Performance Variability Analysis on Road Accident in Yangon

Kyi Pyar Hlaing[1], Nyein Thwet Thwet Aung[2], Swe Zin Hlaing[2] and Koichiro Ochimizu[1]
[1]*University of Information Technology, Myanmar*
[2]*Faculty of Information Science Department, University of Information Technology, Myanmar*

Keywords: Variability Analysis, Functional Resonance Analysis Method, Correlation Analysis, Road Accident, Severity Level, Naive Bayes Algorithm.

Abstract: Myanmar is the second-highest death toll of road accidents in Southeast Asia according to the WHO data published Road Traffic Accidents Deaths in 2018. This study performs Functional Resonance Analysis Method (FRAM) to analyze road accidents in Yangon as an alternative approach to safety management. Firstly, a basic FRAM model is presented that shows the road accident functions. Secondly, this paper develops a quantitative model to predict the functional upstream-downstream coupling by using Naive Bayesian algorithm. Finally, this study performs the Cross-Tabulation analysis and Chi-Square Test method to determine that there is an association between the outputs of the functions. The result proves that the upstream function's output variability affects the downstream function's output variability. The variability of road accident factors such as accident place, accident season, accident time, and type of vehicle affects the severity level of the road accident.

1 INTRODUCTION

Road accidents are the main issues facing Myanmar today. According to the World Health Organization (WHO) report, about 1.24 million individuals in the world die on the road every year. During 19-year, the average number of road accidents in Yangon was over 1000, resulting in nearly 2000 injuries and nearly 300 deaths. Therefore, the Myanmar government needs to define the road safety rule to obey road users such as driver, pedestrian, and passenger. Although there are many factors causing road accidents, it is not easy to know the severity level of road accidents when one road accident factor combines other road accident factors.

To reduce the negative factor effect and develop systems, traditional safety management models are designed. Resilience Engineering follows the Safety-II perspective, taking into account the unpredictability of a system's everyday working environment. It is important to understand not only how things go wrong, as in the Safety I perspective, but also how things go right in an everyday work environment. FRAM helps to understand performance variability as conditions change.

The Naïve Bayes algorithm is one of the most probability-based sample methods for classification. It is based on Bayes' hypothesis that each pair of variables is independent of each other.NB algorithm is applied to predict the dependency of upstream and downstream function lead to the severity level of road accidents. We create a real dataset in Yangon by converting manual form to digital form.

This paper's contribution is as follows. It presents related work on FRAM applications in the first section. The second one describes the method of FRAM. The fourth section uses the NB algorithm to predict the functional upstream-downstream coupling. In the fifth section, Cross-Tabulation and Chi-Square test method is applied to determine the association between categorical variables. Finally, we evaluate the result of the analysis and conclusion of this paper.

2 RELATED WORK

Kaya et al. (2019) introduce the FRAM has been improved to illustrate how the overall system is influenced by functional variability. The FRAM application helped participants understand how to monitor performance variability in the drug administration processes. The contributors consider the application for FRAM to be a way of training

Hlaing, K., Aung, N., Hlaing, S. and Ochimizu, K.
Performance Variability Analysis on Road Accident in Yangon.
DOI: 10.5220/0010451803290336
In *Proceedings of the 23rd International Conference on Enterprise Information Systems (ICEIS 2021) - Volume 2*, pages 329-336
ISBN: 978-989-758-509-8

workers. By using FMV software, the FRAM model is produced and then show the potential interaction for the function to understand the entire system as Work at Done (WAD),

Patriarca et al. (2017) present the evolution of FRAM by combining it with the Monte Carlo Simulation to calculate the function variability. This paper aims to identify the important function leading to the significant accident as stated by the probability of performance variability of each function. To mitigate risks and to control this performance variability, Functional Resonance Analysis Method aids by defining the most appropriate reducing actions.

Amorim and Pereira (2015) apply FRAM for an exploratory study of accidents where some type of improvisation took place. As a result of using the FRAM method, it can examine the improvisations, recognized as variations in performance, coupled with other variations in performance that created a functional resonance effect that led to an accident.

Anitha et al. (2019) apply the Naive Bayes algorithm to find the traffic issue and solutions. To provide safe driving suggestions, the purpose of this paper is to analyze carefully road traffic data to identify variables that are closely linked to fatal accidents.

