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Flood Prediction and Alert System using ML and Sensor Networks

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***Abstract*— Floods and Landslides are the most common disasters that affect the people who dwell across the rivers and hilly areas. The impact of such instances decimates the normal lives of people who are made to either displace from the proximity or permanently relocate themselves to some other regions which in turn collapses the house hold and the country's economy. An early prediction and detection system can act as a warning system to make the concerned authority and the people to prepare themselves in advance to counter the forthcoming devastation. This paper aims at incorporating the environmental based sensors and the Machine Learning algorithms to predict the possible flooding and raise an alert alarm in advance. The system is developed using several data points to predict the possibility of flooding. The parameters to be included to feed, as input, to the machine learning algorithm include the meteorological rainfall data of past years which acts as an empirical data, past data of the flooding which acts as a forehand information of flooding, the forecasted rainfall data of the present year and the actual rainfall data of the present year and the monthly average rainfall. Feeding all these data into the ML system will enable the system to get trained. The system is then capable to analyse and predictions are made. This system to predict in real time demands an array of machine learning algorithms. In this system, we have use an Arduino Uno to design the sensor system which includes sensors like ultrasonic sensor for measuring water levels, a float sensor to detect the level of water in the body, a flow sensor to determine the speed of water, and a humidity sensor to determine the humidity. With the aid of an IOT system, these sensor combinations are used to anticipate floods and warn the appropriate authorities.**

***Index Terms*— Sensors, Machine learning, Linear regression, SVM, ANN, flood, flood alert, cloud storage.**

I. INTRODUCTION

Everything in this universe occurs due to the power and driving force of nature. But it is the fake belief of thoughtless humans to assume themselves as the doers. Ecosystem is self-balanced where each positive deed is compensated with negative feedback by the nature. Floods are the one of the ways that Mother Nature balances herself of the ecosystem which when is severely altered by the human beings through the atrocities he does on the mother nature like mining, bridges, dams, cutting and levelling mountains to name a few. The so-called development in this Common Era tries to ease the life of human beings but this process severely alters the

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balance in the ecosystem. As the word flooding has become a common scenario during the monsoon, the devastating effects of the same proves to be unbearable to the living thing. Due to the fury of the Mother Nature the artificial eco-balance, presumed to be so, created by humans is severely altered and resilience is very hard. It has become pervasive and evident that man has decoupled himself from the nature and thinks he and nature are different is the saddest part. Concerns apart as we try to decouple from the nature to create a solution of our own like dams, bridges, river deviations, etc it also becomes our sole responsibility to address the problems that arise from those so-called solutions. To address the problem of flooding, that we have considered as the point of study in the paper, which destroys the whole manmade systems well as ecology. It is imperative to find a solution for the same. Due to flooding we witness a good number of people as well as animals who come under the vicinity of the flooding have to be relocated either temporarily or permanently to a location. Also, the destruction of the physically facilitates and the damages will be irreversible if not acted on time. To act on time is a challenging task as no present system in technology is able to predict an alert the concerned authority about the possible occurrence of flooding. The need of the flood occurrence and alerts the concerned department to act on time. This system developed will save lives of the living things as well as prevent the damage done by the nature to the physical facilities which when not taken care result to be fatal to the manmade economy.

II. LITERATURE REVIEW

A. Design of early warning flood detection systems for developing countries

Author: Elijabeth Basha. Information and Communication Technologies and Development, 2007. ICTD 2007. The system should be divided into four elements, according to the author: prediction, notification, alert, and community evaluation. Keep an eye on what's going on in a 10,000-kilometer-wide geographic area. Measure a wide range of variables that contribute to the event's occurrence. Recover from the loss of nodes. Analyzing using the CTSTAR and determining the level of distraction and the causes behind it. Rainfall Sensor that is camouflaged for more accurate analysis.

B. Flood Disaster Warning System on the go

Authors:Salami Ifedapo Abdullahi; Mohamed Hadi Habaebi; Noreha Abdul Malik. 2018 7th International Conference on Computer and Communication Engineering (ICCCE). The importance of flood prediction and the setbacks for flase prediction are discussed by the author. The pressure of inflowing water was measured using a pressure gauge and a simulation of the system. The sensor data is sent from the NodeMCU ESP8266 to the Thingspeak channel for real-time analysis and database storage.A pre-defined rule was utilised to predict flood status using Microsoft's Azure Machine Learning (AzureML).

