Take Off and Landing Prediction Using Fuzzy Logic

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Abstract — Each flight must consider several important factors to maintaining the safety of the passengers. Weather is a factor that must be considered when the aircraft takes off and landings. Weather information is important to give a recommendation flight worthiness. The fuzzy method is an excellent method for forecasting the weather whether the aircraft eligible to fly or landing. The data used is from BMKG Meteorological Class 1 Polonia. The data used as inputs of fuzzy logic. Recommendations eligibility is affected by low visibility and wind direction. Both of these parameters are affected by the rain and wind speed. For rainfall prediction model with three inputs, namely visibility, wind speed and wind direction. The output is feasibility. By applying the fuzzy method of the low will help the water traffic control to help the plane that would take off and landing.

Keywords — Fuzzy Logic, Membership Function

I. INTRODUCTION

In Indonesia, there is a government agency to discuss and observe the weather, namely Meteorology and Geophysics Agency (BMKG). Meteorology is the study of weather [5]. Climatology is the study of the climate. Geophysics is the study of terrestrial. The weather itself mean an average state of the physical state of the earth at a certain time (briefly) and a particular wrought. Climate is the average state of weather somewhere in a long time and still.

The Meteorology, Climatology and Geophysics Agency who served in providing weather information and meteorological services geophysics also able to predict the weather by conventional methods either statistical or dynamical method. At this time, the methods based expertise are developing a technique that can analyze weather data (atmospheric) in addition to neural networks and to predict known as fuzzy logic.

In aviation, safety is a very important and major [7]. Many factors affect flight safety one of which is the weather. World Meteorological Organization establishes rules relating to weather and flight safety. Weather affects the activity of three aircraft that is taking off, flying and landing. Poor weather can affect three of these activities and can interfere with the safety of passengers.

Prediction is estimated or certain future expectations that are based on several factors and assumptions [3][4]. Authors interested in discussing the weather predictions which can be useful in the world of flight that flight safety. With fuzzy logic, the outcome can be beneficial for flight worthiness [1][2].

II. THEORIES

A. Aviation Factors

In the field of air transport, the weather affects the human safety aspect. Therefore, it takes the data, and weather predictions are accurate to reduce the number of accidents caused by weather factors. Based on data from the FAA, the main cause of accidents in the aviation world, there are three, human factor (66.7%), fleet factor (27.1%), and weather factor (13.2%).

Weather Flight.

Weather Flight is the weather that is intended specifically for aviation, both for takeoff, landing or during flight. This weather information is given at any time during the aircraft flight plan that is tailored to the flight schedule. Weather information at the time of takeoff, and landing during the trip includes several elements of weather, i.e., wind, visibility, pressure, types of clouds, and temperature [7].

Instrument Landing System (ILS)

ILS is an aircraft landing guidance system using the electronic instrument that serves to guides aircraft on final approach to the runway position. This system helps the aircraft landed right on the center line of the runway and the landing angle right [7]. Instrument Landing System consists of three subsystems, such as:

- ❖ Localizer, which is the equipment that gives a signal about the alignment guides azimuth plane to the runway center line.
- ❖ Glide Slope, which is equipment that provides signals landing glide angle guides (3 degrees), or help the aircraft to be right in the touchdown during landing.
- ❖ Marker Beacon, i.e., equipment that informs the rest of the aircraft's distance to the landing point.

B. Weather

Weather is an average state of the physical condition of the earth at a particular time and place [5]. There are several elements that affect the weather, pressure, temperature, humidity, wind speed and direction, cloud, dew point, the intensity of the sun, evaporation, soil conditions, rainfall, etc. The weather is a behavior that occurs in the atmosphere and has a direct impact on the activities of human life. Meteorology is the study of the state of the weather, atmospheric issues, for example, temperature, air, weather, wind, and various physical properties, and other atmospheric chemicals used for weather forecasting purposes.

BMKG is a Ministry of Non-Government Organization (LPNK) in Indonesia charge of carrying out government duties in the field of meteorology, climatology, air quality, and geophysics by the provisions of applicable law.

Weather prediction is a summary of weather conditions daily to weekly, while the climate predictions are the climate elements in Indonesia is predicted monthly rainfall or monsoon prediction in a season. What distinguishes the weather and climate prediction is the span of time and the type of element that is forecasted [6]. Weather predictions mention almost all the elements of weather, climate predictions over ranges while the amount of rainfall and the beginning of the season. The results of weather and climate predictions are the information systems used to see nature in the future. The observation of the weather that took place in a systematic, data collection and data processing which uses a mathematical equation to form an outcome in the form of weather or climate prediction system. The benefits of weather forecasts are to anticipate weather conditions that could cause material and moral damages for humans.

III. METHODOLOGY

In this chapter will discuss the methodology and procedures used in the study. The fuzzy method used is Mamdani. This section also describes the study of literature, data collection methods, system design, implementation, testing, and conclusions and suggestions.

A. Description

In this study, the system built is an application of decision support system for the aircraft take-off and landing. These applications are included in the category of artificial intelligence. To know the weather

is going to happen, the necessary engineering calculations based on the data obtained. The workings of this system can be divided into two processes. The first process is the data acquisition process performed by Class I Meteorological Station Polonia and the second is the processing of raw data using Fuzzy logic Mamdani method. Fuzzification process is a stage for calculating the raw data in accordance with existing rules.

B. Data Collection

In this study, the data used is data from the Meteorological Station Class I Polonia, Medan. Data on this station is data obtained by accessing the database at BMKG computer and saved to Excel format. This data will be processed using fuzzy logic. After fuzzification, then the data will be saved back to the database and presented by the architecture of decision support system designed.