De Carvalho (2011) shows that FRAM was used to present the critical resilience of the Air Traffic Management System via the mid-air collision investigation between flight N600XL and flight GLO 1907 in the Amazonian sky on 29 September 2006. This study explains the failure of the ATM system to close the control loops of the flight monitoring feature under normal conditions of variability. The outcome highlights the need for a big understanding of how the method operates.

Karacasu and Er (2011) apply the Cross-tabulation and Chi-square test for independence to determine if there is a significant relationship among traffic faults, genders, and ages of those drivers. Using the Chi-Square significance test, the significance between the age and gender of the drivers and the accident fault types is investigated and the frequency distribution of faults in the police reports is calculated with Crosstabs analysis in the SPSS software. The findings indicate that more accidents were caused by male drivers than by middle-aged and older male drivers than by female and young male drivers. Young male drivers caused more injuries, mainly due to drunk-driving and disobeying speed limits, and male drivers caused more accidents than female drivers did.

Hlaing et al. (2018) present a basic FRAM model that has demonstrated the overall causes and effects of the model for the road accident analysis model. By using a case study that depicts two public buses that collided, this paper illustrates the relationship between driver and vehicle, car and pedestrian, and driver and pedestrian.

Hlaing et al. (2019) show a model of analysis of road accidents by using FRAM method. Then, NB algorithm apply to predict the functional upstream-downstream coupling by calculating the severity level of road accidents. By using the Naïve Bayes Classification Method, we define the possible actual variability of functions and the potential for functional variability. In this article, we use real road accident data from the Traffic Police Head Quarter (Yangon Division) in 2018.

In this paper, we use the FRAM method and NB algorithm to find the important factors that affect the accident severity level. We also apply the Descriptive Statistics-Crosstabs and Chi-Square Test to assess if there is a significant difference in one or more categorical variables test between predicted frequencies and observed frequencies. We collect data and create a real dataset from Yangon Police Office Headquarter from 2014-2018.

3 THE PROCESS OF APPLYING FRAM METHOD

3.1 Functional Resonance Analysis Method

Four stages were performed to customize FRAM: (1) Identify road accident functions (2) Identify the variability of each function (3) Create a real dataset in Yangon (4) Use the Naïve Bayes Algorithm to analyze aggregation of functions.FRAM is a qualitative based method. To aid in the analysis, the FRAM Model Visualizer (FMV version 0.4.1) software was used.

3.1.1 Identify Road Accident Function

The roles of an everyday working system have been described in the first phase. A function that refers to an activity or a collection of activities is characterized by six different aspects: Input (I), Output (O), Precondition (P), Resource (R), Time (T), and Control (C). As shown in the figure, the six aspects that characterize a function as shown in Figure1(a)**:**

In the specified scenarios, the six functional features are linked to label the dependencies between human technical activities, as shown in Figure 1 b.

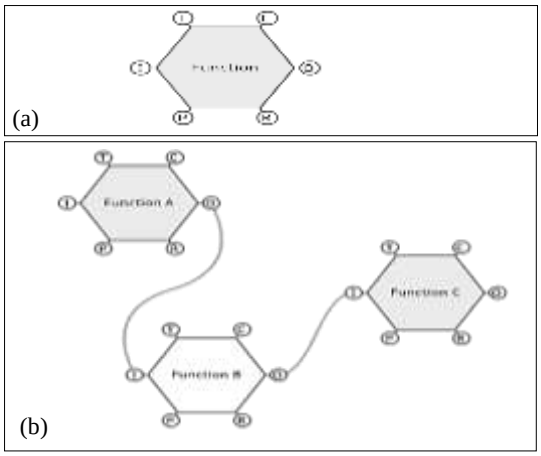


Figure 1: (a) The six aspects which characterize a function. (b) A demonstration of the functional dependencies is represented by connection lines.

The basic operation of road accident functions is shown in Figure 2 and Table 1 using road accident data in Yangon. There are 9 functions such as "F1. Prepare to drive", "F2. Drive the Vehicle" and "F3.Accident" functions, and so on.

