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Multi-Agent based Intelligent Weather Forecasting System

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ABSTRACT: Meteorology Department of Sri Lanka is the department which is providing all meteorological and climatologically information nationally, in accordance with World Meteorological Organization regulations over fifteen years.
When looking at the current processes of deriving meteorological information at Meteorology department, they are capable of giving weather forecast for single day which is mainly based on wind direction and cloud development analysis. This task is very time consuming and needs lots of man power for drawing relevant graphs. Meanwhile there is a new requirement from them for predicting weather for short time period without going through the traditional graph-based analysis.

So, the main aim of this project was to enhance the accuracy of the traditional weather forecasting process of the Meteorology Department by automating the process which then also capable of forecasting weather conditions for short time periods. The system was implemented on a classification rule-based data mining approach for the weather prediction and an agent-based approach for removing the manual involvement to the process. So, the system is capable of predicting weather behavior for next quarter of the day. The predicted information will be presented to the public through the Web and Short Message Service. Developing this system successfully, touched different knowledge areas like Java, Data mining techniques, Artificial Intelligent techniques, Agent base techniques, Web services, Portlets and Mobile technology together.

KEYWORDS: Classification rule-based, Data mining, Agent base techniques, Web services, Portlets, Mobile technology

I. INTRODUCTION

Although the soft weather and climate factors are a blessing to human lives, it turns to opposite directions once they make floods, droughts, storms, etc. Most of the time these types of extreme weather factors directly lead to causing huge losses and destructions to human lives and their properties.

Since the above-mentioned types of weather changes are causing a direct impact on the human lives, economic and social factors of a country, it is a timely need to have a better weather prediction and analyzing process. Weather forecasting is one of the most challenging problems around the world for centuries, because of its practical value in meteorology.

Even though the present ear of technology process having high level technologists like data mining and artificial intelligent concepts like neural network for predicting future events. But the current process of the meteorological department of Sri Lanka is still running on traditional forecasting methodologies, it is not capable of providing such improved forecasting information to the public. The meteorological department is capable of giving weather forecast for the next 24 hours starting from the current day 8.30 am. By looking at the real-time weather records and the satellite images for the particular district and wind flow graphs the officers at the meteorological department derive the weather forecasting using their experience. For this process includes drawing 5 huge graphs for wind direction and cloud

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development which are very time-consuming. To finishes this forecasting task, they have to devote at least 2 hours per day. The forecasting for tomorrow is derived at 8.30 am in today and, between today and tomorrow, none of the prediction is done except this prediction. Since weather is most unreliable, dynamically changing phenomena, it is obvious that 24 hours prediction is not much accurate as it cannot update the changes occur in the atmosphere after forecasting is done for the next day. In that case, the public cannot be aware of the latest weather changes are to occur during the next 2 hours like a short time period.

As the legacy process of weather forecasting at the meteorological department is done in a traditional way, it is unable to provide more accurate weather forecasts for short time periods like 2 hours, By continuing through current weather forecasting process, they try to predict whether for next 2 hour, then they have to draw 60 graphs per day. In that case, it is obvious that using the traditional way for a short time period prediction is wastage of manpower, time and money of the country. But the meteorological department needs to give a short time period prediction to the public for the next quarter of the day including next 2-hour prediction without manual involvement and wasting manpower and time for drawing huge graphs. When considering the value of this kind of short time period weather forecasting it will increase the accuracy of the forecasting data values as it is very much closer to the observation that is used to predict that weather behavior.

Also, it is very difficult for the general public to get information about weather forecasts unless they listen to Radio, watch Television or through daily newspapers. Hence sometimes people feel hopeless as they are unable to know the weather forecasting whenever they wish to know it.

As a solution for the above-mentioned problems, we decided to give an automated solution using better, technologies to enhance this process to provide efficient and accurate weather and climate prediction information to the people. Then it will be really useful for their daily lives while preventing or at least minimizing the destructions which can happen due to these unavoidable weather behaviours.

II. PROPOSED METHODOLOGY

The proposed solution of weather forecasting system uses intelligent multi-agents to perform weather predictions automatically using dynamic data mining approach. Basically, this system has main two core functionalities. Those are;

- Weather Forecasting process
- Presenting forecasted data though Web portlet and Short Message Service (SMS)

Under each component, it has been addressed about the users, inputs, outputs, process, and technologies that implemented these modules.

