Analysis of accident severity factor in Road Accident of Yangon using FRAM and Classification Technique

Kyi Pyar Hlaing, Nyein Thwet Thwet Aung, Swe Zin Hlaing, Koichiro Ochimizu
University of Information Technology, Myanmar
kyipyarhlaing@uit.edu.mm, nyeinthwet@uit.edu.mm, swezin@uit.edu.mm, ochimizu@jaist.ac.jp

Abstract

Road accidents are unpredictable and undetermined occurrence. Analysis of road accidents needs to understand the factor causing road accident severity. Careful analysis of road accident record is important to find out leading indicator factor for road accident. This paper introduces the analysis of severity factor using Functional Resonance Analysis Method (FRAM) that can be used an accident analysis method providing a new concept for people to analyze accidents. It also applies Naïve Bayes (NB) Algorithm is one of the classification techniques and based on probability models that incorporate strong independence assumptions. In this paper, firstly, FRAM shows the model of analysis of road accident. Secondly NB algorithm applies to calculate the probability of severity level attribute. Finally, this paper shows some experiment of the real dataset of road accident in Yangon by applying the actual scenario. The result shows that the performance variability from the function of the model such as accident time, causes of accident reason and type of vehicle are important factor to lead the level of road accident severity.

Key Words- Road Accident, Functional Resonance Analysis Method, Classification, Analysis of Severity Factor.

1. Introduction

Nowadays, road accidents are major problems of Myanmar. There were 17,451 road accidents countrywide in 2018, as reported by Myanmar Traffic Police Force. There were 599 deaths and 3,164 injuries accidents in Yangon. Mostly, road accidents are caused by various fault of driver such as driving with high speed, not having enough driving skill, not having diving license, road user doesn't understand traffic rule, careless of pedestrian, careless of passenger and reckless driving.

Table1 illustrates the road accident trends in Yangon from 2001 to 2017. The number of fatal rate is increased to 122 in 2004.And then, the number of death rate decreases to 98 people in 2005.After that the death rate is steadily increased to 206 in 2006-2009. In 2010, the level of fatalities drop to 175. In 2017, the level of death is increased to the maximum rate.

Table 1.Accident Trends in Yangon in 2001-2017

	Accident	Injuries	Death
2001	821	1302	116
2002	929	1667	125
2003	912	1564	126
2004	914	1372	122
2005	906	1359	98
2006	1371	1880	129
2007	929	1550	133
2008	668	1185	135
2009	864	1619	206
2010	795	1251	175
2011	1169	1830	208
2012	1241	1869	291
2013	2143	2946	325
2014	2231	2934	387
2015	1970	2604	371
2016	1863	2169	388
2017	1746	2046	410

We trust that understanding of road accident data can help to prevent road accident. In this paper we use functional resonance analysis method (FRAM) to drive potential accident scenario. FRAM is used to show clearly how functions can become coupled and how this can guide to unpredicted results. And then we apply Naïve bayes classification algorithm to model a classifier that predicts accidents severity. Naive Bayes algorithm is simple to implement. It can handle missing value. Naïve Bayes does not need a large amount of training data. It merely needs enough data to understand the probabilistic relationship between each attribute in isolation with the target variable. If only little training data is available, Naive Bayes would usually perform better than other model and can handle both numeric and categorical data.

2. Related Work

Ana Gabriella Amorim [3] presents three cases were investigated from companies in Brazil. The FRAM explored the repetitive weakness or luck of command and management over the working process. As the outcome of using the FRAM method to show the cases it became clear that improvisations realized that performance variation combined with other performance variations generating a functional resonance effect that was occurred in an accident.

In the FRAM-based analysis (FRAMA), the derivation of rules reporting function variability (RFV) is focused to understand the impact of system elements on each other, as well as to decide how the various performance of functions can find and aggregate. The RFV enables the analysis to be managed by means of model checking (MC), and in consequence facilitates exhaustive search based on the FRAM modeling, for potential performance of the system functional model. The method FRAM-based analysis was used to a naturally, ferry accident and the model checking results illustrate more particular about the accident which causes than both the details provided in the officially-issued inquiry report and those made by the current FRAM [2].