3.1.2 Identify the Variability of Each Function

In the second step, the potential variability of each function was determined. The variability in FRAM can describe three ways, (1) internal variability: the variability of the Output can be due to the variability of the function itself (2) external variability: the variability of the Output can be due to the variability of the working environment. (3) Upstream-downstream functional coupling Hollnagel (2014). Finally, the variability of the output may be due to the variability of the output from the upstream functions as this provides the downstream functions with Input, Requirement, Resource, Control or time. The condition of the traffic office domain, the output of function variability may be static by applying several important attributes or data for the accident data. The variability of each road accident function shows in table 2. Eg. The output of function F2. Drive the Vehicle function may be Motorcycle, Taxi, Private Car, Bus and Cargo Vehicle, etc.

Table 1: Road Accident Functions.

Function Name
F1. Prepare to drive
F2.Drive the Vehicle
F3.Accident
F4. Take Time
F5. Take Season
F6.Take Accident Reason
F7.Take Accident Place
F8.Type of Casualty Class
F9.Cross the road by Pedestrian

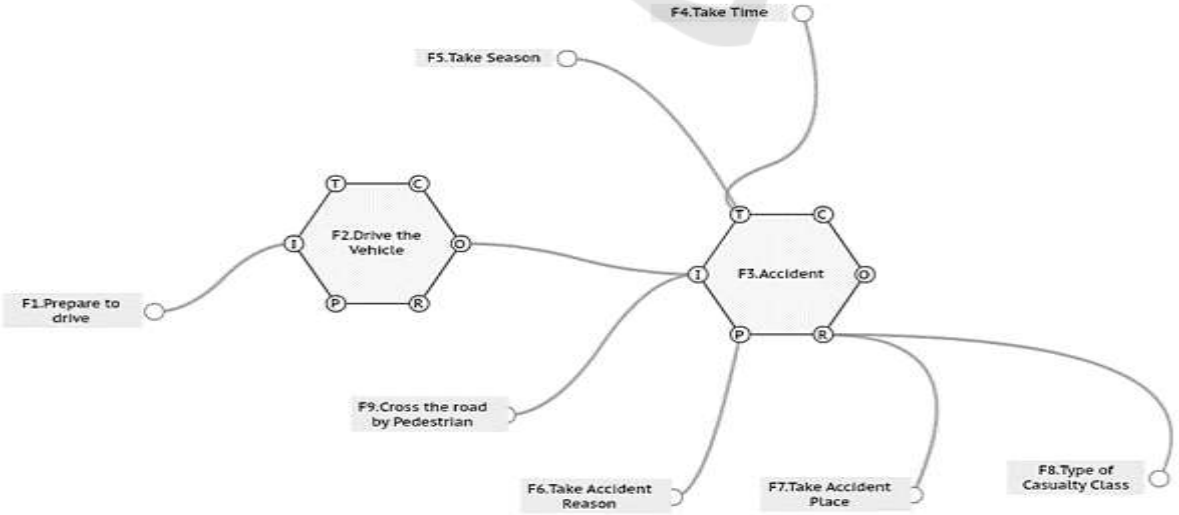


Figure 2: Basic FRAM model of Yangon's road accident.

Table 2: Identify the variability of each function.

Function Name	Variability of the Output from function
F2. Drive the Vehicle	Different types of vehicles such as Private Car, Taxi, Motorcycle, Bus, Cargo Vehicle, etc.
F3. Accident	Slight or Serious or Fatal.
F4. Take Time	Morning, Afternoon, Evening or Night
F5. Take Season	Summer, Rainy or Winter
F6.Take Accident Reason	Reckless Driving, Careless of Passenger, Not having a driving license, High Speed, Careless of Pedestrian, Cross the red light, or Not having enough driving skill.
F8. Take Accident Place	North Okkalapa, South Dagon, South Okkalapa, Thingagyun, Hlaingthaya, Kamayut, Mayangon, Mingaladon, Shwepyitha, etc.
F8. Type of Casualty Class	Driver Passenger or Pedestrian

3.1.3 Create a Dataset in Yangon

In data preprocessing, the recorded manual data was obtained from the Yangon Traffic Police Headquarter. We have to change manual record data to digital format to use Naive Bayes classification. Therefore, 9775 manual records for incidents that took place from 2014 to 2018 are available. Seven attributes offer a detailed overview of the incidents. Each aspect is explained as follows in table 3.

Table 3: Road Accident Attributes and Description.

