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Expert System for Identifying Traffic Accident Risk Levels in Samarinda City Based on Vehicle Density Patterns Using the Certainty Factor Method

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Abstract

Traffic accidents are an increasingly serious problem, especially in urban areas such as Samarinda City. This study aims to design and implement an expert system to identify the level of traffic accident risk based on vehicle density patterns using the Certainty Factor (CF) method. The system utilizes expert knowledge and factors influencing accidents, such as traffic density, road conditions, and environmental conditions, to assess the level of risk. The method applied in this study is the Certainty Factor method, which is capable of handling uncertainty in the decision-making process by calculating the Measure of Belief (MB) and Measure of Disbelief (MD) values. The data used consist of secondary data related to road accidents and vehicle density levels. The system was developed using a rule-based approach and modeled using Unified Modeling Language (UML). The research findings indicate that the designed expert system is capable of identifying traffic accident risk levels effectively and efficiently. The calculation using the Certainty Factor method produced a value of 0.91, indicating a high level of risk. This demonstrates that the system can assist users in systematically analyzing accident risks and provide recommendations to reduce the likelihood of accidents. However, the system still has limitations, particularly regarding its dependence on data quality and the completeness of the knowledge base. Therefore, future studies are expected to further develop the system by adding more complex variables and integrating other methods to improve the system's accuracy and performance.

1. Introduction

Traffic accidents are unintentional events that occur on roads involving vehicles, with or without other road users, resulting in human, property, or environmental losses. Based on Law Number 22 of 2009 concerning Road Traffic and Transportation, a traffic accident is defined as an event on the road involving a vehicle, with or without other road users, that results in fatalities and/or material losses [1]. This indicates that traffic accidents are not only technical events but also have broad social impacts on society.

Traffic accidents are not only caused by technical factors but are also influenced by human factors, such as the psychological condition of drivers. One influential factor is stress resulting from the pressures of urban life, which can affect driving behavior. This condition may lead to aggressive actions and decreased levels of alertness, thereby increasing the risk of traffic accidents [2]. In addition, various studies have shown that behavioral factors, environmental conditions, and vehicle conditions significantly contribute to the occurrence of traffic accidents [7].

The continuous increase in the number of traffic accidents indicates that road safety in Indonesia still faces significant challenges. In Samarinda City, this issue has become more complex due to the increasing number of vehicles, which is not proportional to the existing road infrastructure conditions. In addition, poor road conditions and damaged supporting facilities contribute to the emergence of accident-prone areas (black spots) [3]. On the other hand, driver behavior also contributes significantly to the level of accident risk. Knowledge of traffic regulations is known to have the greatest influence, with a risk ratio of 1.966

compared to other factors [4]. Other studies have also shown that road infrastructure conditions, such as road geometry, street lighting, road markings, and traffic signs, significantly affect traffic safety levels, especially in developing countries that still face limitations in safe and standard-compliant road facilities [8]. This indicates that without proper intervention, the rate of traffic accidents has the potential to continue increasing.

One approach that can be used to assist in analyzing and identifying accident risk levels is by utilizing expert system technology. An expert system is a computer application designed to support decision-making or problem-solving in a specific field. This system works by utilizing knowledge and analytical methods obtained from an expert according to their field of expertise. Expert systems are capable of imitating the thinking process and decision-making abilities of an expert in solving problems, making them useful as decision support systems [5], [9].

The Certainty Factor (CF) method is a technique used to determine the level of certainty regarding a fact or rule based on an expert's degree of confidence. This method is capable of representing uncertainty in the decision-making process by using the values of Measure of Belief (MB) and Measure of Disbelief (MD). In this study, the Certainty Factor method is used to analyze the level of traffic accident risk by considering various influencing factors, such as driver behavior and the level of knowledge of traffic regulations. By applying combining rules, the system can accumulate these various variables to produce a more accurate and measurable final conclusion regarding the level of accident risk [6], [10].

