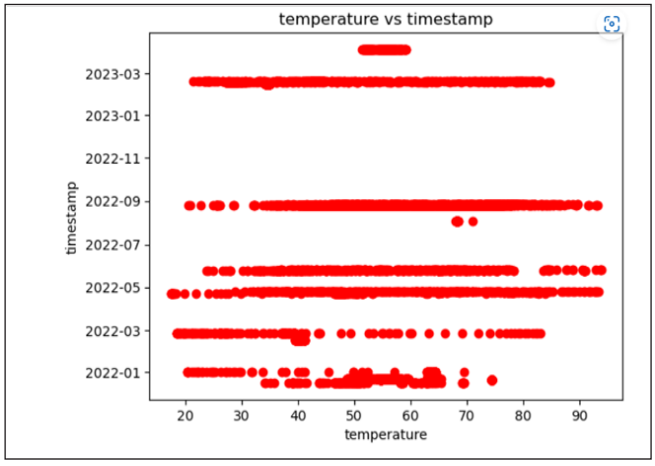
Graph 4.Days Temperature Graph



Graph 5.Battery Level of IoT syte



Graph 6.Humidity Prediction



Graph 7.Temperature Prediction

Conclusion

The system used for keeping and distributing vaccines in good condition at the recommended temperature range (-5 to +8°C). Also a technology that can transport larger volume of vaccines with is also needed as existing cool boxes can transport a limited number of vaccines at a time The temperature, humidity and other parameters should be continuously monitored during its transportation as it may affect the vaccine life drastically. Proposed experimental set up will easily transport because it is portable and will available in low cost. Due to thermal storage it will help to maintain constant temperature (2 to 8 degree) for longer duration of time even though power outage exists. It will helpful for doctors, pharmacist, medical stores, hospitals to store vaccine and medicines. We use IOT devices and machine learning to track and forecast variables like temperature and humidity while displaying data on a specified smartphone, tablet, laptop, or PC.

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