Attribute Name	Attribute Implication
Accident Place	Pazundaung, Lanmadaw, Tamwe, South Dagon, North Okkalapa, Dagon Seikkan, South Okkalapa etc.
Accident Season	Summer, Rainy, Winter
Accident Time	Morning(6:00am-11:59am), Afternoon (12:00pm-5:00pm), Evening(5:01pm-8:00pm), Night (8:01pm-5:59am)
Type of Vehicle	Private Car, Taxi, Motorcycle, Bus, Cargo Vehicle, etc.
Casualty Class	Driver, Pedestrian, Passenger.
Accident Reason	Not having a driving license, High Speed, Careless of Pedestrian, Cross the red light, Not having a driving license, Not having enough driving skill
Casualty Severity	Slight, Serious, Fatal

Data preprocessing is an important process to get data for analysis. For the data mining application, the original data format is not ready to use. From the dataset, which has several missing values, we eliminate some rows. Data was collected from Yangon Traffic Police Headquarter relevant to the reported road accident. There are several characteristics of the crash, the driver, and the vehicle involved in the dataset.10299 digital records are acceptable for future analysis after data set preprocessing. There are 1792 records for the number of slight injuries, 6978 records for the number of serious injuries, and 1629 for accidents that lead to fatal.

Table 4: Aggregation of performance variability with Function F3.Accident.

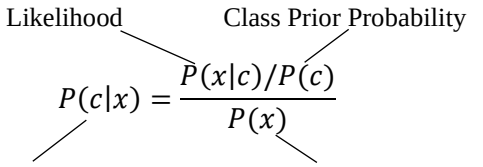
Function	Variability Description
F2. Drive the Vehicle	-The output variability of accident function is depending on the type of vehicles such as Private Car, Taxi, Motorcycle, Bus, or Cargo Vehicle.
F4. Take Time	-The output variability of accident function is depending on Morning, Afternoon, Evening, or Night.
F5. Take Season	-The output variability of accident function is depending on Summer, Rainy, or Winter.
F7.Take Accident Place	-North Okkalapa, South Dagon, South Okkalapa, Thingagyun, Hlaingthaya, Kamayut, Mayangon, Mingaladon, Shwepyitha,etc.
F6. Take Accident Reason	-The output variability of accident function is depending on accident reasons such as Reckless Driving, Careless of Passenger, Not having a driving license, High Speed, Careless of Pedestrian, Cross the red light, or Not having enough driving skill.
F8. Type of Casualty Class	-The output variability of accident function is depending on casualty class such as Driver, Passenger, or Pedestrian.

3.1.4 Analyzing Aggregation of Function by using Naive Bayes Algorithm

In the third step, a Naive Bayes algorithm is applied to predict quantitatively the functional upstream-downstream coupling by calculating the severity level of road accidents. For classification problems, NB is a simple machine learning algorithm. The probability of an object with certain characteristics belonging to a certain group is learned. The Naive Bayes algorithm is called "naive" because it assumes that a certain feature's occurrence is independent of other features' occurrence. The Naive Bayes algorithm's main objective is to measure the conditional probability of an object belonging to a

particular class with a feature vector.

The Bayesian formula can be written as follows,



-$P(c \mid x)$ is the posterior probability of class(c, target) given predictor (x, attributes).
-*P (x | c)* is the likelihood which is the probability of predictor given class.
-*P (c)* is the prior probability of class.
-*P (x)* is the prior probability of predictor.

The basic principle of the Bayes rule is that it is possible to predict the result of a hypothesis or occurrence based on any facts that can be viewed from the rule of the Bayes. The six examples of case studies shown in table 5 as follow.

Table 6 illustrates the variability of road accident factors affects the severity level of road accidents by using the NB algorithm based on six attributes. After testing with some examples of six case studies, this study shows that the variability of accident place, accident season, accident time, and type of vehicle can change the casualty severity.

Table 5: Examples of Case Study.

