Functional Resonance Analysis Method on Road Accidents in Myanmar

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Abstract

In Myanmar, there are increasing numbers of road accidents in recent year. Because of road accident, 3480 people died in Myanmar in 2016 and approximately 10 people die from road accidents every day, according to Myanmar Organization Road Safety. Reasons for the accidents may include motorcyclists who are not wearing helmets, poor quality of road, driver behavior, mechanical failure of vehicles, violation of traffic rule, and bad weather. Functional Resonance Analysis Method (FRAM) is an accident analysis method providing a new concept for people to analyze accidents. FRAM can be applied by identifying functions with the detailed variability of functions, interpreting possible couplings of the variability and providing suggestions to manage the unexpected variability. This paper intends to propose basic FRAM model that analyzes the road accident. So it can provide a better understanding of accidents resulting from road accident. Based on this model, a case study was selected and the performance variability of function betweentwo functions by using FRAM model.

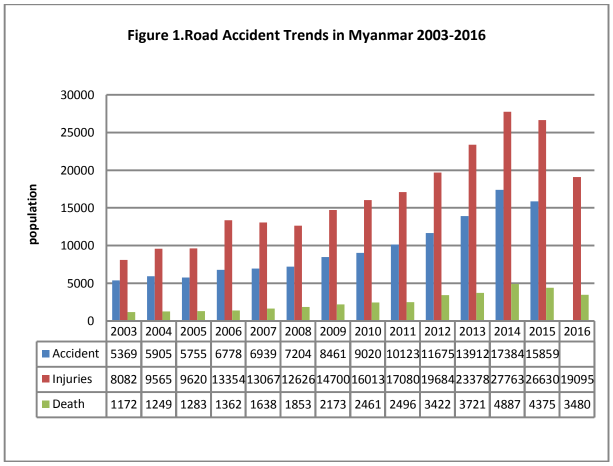
Keywords- Road Accident, Functional Resonance Analysis Method, Road Safety.

1. Introduction

Myanmar has the second highest death toll of road accidents in Southeast Asia, according to the Myanmar Organization for Road Safetythat quoted a WHO study. In Myanmar, road accidents are now major problems of country. Most of road accidents are caused by various defaults of drivers such as driving skill, drivers' judgment errors and violation of traffic rule, careless in driving and careless of pedestrian in walking.Some accidents are due to mechanical failure of the vehicles. All drivers are not aware of proper vehicles maintenance. According to an interview, one of the drivers discussed vehicles maintenance for highway express. He says that "to start a highway, they usually do general preparation and observation of vehicles' conditions only with their eye sight." Therefore they cannot know in detail about inside mechanical parts[6].

Functional Resonance analysis methods are promisingly used to derive potential accident scenarios. FRAM has many advantages in accident analysis. Therefore, FRAM is applied to investigate accident. FRAM focuses on the understanding of interactions andemergence phenomena in complex systems.FRAM can be applied by identifying functions with detailed information about how something is done, characterizing the variability of the functions, interpreting possible couplings of the variability, and providing suggestions to manage the unexpected variability.

Figure 1 shows the road accident trends in Myanmar, from 2003 to 2016.Fatalities increased to 1,853 in 2008, 2,496 in 2011, 3,721 in 2013,and then to 4,313 in 2014. The growth in the level of fatalities from 2013 to 2014 was 16%.The level of fatalities decreased in 2005-2016 [4].This paper aims to analyze road accidents between, driver and car.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Accident	5369	5905	5755	6778	6939	7204	8461	9020	10123	11675	13912	17384	15859	
Injuries	8082	9565	9620	13354	13067	12626	14700	16013	17080	19684	23378	27763	26630	19095
Death	1172	1249	1283	1362	1638	1853	2173	2461	2496	3422	3721	4887	4375	3480

Figure1.Road Accident Trends in Myanmar, 2003-2016

2. Related work

Ana Gabriella Amorim [4]presents an application of functional resonance analysis method for an exploratory study of accidents at workplace where some types of improvisation took place. The FRAMexposed the recurrent weaknessor luck of control and supervision over the working process. As the result of using the FRAM method to explore the cases, it became clear that improvisations recognized as performance variation combined with other performance variations generating a functional resonance effect that was resulted in an accident.