Tarcisio Abreu Sanurin [4] presents an eleven-step framework for the analysis of slack, which: (i) allows the joint analysis of slack resources of different natures, based on a shared construct, metric, and classification scheme; (ii) allows a prioritization of variability sources, based on how effectually they are covered by slack resources; (iii) sheds light on sources of variability and slack resources that rise from self-organization; and (iv) realizes the continuous improvement principle. The steps for making the framework require the collection and analysis of data from multiple sources of evidence. An application in the maternity ward of a hospital shows the use of the framework, setting an experimental basis for exploring its implications.

Tadesse Kebede Bahiru [9] applies data mining classification technique to set up model to define accident factors and to predict road accident severity using previous recorded accident data. Using WEKA data mining decision tree (J48, ID3, and CART and Naïve Bayes classifiers are constructed to show the injury severity. The analysis shows that speed limit, weather condition; number of traffic lanes, lighting state, and accident time are most influential road accident factors. On the other Side, gender, age, crash area, and type of vehicle are factors that have less effect on road accident severity. Most fatal accident severities are found in the raining weather conditions that drive at the mid night and also serious accidents are found in the cloudy weather condition in one lane roads.

In reference [6], we proposed basic FRAM model that has shown the overall causes and effects of the road accident analysis model. Among the accidents in Yangon, two public buses collided as a case study and shown the interaction between cars, driver and, car and pedestrian.

In this paper we use real data of road accident from Traffic Police Head Quarter (Yangon Division). We use FRAM method to show the model of analysis of road accident. And then we also applies NB algorithm to calculate the probability of severity level. We must identify the possible actual variability of the functions and the potential for functional variability by applying Naïve Bayes Classification Technique.

3. Background Theory

3.1. Functional Resonance Analysis Method

Functional Resonance Analysis Method is applied to show the functions that are required for everyday performance to succeed. This model can then be used to give the explanation specific events, by exploring how functions can be coupled and how the variability of everyday performance may lead to unpredicted results. The four principles on which the FRAM is built are: failure and successes are equivalence, approximate adjustments, emergence, and functional resonance. FRAM is used to drive potential accident scenario. So FRAM is used to investigate accident. FRAM can be applied by identifying and describing the functions, identifying the variability of the function, determining how variability may be combining, and finally considering how the outcome of a FRAM analysis can be applied to improve practice.

Step 1: Identifying and describing the function

The first step of FRAM is to indicate functions that are needed for everyday work to succeed. The purpose is to describe the task in sufficient details. The six aspects characterizing a function as shown in Figure 1(a)**:**

Input (I): The role of the Input as a signal that marks the beginning of a function that suggests how the variability of functions can arise. The input can represent matter energy or information.

Output (O): The output can be seen as representing a change of state of the system.

Preconditions (P): Precondition is a state that must be true before a function is carried out, but the Precondition does not itself constitute a signal that starts the function.

Resources (R): A resource is something that is needed or consumed while the function is carried out.
Time (T): Time can affect how a function is carried out.
Control (C): Control input is which supervises or regulates a function in case it results in the desired output. Control can be a plan, a schedule, a procedure, a set of guidelines or instructions, a program, a measure and correct functionality and so on.

The six functional features are connected together to label the dependencies between the human technical activities during the specified scenarios as shown in figure 2 b.

Step 2: Characterizing the performance variability

The characterization of function performance variability is required to know how functions can become couple and how this can lead to unexpected outcomes.

Step 3: Aggregation of performance variability

The FRAM makes a main difference between a model of the target system and the instantiations of the model. The FRAM model constitutes the set of functions that together account for the activity being analyzed and the potential couplings among the functions.

Step 4: Responding to performance variability

The fourth and final step in FRAM is to show ways to control the possible occurrence of uncontrolled performance variability or possible conditions of functional resonance that have been found by the previous steps.

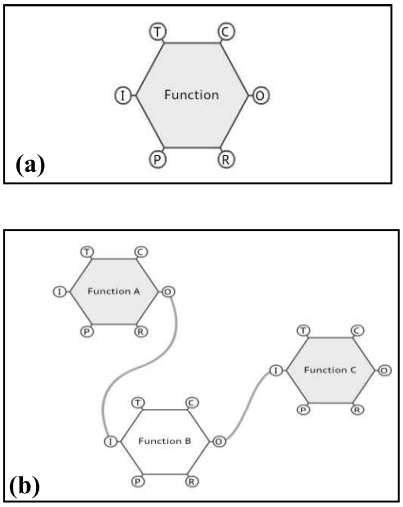

Figure1. (a) The six aspects which characterize a function. (b) A demonstration of the functional dependencies is represented by connection lines.

