

## Data visualisation of vehicle crash using interactive map and data dashboard

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### ABSTRACT

Vehicle crash contributes to a significant number of deaths and injuries in human races around the world. The government and the transportation expert work together around the clock to lessen the number of injuries and fatalities cause from vehicle crash issues. To come out with an effective solution whether from improving the trafficking system including road conditions or increasing awareness among drivers, the experts must analyse the data of vehicle crash from the past decades to find the major causes and come out with a decision. The lack of suitable techniques and tools to analyse a large amount of data is a deterrent in analysing vehicle crash datasets, and the process costs a lot of time. Data visualisation is a technique that allows people to display data in a more infographic form via data visualisation models. Therefore, this study aims to promote and elaborate more on data visualisation techniques using the interactive map and data dashboard to display vehicle crash data. Interactive map and data dashboard can help the government and transportation experts to describe vehicle crash data for them to make right decision to lessen car accident issues. The interactive map focuses on displaying vehicle crash data in map presentation while the data dashboard shows some charts and graph that describe the vehicle crash data in the statistical form. This study can be a reference model of creating interactive map and data dashboard or enhancing the capabilities in managing vehicle crash.

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## 1. INTRODUCTION

Traffic is one of the costs of urbanisation and modern life [1]. Urban streets and highways clogged with vehicles' engine, and two noteworthy outcomes of so much activity are air contamination and a huge number of death and wounds from vehicular accidents. Road accidents contribute about 1.2 million of death, and around 50 million are non-fatal cases each year around the world [2]. More than 38% of vehicle crash cases involved fatality occurred in urban areas [3]. Urban areas have a higher density of road networks, and that brings more transportation usage capacity on the path than the countryside.

Professionals and experts must find the best solution to at least lessen the casualties. It is a pressing need for governmental agencies, and other key foundations, to increment and manage action to prevent human fatality and injuries from vehicle crashes [3]. But, to cope with this problem, several solutions have been taken including the technical part. For instance, the utilization of computer vision concentrated on recognizing traffic signs [4], lane estimation [5], or exhaustion and diversion [6], and then cautions the drivers as needs be. One of the strategies to make driving so burdensome is by increasing the toll rate for

cars, indirectly to encourage car drivers to try and seek other forms of public transportation [7]. It is a good effort in lessening the vehicle number on the road that will result in less vehicle crash issues.

However, prior solutions do not solve the problem. The reason for an accident can vary with each different case. Some crash-related components, such as driver age and gender, roadway movement, and environmental conditions may impact a driver's likelihood of participating in non-driving activities [8]. Some useful solution may come out from necessary and relevant data visualisation of the vehicle crash. That may bring a lot of benefit in decision making and provide a bird view to the problem.

Data visualisation enables decision maker, in this case, city council, and transportation experts to see the data presented visually, so they can learn the difficult concepts or identify new patterns lead to good ideas and solution [10]. With interactive visualisation, they can take the idea a step further by using technology to drill down into charts and graphs for more detail. Data visualisation of vehicle crash important because using charts or graphs to visualise large amounts of complex data is easier for the human to interpret information, than poring over spreadsheets or reports. Without interactive visualisation of the data, the analysis process or the way expertise extract the information from the raw data can be wrongly done.

This study aims to promote and elaborate on data visualization techniques using the interactive map and data dashboard to visualize vehicle crash data. In addition, this study intends to evaluate the suitability of the interactive map and data dashboard.

The next section describes the background and related studies. Next, the section describes the method used to design and develop interactive map and data dashboard. It then follows by the evaluation of the prototype. The last section in this paper concludes the study and list the future works.

## 2. RELATED STUDIES

Transportation system developed by the government can ease people in moving and travelling. An excellent transport network must have the ability in connecting people to their needy places by providing a standard infrastructure. Transportation infrastructure solely as a means of connecting people, markets, and resources, not on the differential effects of its accessibility [9]. But illegal behaviour from road user or the weakness from the road conditions can lead to a vehicle crash and bring harm to the people that all involve in trafficking system.