In the FRAM-based analysis(FRAMA), the derivation of rules describing function variability (RFV) is highlighted to understand theinfluence of systemelements on each other, as well as to determine how the various performance of functionscan occur and aggregate. The RFV enables the analysis to be conducted by means of model checking(MC), and consequently facilitates exhaustive search based on the FRAM modeling, for potential performanceof the system functional model.The method FRAMA was applied to a typical ferry capsizal accident and the model checking resultsilluminate more details about the accident which causes than both the details provided in the officially-issuedinvestigation report and those produced by the current FRAM [3].

This paper proposed dynamic FRAM by combining thesystem analysis method of academic and industrial communityand tried to develop FRAM into a real-time analysis accordingto the time order. Dynamic FRAM is more effective to meetthe needs of the actual investigators, and it is also more effective in theanalysis of the relevant measures in the accident process. Theapplication of the method is illustrated by the case study of"7.23" Yong Wen serious railway accident [2].

This research investigates the linkage between highway road accidents and human rights issues in Myanmar.The research explores the reasons why there are so many accidents on the road and the underlying causes behind those accidents, the human rights issues emerged from those accidents and the required state obligations to promote right to life and right to health of passengers as parts of fundamental human rights [6].

FRAM provides an overview of how the system functions and how the emergent to explain the way that accidents happen. The research describes the cause of road accident by using FRAM to minimize accident in Myanmar.

3. Functional resonance analysis method (FRAM)

FRAM was originally developed for accident analysis (Hollnagel, 2004)[1,7]. However, it can also be used as an alternative approach to risk assessment and system modeling, bringing a new paradigm to manage and understand safety in complex socio-technical systems (Hollnagel, 2014)[1,7]. FRAM adopts a systemic and non-linear qualitative approach for system modeling and analysis by describing the normal performance variability within a socio-technical system. Variability in measured outcomes (such as performance, safety, etc.) is therefore introduced in socio-technical systems as an emergent property that is attributable to individual and collective/interacting human behavior during normal operations. Unexpected situations arise from higher degrees of this variability.

The FRAM method can be summarized with the following procedural steps:

Step 1: Identifying and describing the function

The premise of FRAM is the decomposition of the system into its functional entities, including the technical, operational, and organizational activities, which are involved in the day to day work of the system to succeed. Function can be characterized by the six different aspects or featuresbelow (Hollnagel, 2012), as shown in Fig. 2.

Input (I): that which the function processes or transforms orthat which starts the function.

Output (O): is the result of the function, either anentity or a state change.

Preconditions (P): conditions that must exist before a functioncan be carried out.

Resources (R):that which the function needs when it is carriedout (Execution Condition) or consumers’ to produce the Output.

Time (T): temporal constraints affecting the function (withregard to starting time, finishing time or duration).

Control (C): how the function is monitored or controlled.

The six functional aspects are linked together to address the dependencies between the human technical activities during the specified scenarios as show in figure2 b.

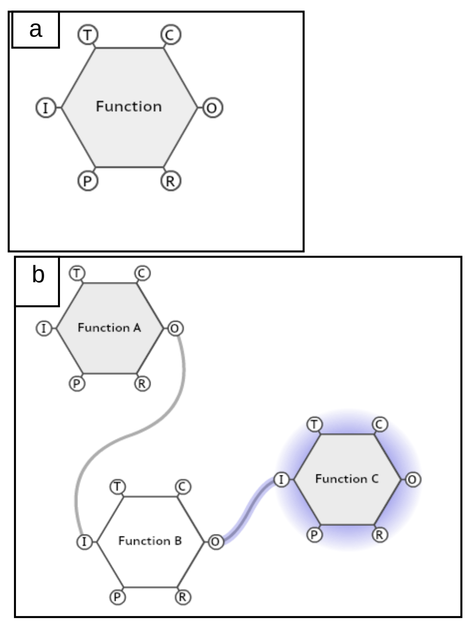


Figure 2 .(a)The six aspects characterizing a function (b)a demonstration of the functional dependencies are represented by the connecting lines.