	Examples of Case Study
1.	At 11:50 pm on 10 October 2014, a self-driving driver who was driving along Thudamma Road in North Okkalapa Township collided with a pedestrian in front of Pyae Wa guesthouse. The victim was discharged to North Okkalapa Hospital as an inpatient. It is caused by the carelessness of the pedestrian.
2	At 1:15 pm on 14 June 2017, a self-driving driver who was driving from west to east along Thitsar Road in North Okkalapa Township hit a pedestrian near the 4th Ward Fire Station. The victim was injured due to his negligence.
3	At 6:30 pm on 10 May 2015, a self-driver who was driving east-west along Pyay Road in Mayangone Township collided with a female pedestrian near Visa Road. The victim suffered blisters on his forehead and back and was taken to Insein Hospital
4.	At 10:30 pm on 20 August 2014, a private car that was traveling on Maungmakan Road, South Dagon Township, collided with two pedestrian crossings at a traffic light, killing one at the scene and one of them was injured in the groin, elbow, ankle, and back. The victim was taken to Thingangyun Model Hospital as an inpatient. It is caused by the carelessness of the pedestrian.
5.	At 8:30 pm on 22 January 2015, a motorcyclist, who was driving north-south along Lay Daung Kan Road, Thingagyun Township collided with a woman who was traveling from east to west, near the Bawa Myint bus stop. The victim suffered head, back, shoulder pain, and was taken to Thingagyun Hospital. It was caused by the carelessness of the pedestrian.
6	At 8:30 pm on 1 January 2015, a black Kanbo motorcycle driving south-north along Anawrahta Road in Hlaingtharya Township collided with a man crossing the road from west to east. The victim suffered a broken leg and ankle and was treated as an outpatient at Hlaingthaya Hospital. The victim was injured due to his negligence.

Table 6: Severity of road accident in Yangon with road accident attribute.

	Accident Place	Accident Season	Accident Time	Type of Vehicle	Casualty Class	Accident Reason	Casualty Severity		
							Slight	Serious	Fatal
1	North Okkalapa	Winter	Afternoon	Private car	pedestrian	Careless of Pedestrian	0.22315	0.43984	0.337012
2	North Okkalapa	Winter	Night	Private car	pedestrian	Careless of Pedestrian	0.09951	0.41694	0.483552
3	Mayangon	Summer	Evening	Private car	pedestrian	Careless of Pedestrian	0.27426	0.50436	0.221378
4	South Dagon	Rainy	Evening	Private car	pedestrian	Careless of Pedestrian	0.21017	0.3440	0.44583
5	Thingangyun	Winter	Night	Motor cycle	pedestrian	Careless of Pedestrian	0.22631	0.41142	0.362227
6	Hlaingthaya	Winter	Night	Motor cycle	pedestrian	Careless of Pedestrian	0.12556	0.26893	0.605514

4 CORRELATION ANALYSIS USING CROSS TABULATION AND CHI-SQUARE TEST

This study is interested in the relationship between casualty severity, accident place, accident time, accident season, and type of vehicle by considering some significant categorical variables value in table 6. The Cross-Tabulation and Chi-Square test correlation method are used to evaluate whether there is an association between the rows and columns in a contingency table. 1180 accident records took place in Yangon from 2014 to 2018. With the SPSS 15.0 Statistical Analysis Software, accident data was analyzed, and the Descriptive Statistics-Crosstabs approach was used. Cross-Tabulation the Chi-Square statistic is most widely used to evaluate independence tests.The relationship between multiple variables is presented by cross-tabulation.

The formula for calculating a Chi-Square statistic is:

$$x^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

Where,
O_i = the observed frequency
E_i= the expected frequency

The statistics of Chi-Square are based on the difference between what is observed in the data and what would be expected if the variables were not associated. These statistics can be measured by comparing the real value with a critical value contained in a Chi-Square distribution (where degrees of freedom are determined as the number of columns − 1) *(number of rows − 1). To conclude the hypothesis with 95% confidence, the value labeled Asymp. Sig. which is the p-value of the Chi-Square statistic should be less than .05 which is the alpha level associated with a 95% confidence level. We can assume that the variables are not independent of each other and that the categorical variables have a statistical relationship if the p-value (labeled Asymp.Sig.) is less than 0.05.

Cross-Tabulation and Chi-Square test method is used to determine there is an association between categorical variables. The description of road accident analysis using Cross-Tabulation and Chi-Square Test method is shown in table 7. The most frequently observed fatal casualty severity is in Hlaingthaya and South Dagon To wnship and the least frequently observed fatal casualty severity is in Thingagyun and North Okkalapa Township. Accident season is one of the significant factors affecting the severity of road accidents. The most frequently observed fatal casualty severity is in the

Table 7: Description of road accident analysis using Cross-Tabulation and Chi-Square Test Method.