3.2. Variability

In the FRAM, the characterization of performance variability if needed to know how functions can become coupled and how this can lead to unexpected outcomes. There can in principle be three different reasons for the variability of the output from a function. The variability of the output can be a result of the variability of the function itself. This can be considered as a kind of internal or endogenous variability. The variability of the output can finally be a result of influences from upstream functions, where the outputs form upstream functions may be variable. This kind of coupling is the basis of functional resonance. It can also be called function upstream - downstream coupling. [5]

3.4. Naïve Bayes Classification

A Naïve Bayes classifier is a probabilistic machine learning model that is applied for classification task. They can estimate class membership probabilities such as the probability that a given tuple belong to a particular class. Bayesian classifiers have also modeled high accuracy and speed when we applied to large database. Bayesian classifiers have showed high accuracy and speed when used to large database. Naive Bayes classifiers assume that the consequence of attribute value on a given class conditional independence. It is suited when input is high.

Bayesian formula can be written as [4]:

Likelihood Predictor Prior Probability

$$P(H|X) = \frac{P(X \mid H) / P(H)}{P(X)}$$

Posterior Probability Class Prior

-P (H | X) is the posterior probability of H conditioned on X.
-P (H) is the prior probability of H.
-P (X | H) is the posterior probability of X conditioned on X.
-P (X) is the prior probability of predictor.
The basic idea of Bayes's rule is that the outcome of a hypothesis or an event (H) can be predicted based on some evidences (X) that can be perceived from the Bayes's rule.

4. Methodology

4.1. Data Description, Collection and Preprocessing

The recorded manual data was obtained from the Traffic Police Headquarter (Yangon Division). In order to apply Naïve Bayes classification, we must transform

manual record to digital form. So there are 1968 records for accidents that occurred from January to December in 2018. Among them, 547 records for accidents with no injuries (slight), 1039 records for accidents that resulted in that resulted in injuries (serious), and 381 for accidents that lead to death (fatal).There are seven attributes that provide detailed description of the accidents. The explanation of each element is shown in table 2.

Table 2. Road Accident Attributes and Description

	Attribute Implication
Number of vehicle	1,2,3,4,5,6
Accident Time	Day , Night
Type of Vehicle	Private car, Taxi, Motor Cycle, Bicycle, Bus, Cargo Vehicle, Passenger vehicle
Casualty Class	Passenger, Driver/Rider, Pedestrian
Sex of Casualty	Male, Female
Causes of Accident	Reckless Driving, Careless of Passenger, Not having driving license, High Speed, Careless of Pedestrian, Cross the red light, Not having enough driving skill
Casualty Severity	Slight, Serious, Fatal

Data preprocessing is the primary task to be done prior to analysis to get data ready for analysis. The original data format is not ready for the application of data mining. We remove some rows from dataset which has multiple missing values. The data was been taken from the official reports related to the road accidents recorded. The dataset has several characteristics of the crash, the vehicles and the people involved in the accident. After preprocessing of dataset, 1640 road accidents are suitable for future analysis. Dataset consist of attributes which are Time (accident time), Vehicle Type, Causes of Accident, Casualty Class, Casualty Sex and Casualty Severity The sample dataset shows in Table 3.

Table 3.Dataset Description

Time	Vehicle Type	Cause of accident	Casualty		
			Class	Sex	Severity
Night	Cargo	Reckless Driving	Pedestrian	Male	Fatal
Day	Motor Cycle	Reckless Driving	Passenger	Female	Serious
Night	Private Car	Reckless Driving	Pedestrian	Male	Fatal
Day	Bus	Carless of Passenger	Passenger	Male	Slight
Night	Taxi	Careless of Pedestrian	Pedestrian	Male	Fatal

4.2. Case Study

When we analyze road accident of Yangon, this paper especially considers two cases of road accident in Yangon. These two cases are shown as follow:
Case1: The accident happened at 7:30 am on August 15.When the victim's car driver hits motor cycle with two people. Motor cycle driver and passenger were injuries seriously. Driving skill of the driver isn't enough to drive.
Case2: A taxi hits a pedestrian at about 20:45 pm on June 8.Pedestrian was died. Accident was caused by careless of pedestrian.