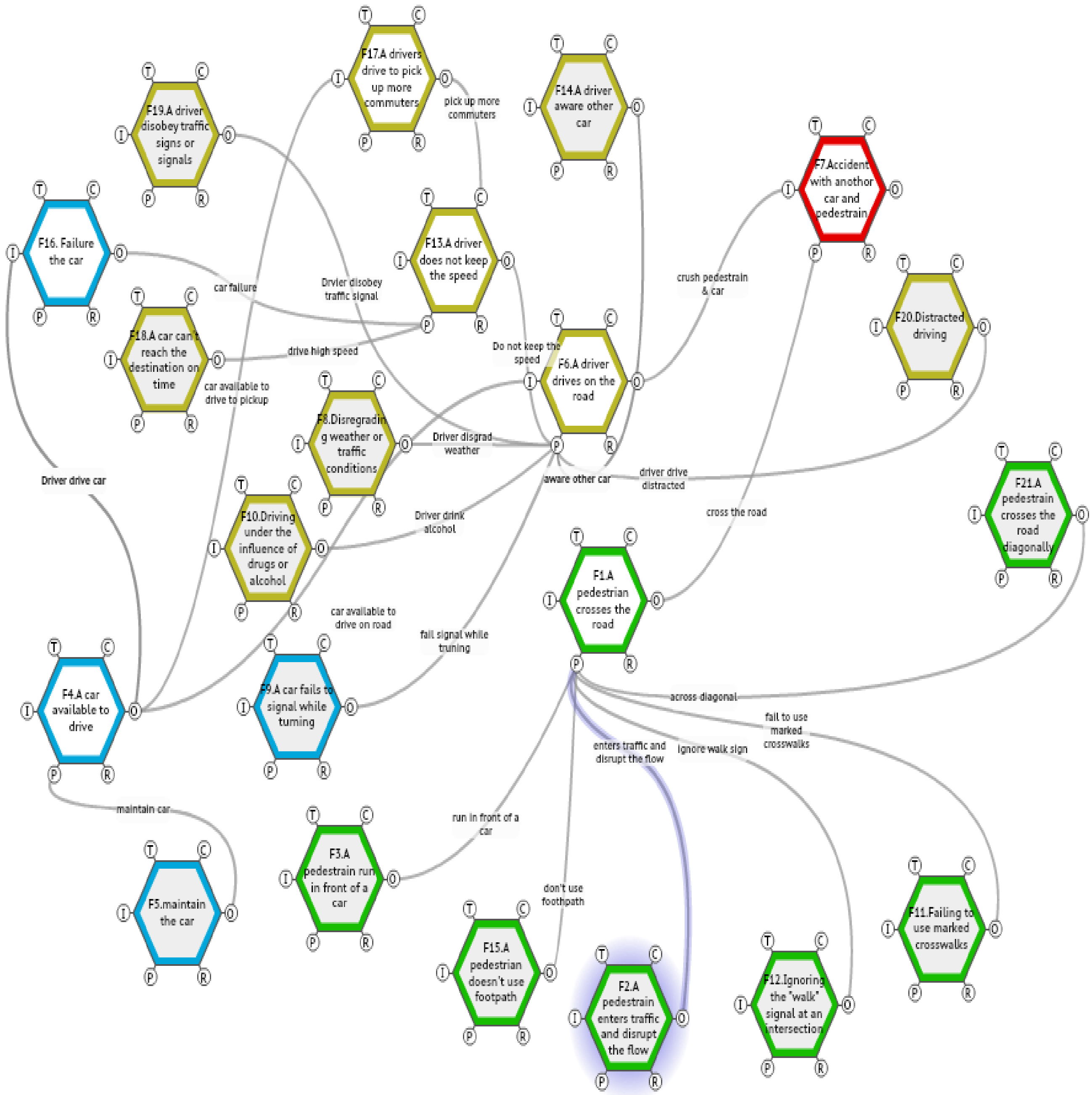


Figure4. FRAM model of Cause of road accident

Step 2: Characterizing the performance variability
The purpose of the second step is to characterize the variability of these functions. This should include both the potential variability of the functions in the model and the expected actual variability of the functions in an instantiation of the model.

Step 3: Aggregation of performance variability
The purpose of the third step is to look at specific instantiation of the model to understand how the variability of the functions may become coupled and determine whether this can lead to unexpected outcomes.

Step 4: Responding to performance variability

The purpose of the fourth and final step is to propose ways to manage the possible occurrence of uncontrolled performance variability that have been found by the preceding steps.

3.1. Variability

The FRAM comprises a number of functions that each describes an activity performed in theillustrated process.A key element of the FRAM is that it illustrates how different tasks areconnected or coupled to each other and how earlier activities can affect later activities by delayingor affecting the quality of the activity. The visualization of the FRAM illustrates that complexprocesses are difficult to describe in a linear way. Actions can vary or occur concurrently if thecircumstances or surroundings change [1]. Therefore, variability is investigated to provide anunderstanding of the couplings of functions.Variability can occur for different reasons [1]. First, functions can be affected by internalvariability caused by psychological or physiological factors. These can include stress, fatigue, well-being, decision-making ability, personal judgment and past experiences. Second, functions canvary due to the working environment in which they are carried out. This includes social factors suchas group pressure, social norms, relations with