Based on the problems that have been described, this study aims to develop an expert system capable of identifying the level of traffic accident risk in Samarinda City using the Certainty Factor method. This system is expected to assist in decision-making and provide more accurate information regarding risk levels as an effort to prevent traffic accidents.

Expert systems are one of the branches of artificial intelligence designed to imitate the capabilities of an expert in solving specific problems. These systems operate by utilizing knowledge obtained from experts and stored in a knowledge base, which is then processed using inference mechanisms to generate decisions and solutions. In practice, expert systems are widely used to support diagnostic processes and decision-making in various fields. Research conducted by Rusito and Putra (2022) showed that expert systems can be used to detect computer damage using the Certainty Factor method, producing results that closely resemble expert decisions. This indicates that expert systems have the capability to effectively handle knowledge-based problems [11].

In addition, the development of expert systems continues to improve, one of which is through rule-based approaches such as belief rule-base systems. Research conducted by Zhou et al. (2019) explained that belief rule-base expert systems are capable of accommodating uncertainty and improving accuracy in knowledge-based decision-making [14]. This indicates that modern expert systems not only rely on static rules but are also able to manage uncertain information more flexibly.

The Certainty Factor (CF) method is a method used in expert systems to measure the level of certainty regarding a hypothesis based on the confidence level of an expert. This method is used to handle uncertainty in the decision-making process by utilizing the values of Measure of Belief (MB) and Measure of Disbelief (MD). Research conducted by Sipata and Susilawati (2025) showed that the Certainty Factor method can be applied in expert systems to diagnose anxiety disorders with a good level of accuracy. This demonstrates that the Certainty Factor method is effective in processing data containing uncertainty and producing more flexible decisions in various fields, including diagnosis and system-based decision-making [12].

Another study by Setyohadi et al. (2018) also demonstrated that the Certainty Factor method can be applied in expert systems for diagnosing poultry diseases with fairly accurate results [15]. In addition, Sari et al. (2025) developed an intelligent system for diagnosing mental health disorders using the Certainty Factor method, which showed good performance in handling uncertain data [16]. Furthermore, this method has also been applied in various other cases, such as the detection of online game addiction by Muslimin et al. (2023), proving that the combination of the Certainty Factor method and inference techniques can improve the quality of decision support systems [19].

Traffic accidents are events that occur on roads involving vehicles and may result in casualties as well as material losses. The causes of traffic accidents include human factors, vehicle conditions, and environmental factors. Research conducted by Anitasari et al. (2025) showed that traffic accident analysis

in Samarinda City can be carried out using classification methods such as K-Nearest Neighbor to classify accident levels. The results of the study indicate that traffic accident data can be systematically analyzed for the development of systems that can help identify accident risks more accurately [13].

In addition, an international study conducted by Jakobsen et al. (2023) showed that traffic accident risk factors among professional drivers are influenced by working conditions, fatigue, and environmental factors, all of which significantly increase the likelihood of accidents [17]. Meanwhile, Chen (2024) revealed that data mining techniques such as association rules can be used to identify traffic accident patterns in a more systematic and data-driven manner [18]. This indicates that traffic accident analysis can be conducted using various approaches, both statistical and artificial intelligence-based.

Several studies related to expert systems using the Certainty Factor method have been conducted in various fields. Rusito and Putra (2022) developed an expert system for detecting computer damage using the Certainty Factor method, demonstrating that the system was capable of producing results consistent with expert analysis. In addition, Sipata and Susilawati (2025) as well as Sari et al. (2025) also applied the Certainty Factor method in diagnosing health disorders and achieved fairly accurate results in handling uncertainty. On the other hand, studies conducted by Anitasari et al. (2025) and Chen (2024) showed that traffic accident analysis can be performed using classification and data mining methods to identify accident patterns.