C. Flood surveillance and alert system an advance the IoT

Authors:Yupin Suppakhun. 2019 IEEE Asia Pacific Conference on Circuits and Systems (APCCAS). The IoT will be used to undertake flood surveillance and alert the system, according to the discussion. Water information and related variables, as well as the danger in the risk region, can be tracked by the appropriate personnel. At each station, compile a data report. It aids in the effective and timely notification of alarms, as well as the reduction of losses. Flooding is a threat that must be avoided. The goal is to create methods and sensors for analysing flood warnings.The application of Internet of thing (IoT) technology to assist in developing a system to measure and send information and notifications to user. The system is divided into two parts,The first is to measure the variables involved. The need to assess the flood alert. Installed in the basin's flood risk areas.The second part is the display and alarm monitoring floods.The system is made to be on show. By retrieving data from the server, data from the measuring devices can be obtained. The development of technologies and sensors for flood warning analysis is discussed in this study. The use of Internet of Things (IoT) technologies to aid in the development of a measurement system.Installing sensors in flood-prone sections of the basin will send information and alarms. By retrieving data from the server, data from the measuring devices can be obtained. In order to determine the extent of the flooding. Through the Blynk app and the Line app, you can receive important water level notifications. This technique makes flood warnings more effective and reduces losses to those living in flood-prone areas.

III. PREDICTION SYSTEM DESIGN

The process illustrated in the Figure 1 takes the input of the empirical data which is the actual amount of the rainfall occurred in the various subdivisions of the nation in the past years, forecasted data of the present year and the actual rainfall data of the present year in and around the subdivisions of the region of study.

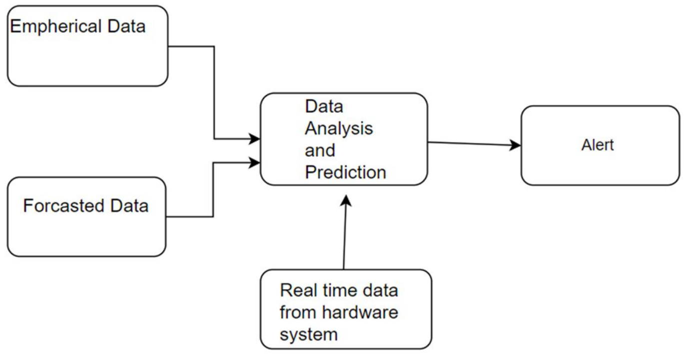


Fig 1: Prediction Process

The hardware system is designed to fetch the details of the real-time measurements of factors which contribute for the occurrence of floods. All the data is then fed to the machine learning system to predict. The hardware device contains the Wireless network module for communication which passes the alert to the authority to take the necessary and timely action.

IV. DATA ANALYSIS

The dataset containing 4116 rows of data of the 36 subdivisions of India from the year 1901 to 2015 of 115 years. The dataset is divided into 36 subdivisions on the quantity of rainfall they receive.