and expectations of co-workers, and the overallorganizational culture [1]. Finally, variability can evolve from upstream–downstream couplings [1]. Detecting such couplings is based on detecting potential variability and considering how itmay spread through the system and affect functions later in the process [1]. This view of processesand systems shows how variability emerges and how it is either amplified or dampened by actionslater in the process. Analysis of variability and couplings can help highlight the emergence ofunexpected outcomes; more importantly, it can describe how expected outcomes succeed despite variability in functions [1].

4. Functional Resonance Analysis Method on Road Accidents

In our propose system, there are four steps to analyze the cause of road accidents .In figure3; the first step is to identify the cause of road accident between car and driver, cars, and car and pedestrian. The second step identifies the actual or potential variability of each function according to the four basic groups (time/duration; force/distance/direction; object and sequence).Next step is to look at specific instantiations of the model to understand how the variability of the function may become coupled and to determine whether this can lead to unexpected outcome. The final step is to identify the key cause factors of road accident.

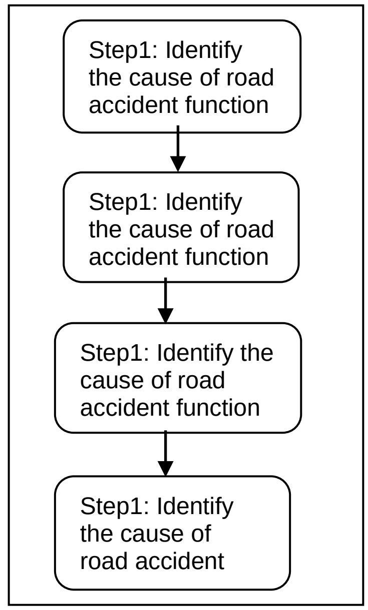


Figure3.The overview of proposed system

Step1: Identify the cause of road accident function

The functions arecharacterized by the six aspects of Input, Output, Precondition, Resource, Time, and Control. The FRAM diagram aims to explain how normal performance variability may cause road accident. The diagram shows many functions when the driver and pedestrian cross the road.The six functional aspectswhich are linked together to address the FRAM diagram of Figure4 indicates the action of car, driver and pedestrian when they cross on the road.