As reported around the globe, vehicle crash becomes one of the main concerns especially in urban areas that hold the high capacity of people. One of the substantial evidence come from the United States when each day in 2010, pedestrian–vehicle crashes killed around 11 people and made harm 191 individuals in the United States [11]. This statistic is a surprisingly high number of casualties along with the injuries for a short time. Tremendous losses in terms of death, wound, and goods damage in community due to traffic crashes [12]. The professional community must get the some idea to tackle this vehicle crash issues. Some useful solution may come out from necessary and relevant data visualisation of the vehicle crash.

Convey information plainly and viable through graphical means is the primary objective of data visualization [13]. There are many types and techniques in visualising data. Infographics, geographical maps, heat maps, pie charts, fever chart, and interactive map are some examples of data visualisation techniques.

A heat map is any data visualisation which utilises shading to represent data values in a two-dimensional picture. There are many different types of heat maps used as a part of various orders, each referred to by the term "heat map", despite the fact that they use different visualisation techniques. Heat mapping is a very suitable method for visualising the degree of seriousness of a zone according to the real accidents data in the form of the critical area, medium or safe zone [14].

Data dashboard is a suitable method for visualising all relevant information in a single screen [15]. This approach allows the people to grasp the knowledge based on the data dashboard representation efficiently, without wasting a lot of time to analyse the raw data and information [16]. Thus, data dashboard is a suitable tool and technique in summarising a large amount of data of vehicle crash for the use of public people and experts to get the big picture of car accident issues.

Interactive maps allow users to select from a range of data layers and map features to create and view their customised map [17]. Functions such as zoom and hover-over pop-ups create a dynamic experience that enables users to engage with the data and explore the map's underlying patterns in greater depth. The map can be enlarged to whatever scale the user prefers and shows increasing amounts of geo-referenced information at higher resolutions [17]. Compared to a static map, static maps are simply maps that displayed as a fixed image.

Data chart is a sort of diagram or graph that composes and represents a set of numerical or qualitative data. Charts can usually be read more quickly than the raw data. Bar, dot, line, pie, matrix, and progress bars are some of the charts examples in displaying data [18]. Besides, chart types have evolved from simple bar graphs and pie charts to word clouds, pictorials, and pyramids to visualise data. Meanwhile,

data charts have a few drawback including required an ample space to view limited data presentation compared to other data visualisation model.

The data visualisation techniques must be suitable to the data type that the user wants to convey [19]. For this study, the interactive map and data dashboard are chosen to visualise designated vehicle crash dataset based on several factor and advantages. The interactive map selected because of the map flexibility in controlling data element. The interactive map allows the user to control the data based on the filter panel and other user-interactive function [20]. Compared to the heat map models, the interactive map can add more feature than just displaying the data from the dataset as the user can perform two-way of interaction with the map. The interactive map typically equipped with several controlling user-interactive function. Map control functions enable the user to understand more about the displayed data variously. For example, users can filter the data according to the desired map layer outcome and do the comparison between the available data source layers. Data dashboard is chosen to support the statistical data presentation of the data set while the interactive map focuses on displaying the data in geographical styles. Both of the data models needed in resulting better understanding about the data set. Data dashboard created to view the standard data models such as pie charts and line graph.

### 3. METHODOLOGY

This section describes the method used to develop an interactive map and data dashboard.