SUBDIVISION	YEAR	Jan_forecast	JAN	Feb_forecast	FEB	Mar_forecast	MAR	Apr_forecast	APR	May_forecast	MAY	Jun_forecast	JUN	July_forecast	JUL	Aug_forecast	AUG	Sep_forecast
ANDAMAN & NICOBAR ISLANDS	1901	48.708	49.2	86.229	87.1	28.908	29.2	84.487	2.3	507.648	528.8	512.325	517.5	350.496	365.1	476.289	481.1	325.948
ANDAMAN & NICOBAR ISLANDS	1902	0	0	158.202	159.8	12.078	12.2	155.006	0	428.256	446.1	531.729	537.1	219.744	228.9	746.163	753.7	652.876
ANDAMAN & NICOBAR ISLANDS	1903	10	12.7	142.56	144	0	0	139.68	1	225.696	235.1	475.101	479.9	699.264	728.4	323.433	326.7	332.22
ANDAMAN & NICOBAR ISLANDS	1904	9.306	9.4	14.553	14.7	0	0	14.259	202.4	292.32	304.5	490.149	495.1	481.92	502	158.499	160.1	803.992
ANDAMAN & NICOBAR ISLANDS	1905	1.287	1.3	0	0	3.267	3.3	0	26.9	268.32	279.5	622.413	628.7	353.952	368.7	327.195	330.5	291.06
ANDAMAN & NICOBAR ISLANDS	1906	36.234	36.6	0	0	0	0	0	0	533.856	556.1	725.967	733.3	237.792	247.7	317.295	320.5	161.014
ANDAMAN & NICOBAR ISLANDS	1907	109.593	110.7	0	0	112.167	113.3	0	21.6	591.648	616.3	302.148	305.2	426.144	443.9	373.824	377.6	196.392
ANDAMAN & NICOBAR ISLANDS	1908	7	20.9	84.249	85.1	0	0	82.547	29	539.52	562	686.664	693.6	462.144	481.4	692.901	699.9	420.224
ANDAMAN & NICOBAR ISLANDS	1910	26.334	26.6	22.473	22.7	204.237	206.3	22.019	89.3	215.52	224.5	467.973	472.7	253.728	264.3	334.026	337.4	614.068
ANDAMAN & NICOBAR ISLANDS	1911	0	0	8.316	8.4	0	0	8.148	122.5	314.208	327.3	642.51	649	242.88	253	185.229	187.1	455.21
ANDAMAN & NICOBAR ISLANDS	1912	577.863	583.7	0.792	0.8	0	0	0.776	21.9	135.072	140.7	544.302	549.8	450.144	468.9	366.597	370.3	378.476
ANDAMAN & NICOBAR ISLANDS	1913	83.952	84.8	0.495	0.5	1.287	1.3	0.485	2.5	183.072	190.7	524.7	530	269.568	280.8	203.742	205.8	568.498
ANDAMAN & NICOBAR ISLANDS	1914	0	0	0	0	0	0	0	37.7	286.848	298.8	379.467	383.3	761.088	792.8	515.295	520.5	304.584
ANDAMAN & NICOBAR ISLANDS	1915	44.55	45	56.133	56.7	32.967	33.3	54.999	40.9	163.392	170.2	331.353	334.7	258.24	269	314.028	317.2	421.204
ANDAMAN & NICOBAR ISLANDS	1916	0	0	0	0	0	0	0	0.5	467.904	487.4	445.599	450.1	304.608	317.3	420.75	425	549.976
ANDAMAN & NICOBAR ISLANDS	1917	7.92	8	3.564	3.6	110.88	112	3.492	4.5	284.064	295.9	298.089	301.1	379.008	394.8	433.026	437.4	462.364
ANDAMAN & NICOBAR ISLANDS	1918	76.626	77.4	6.831	6.9	11.286	11.4	6.693	10.7	700.128	729.3	703.692	710.8	192.864	200.9	450.846	455.4	297.234
ANDAMAN & NICOBAR ISLANDS	1919	10.098	10.2	17.82	18	0	0	17.46	35.5	272.544	283.9	537.075	542.5	236.64	246.5	257.202	259.8	167.286
ANDAMAN & NICOBAR ISLANDS	1920	121.077	122.3	7.326	7.4	3.069	3.1	7.178	13	227.904	237.4	541.431	546.9	282.624	294.4	462.726	467.4	495.292
ANDAMAN & NICOBAR ISLANDS	1921	13.068	13.2	3.069	3.1	0	0	3.007	37.5	337.152	351.2	279.873	282.7	467.616	487.1	326.7	330	569.576
ANDAMAN & NICOBAR ISLANDS	1922	242.847	245.3	33.957	34.3	15.444	15.6	33.271	323.1	278.112	289.7	501.039	506.1	408.768	425.8	304.326	307.4	501.466
ANDAMAN & NICOBAR ISLANDS	1923	78.705	79.5	0	0	0	NA	0	91.3	281.76	293.5	800.316	808.4	611.424	636.9	180.378	182.2	549.29

Fig 2: Data-set

Each row contains the data of each subdivision with average the quantity of rainfall they receive in each month and the forecast that was done before the actual rainfall in each month. They contain the average annual rainfall they received and the forecast of rainfall that was forecasted. They contain the average of the seasonal rainfall the subdivision receives.

The annual rainfall of the 115 years is represented in the graph.

```
data.groupby("YEAR").sum()['ANNUAL'].plot(figsize=(12,8));
```

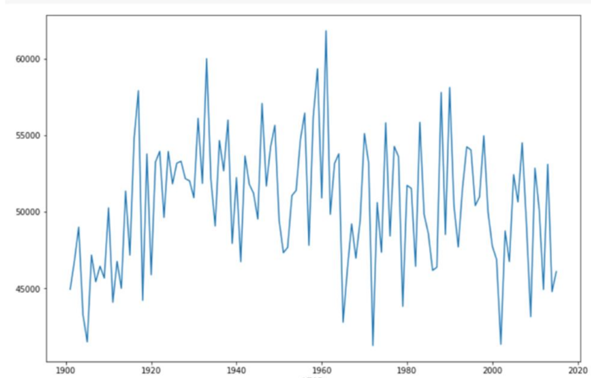


Fig 3: Annual Rainfall

The major part of annual rainfall was received in the year around 1960s.
The monthly rainfall of each month for 115 years is represented in the graph.

```
data[['YEAR', 'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL',
      'AUG', 'SEP', 'OCT', 'NOV', 'DEC']].groupby("YEAR").sum().plot(figsize=(15,8));
```