Accident Place	Casualty Severity			No of the Valid cases	X^2	df	P-value(Asymptotic Significant(2 sided))	Remark
	Fatal	Serious	Slight	1180	35.959	8	<.001	Significient
Hlaingthaya	85	268	65					
North Okkalapa	26	227	28					
Mayangon	29	88	20					
South Dagon	38	113	32					
Thingagyun	21	125	15					
Accident Season	Casualty Severity							
	Fatal	Serious	Slight	1180	14.708	4	.004	Significient
Rainy	65	259	67					
Summer	62	282	31					
Winter	72	280	62					
Accident Time	Casualty Severity							
	Fatal	Serious	Slight	1180	12.715	4	.013	Significient
Afternoon	25	181	39					
Evening	34	130	32					
Night	140	510	89					
Type of Vehicle	Casualty Severity							
	Fatal	Serious	Slight	1180	3.949	2	.139	Insignificient
Motorcycle	99	363	82					
Private Car	100	458	78					

winter season , and the least frequently observed fatal casualty severity is in the summer season. The important factor affecting the severity level of road accidents is accident time. The most frequently observed fatal casualty severity is at night and the least frequently observed fatal casualty severity is in the afternoon. The most frequently observed fatal casualty severity is in private car and the least frequently observed fatal casualty severity is in motor cycle. The result with the Chi-Square significance test that there are significant relationships among casualty severity, accident place, accident season, and accident time.

5 DISCUSSION AND EVALUATION

The FRAM model developed by the FRAM Model Visualizer (FMV version 0.4.1) software shows the function's potential interaction to understand the entire system. In the FRAM model, we identify 9 functions by investigating road accident information. The objective of FRAM is to show the performance variability of road accident factors from functions that leads to the unexpected outcome of the severity level. FRAM is a qualitative based method. The Naive Bayes algorithm is used to quantitatively predict the dependence of the upstream and downstream functions leading to the road accident severity level.

Cross-Tabulation and Chi-Square test method is used to determine there is an association between categorical variables. The description of road accident analysis using Cross-Tabulation and Chi-Square Test method is shown in table 7. The result with the Chi-Square significance test that there are significant relationships among casualty severity, accident place, accident season, and accident time.

The most significant association is between the accident place and casualty severity because the p-value is the smallest value. There is not a significant association between casualty severity and type of vehicle because that p-value is greater than the α level.

Figure 3 shows the instantiation of the FRAM model for six case studies. This figure shows that function F3. Accident function is connected with the seven functions. The output of function F3 is depended on upstream output variability. After testing with the Chi-Square test method, the association between the F3.Accident function and F7.Take Accident Place function are the most significant. The result proves that the upstream function's output variability affects the downstream function's output variability.

6 CONCLUSIONS AND FUTURE WORK

This paper applies FRAM to show the performance variability of road accident factors from function lead to unexpected outcome the severity level of the road accident. After investigating road accident cases, the FRAM is used to understand the performance variability of road accident function. The real data is