Whether Forecasting process

In this weather forecasting process, the ultimate goal is to derive the weather prediction for the next quarter of the day by using past weather records. According to the weather record collection process in the Meteorological department, they collect weather condition from each weather station in all around the country for every two hours. This record includes the details about;

- Current weather condition
- Weather condition before 1 hour to the current observation
- Weather condition before 1 ½ hour to the current observation

Since these three factors are relating to each other consecutively, they were chosen to use as the prediction attributes to the data mining process. So, the ultimate approach is to predict the weather forecasting for the next quarter of the day including two hours prediction by analyzing the patterns among these three factors. For every two hours, the system will update the weather prediction for the next quarter of the day.

A. Prediction Approach

Users: Agents

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Inputs: Latest past 500 weather record set for a particular district.

Process:

When considering a phenomenon like the weather is characterized by a high level of dynamics because of this data are changing dynamically. Therefore, there is a need for a new method for dynamic data mining. Agent-based software is very effective for real-time resource allocation under the condition of uncertainty and dynamics. In dynamic data mining, it can be considered as an allocation problem: data is allocated to a particular class as it arrives. To decide which record goes to which class, rule set or a model is required. By using agents, they can train a model using a given data set and continue the prediction without any human involvement. Therefore, in this dynamic data mining approach, two types of agents can be used.

Record Agent- Once a new record has arrived, it uses the Record Validation Formula which specifies desirable features of a record and sends the new record to the training the data set and update it. Then it informs Data mining agents to train the models and continue the prediction to choose the best host for new records

Data Mining Agent - There are mainly two functionalities are carried out by these types of agent. The Data Mining Agent which receives new record trains the model for the new ruleset. When training decision tree-based classification, approach is used. Once the training is finished, the prediction of the derived new model is performed.

1. Decision Tree-Based Classification on Data Mining Agent

As mentioned earlier, the main two responsibilities of Data Mining Agent are training a model and do predictions dynamically according to the given input weather record. Let's look at how these two functionalities are carried out by the agents.

2. Training Model

When modeling a rule set there are mainly four steps have to be followed.

- Gathering a known result set
- Data preprocessing and deriving a training set
- Training the Train set
- Evaluate it on test set

When a prediction is done for e city it is using the last 48 hours' weather records related to that location. Basically, it considers only past 16 records which were collected for every 2 hours per day. But for the model construction of this amount of records are not sufficient and at least 500 of past weather records have to be used.
Once records are collected those have to be cleaned against missing values and repetitions. Then these pre-processed data can be taken as the training set for the model construction.
Then the train data set can be classified using a decision tree approach to recognize most frequent weather patterns occurred within the data set. Then with a known result, it can be tested and adjusted. Since the records are changing for every 3 hours per day, the model also needed to update dynamically. Since this approach uses practically implementable algorithms for classifying frequent pattern recognition, the efficiency and accuracy of those algorithms were highly proven.
Algorithm:

- Record Validation Function for validating a new input
- Classification Rules- for deriving the rules for identifying frequent weather patterns and deciding the next weather condition
- Decision Tree- For deriving the classification rules
- Attribute Selection, tree over-fitting, and per-pruning and post-pruning function

By using this algorithm, a new weather record for the first 3 hours' interval is derived and by using that records as a new weather record, predict the weather forecast for 2nd two hours' interval. This will enable to give the latest weather prediction for the next quarter of the day.

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3. Prediction on the Model

Once a model is constructed, the Data Mining Agent uses it to predict the next weather condition. Once the next weather condition is derived, the output is used to derive the next weather conditions iteratively by applying it to the model. The model is updated for each of new record insertion to its training data set.

Weather Information through Web Portlet

The users for this sub-component are the people who wish to know the weather forecasting for locations within Sri Lanka.

The Weather Portlet is the one way of presenting the forecasted data to the citizen. Once a new forecasted data is captured by the GUI Agent, it is responsible for updating Portlet regarding the new weather forecast information. For the development of the Weather Portlet, Liferay Portlet development framework [11] and Struts 2.0 and tomcat application server have been decided to use.

Weather Information through Mobile phone (SMS service)

Using the purposed system, citizens are able to get the latest weather forecasting information through their mobile phones by simply sending an SMS. Since mobile phones are a commodity today, and SMS messages offer an intriguing solution. Messages are delivered in a matter of seconds, and citizens can get the weather forecasting details before starting any work which may be affected by the weather behavior.

The approach can be described using the following block diagram Figure 04.