Step 2: The identification of performance variability

Variability of a function is important for the process and can affect the later function in different way related to either time or quality, whether they varied internally,externally or due to couplings.This variability was caused by the default of drivers.Theyare absent to maintain andcheck the driver carefully. The possibility and consequences of internal variability were considered for functions in all sets in relation to how the variability affected the output of the functions. Upstream–downstream couplings will be described in further detail in the next step. In this case external variability was mainly considered in relation to the performance of technology function.

Another example of internal variability was observed at the function of adriver who does not keep the speed'. This variability can be causedbecause a car can't reach the destination on time and a driver drives to pick up more commuters. In table 2, there are many reasons that show the performance variability of functions.

Table2. Identification of performance variability

Function	Function Name	Variability Description
F1	A pedestrian crosses the road	-A pedestriancrosses the road on time. -A pedestrian crosses the road later. -A pedestriancrosses the road earlier.
F4	A car available to drive	-A car is insufficient to drive -A car is ready to drive
F5	Maintain the car	The car has wrong action. The car has wrong object.
F6	A driver drives on the road	A driver drives wrong direction. A driver drives too fast. A driver drives too slow.
F10	Driving under the influence of drugs or alcohol	A driver drives wrong direction
F13	A driver does not keep the speed	-A driverspeed is too fast. -A driver speed is too slow.
F15	A pedestrian doesn't use footpath	Pedestrian can crush with car.

Step3. Aggregation of performance variability

In addition to variations caused by internal and external factors, function can vary because of upstream-downstream couplings. When attempting to understand a representation of reality, it is not necessary to know how variability may be combined. An example is presented in table3 and the function 'drives on the road'. In table 3, this function has many preconditions. The output of the precondition can be effect the downstream function.

Table3. The aggregation of performance variability

Function	Function	Variability Description
F4.A car is available to drive	F5.A driver doesn't check and maintain the car before driving	-Failure of the car -A car can't reach the destination on time. -Fail to signal while turning
F6.A driver drives on the road	F8.A driver disregards weather or traffic conditions F9.A car fails to signal while turning F10.A driver drives under the influence of drugs or alcohol. F14.A driver aware other car F19.A driver disobeys traffic signs or signals. F20.Distracted driving	-A driver can't drive the road safely -A driver can drive safely on the road
F1.A pedestrian crosses the road	F2.A pedestrian enters traffic and disrupts the flow F3.A pedestrian runs in front of a car F11.A pedestrian fails to use marked crosswalks. F12.A pedestrian ignores the "walk" signal at an intersection. F13.A driver doesn't keep the speed F15.A pedestrian doesn't use footpath. F21.A pedestrian crosses the road diagonally	A pedestrian can't across the road safely
F13. Driver does not keep	F16. If the car doesn't maintain and check, the car will fail. F17.If a driver drives to pick up more commuters. F18.A car can't reach the destination on time	-A driver doesn't keep the speed or keep the speed.
F16.Failure the car	F4.A car is not available to drive	-A driver doesn't keep the speed.
F17.A drivers drive to pick up more commuters	F16.A car isn't available to drive or doesn't available to drive.	-A driver drives the car with high speed to pick up more

		commuters.
F7.Accident with another car and pedestrian	F1.A pedestrian crosses the road F6.A driver drives on the road.	Accident can causebetween car and pedestrian

Step4. Identify the key cause factors

According to the functional resonance analysis method, the basic events in the process of accident are cleared. According to the cause study, table 4 shows some key causes factor of road factor and major damage of road accident. For example, failure of car's equipment is the key cause of road accident. Major damage that is failure of relevant components can't be replaced in time.