#### 3.1. Preparation of Datasets

For purpose of this study, raw data of vehicle crash from the year 2011 to 2013 are downloaded from Fatality Analysis Reporting System (FARS) [9] and analysed before proceed to data editing. The purpose of examining the raw data is to make the datasets smaller by eliminating the unnecessary data element that unrelated to the interactive map and data dashboard development. Since the data is too large in volume, particular data element are selected to fill up the designated dataset and suit with the project scale and requirement. Out of fifty (50) states in the United States of America, the project will focus on New York area. Since the FARS raw data is listed using codes name or also referred as Statistical Analysis System (SAS) name, FARS Analytical User's Manual used to define the SAS names. Requirement analysis sub-phase results in a list of data elements used for this study. It consists of selected data elements with the data definition. The selected data elements come from three types of FARS SAS data files which are from ACCIDENT, VEHICLE, and, PERSON data files. The dataset consists of thirteen (13) columns and three thousand three hundred and eleven (3311) vehicle crash cases from the year 2011 to 2013. All the data selected involved fatal crash cases. The datasets then saved in comma separated values (.csv). The details of the selected data elements of the car crash for the interactive map and data dashboard includes month, day, hour, year, fatals, drunk\_dr, st\_case, latitude, longitude, age, sex, per\_typ, and speedrel.

#### 3.2. Application Development

In application development phase, the costumed vehicle crash dataset is converted into interactive map and data dashboard. Following describes in details about the method used to design an interactive map and data dashboard.

##### 3.2.1 Interactive Map Design

Interactive map development starts with importing costumed datasets into Mapbox Studio Classic as metadata. The comma separated value (.csv) file must have at least longitude and latitude column to import the data sets into Mapbox Studio Classic software. Comma separated value (.csv) data files are auto-detected by Mapbox Studio Classic and converted into Mapbox vector tiles since the dataset has both latitude and longitude data elements. Each marker point will occur to represent a distinct vehicle crash case by the map preview pane.

CartoCSS styling language is used to filter the data points based on the suitable data elements. For this study, the gender and person type data elements are filtered based on colour and shape. Person type categorised into four-person roles which are a driver, passenger, pedestrian and bicyclist. Also, there are two gender data elements which are man and woman. The filtration for children based on the age data element. The vehicle crash victims that aged below 13 years old is considered children. If the number of fatal victims is more than one person, it regarded as multiple victims.

Scalable Vector Graphics (SVG) is used to filter the points marker according to the gender, person types and other related conditions on the source layer. SVG is an XML-based vector image format for two-dimensional graphics for animation support. Then, the colour and the marker size are adjusted accordingly

using CartoCSS syntax and documentation. Marker size is adapted to sync with the map zooming level to avoid the overlap between markers, and controlled by CartoCSS programming block.

Mapbox Studio Classic software provides various of map styles for developers to match their desired map outcome. Mapbox prepare numbers of tools and web services to assist the developers in creating their map. Every registered user of Mapbox Studio will get a unique access token each. The access token is a pass for the user, to Mapbox application programming interface (API) that allows for programmatic access to Mapbox tools and services [21]. These APIs used for access, upload and change map resources, and use core Mapbox tools, like geocoding. Mapbox web service APIs can be accessed through several programming techniques across many program languages. The access token is unique, so Mapbox can know specifically which user is requesting the data. The access token is required to use any tools, and APIs provided by Mapbox Studio. All the access token can be found, create, and delete by the API Access Token page at Mapbox.com. Coding activity is performed to access Mapbox APIs and to connect all map source layers in one web interface.

The interactive map consists of seven (7) layers of map canvas that have the different purpose and data representation. The first layer is the map base layer that covers the geographical data of the world map. Map base layer controlled by CartoCSS programming language that includes every detail of geographic data such as road network, waters, earth surface, and their labels. The second layer governs the source layer that represents all fatal cases from the year 2011 to 2013 by sorted point marker. Meanwhile, the third and fourth layer displayed every fatal case that caused by speeding and alcohol factor. The last three (3) layer show fatal crashes that happen in 2011, 2012, and 2013 respectively. Every map layer is equipped with unique map ID. In the programming part, each map layer is called by the map ID.