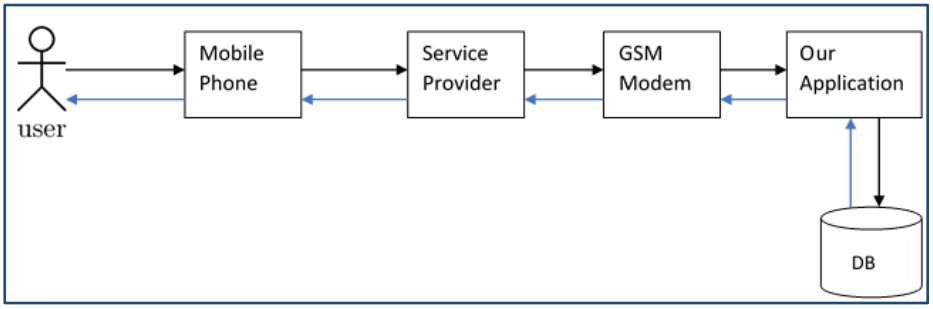

Figure 01: Flow diagram for getting the forecasting information Via Mobile

For request the forecasting information, the citizen has to send an SMS with the proper format. There two types of format are accepted by the system. Those two formats are:

Format no.01

WF<space><the district name>

Eg: Suppose citizen needs to get the weather forecasting for next quarter for Colombo district, so, he should send his message as follows;

WF Colombo

Format no.02

WF<space><the district name><space> <time duration> DATE <day/month>

Eg: Suppose citizen needs to get the weather forecasting for a district for a specific time period, so he should send his message as follows;

WF Colombo 12.30-3.30 DATE 30/03

Here the WF and DATE are key words of the format.

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If the citizen makes a proper request, he or she will receive a message containing forecasting information that he wishes to know. Otherwise, an error message with an appropriate explanation will be delivered to the phone.
The actual happening here is, once a citizen sends an SMS by requesting forecasting information which is coming through the service provider, it listens through the serial port of a GSM [8] modem. The GSM modem can modulate an analog transporter signal to encode digital information, and also demodulates such a carrier signal to decode the transmitted information. Therefore, it can easily listen and detect the incoming requests to the application.
Once a message is detected by the modem it is passed to the application which is coded using Java and Java transaction management technology. Here using Java, the incoming messages are processed and outgoing messages are generated. Since Java provides the relevant packages for working with the SMS, the solution will be able to implement easily. Then the requested data is querying from the database where the master records about the forecast are stored. To create the interface between the application and the database, a database layer is created. For that, the most popular and effective java concept called Java Transaction Management (JTM) package is used. In the case of JTM, it is a powerful, high-performance object/relational persistence and query service. JTM lets developers develop persistent classes following object-oriented idiom - including association, inheritance, polymorphism, composition, and collections.
Once the results are fetched from the database, the reply is created and sent back to the passenger through the GSM modem.

Technology adopts

The following technologies adopted to develop the System.
Table 01: Technologies adopted

Weather forecasting	Web Portlet	SMS service
Java 1.6	Liferay framework 5.2	J2SE
JADE 3.6.1	Struts 2.0 framework	MySQL 5.1
MySQL 5.1	Tomcat 6.0	Eclipse
Java transaction Manager	Eclipse	
Eclipse		

III. RESULTS

Implementation Weather Forecastingprocess

The implementation of the Forecasting process was done under mainly two subcomponents as;

- Agents Arrangement
- Data mining Implementation

The implementation of this system was entirely based on the dynamic data mining with the involvement of Agents. When implementing agents, first the JADE[7]environment was configured. Implementation of the classification includes three classes; RecordAgent.java, Data_miningAgent.java and Ontology.java

RecordAgent. Java

Once new record arrives to the system the new Record agent considers Record Valuation Formula which specifies desirable features of a record. If it is valid record then update the training set by inserting the record. Then it notifies the Training Agent for new model change for deriving updated rules.

Data miningAgent.java

Once record agent notifies, the Training agent invoked and started to model the data and deriving new frequent weather patterns When modeling the ruleset, decision tree-based classification approach is used. Once model construction is finished, the Prediction agent is invoked and started to predict the weather condition. This process looped for 3 times per every 2 hours with triggering to the new arrival of a weather record from a weather station.

Ontology.java

It defines the rules set for agents' behaviors and message passing among them. For their communication they keep their own keywords set.
Eg: public final constant TRAIN = "TRAINING";
Once a new record arrives, the Record agent selects class by doing the record valuation on it. Then it updates the train set and informs to Training agent to start to train the model. This implementation approach can be further shown using Figure 01. The implemented ontology for the Dynamic agent-based mining approach is as follows.

