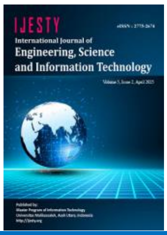
International Journal of Engineering, Science and Information Technology
Volume 5 No. 2 (2025) pp. 182-189
ISSN 2775-2674 (online)
Website: http://ijesty.org/index.php/ijesty
DOI: https://doi.org/10.52088/ijesty.v5i2.806
Research Paper, Short Communication, Review, Technical Paper



Weather Classification and Prediction on Imagery Using Boltzmann Machine

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The manuscript was received on 18 June 2024, revised on 1 October 2024, and accepted on 2 February 2025, date of publication 3 April 2025

Abstract

Weather is a physical process or event that occurs in the atmosphere at a specific time and place, as well as its changes over a short period in a particular location on Earth. To produce weather forecast information, there is a series of processes that must be carried out until the weather information is conveyed accurately. The stages involved in the feature extraction process are carried out first. This process is carried out to obtain specific characteristics or features from a dataset. After the feature extraction process has been completed, the next step is to predict the weather based on the input images. To classify the weather on Earth using various algorithms, one of which is the Machine Boltzmann. The pattern recognition method used is Machine Boltzmann as an application of a simpler and more complex method. Generally, the weather prediction system using Machine Boltzmann consists of several stages, namely image acquisition, greyscale processing, segmentation/location using Sobel edge detection, classification using the Machine Boltzmann method, and finally producing output in the form of weather class results. The classification process in this research involves images of clear, cloudy, and rainy weather as inputs. The output of the system is the determination of whether the input weather image falls into the category of clear, cloudy, or rainy weather. The results of the study show that the classification of weather based on captured images has the highest accuracy for clear weather, with a percentage of 73.33%. For cloudy weather, the success rate is equal to the error rate, which is 50%, while rainy weather was not recognized at all.

Keywords: *Weather, Machine Boltzman, Image, Grey-Scale, Prediction.*

1. Introduction

Weather is a physical process or event that occurs or occurs in the atmosphere at a certain time and place or the momentary value of the atmosphere and its changes in the short term in a certain place on earth [1] [2].
In general, some elements affect the weather and climate conditions of an area or region, namely: air temperature, wind, air pressure, air humidity, and rainfall. Air temperature is the degree of heat from the activity of molecules in the atmosphere, usually the measurement of temperature or air temperature is expressed in Celsius (C), Reamur (R), and Fahrenheit (F) scales [3][4]. Wind is the movement of air that is parallel to the earth's surface. The strength of the wind is determined by its speed, the faster the wind blows, the higher the strength [5]. Air pressure is a force that arises due to the weight of the air layer. Air humidity is the amount of water vapor contained in the air mass at a certain time and place. Rainfall is the amount of rainwater that falls in an area at a certain time. Rainfall is measured in daily, monthly, and yearly. According to BMKG, based on rainfall, the rainfall is classified into moderate rain with rainfall of 20-50 mm per day, heavy rain with rainfall of 50-100 mm per day, and very heavy rain with rainfall above 100 mm per day [6].
Weather forecasting is a thing that is needed in determining a decision on a weather-related activity, such as agriculture, shipping, and aviation [7]. To produce weather forecast information, there are a series of processes that must be carried out until the weather information is conveyed correctly. The stages of the feature extraction process are carried out first. This process is carried out to get

special characteristics or features of data. After the feature extraction process has been carried out, the weather prediction process is carried out based on the input image.
The pattern recognition method used is Machine Boltzman as the application of simpler and more complex methods [8][9]. Based on these problems, the author feels the need to develop a system application that can classify weather patterns based on image images with a high level of sensitivity. By applying simpler and more complex methods

2. Literature Review

2.1. Image

An image is a representation (image), likeness, or imitation of an object. Images as the output of a data recording system can be optical in the form of photos, analogue in the form of video signals such as images on television monitors, or digital in the form of storage media.
Analogue images are continuous images, such as images on television monitors, X-ray photos, photos printed on photo paper, paintings, natural landscapes, CT scan results, images recorded on cassette tapes, and so on.
Digital image processing is a discipline of science that studies things related to image quality improvement (contrast enhancement, colour transformation, image restoration), and image transformation (rotation, translation, scale, geometric transformation) [10].