4.3. Step1. Functional Resonance Analysis Method

Functional Resonance Analysis Method is applied to show the functions that are needed for everyday performance to succeed. The first step of FRAM is to identify the functions that are needed for everyday work to succeed. In figure 2 shows the basic activity of road accident functions with six aspects by using two accident cases and some road accident data in Yangon. There are 15 functions such as "F1.Drives the Car", "F2. Crosses the road by Pedestrian" and "F3.Drives Motor Cycle" functions and so on. The second step of FRAM method is to identify the variability of each function. The output of each function can change because of the potential variability of six aspects function. For example, if "F1.Drives the Car" and "F2.Crosses the road by Pedestrian" functions can change because of the variability of precondition function and resource function.

4.3. Step2. Calculation of Naïve Bayes Classification Algorithm

In this paper, we use classification techniques to analyze records of road accident in Yangon City. Classification is an important data mining task. It is usually mentioned to as supervised learning, since a model is constructed based on a set of records with known labels (training dataset).This model is then evaluated using previously unseen records with unknown labels(test dataset).Classification techniques are applicable to a large spectrum of issues due to the capability to study by example[10].
Case 1: If Accident Time =Night, Vehicle Type=Motor Cycle, Casualty Class=Passenger, Sex=Male, Causes of Accident=not having enough driving skill, what is the probability of serious accident severity? We can solve it using above discussed method of posterior probability.

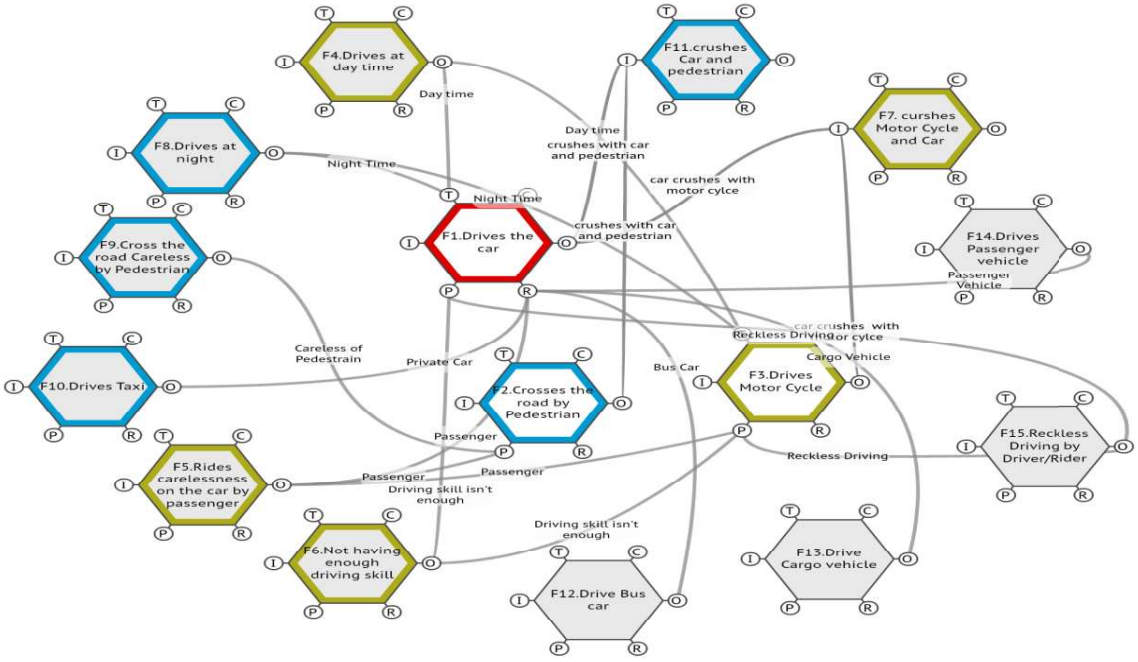

Figure2.**The FRAM model of Cause of Yangon's road accident**

P (Serious|<Night, Motor Cycle, Passenger, Male, Not having enough driving skill>)