However, these previous studies have not specifically combined the expert system approach with the Certainty Factor method in identifying traffic accident risk levels. Therefore, this study aims to develop a Certainty Factor-based expert system to identify traffic accident risk levels, particularly in Samarinda City, in order to provide more specific results and support decision-making processes.

2. Research Methodology

This section describes the structured stages conducted in this research to develop the expert system for identifying traffic accident risks in Samarinda City. The methodology consists of research stages, data and risk factors identification, implementation of the Certainty Factor method, and system modeling using UML.

A. Data Collection and Processing

The data collection process was carried out by gathering data related to traffic accidents and the factors influencing them. The data used were secondary data obtained from reliable sources such as official publications and online datasets. These data included variables such as vehicle density, road conditions, driver behavior, and the number of accident occurrences.

The next stage was data processing, which included data selection, data cleaning, and data grouping. This process aimed to ensure that the data used were relevant and ready to be analyzed within the system. The grouping process was conducted based on traffic accident risk levels in order to facilitate pattern identification and the development of the knowledge base in the expert system [21].

Furthermore, the processed data were used to determine the symptoms (evidence) in the expert system. These symptoms represented conditions affecting the level of traffic accident risk, such as high vehicle volume and an increase in the number of accidents. Based on these symptoms, hypotheses were determined in the form of low, medium, and highrisk levels as the system output [22].

B. Certainty Factor Method

The Certainty Factor (CF) is a method used to measure the level of confidence in a hypothesis based on existing facts. The CF value is obtained from the difference between the Measure of Belief (MB) and the Measure of Disbelief (MD). The basic formula for the Certainty Factor is:

$$CF(H,E) = MB(H,E) - MD(H,E)$$

Description:
CF(H,E) = certainty value for hypothesis H based on evidence E
MB(H,E) = Measure of Belief for the hypothesis
MD(H,E) = Measure of Disbelief for the hypothesis
To combine several CF values, the following formula is used:

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For combining multiple pieces of evidence with the same conclusion, the following equation is used:

$$CFcombine = CF1 + CF2(1- CF1)$$

This method allows the system to combine multiple symptoms or conditions in determining the level of traffic accident risk.

C. Data Sources

The data used in this study were obtained from publicly available online datasets related to vehicle density and factors influencing traffic accidents. The dataset includes information such as vehicle density levels, weather conditions, road conditions, and other relevant factors used to determine accident risk levels.

D. System Design

System design was carried out using the Unified Modeling Language (UML) approach with the assistance of Rational Rose software. The diagrams used in the system design include: A use case diagram that illustrates the interaction between actors and the system. The Use Case Diagram is used to identify the involved actors, namely the admin and the public, as well as the functions that can be performed by each actor.