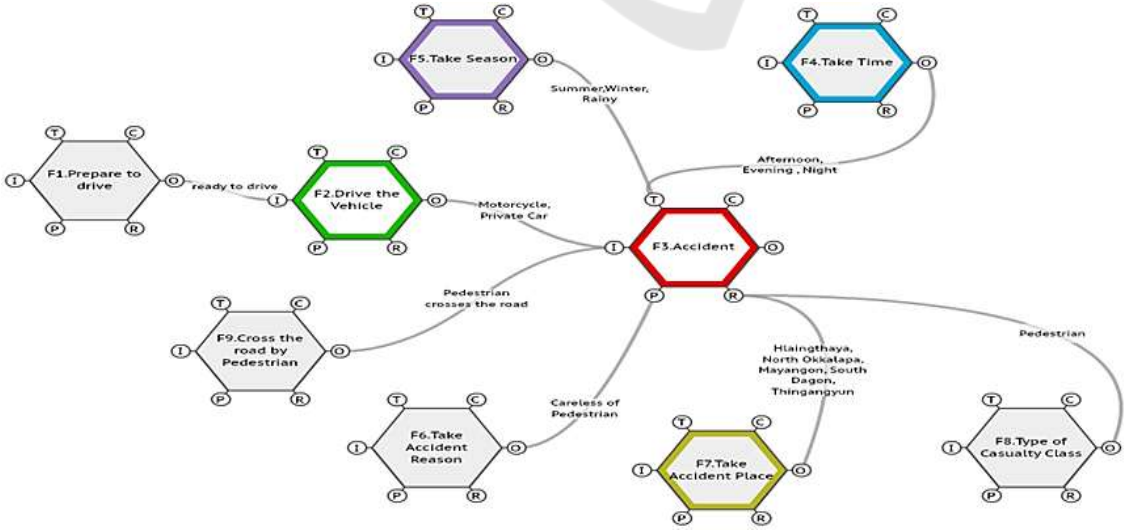


Figure 3: Instantiation of the FRAM model for six Case Studies.

created from the Yangon Police Office Headquarter from 2014 to 2018. NB classification result shows that which factors are mainly affecting the severity level of a road accident and the variability of function output can change the severity level of the road accident. The Cross-Tabulation and Chi-Square test method is used to determine there is an association between categorical variables. The result shows that there is a significant association between casualty severity and accident place, between casualty class and accident season, between casualty class and accident time.

In the future, this study can support defining road safety rules for road users such as drivers, passengers, and pedestrians because we can pickup several useful information from the research that affect accident factors .In this study, we omit some independed test for function and some road accident factors because it is a few effect the severity level of road accidents.In future we plan to analysis the missing functions and factors.There are still road accidents occurring in Myanmar. We need to do a further behavioral analysis of accidents which violate road safety rule in Myanmar.

REFERENCES

Kaya, G. K., Ovali, H.F., and Ozturk, F., 2019. Using the functional resonance analysis method on the drug administration process to assess performance variability. *Safety Science*, 118, pp.835-840.

Hollnagel, E., 2014. *Safety-I and safety–II: the past and future of safety management*. Ashgate Publishing, Ltd.

Hollnagel, E., 2012. *FRAM, the functional resonance analysis method: modelling complex socio-technical systems*. Ashgate Publishing, Ltd.

Bahiru, T. K., Singh, D.K., and Tessfaw, E.A., 2018, April. Comparative study on data mining classification algorithms for predicting road traffic accident severity. *In 2018 Second International Conference on Inventive Communication and omputational Technologies (ICICCT) (pp. 1655-1660)*. IEEE.

Amorim, A.G. and Pereira, C.M., 2015. Improvisation at workplace and accident causation-an exploratory study. *Procedia manufacturing*, 3, pp.1804-1811.

Hlaing, K. P., Aung, N.T.T., Hlaing, S.Z., and Ochimizu, K., 2018. Functional Resonance Analysis Method on Road Accidents in Myanmar. *Proceedings of 2nd International Conference Eon Advanced Information Technologies (ICAIT)*, pp.107-113.

Patriarca, R., Di Gravio, G., and Costantino, F., 2017. A Monte Carlo evolution of the Functional Resonance Analysis Method (FRAM) to assess performance variability in complex systems. *Safety Science, 91,* pp.49-60.

De Carvalho, P.V.R., 2011. The use of Functional Resonance Analysis Method (FRAM) in a mid-air collision to understand some characteristics of the air traffic management system resilience. *Reliability Engineering & System Safety*, 96(11), pp.1482-1498.

Hlaing, K.P., Aung, N.T.T., Hlaing, S.Z., and Ochimizu, K., 2019, November. Analysis of accident severity factor in Road Accident of Yangon using FRAM and Classification Technique. *In 2019 International Conference on Advanced Information Technologies (ICAIT)* (pp. 256-261). IEEE.

Anitha, E.B., Aravinth, R., Deepak, S., Jotheeswari, R., and Karthikeyan, G., 2019. Prediction of road traffic using naive Bayes algorithm. *Int. J. Eng. Res. Technol.,* 7(1), pp.1-4.

Karacasu, M., and Er, A., 2011. An analysis on distribution of traffic faults in accidents, based on driver's age and gender: Eskisehir case. *Procedia-Social and Behavioral Sciences*, 20, pp.776-785.

http://www.myanmarrtad.com/