= (P (Serious)*P (Night| Serious)*P (Motor Cycle| Serious)*P (Passenger | Serious)*P (Male| Serious) *P (Not having enough driving| Serious))/ P (<Night, Motor Cycle, Passenger, Male, Not having enough driving skill >)

= ((949/1640)* (553/949)* (232/949)* (427/949)* (276/949)* (134/949)) /P (<Night, Motor Cycle, Passenger, Male, Not having enough driving>)

=0.00152/P (<Night, Motor Cycle, Passenger, Male, Not having enough driving skill >)

= 0.00152/0.00180

=0.84527

Naive Bayes uses a method to predict the probability of different class based on various attribute .In case 1, when we predict the severity level based on road accident attribute such as accident Time, Vehicle Type, Casualty Class, Sex of Casualty, Cause of Accident, the class label value is serious.

Table 4 shows the relationship between the road accident factors and the severity level of road accident by accident by using real dataset of road accident in Yangon. The result concludes the following points: The first row indicates that the probability of slight in road accident mainly depends on the dependency of causes of accident, vehicle type and sex of casualty. The second row shows that the possibility of serious is depending on the dependency of causes of accident and casualty class. The last row indicates that the possibility of fatal is depending on causes of accident and accident time and sex of casualty.

Table 4. Severity levels of road accident in Yangon with road accident attribute

Causes of Accident	Time	Vehicle Type	Casualty Class	Sex of Casualty	Severity Level
Reckless Driving	Day	Bus	Pedestrian	Male	Slight
	Night	Bus	Pedestrian	Male	
Not having enough driving skill	Day	Private Car	Passenger	Female	Serious
		Motor Cycle	Passenger	Female	
	Night	Taxi	Passenger	Female	
			Pedestrian	Male	
		Motor Cycle	Passenger	Female	
Careless Of Pedestrian	Night	Bicycle	Pedestrian	Male	Fatal
		Taxi	Pedestrian	Male	
		Private Car	Pedestrian	Male	
		Bus	Pedestrian	Male	
		Cargo Vehicle	Pedestrian	Male	

4.4. Discussion

The aim of this paper is to present the performance variability of function from the FRAM to model to analyze the severity level of road accident. First, we introduce two case studies by visualizating FRAM to calculate the probability of severity level from the aggregation of variability by using Naïve Bayes classification algorithm. In figure 3, we can show basic activity of road accident functions with six aspects and the relationship between some function by using FRAM tool. If precondition of "F1. Car driver drives on the road" function changes from "F15.Reckless Driving by Driver/Rider" function to "F6.Not having enough driving skill "function, the level of severity changes from slight to serious. Moreover, if resource function changes "F10.Drive Taxi" to "F13.Drives Cargo Vehicle", the severity level of road accident changes from serious to fatal. Naive Bayes classifier picks up an attribute (Eg, Accident Time, Casualty Class, Causes of accident and so on) and chooses the largest probability of class label (Slight or Serious or Fatal). Class label value supports FRAM diagram to make sure the cause of related Driver/Rider function, Pedestrian function that is real information and this information can be used to prevent and eliminate road accident. This technique give a way to find and prevent newly occurred accident severity. Naive Bayes classification model will predict road accident severity using main influential accident factor from previously recorded accident data.

5. Conclusion

This paper proposes the analysis of accident severity factor in road accident in Yangon using FRAM and Naïve Bayes Classification algorithm. We use real data of road accident from Traffic Police Head Quarter (Yangon Division). Firstly, FRAM method is used to extract road accident factors and understand the potential variability of the function by using two cases of road accident in Yangon. Secondly, this paper shows that potential variability of road accident factor can affect the severity level of road accident. In order to identify ways are to show the development of resonance either to dampen variability that may lead to unwanted outcomes or to amplify variability that may lead to wanted outcomes. Finally, the result shows the performance variability from functions of the model lead to the level of road accident severity. If more data are available, more test could be performed more suggestions could be reported.

In future we plan to define 4-hour period to determine the expected result of accident severity and to find importance causes of road accident in Myanmar.

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