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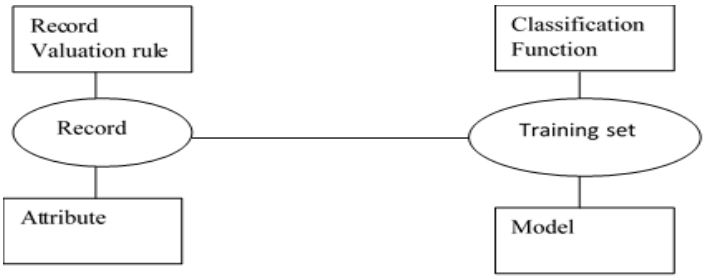

Figure 02: Ontology for Dynamic Data Mining

A. Record Valuation

In Data mining approach, similar data are recognized and grouped them to the same class. Identifying these classes is the main functionality of the Training agents. For this identification, data mining algorithms have to be used. The main algorithms that used within this task are mining are Record valuation and the Decision tree-based approach for model creation. The Implementations for those algorithms are as follows;

1. Algorithm

Each class contains its own interesting similar data. It only contains the data which satisfy some condition sets. Without going for a model change as soon as a new record arrives, first the agent's checks for the relevancy of that data to the system. For each class, there are such rules set which helps to measure the support and confidence to each class and those are mentioned within the Ontology. For each time a new model formation occurred or update of the model occurs, new rules set are derived for that class and update the Ontology. The Record agent use these rules set for Record Valuation. For deriving these rules set classification technique in data mining is used. It makes IF, THEN like rule set for each and every class.

E.g: IF sunny=current_observation&& cloudy=l hour before observation THEN forecast = sunny

The Record Valuation formula is entirely based on a function called Category Utility [13], which measures the overall quality of a partition of instances into classes. It resembles a kind of quadratic loss function defined on conditional probabilities.

1.1. Category Utility for calculating the relevancy

In weather forecasting, the most important part is predicting the weather condition. There are 4 weather conditions that the system considers as; Sunny, Rainy, Windy, and Cloudy. Inside the classifying data arrangement, the data are grouped under these weather conditions. In that case, once a new record has arrived, the category utility calculates the relevance of the record to the class. The definition of the category utility is as follows;

$$\mathrm{CU}(\mathrm{C}_{1,}\mathrm{C}_{2,\ldots,}\mathrm{C}_{k}) = \frac{\Sigma_l \Pr[C_l]\Sigma_i\Sigma_j (\Pr[a_i=v_{ij}|\mathrm{C}_l]^2 - \Pr[a_i=v_{ij}]^2)}{k} \quad (1)$$

Where $\mathbf{C_1, C_2, \ldots..,C_k}$ are the **k** classes; the outer summation is over these classes; the next inner one sums Over the attributes; $\mathbf{a_i}$ is the $\mathbf{i^{th}}$ attribute, and it takes on values $\mathbf{v_{i1}, v_{i2}, \ldots.}$ which are dealing with by the sum over **j**. The Probabilities themselves are obtained by summing over all instances: thus, there is a further implied level of summation. The point of having a class is that it will give some advantage in predicting the values of attributes of instances in that class: that is, $\mathbf{Pr\ [a_i = v_{ij}\ |C_l]}$ is a better estimate of the probability that attribute $\mathbf{a}i$ has value $\mathbf{v_{ij}}$, for an instance in class $\mathbf{C_l}$, than $\mathbf{Pr[\ a_i = v_{ij}\ ]}$ because it takes account of the class the instance is in. If that information doesn't help, the classes aren't doing much good. So, what the preceding measure calculates, inside the multiple summations, is the amount by which that information does help in terms of the differences between squares of probabilities.