2.2. Image Digitization

Analogue images must be converted into digital images (imaging) for the computer to process them. The process of converting analogue images into digital images is called image digitization. Two things are done in the image digitization process, namely spatial digitization, also known as sampling (erosion), and intensity digitization, which is often called quantity. There are two types of image digitization processes, namely spatial digitization (x,y) and f(x,y) intensity digitization [11].

2.3. Pattern Recognition

In general, pattern recognition (pattern recognition) is a science to classify or describe something based on quantitative measurements of features (characteristics) or the main properties of an object. The pattern itself is an entity that is defined and can be identified and named. Pattern recognition can be through handwriting, eyes, face, and skin. An example of the application of pattern recognition is the recognition of characters in letters as learning. Patterns can be a collection of measurement or monitoring results and can be expressed in vector or matrix notation [12].

2.4. Digital Image Processing

The steps in digital image processing can be described into several steps described [13] as follows:
1. Image acquisition is the initial stage to obtain a digital image.
2. Preprocessing is necessary to ensure the smoothness of the next process.
3. Segmentation aims to partition the image into main parts that contain important information.
4. In this case, representation is a process of representing an area as a list of coordinate points in a closed curve, with a description of its area or perimeter. The next process is to describe the image using feature extraction and selection. Feature selection aims to select quantitative information from existing features, which can distinguish the classes of objects well.
5. The recognition stage aims to label an object whose information is provided by a descriptor, while the interpretation stage aims to give meaning or meaning to a group of recognized objects.
6. The knowledge base as a knowledge database is useful for guiding the operation of each process module and controlling the interaction between the modules, in addition, the knowledge base is also used as a reference in the template matching process or pattern recognition.

2.5. Image Histogram

An image histogram is a graph that contains the distribution of pixel intensity values from an image. Suppose the image has an L grey level, from 0 to 1-L (an 8-bit image has a range of 0 to 255 grey level) [14].

2.6. Bitmap (.bmp)

A bitmap image is an arrangement of colour bits for each pixel that forms a specific pattern. These colour patterns present information that can be understood according to the perception of the human sense of sight. This file format is a flexible graphics format for the Windows platform so that it can be read by any graphics program. This format is capable of storing information with quality levels of 1 bit to 24 bits [15].

2.7. Grey-Scale

Colour models in digital images have been developed by many experts, including RGB colour models. Colour processing using RGB colours is easy and simple because the colour information in the computer is already packaged in the same model. What needs to be done is to read the values Red (R), Green (G), and Blue (B) on a pixel, display, and interpret the color of the calculation so that it has the desired meaning [16].

2.8. Edge Detection Using Sobel Operators

Edge detection (Edge Detection) in an image is a process that produces the edges of the image objects [17], the objectives are:
1. To mark the parts that are imagery details
2. To fix the details of blurred imagery, which occurs due to an error or effect of the image acquisition process

A point (x,y) is said to be the edge of an image if the point has a high difference from its neighbours. Sobel operators are more sensitive to diagonal edges than vertical and horizontal edges. This operator is formed from a matrix measuring 3x3.

2.9. Artificial Neural Network (JST)

JST is a computational technology that is based on biological neural models and tries to simulate the behaviour and work of neural models on various kinds of inputs. As a computing technology, JST is an information processing technique that uses a quantitative model of biological nerves to inspire the creation of a computational process that is identical to the work of neurons in the human nervous system [18].

2.10. Machine Boltzmann

The Boltzmann machine is a symmetrically connected, neuron-like network of units that make decisions about whether the stochastic is on or off. Boltzmann machines have a simple learning algorithm that allows them to find interesting features that represent complex regularities in the training data. The learning algorithm is very slow in a network with many layers of detector features, but fast in the "Boltzmann machine throttling" which has a single layer of detector features. Many hidden layers can be learned efficiently by composing a Boltzmann machine-constrained, using the activation of one feature as training data for the next [19].

2.11. Weather

Weather is very important and very influential in fields such as agriculture, aviation, and shipping. [20] An example in the agricultural sector is weather forecasting as a major need as well as the selection of seeds, fertilizers, and pest eradication. Weather information is also a reference in the selection of seed types and planting times. If the weather forecast misses, for example, the allegation about the arrival of rain music and the rainy season period misses far away, the impact can be in the form of big losses for farmers due to crop failure and food scarcity.