Fig 4: Monthly rainfall

July receives the highest rainfall in all years.
The seasonal rainfall of each year for 115 years is represented in the graph.

```
data[['YEAR','Jan-Feb', 'Mar-May',
      'Jun-Sep', 'Oct-Dec']].groupby("YEAR").sum().plot(figsize=(13,8));
```

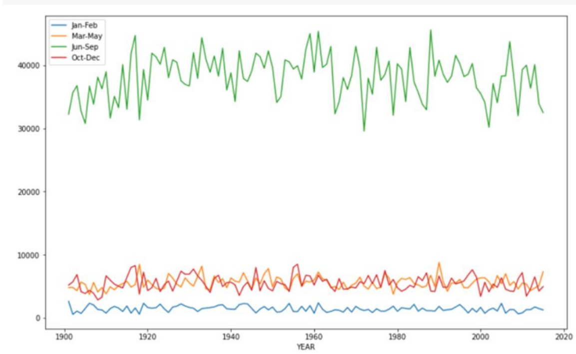


Fig 5: Seasonal rainfall

The July to September receives the highest rainfall each year with a very high difference from others. In India it is the monsoon season which receives more rainfall.
The subdivisional monthly rainfall is represented in the graph.

```
data[['SUBDIVISION', 'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL',
      'AUG', 'SEP', 'OCT', 'NOV', 'DEC']].groupby("SUBDIVISION").mean().plot.barh(stacked=True,figsize=(13,8));
```

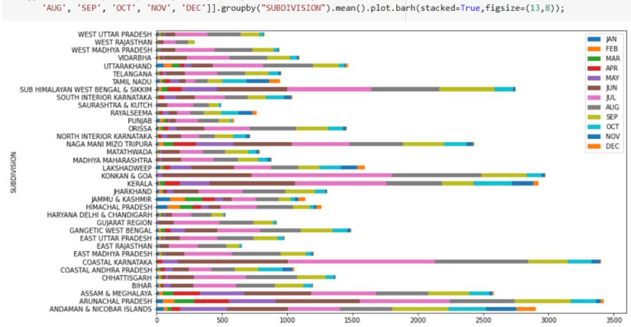


Fig 6: Sub divisional monthly rainfall

Each month of each subdivision is compared so that the amount of rainfall received in other subdivision.

The graph represents seasonal rainfall of each of the season of all years from 1901 to 2015.

```
data[['SUBDIVISION', 'Jan-Feb', 'Mar-May',
      'Jun-Sep', 'Oct-Dec']].groupby("SUBDIVISION").sum().plot.barh(stacked=True,figsize=(16,8));
```

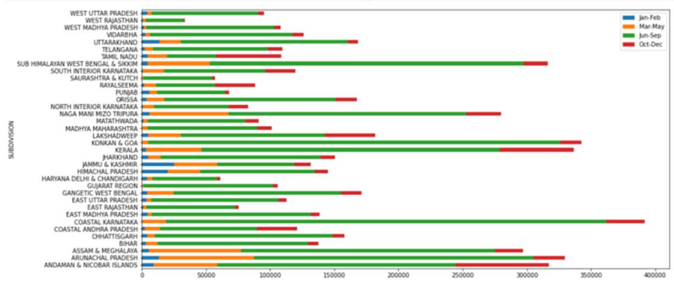


Fig 7 : Seasonal sub divisional rainfall

The graph depicts the July season receives the rainfall again.
The heat maps represents the co-relation between the monthly rainfalls.

```
plt.figure(figsize=(11,4))
sns.heatmap(data[['JAN','FEB','MAR','APR','MAY','JUN','JUL','AUG','SEP','OCT','NOV
plt.show()
```