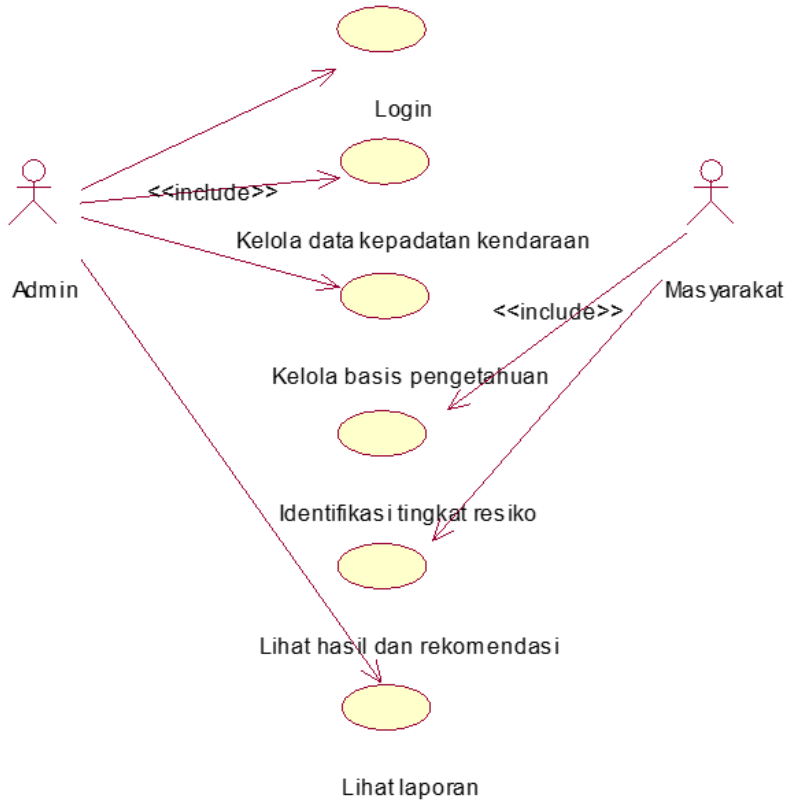

Figure 1. Use Case Diagram

E. System Flow

The system flow begins with users (the public) entering data on vehicle density and environmental conditions such as weather and road conditions. The data is then processed by the system using the Certainty Factor method based on rules stored in the knowledge base. Next, the system calculates certainty values to determine the level of accident risk, which is then presented to the user as identification results along with appropriate recommendations.

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3. Results and Discussion

A. System Implementation

The Results and Discussion section presents the research findings and analysis obtained based on the tests conducted. Results can be presented descriptively, either qualitatively or quantitatively, depending on the characteristics of the data used.

To clarify the findings, it is recommended that they be presented in tables, graphs, or other relevant visualizations for easier understanding. In the discussion section, the author interprets the results, compares them with previous research, and explains the implications of the findings for the scientific field and practical applications. Therefore, this section not only presents data but also provides critical analysis, theoretical explanations, and concrete contributions of the research.