3. Research Method

3.1. Research Flow Diagram

The overall workflow in this study can be seen in detail in Figure 1 below:

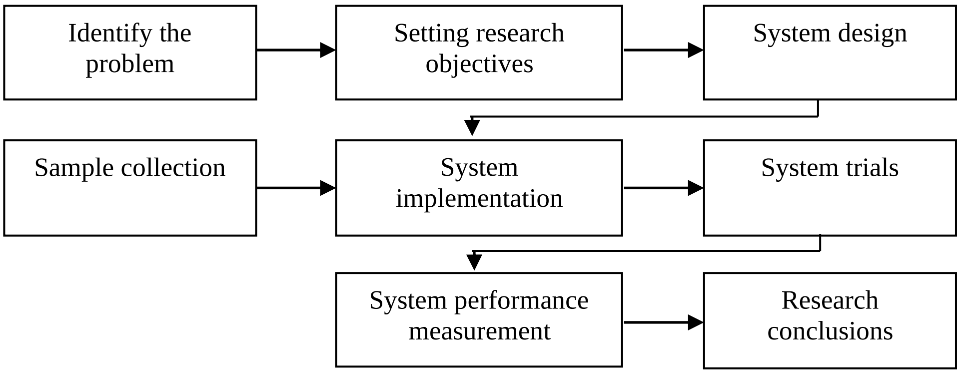

Fig 1. General Research Workflow

3.2. Data Collection

The data used in the study is data in the form of images, the data consists of a set of images for training (training data set) and a set of images for testing (testing data set). Images for training and testing are obtained from various sources such as camera captures. The imagery used is limited to images with a .bmp extension.

Table 1. Sample Details

Weather Training Sample			
Bright	Cloudy	Rain	Total Samples
20	15	5	40

The weather sample is taken directly by the camera (capture). The captured weather samples are used as a comparison to see the accuracy of the classification system and weather prediction directly by conducting the process of testing the captured weather images according to the conditions during the training.

3.3. Literature Studies

Literature studies aim to collect scientific data and information, in the form of theories, journals, methods, or approaches that have developed and have been documented in the form of books, magazines, manuscripts, and so on.

3.4. System Needs Analysis

The data used in this study consisted of a set of images for training (training data set) and a set of images for testing (testing data set). The data collection process (image sample) is carried out with the following steps:

1. The weather image object to be planted in the training sample consists of 3 object samples according to the number of classifications and weather predictions that have been determined.
2. Collecting weather image objects consists of sunny weather images, cloudy weather images, and rainy weather images.
3. The training was carried out with several weather image objects as samples for training in sunny weather images, cloudy weather images, and rainy weather images.
4. The test was carried out with several weather image objects as samples for the classification and prediction of sunny weather images, cloudy weather images, and rainy weather images.

The images used are limited to 24-bit images .bmp extension. The reason for choosing the .bmp image is because the .bmp image format is the default standard in video processing on the Windows operating system.

3.5. System Schematics

The overall system is schematic is carried out after the system receives image input, namely grey-scale stages, convolution, classification tests, and weather prediction through the Mechine-Boltzmann method. In the pre-processing stage, the input source image will be resized first to save time and the number of iterations. After resizing, the image will be represented in the form of a single channel, and end with edge detection through the convolution process. In the main process, the calculation uses the Boltzmann Machine method, the pattern of the weather object will be trained to obtain an energy value, which is then used as test energy.

3.6. System Performance Evaluation Measurement Parameters

The measurement of the performance evaluation of this weather classification and prediction system generally uses two parameters, namely the detection rate and false positive rate. The detection rate is a comparison or percentage of the number of weather classifications that are successfully recognized per the total number of weather images tested, while the false positive rate is the number of weather images that are not successfully recognized.

4. Result And Discussions

4.1. System Analysis

The results discussed include the selection of weather image training samples where these samples will be input from computers that have been stored in the system. System training, the system training process includes the process of calculating the matrix value of the original image, then the gray-scale process, and the edge detection process using convolution with a kernel, namely the Sobel operator. System testing, the steps of the system testing process are the same as the training process, where the matrix value of the original image will be processed in the gray-scale process and then entered into the edge detection process using convolution with a kernel, namely the Sobel operator and calculated using the Boltzmann Machine to get the energy from an image. The approach or similarity of energy values is the reference for classification and prediction of weather, this is also called the statistical approach. The measurement of system performance is a description of the results of the entire training and testing process that has been carried out. Which is depicted directly in the form of a table containing actual data from the results of the research.

4.2. System Implementation

System implementation is a continuation of system analysis, which is the stage of translating application development needs into software representation, following the results of the analysis in the previous explanation. After the implementation stage, the system testing stage was carried out to see the shortcomings in the system. The implementation in this part of the implementation stage is a translation of the design based on the results of the previous analysis into a programming language that can be understood by the computer. The programming language in this system uses the Delphi XE language.