1.2. Category Utility for predicting Temperature, Humidity and Wind

This category utility formula put on only to nominal attributes. That means to predict the weather condition. However, it can easily be extended to numeric attributes, of Temperature and Humidity prediction by assuming that their distribution $\boldsymbol{\mu}$is normal with a given mean and standard deviation $\boldsymbol{\sigma}$. Theprobability density function [15] for an attribute **a** is,

$$f(a) = \frac{1}{\sqrt{2\pi}\sigma}\exp\left(\frac{(a-\mu)^2}{2\sigma^2}\right) \quad (2)$$

The analog of summing the squares of attribute value probabilities is;

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$$\Sigma_j \Pr[a_i = v_{ij}]^2 \Leftrightarrow \int f(a_i)^2 \, da_i = \frac{1}{2\sqrt{\pi}\sigma_i} \quad (3)$$

Where $\boldsymbol{\sigma_i}$, is the standard deviation of the attribute $\mathbf{a_i}$. Thus, for a $\boldsymbol{\sigma_{il}}$ numeric attribute, we estimate the standard deviation from the data, both within the classes and for the data over all classes $\boldsymbol{\sigma_i}$, and use these in the category utility formula:

$$\mathrm{CU}(\mathrm{C}_1, \mathrm{C}_2, \ldots, \mathrm{Ck}) = \frac{1}{k} \Sigma_l \Pr[C_l] \frac{1}{2\sqrt{\pi}} \Sigma_i \left(\frac{1}{\sigma_{il}} - \frac{1}{\sigma_i}\right) \quad (4)$$

2. Data Mining for Model Construction

The input parameters for the class attributes in model construction are;

- Current weather condition
- Weather condition before 1 hour to the current observation
- Weather condition before 1 1/2 hours to the current observation

When implementing the model each instance or tuple is assumed to belong to a predetermined class, as determined by the class attribute. The set of tuples used for model construction is called as 'Training Set'. The model is represented as a decision tree.

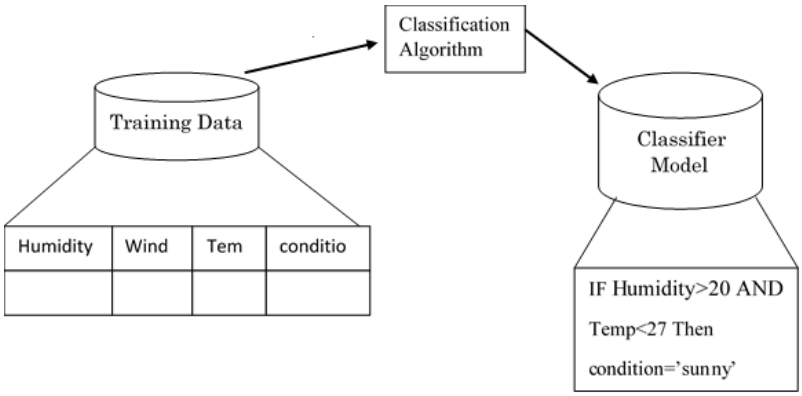

Figure 03: Model Construction using classification

2.1. Process of Model Construction

In classification, supervised learning is done. Further, the training data are accompanied by labels indicating the class of the observations. Then the new data classified based on the training set.

2.1.1. Algorithm for Decision tree induction

- A tree is constructed in a top-down recursive divide-and-conquer manner
- At the start, all the training example are at the root
- Attributes are categorical (if continuous-valued, they are discredited in advance)
- Instances are partitioned recursively based on selected attributes
- Test attributes are selected on the basis of a heuristic or statistical measure (e.g., information gain)

2.1.2. Conditions for stopping partitioning

- All instances belong to the same class for a given node.
- Further partitioning has no remaining attributes — majority voting is employed for classifying the leaf
- There are no instances left

The pseudo code for the implementation of algorithm is as follows;

Algorithm: Generate decision tree. Generate a decision tree from the training tuples of data partition D.

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Inputs: Data partition, D, which is a set of training tuples and their associated class labels. The attribute list, the set of candidate attributes. Use an Attribute selection method, a procedure to determine the splitting criterion that "best" partitions the data tuples into individual classes. This standard consists of a splitting attribute and, possibly, either a split point or splitting subset.
Output: A decision tree.
Method: [6]

1) create a node N;
2) if tuples in D are all of the same class, C then
3) return N as a leaf node labeled with the class C;
4) if attribute list is empty then
5) return N a leaf node labeled with the majority class in D; // majority voting
6) apply Attribute selection method (D, attribute list) to find the "best" splitting criterion
7) label node N with splitting criterion;
8) if splitting attribute is discrete-valued and multiway splits allowed then // not restricted to binary trees
9) attribute list attribute list splitting atribute // remove splitting attribute
10) for each outcome j of splitting criterion; // partition the tuples and grow subtrees for each partition
11) let Dj be the set of data tuples in D satisfying outcome j // a partition
12) if Dj is empty then ;
13) attach a leaf labeled with the majority class in D to node N;
14) else attach the node returned by Generate decision tree (Dj, attribute list) to node N;

endfor

15) return N;