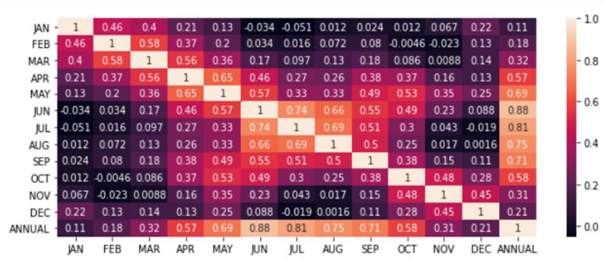


Fig8: Heatmap for month

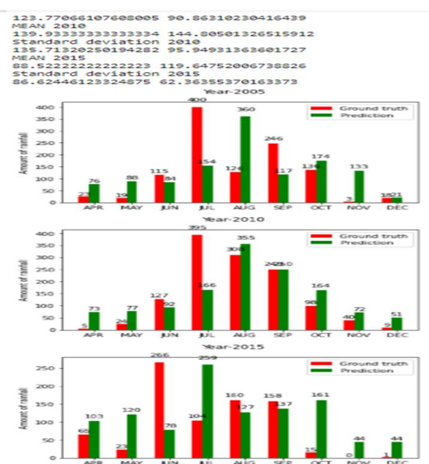
```
plt.figure(figsize=(11,4))
sns.heatmap(data[['Jan-Feb','Mar-May','Jun-Sep','Oct-Dec','ANNUAL']].corr(),ann
plt.show()
```

Fig 9: Heatmap for season

And the other heat map represent the co-relation between the seasons to analyse the quantity of rainfall.

V. Linear Regression

The Linear Regression method is a supervised learning approach. It carries out a regression job. The linear relationship between x (input) and y (output) is discovered using this regression approach (output).




```
from sklearn import linear_model

# linear model
reg = linear_model.ElasticNet(alpha=0.5)
reg.fit(X_train, y_train)
y_pred = reg.predict(X_test)
print mean_absolute_error(y_test, y_pred)
```

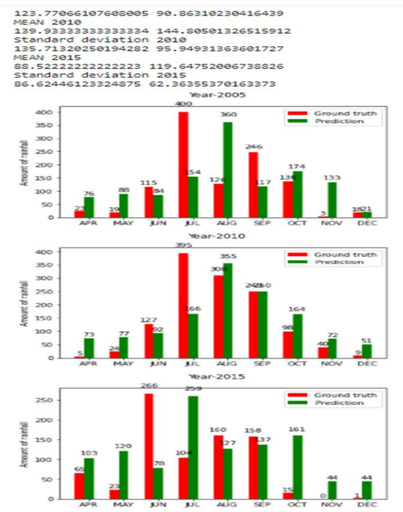
96.32435229744095

Fig 10: Linear regression implementation

Regression makes the assumption that the relationship between your input and outcome is linear.

VI. SVM

The implementation of SVM, a supervised method that will be utilised for both classification and regression tasks, is shown in Figure 11. We represent each data point as an extent in n-dimensional space, with the value of each feature corresponding to a given coordinate.




```
from sklearn.svm import SVR

# SVM model
clf = SVR(gamma='auto', C=0.1, epsilon=0.2)
clf.fit(X_train, y_train)
y_pred = clf.predict(X_test)
print mean_absolute_error(y_test, y_pred)
```

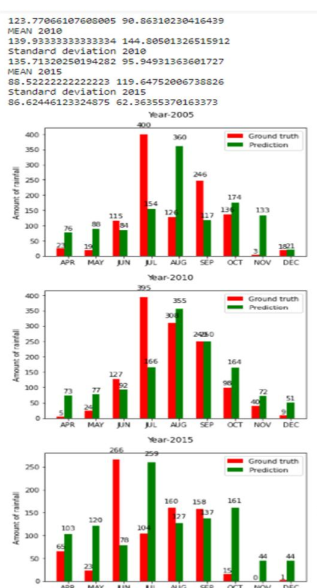
```
127.1600615632603
```

Fig 11: SVM implementation

It does some highly complicated data transformations before determining the best approach for separating the data from the labels.

VII. Artificial Neural Network

Artificial intelligence algorithms have long been utilised for modelling decision-making systems because they provide automated information extraction and excellent inference accuracy, as shown in Figure 3.17.




```
from keras.models import Model
from keras.layers import Dense, Input, Conv1D, Flatten

# NN model
inputs = Input(shape=(3,1))
x = Conv1D(64, 2, padding='same', activation='elu')(inputs)
x = Conv1D(128, 2, padding='same', activation='elu')(x)
x = Flatten()(x)
x = Dense(128, activation='elu')(x)
x = Dense(64, activation='elu')(x)
x = Dense(32, activation='elu')(x)
x = Dense(1, activation='linear')(x)
model = Model(inputs=[inputs], outputs=[x])
model.compile(loss='mean_squared_error', optimizer='adamax', metrics=['mae'])
model.summary()
```

```
model.fit(x=np.expand_dims(X_train, axis=2), y=y_train, batch_size=64, epochs=10,
y_pred = model.predict(np.expand_dims(X_test, axis=2))
print (mean_absolute_error(y_test, y_pred))
```

Fig 12: ANN implementation

The different features or parts of learning, such as the method to learn, the way to induce, and the way to deduce, were motivated to be handled by ANNs.