4.3. Manual Calculation

The calculation of the Boltzmann Machine for learning with the input of Javanese script images, the input values for Javanese script images are as follows:

Table 2. Manual RGB to Grayscale Conversion

(x,y)	0	1	2	3	4
0	30,50,10	120,50,30	250,100,50	20,80,100	10,20,30
1	40,70,70	70,100,20	100,55,105	255,105,100	80,50,40
2	40,80,120	150,180,90	180,80,200	55,180,50	30,15,250
3	10,50,80	40,20,180	100,90,255	150,10,80	250,150,200
4	15,25,80	55,100,100	170,80,100	20,30,60	85,45,71
5	50,40,60	100,30,50	70,60,80	90,100,80	150,75,75

For colour conversion to RGB, the formula is used:

$$s = \frac{r+g+b}{3} \qquad (1)$$

The calculation is done for each coordinate so that the matrix of the converted image is as follows:

Table 3. Grayscale Convention Manual Calculation Results

(x,y)	0	1	2	3	4
0	30	67	100	67	20
1	60	63	87	143	57
2	80	140	153	95	98
3	47	80	148	80	200
4	40	85	117	37	67
5	50	60	70	167	100

After obtaining a grayscale image, the image is then processed by converting it into sobel (image edge detection). The Sobel process (image edge detection) can be seen below:
1. Horizontal sobel operator

…………………………………………………………………………………………...(2)

$$S_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

2. Vertical sobel operator

…………………………………………………………………………………………...(3)

$$S_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

3. The Sobel operator is the magnitude of the gradient

…………………………………………………………………………………………...(4)

$$M = \sqrt{S_x^2 + S_y^2}$$

Here's one example of the calculation:

Sx = (30)(-1) + (60)(-2) + (80)(-1) + (100)(1) + (87)(2) + (153)(1) = 197

Sy = (30)(1) + (67)(2) + (100)(1) + (80)(-1) + (140)(-2) + (153)(-1) = -249

M==M=27 $\sqrt{Sx^2 + Sy^2}\sqrt{197^2 + -249^2}$

The results of the calculation of the sobel (detection of the edge of the image) can be seen in Table 4.

Table 4. Results of Sobel Image Value

(x,y)	0	1	2	3	4
0	*	*	*	*	*
1	*	27	395	269	*
2	*	286	77	117	*
3	*	480	249	296	*
4	*	298	179	18	*
5	*	*	*	*	*

Normalize pixel values: If M >= 255 then M=255, If M<=0 then M=0

Table 5. Pixel Value Normalization Results

(x,y)	0	1	2	3	4
0	*	*	*	*	*
1	*	27	255	255	*
2	*	255	77	117	*
3	*	255	249	255	*
4	*	255	179	18	*
5	*	*	*	*	*

Normalization of binary image: If M >=20 then M=1, If M<20 then M=0

Table 6. Binary Image Normalization Results

(x,y)	0	1	2	3	4
0	*	*	*	*	*
1	*	0	1	1	*
2	*	1	1	1	*
3	*	1	1	1	*
4	*	1	1	0	*
5	*	*	*	*	*

The binary image values are as follows:

0	1	1
1	1	1
1	1	1
1	1	0

The calculation of the Boltzmann Machine is as follows:

Known image value = 0.1.1.1.1.1.1.1.1.1.1.0
W = 1.1.1.1.1.1.1.1.1.1.1.1.1
Value (x,y)

ht=0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1 xo= 1
ct=0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1 y0= 1
dt=0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2 u = 1
bt=0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2,0.2 x1= 0
x=1.2.3.4.5.6.7.8.9.10.11.12 y1= 0
y= 1.2.3.4.5.6.7.8.9.10.11.12