2.1.3. Attribute Selection measure

Select the attribute with the highest information gain.[6]
Let *pi* be the probability that an arbitrary tuple in D belongs to class Ci, estimated by |Ci, D|/|D|

- Expected information (entropy) required.

$$Info(D) = -\sum_{i=0}^{m} pi\ log_2\ (pi) \qquad (5)$$

- Information needed (after using A to split D into v partitions) to classify D.

$$Info_A(D) = \sum_{j=1}^{v} \frac{|D_j|}{D}\ X\ Info(D_j\ ) \qquad (6)$$

- Information gained by branching on attribute A.

$$Gain(A) = Info(D) - Info_A(D) \qquad (7)$$

The gain is calculated for each and every attribute of our train data. Then the attribute which has the highest gain is selected as a node and tree construction is continued. Finally, a decision tree can be derived as follows;

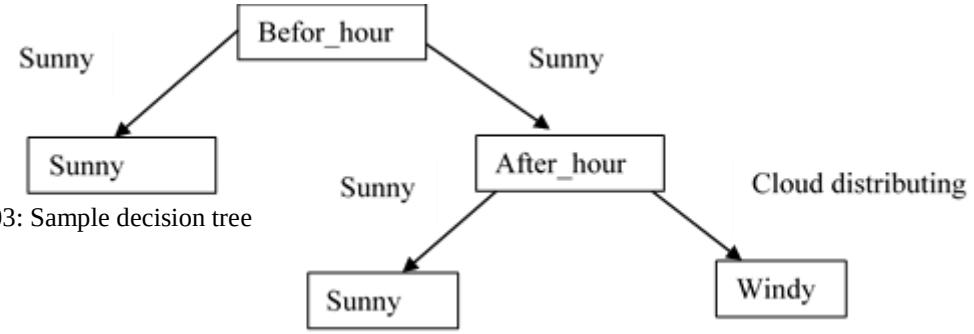

Figure 03: Sample decision tree

2.1.4. Over- fitting and Tree pruning

Over- fitting- An include tree may over fit the training data due to too many branches,some may reflect anomalies due to noise or outliers. In that case it will poorly accurate for unseen samples. Two approach that used for avoid over fitting;

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Per-pruning: Halt tree construction early-do not split a node if this would result in the goodness measure falling below a threshold. [5]
Post-pruning: Remove branches from a "fully grown" tree-get a sequence of progressively pruned trees. [5] It uses a set of data different from the training data to decide which is the "best-pruned tree".

2.2. Weka for Data mining

For the mining process, for implementing algorithms and other data mining techniques Weka data mining API Support were taken. The used Weka packages, classed and methods are as follows;
weka.classifiers.trees;
buildClassifier (Instances data) - Generates a classifier.
classifyInstance (Instance instance) - Classifies a given instance
for its membership class
numberOfClasses () - Return no of classes within the model
weka.ClassifierEvaluation; - Evaluate the model

Implementation of the Weather Portlet
When implementing the Weather portlet, the .xml files, .jsp file and .java files have been written according to the Model View Controller (MVC) Architecture.

Implementing the Graphical user Interface
The functionalities covered by this implementation;

- People can search for the weather forecasting for a particular location.
- The searching for the location can do using City name.
- Then displays the weather forecasting details belong to that location.

There are three user interfaces within this weather forecasting Web Portlet. Those are;

- **Welcome screen** - This is the first screen which can be seen within the main window. Once a user clicks on the Set-Up button, he is directed to the search

- **Search screen** -By using this screen of the Portlet, users can select the location that they wish to obtain the weather forecasting details. For that, they have to enter the name of the city and click on the 'Go button. According to the city name that he enters the resulting forecasting weather information for a particular location are presented

- **Result screen -**This window shows at a glance weather forecasting data relevant to a particular location for the current day as well as for the future days.

Implementation of Messages or SMS handling

The implementation of this component is carried out using four sub-components mainly. Those are,

- Listening and catching incoming messages through a modem
- Message Processing
- Sending reply message to the originator
- Keep track of incoming and outgoing messages in Database

A. Listening and catching incoming messages

ReceiveSMS

This class is responsible for catching the incoming requests from the citizens. First, it creates a connection between the modem and the server computer. After the connection is successfully created, then it listens on a continuously running while loop for the incoming requests. Once a request is detected, it puts that message into a queue. Then it serves them as first in first out fashion. This is the place where the SMS is broken down to derive the user's mobile phone number and his request for weather forecasting information. Then the request is sent for message processing.