A parameter is a tool needed in the process of identifying the data in the study. The need in this study followed the research purposes so that raw materials can be used as a valid source. To obtain the data in this study, it needs observations of the research object.

The variables used for weather forecasting, such as:

1. Visibility
2. Wind Direction
3. Wind Speed

C. Outcome

Fuzzy logic models are affected by the data input and output data, or so-called variable input and output variables. In terms of feasibility weather for flight recommendations, the most influential variables are the visibility, wind direction and wind speed. Those variables will be used as the input variables of fuzzy logic. On the input and output of data processing, the clustering process is performed to classify the data into groups or clusters. This cluster information will help build a Fuzzy Inference System.

D. Variables

The variables are the criteria to be a reference to get results. Variables can be one piece or even more than one according to the characteristics that determine the outcome of the calculation data. The variables used are:

- Visibility

Fuzzy Set [Near, Medium, Far]

Domain:

Near	: 100 - 1100
Medium	: 1000 - 7000
Far	: 6000 - 10000

- Wind Direction

Fuzzy Set [Safe_1, Danger_1, Safe_2,
Danger_2, Safe_3]

Domain:

Safe_1	: 0 - 120
Danger_1	: 100 - 180
Safe_2	: 160 - 300
Danger_2	: 280 - 360
Safe_3	: 340 - 360

- Wind Speed

Fuzzy Set [Low, Average, High]

Domain:

Low : 0 - 5
Average : 3 - 13
High : 10 - 30

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Output

Fuzzy Set [Feasible, Careful, Not Feasible]

Domain:

Feasible : 0 - 40
Careful : 20 - 80
Not Feasible : 60 - 100

The following figures are the membership functions of the input and output parameters.

Fig. 1 Visibility Membership Function

Fig. 2 Wind Direction Membership Function

Fig. 3 Wind Speed Membership Function

Fig. 4 Output Membership Function

Table 1 Output Rule

DIRECTION	VISIBILITY	SPEED
SAFE_1	NEAR	LOW
		AVERAGE
		HIGH
	MEDIUM	LOW
		AVERAGE
		HIGH
	FAR	LOW
		AVERAGE
		HIGH
DANGER_1	NEAR	LOW
		AVERAGE
		HIGH
	MEDIUM	LOW
		AVERAGE
		HIGH
	FAR	LOW
		AVERAGE
		HIGH
SAFE_2	NEAR	LOW
		AVERAGE
		HIGH
	MEDIUM	LOW
		AVERAGE
		HIGH
	FAR	LOW
		AVERAGE
		HIGH
DANGER_2	NEAR	LOW
		AVERAGE
		HIGH
	MEDIUM	LOW
		AVERAGE

SAFE_3	FAR	HIGH
		LOW
		AVERAGE
	NEAR	HIGH
		LOW
		AVERAGE
	MEDIUM	HIGH
		LOW
		AVERAGE
	FAR	HIGH
		LOW
		AVERAGE

Table 1 describes the rule to determine the feasibility. There are 45 rules represent the feasibility output. Each output is designed to a specific condition.

$$Z = \frac{\alpha_1(w_1) + \alpha_2(w_2) + \alpha_3(w_3) + \dots + \alpha_n(w_n)}{\alpha_1 + \alpha_2 + \alpha_3 + \dots + \alpha_n}$$

In determining forecasts for take-off and landing at the airport, it takes a combination of criteria of three pieces of the above variables. The output can be obtained by the following formula.

Information :

- Z = the average output which has been given weight and be constant (k),
 α = α -predicate is the minimum value of the operating results of the formation of fuzzy rules to n
w = weight for each forecast in the formation of fuzzy rules.

IV. EVALUATION

In this section, the testing is done by category unsafe for Take-Off and Landing. In this test, the calculation results are expected to generate fuzzy logic "NOT FEASIBLE" value. The values entered in the input variables, such as:

Visibilty : 1000 m
Wind Direction : 140°
Wind Speed : 20 Knot

Prior to the inference, it is necessary to find the degree of membership value of each variable in each fuzzy set as follows:

Wind Direction

$\mu_{SAFE_1}(140)$ = 0
 $\mu_{DANGER_1}(140)$ = 1
 $\mu_{SAFE_2}(140)$ = 0
 $\mu_{DANGER_2}(140)$ = 0

$$\mu_{\text{SAFE}_3}(140) = 0$$

Visibility

$$\mu_{\text{NEAR}}(1000) = 1$$

$$\mu_{\text{MEDIUM}}(1000) = 0$$

$$\mu_{\text{FAR}}(1000) = 0$$

Wind Speed

$$\mu_{\text{LOW}}(20) = 0$$

$$\mu_{\text{AVERAGE}}(20) = 0$$

$$\mu_{\text{HIGH}}(20) = 1$$

After getting the membership function of each variable, the next step is to test the program in MatLab that at the end of the calculation will be obtained values of Z are the result of the calculation using fuzzy logic Mamdani. The following figure shows the results of tests based on the data entered to the fuzzy variables.

Fig. 5 MatLab Result

From the above results, it can be seen that the output value is 84.7. It indicates if the entered value is in accordance with the previous rules, the fuzzy calculation process will produce a statement that in the position 84.7, the aircraft is NOT FEASIBLE to fly and land. The figure below shows the test results with the value of 84.7 in a NOT FEASIBLE position.

Fig. 6 Output Variable

V. CONCLUSION

Applications built using the concept of fuzzy logic can easily determine the competence of a lecturer. So the research produced keeps perfect. The process of determining the thesis adviser is similar to the conventional process. It occurs since the algorithm comes from the natural way of human reasoning. Fuzzification can adjust the lecturer's knowledge level, so the given topic is not to deviate from the background of the problem. However, using this application, the academic authorities will get more consistent without having the burden to analyze which specification is the most appropriate.

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