Learning constants = 0.5

Stage a = $E(y, x, h) = -h^{TWx-bT} x - cTh - dT\, y - hTUy$ ……………………………………………………..(5)
= E(y, x, h) = -(0.1*1*1)-(0.2*1)-(0.1*1)-(0.2*0)-(0.1*1*1)
= -0.4
Stage b = $P(y,x,h) \approx e^{-E(y,x,h)}$ ……………………………………………………..(6)
Level c = L_{gen} (D train) = $\sum_{i=1}^{[\text{Dtrain}]} \log p\,(yi, xi)$ ……………………………………………………..(7)
Stage d = Calculating Positive and Negative Phases
= + Phase ……………………………………………………..(8)

$$\frac{1}{1+e^{(c+w.x^0+uy^0)}}$$

= - Phase ……………………………………………………..(9)

$$\frac{1}{1+e^{(c+w.x^1+uy^1)}}$$

Stage e = Update Weight
= if (phase 1<phase 2(weight+learning constant *phase1) ……………………………………………………(10)
= (phase2+learning constant *phase2-weight)
= if(8.8621< 8.688 (1+0.5*8.8621)(8.688+0.5*8.688-1)
= 12.03267

4.4. System Show

The measurement of the performance of the system is carried out based on the measurement of all test data based on certain specifications or introductions that are correlated with the amount of training data used.

Percentage of Truth =

$$\frac{\text{Number of Images Correct}}{\text{Number of Test Images}} \text{ x } 100\%$$

= x100% =56.67 $\frac{17}{30}$

Error Percentage =

$$\frac{\text{Number of Images Incorrect}}{\text{Number of Test Images}} \text{ x } 100\%$$

$= \frac{13}{30} \text{x}100\% = 43.33$

The test results of 3 types of sunny, cloudy, and rainy weather varied in the number of weather images recognized, for clear weather images 73.33% could be recognized, for cloudy weather images 50% could be recognized, and for rainy weather images could not be recognized. The following Figure 2 shows a graph of the performance of the weather classification system based on the captured image.

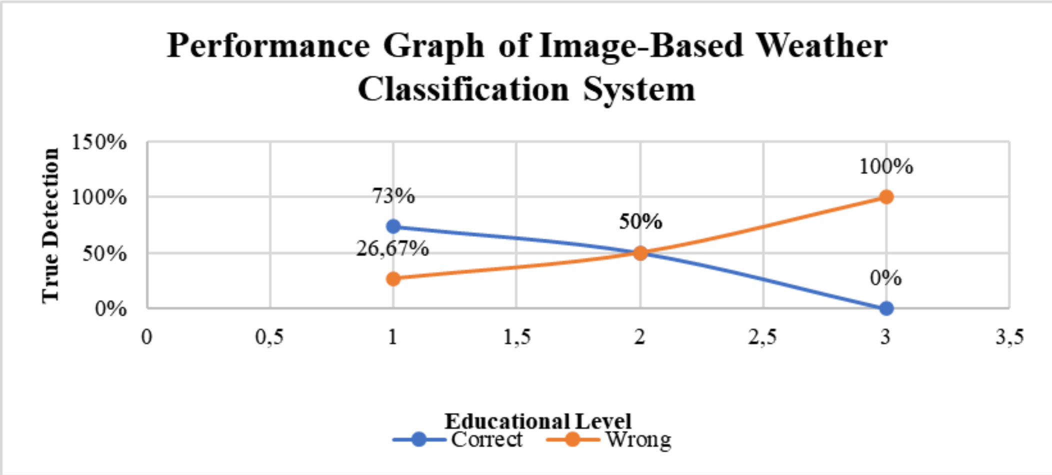

Fig 2. Weather Classification System Performance Chart

Figure 2 above is an illustration of the accuracy level of classification and weather prediction based on imagery. Based on the graph above, it can be seen that the highest level of truth is in sunny weather with a percentage of 73.33% and for cloudy weather, the success rate is the same as the error rate, which is 50%, while for rainy weather, it is not recognized at all.

The results show that the weather classification system based on imagery has a detection rate of around 56.67%. The percentage of detection rate shows that this method is very minimal to be used as one of the supportive approaches for weather classification through captured imagery.

Based on the results of the detection rate achieved, the proposed system scheme has been able to classify through image capture using economical computing even though the percentage of truth is not so high.

5. Conclusion

Based on the results of the research that has been carried out, conclusions can be drawn:

1. Machine Boltzman's performance for weather calcification based on the captured images has the highest level of accuracy in sunny weather with a percentage of 73.33% and for cloudy weather, the success rate is the same as the error rate of 50% while for rainy weather it is not recognized at all.
2. The advantage of Machine Boltzman is that in the process of calculating its network, there are several hidden vectors of 56.67%.and vector transpose to improve neural networks in weather pattern recognition so that it is more accurate in image matching.
3. Machine Boltzman can work well on images that do not contain noise.
4. The Boltzman Machine is particularly suitable for image-based weather classification systems.

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