VIII. ALERT SYSTEM DESIGN

Hardware architecture shown is in the figure 13. Arduino uno is used as a device which will connect all the devices to the computer system. Four sensors are used in this project: 1. Temperature and Humidity sensor: This will measure the temperature and humidity of the environment and display it on the LCD screen. 2. Water flow sensor: This sensor consists of plastic valve, rotor and Hall Effect sensor. When the water flows, rotor present in it rotates. The speed with which it rotates helps to determine the speed of the water flow. It the flow of water is high it can result to be dangerous. 3. Ultrasonic sensor: This is put to measure the distance of water from a particular location. It is put at particular height where it senses how far water present from it is. If the distance between the sensor and water is less that means water level is high which in turn an indication for danger. 4. Water level sensor: This is put in a place where level of water needs to be detected. The switch is used to make an alarming sound when the water level goes high.

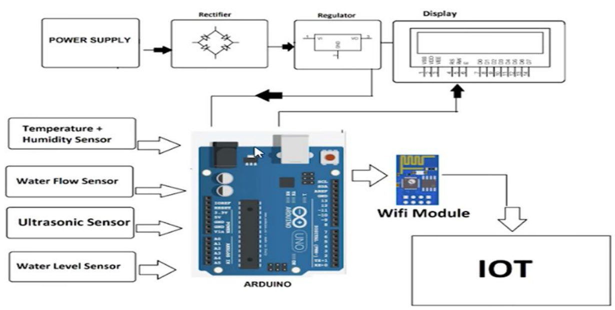


Fig 13: Sensor network

The alarming sound create an immediate alert to the people living nearby and to the ones who are not updated with everyday news. IOT systems helps the authorities and the people to know about their surroundings so that correct decision is taken at correct time. All these sensors and devices are used for better communication of correct information among the mass and the authorities. Wireless network module is used by the sensors to provide the data to IOT. Since the data is stored in cloud using IOT, admin can login to the application and stay updated with the values and think of further steps which should be undertaken. When any indication of flood is detected, the time left to escape and be predicted and action can be taken. Even the severity of the risk can be analyzed so that no negligence happens. Even the right decision becomes the wrong one if not acted at the right time.

IX. RESULTS

IOT Gecko may be a free platform for college students, academics, and developers to create IoT systems. Process the data from the sensor and show it online. Use simple mouse clicks to control motors and physical objects.

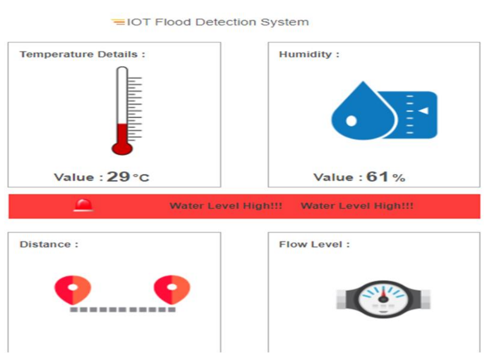


Fig 14: System alerting with an alarm

With API support for all platforms, you can simply debug your IoT devices and combine them with your favourite programming languages. IOT Gecko Development does not need much coding experience and provides excellent assistance for IOT-based development. It provides an effective GUI development platform to help hardware devices in processing and displaying parameters.

X. CONCLUSION

There are many reasons for flood to occur like dam breakage, rising of water level, overflow of water bodies. Flood risks will increase in the time to come. So, system should be designed to reduce the damages. This project analyses the data available of the actual rainfall and the forecast so that the prediction comes accurate. The hardware sensor system is designed to alert the person responsible for it. The Wi-Fi module for alert system makes the alert more efficient. It is fast and the best way for the prediction.

Future Works

Laser range finder can replace ultrasonic sensor. Wireless hardware connection with the help of some IR, 2 wireless routers can be used to upload data instead of internet. Small chip to reduce the overall size.

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