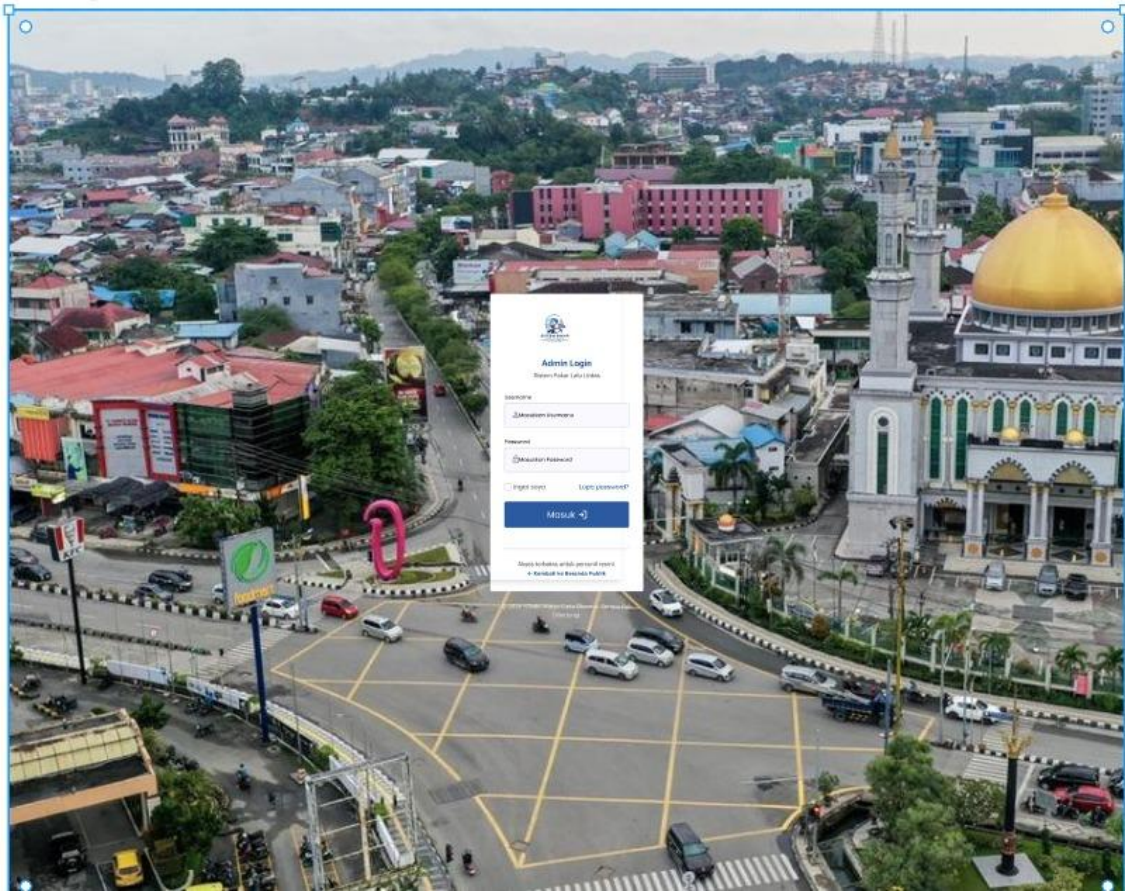

Figure 2. Login Page

Figure 2 shows the login page of the expert system used by the administrator to access the system. This page consists of an input form containing a username and password, which must be filled in by the user. The system validates the entered data before the user can access the dashboard. This login page serves as a security measure to restrict access only to authorized users.

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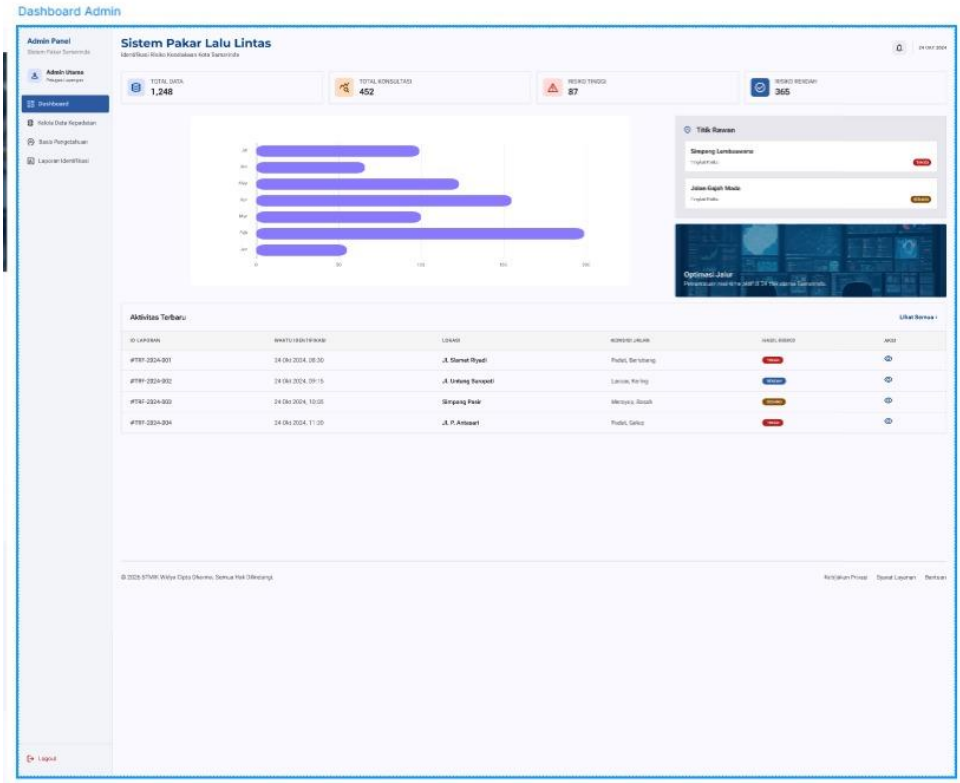

Figure 3. Dashboard Admin

Figure 3 shows the admin dashboard, which is the main page displayed after a successful login. This page contains several main menus, including vehicle density data management, knowledge base management, and identification reports. The dashboard is designed to facilitate administrative data management and the integration of accident risk identification results.