Table 4.Some of key causes of accident and related suggestions

Function	Major damage	Suggestion
-Failure of car's equipment	-Failure of relevant components that can't be replaced in time.	-Maintain the vehicle
- A driver didn't check a vehicle	- Can be accident during driving the car.	- Check the vehicle thoroughly
-A driver drinks alcohol	-A driver loses the ability to focus function and it's very dangerous when operating a vehicle.	-A driver shouldn't drink alcohol.
-A driver does not keep the speed	-A car can be crushed when a driver does not keep the speed.	-A driver should drive the normal speed
-A car can't reach the destination on time	- A car can be crushed when a driver drives with high speed	-A driver should drive the car to reach the destination on time.
-A driver running the red light	-They often cause side-impact collisions at high speeds	-To avoid a car accident, look both ways for oncoming car
-A pedestrians across the road diagonally	-It is very dangerous to the driver and the pedestrian	-To avoid a car accident, look both ways for oncoming cars

5. Evaluation

The aim of this research is to propose the basic FRAM model that analyzes on the road accident. So it can provide a better understanding of accidents resulting from road accident. Based on this model, a case study was selected that sow the the performance variability of function between driver and car by using FRAM model.

5.1 Case Study: YBS Accident

On July 7, 2017, Bus no. 55 and colliding with Bus no. 37that killed nine people and caused serious injuries to 30 other passengers. The accident was the worst since the Yangon Bus Service (YBS) started operating over one year in Yangon. Six people died on the spot and three people died at the hospital. The Bus no. 55 is 1998 model buses. The case study was used to extract the probability of road accident between cars, driver and car, car and pedestrian. According to the case study, figure 5 illustrates the model of the cause of road accident.

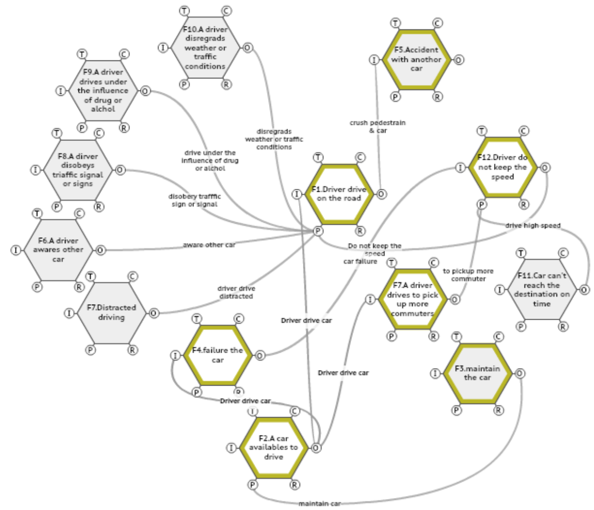


Figure5. FRAM model of Cause of YBS' accident

5.2 Discussion on analyzing of accident

The traditional report for the accident is the failure of vehicle. The proposed method shows the road accident which can be caused because of the driver who didn't check the vehicle, keep the speed, and drive to pickup more commuters, car can't reach the destination on time, failure of car's equipment. According to the investigation result, all the solutions were depended on the variations of the function performance. Such performance variations combined in an expected way and resulted in adverse situation.The comparison between accident report and FRAM application exemplifies that FRAM process does have strength over the traditional analysis process used in the accident investigation.By using FRAM model, we can express the cause of road accident in detail. The output of upstream function can affect the downstream function.

6. Conclusion

In this research, we proposed basic FRAM model that shows the causes of road accident. In Myanmar, there arean increasing number of road accidents in recent year. Road accidents are now the major problem of the country. By investigating the cause of road, we proposed a basic FRAM model which shows the interaction between cars, driver and car, and car and pedestrian. Based on the model, a case study was used to analyze the possible cause of road accident. By comparing the traditional accident report and proposed FRAM method there can be hidden causes of road accident. Method is applied to analyze the cause of road accident in Myanmar to minimize accidents. The proposed system has planned to consider more reliable in the future.

7. References

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