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B. Message Processing

The message processing part also has mainly 4 subcomponents; those are handling the body of the received message, formatting the message, querying adatabase and creating output message.

1. Handling received message

In this subcomponent, the body of the message is taken as the parameter. In that case, the class InputMessageHandler used to handle the message body to be processed by the system. It uses a method called public HashMap messageBreaker (String SMS) which takes the body of the SMS as the input. By using this method, the district name or district name and the date (if he specifies) that he wishes to aware are derived and assigned to the variables. Then those data are passed through a Hash Map to the relevant classes.

2. Message formatting

For Message formatting it involves class called; MessageFormatter. It takes input from InputMessageHandler which derives the location or the district and the time information. MessageFormatter has following methods.

- **Public Boolean isValidDistrict()**-This method is responsible for checking the validity of the district name.
- **Public Boolean hasCorrectNoOfElements ()**-This method checks whether the message body has the correct number of elements and the spaces.
- **Public Boolean isValidTime()**-This method is responsible for checking the validity of the times specsifie6 the user in order to get the weather forecasting.
- **Public Boolean isDistrictNull()**-This method checks the given district name is null or not.
- **Public Boolean isStringDistrict()**This method checks the given district is a string value or not.
- **Public Boolean isDateNull()**- This method checks the given district name is null or not.
- **Public List spellChecker()** -This method is responsible for checking spellings of the city part of the messages.

3. Querying database

Under this subcomponent, all the database activities are handled. For that the class called DatabaseQuerier involves. The class is responsible for working with the database. Once valid in arriving, this class responsible for querying the database in accordingly gets the result what user requests. To perform that it uses a method called listForecastingData().

Public list ForecastingData(String districtName, Time time) -It gets the district name and the date as inputs and then makes the query to fetch the forecasting data from the database.

4. Creating body of the output message

According to the design of this module, for each and every request that user made should be facilities with an appropriate resulting message unless the message is not so delayed one. To perform that OutputMessageCreator class is used. This class is responsible for generating the output message's body. It uses getOutputMessage() method to generate the body of the output message.

Public String gerOutputMessage()

Here, for invalid request that user made such as invalid district and dates, error messages are generated by briefly describing the error that the user has made. Else, if there are results for the requested, the result is formatted very understandable to the user.

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C. Sending reply message to the originator

This subcomponent is responsible for responding to the request made by the user. To perform this the class called SendSMS is used. It takes input from OutputMessageCreator class and ReceiveSMS classes. Once it is given the body of the output message and the receivers mobile phone number, the complete output SMS is generated. It uses the send0 method for sending the message to the receiver.

D. Keep log for all incoming and outgoing messages

Each and every time the message is received and sent by the system; it keeps track of those messages by simply saving their information in the database. This is done through Auditor class. An auditor is responsible for tracking the incoming and outgoing SMSs. To implement this operation, JAVA CRON operations are used.

while implementing this module for the testing purposes, a blue tooth enables mobile Phone is configured as a GSM modem. Then the mobile phone and the computer Which the SMS application is deployed connected via blue tooth.

IV. DISCUSSION

The main reason for decided to develop such a system is the drawbacks lie within the current weather forecasting system in the meteorological department. Since the current process is carried out through a manual process, the accuracy of the forecasted data was not much accurate. To solve this problem, an automated multi-agent base for the system was proposed. Which all forecasting inside the process is carried out by the intelligent agents. The main core functionalities within the system are;

- Forecasting the weather using data mining
- Presenting those forecasted data to the citizen
  - Display weather forecasting though web via Web Portlet
  - Getting weather forecasting information via SMSs

If weighted both of these functionalities by considering their functionality levels, the latter one fulfills 45% of functionalities within the system. Since both ways for presenting forecasted data have been implemented first, a quality assurance cycle is carried out in order to assure the quality within those functionalities. While evaluating these two services so many test cases have been used. Then the core of the system, the Multi-agent-based weather forecasting process has been implemented. By using the Weka data mining tool kit, the error rate for 20 different training set is calculated to evaluate the accuracy of the final forecasting output value.

V.CONCLUSION

So, throughout this project, the main aim is to remove these inaccuracies lie within the forecasting process and provides the most accurate weather forecasting information to the public. Therefore, the eventual output of this project or the Data mining approach-based weather forecasting system is, providing the forecast for the next quarter of the day. Once a new prediction is derived from this automated weather forecasting system, it is distributed to the public via a Web Portlet and Short Message Service.