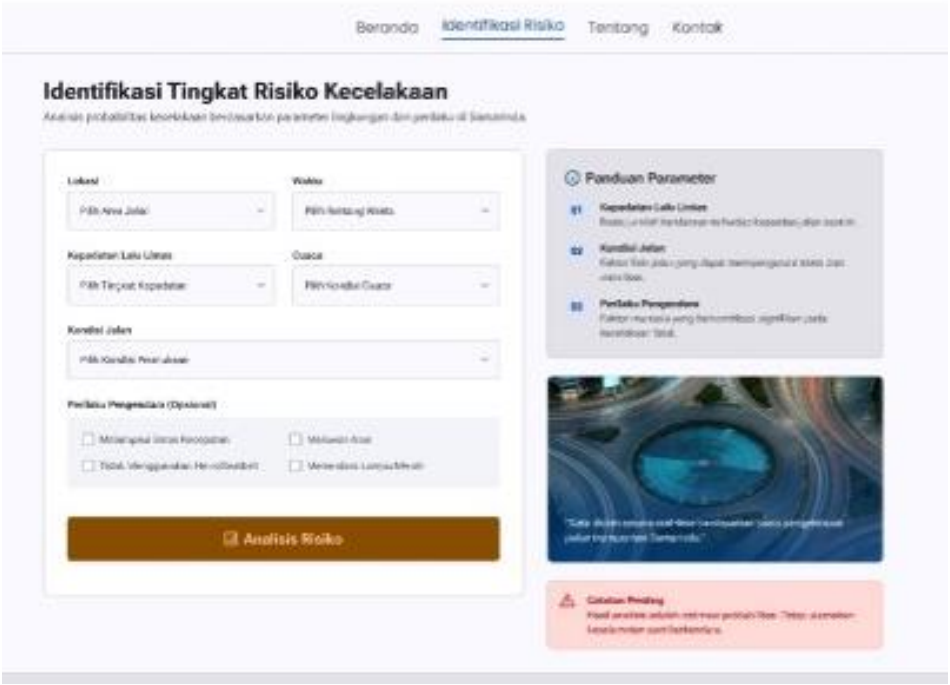

Figure 4. Risk Identification Page

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Figure 4 shows the risk identification page used by the public to analyze accident risk levels. On this page, users are required to enter several parameters such as traffic density, weather conditions, road conditions, and other factors. The input data is processed by the system using the Certainty Factor method to determine the level of accident risk.

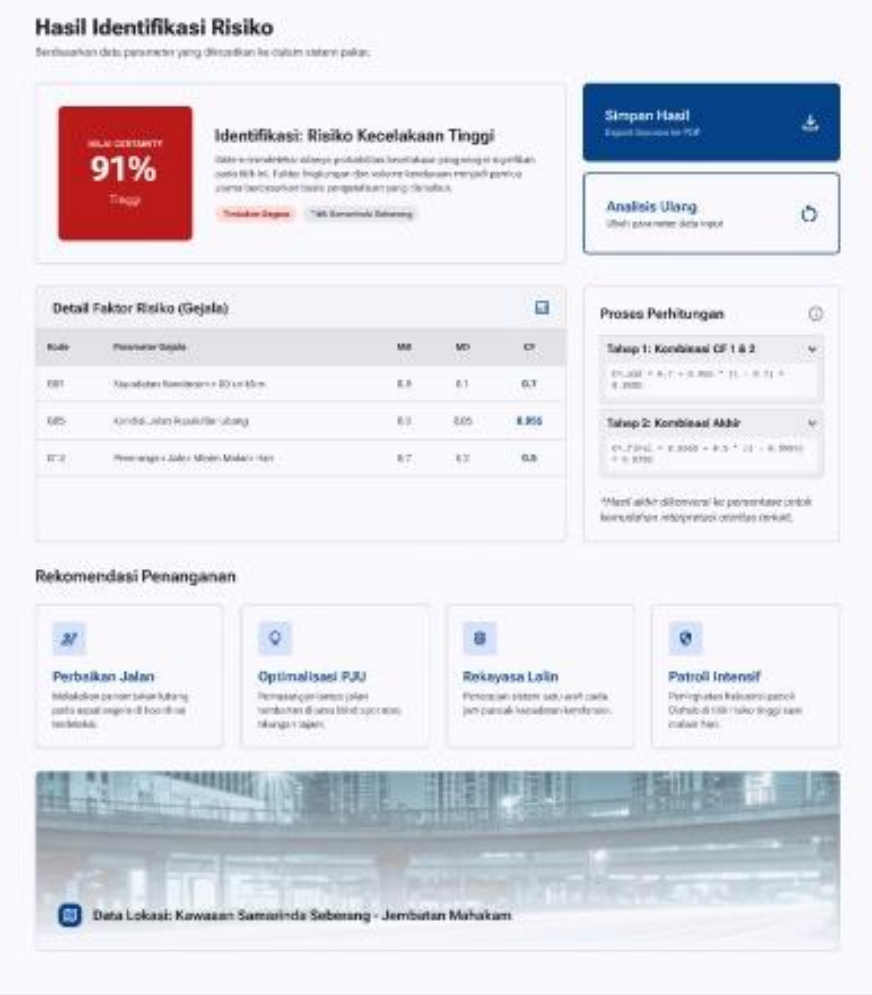

Figure 5. Results Page for Recommendation and Risk Identification

Figure 5 shows the results of the accident risk identification process performed by the system. This page displays the accident risk level along with the resulting Certainty Factor value. In addition, the system also provides recommendations that users can use to reduce the potential for accidents. This page is the main output of the developed expert system.

B. Certainty Factor Calculation Results

To test the developed system, Certainty Factor calculations were performed based on several symptoms that influence traffic accident risk. The following table shows the values of Measure of Belief (MB) and Measure of Disbelief (MD):

Table 1. Table Symptom

Symptom	MB	MD
High Vehicle Density	0.8	0.1
Slippery Road Conditions	0.7	0.2
Rainy Weather	0.6	0.2

The first step is to calculate the Certainty Factor value for each symptom:
CF1 = 0.8 – 0.1 = 0.7
CF2 = 0.7 – 0.2 = 0.5
CF3 = 0.6 – 0.2 = 0.4
Next, the CF values are combined:
CF12 = 0.7 + (0.5 × (1 – 0.7)) = 0.85
CFfinal = 0.85 + (0.4 × (1 – 0.85)) = 0.91

Based on these calculations, a Certainty Factor value of 0.91 was obtained.

4. Conclusion

Based on the results of this study, it can be concluded that an expert system for identifying traffic accident risk levels based on vehicle density patterns using the Certainty Factor method has been successfully designed and implemented. This system is able to assist users, particularly the public, in analyzing accident risk levels quickly and systematically based on input data. With this system, the identification process, which was previously performed manually, can become more efficient and produce more structured and understandable results.

The results of the Certainty Factor calculations show that the combination of factors such as vehicle density, road conditions, and weather significantly influences traffic accident risk levels. The test produced a Certainty Factor value of 0.91, indicating a high risk level. This value demonstrates that the Certainty Factor method can provide a level of confidence in the decision-making process.

In addition, the developed system not only provides risk level results but also offers recommendations to help users reduce the potential for accidents. However, this system still has limitations, particularly in its dependence on the quality of the data and knowledge base used. Therefore, further development can be carried out by adding more complex variables and integrating other methods to improve the overall accuracy and performance of the system.

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