The main difficulty faced when developing this system was to implement the classification algorithms practically. Understanding the algorithm like category utility is really hard. Another difficulty faced was the testing of the rule sets derived by the decision tree algorithm. Since there is no direct influence on one weather factor to another factor (the relationship between humidity and temperature), once a classification rule is defined by combing weather factors, we cannot accurately say there is this kind of relationship is within these weather factors. So, the model had to be adjusted with test data. But this approach provides an accurate, robustness, scalable and fast evaluation when predicting. Also, the interpretability of the rules is very high.

The automated weather forecasting system comprises mainly three components. Altogether each of those components meets their goals to provide accurate weather forecasting details to the public. The core of the entire system is based on the dynamic data mining and classification approach on weather pattern recognition and classifications which effective involvement of intelligent agents.

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When considering the current process of weather forecasting in the meteorological department, they use the plotted map for displaying wind behavior and flow. Most of the time they use this graph to decide the probability of rain. Hence the system can future enhance to predict the rain using image processing of plotted wind chart and applying data mining techniques on it.

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REFERENCES

[1] Dance, S., Gorman, M., Padgham, L., &Winikoff, M. (2003). An evolving multi agent system for meteorological alerts. Proceedings of the Second International Joint Conference on Autonomous Agents and Multiagent Systems - AAMAS 03.

[2] Lee, R. and Liu, J. (2004). iJADEWeatherMAN: A Weather Forecasting System Using Intelligent Multiagent-Based Fuzzy Neuro Network. IEEE Transactions on Systems, Man and Cybernetics, Part C (Applications and Reviews), 34(3), pp.369-377.

[3] Williams, A. (2004). Learning to Share Meaning in a Multi-Agent System. Autonomous Agents and Multi-Agent Systems, 8(2), pp.165-193.

[4] Masinde, M. (2015). MAS-DEWS: A multi-agent system for predicting Africa's drought. 2015 International Joint Conference on Neural Networks (IJCNN).

[5] Coursehero.com. (2019). Halt tree construction early do not split a node if this would result in the | Course Hero. [online] Available at:https://www.coursehero.com/file/p2ngapcj/Halt-tree-construction-early-do-not-split-a-node-if-this-would-result-in-the/ [Accessed 18 May 2019].

[6] Hanj.cs.illinois.edu. (2010). [online] Available at: http://hanj.cs.illinois.edu/cs412/bk3/08.pdf [Accessed 25 May 2019].

[7] Jade.tilab.com. (2019). *Jade Site | Java Agent Development Framework*. [online] Available at: https://jade.tilab.com/ [Accessed 27 Aug. 2019].

[8] Developershome.com. (2019). SMS Tutorial: Introduction to wireless modems, GSM Modems and GPRS Modems. Comparison of Mobile Phones with GSM/GPRS Modems. [online] Available at: https://www.developershome.com/sms/GSMModemIntro.asp [Accessed 6 Jul. 2019].

[9] Yahoo.com. (2019). Yahoo is now part of Oath. [online] Available at: https://www.yahoo.com/news/weather/ [Accessed 27 Aug. 2019].

[10] Vvo-online.de. (2019). Timetable for your website | VVO Navigator - Your mobility portal for Dresden and the region. [online] Available at: https://www.vvo-online.de/en/service/timetable-for-your-website/index.cshtml [Accessed 27 Aug. 2019].

[11] Liferay.com. (2019). *Digital Experience Software Tailored to Your Needs | Liferay*. [online] Available at: https://www.liferay.com/ [Accessed 27 Aug. 2019].

[12] Brownlee, J. (2019). *How to Save Your Machine Learning Model and Make Predictions in Weka*. [online] Machine Learning Mastery. Available at: https://machinelearningmastery.com/save-machine-learning-model-make-predictions-weka/ [Accessed 27 Aug. 2019].

[13] Han, J., Kamber, M. and Pei, J. (n.d.). *Data mining*.

[14] Ian H. Witten, Eibe Frank, Mark A. Hall, (3rded), Data Mining: Practical Machine Learning Tools and Techniques

[15] Itl.nist.gov. (2019). 1.3.6.6.1. Normal Distribution. [online] Available at: https://www.itl.nist.gov/div898/handbook/eda/section3/eda3661.htm [Accessed 28 Aug. 2019].