All map layers are bind together in a single web page, and the interactive user function is set up to able the user to control the behaviour of the interactive map. Notepad++ software used to write the JavaScript programming language that enables a user to triggered user interaction function with the interactive map. For this project, the user can select, sort and, view the vehicle crash data according to vehicle crash contributing factor; all crash happened between the year 2011 to 2013 by clicking on the user-interactive button under map filtering options. The user also can control the map base layer by disabling the layer, if they want to focus on the pattern of the data. The map legend consists of two (2) pictures designed using Adobe Photoshop CS6 application software to assist the user while navigating the interactive map. HTML and CSS programming language used to manage the legend styling and label in the interactive map display.

The interactive map also equipped with hover effect and pop-up information box when the user hovers on the point marker. This function is created by editing a part of the code block in the project.yml files. Every Mapbox Studio Classic style project stored in a single file directory named. tm2 file extension. One of the components stored in the project directory is project.yml file. The project's core metadata that acts as a reference to its vector tile source and the CartoCSS stylesheets located in this file. HTML and Mustache template code are written inside the project.yml file to enable hover effect and pop-up information box.

### 3.2.2 Data Dashboard Design

Plotly online analytics tool used to create data dashboard and its environment [22], [23]. Plotly eases the developer to study the desired data and provide graphical plotting platform [24], [25]. Users can create custom conditions to filter data and of the dat set by using a set of filters. Earlier dataset form used for interactive map creation edited and organised using Microsoft Excel 2010 application software to produce desired statistics models.

### 3.3. Data Model Prototype

A web page designed as a web-based page to compile the complete data models which are interactive map and data dashboard that visualise vehicle crash data. HTML5 and CSS programming language used to develop the web page. Some of the important details about the project also displayed as web page content. Button "Launch Map" provided at the top web page that will open the interactive map in a new tab of browser. Data dashboard can be accessed by clicking on "View Dashboard" button. Figure 1 illustrates the web page and the buttons' interface.

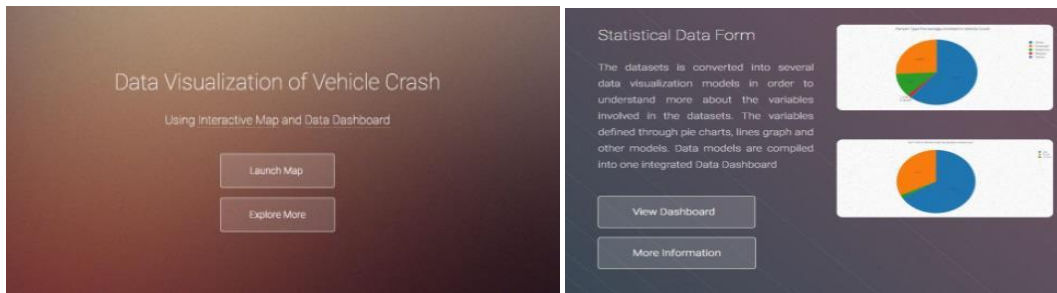


Figure 1. Data dashboard section on the web page

**3.4. Interactive Map and Data Dashboard Model**

The interactive map model consists of several parts to make it function effectively. The interactive map equipped with a legend to guide the user in describing the data. The legend located at the right side of the map. Meanwhile, at the right side of the map canvas is the filtering option for interactive user purposes. There is two column data filtering mode. The first column named "Map Filter" used to activate and deactivate map base layer, shows all crash cases, and sorting the data based on the vehicle crash contributing factors which are speeding factor and alcohol influence. The second column provides data filtration function according to the year of the crashes. The user may select more than one data filtration options, for example, to see all vehicle crash happened in the year 2011 and 2013. The details about each of the victims can be displayed as user click or hover on the point marker. The details about the victim will pop-up and appear on the top-right of the map in the form of information block.

Pie Chart and line graph are chosen as the data models to be displayed on the data dashboard. There are two (2) pie charts and one (1) line graph data model created to fill up the data dashboard. First pie chart describes the percentage of vehicle crash victims based on their gender and the second pie chart is to view the percentage of the victims based on their roles. Line graph model displays the total vehicle crashes against months. The user can hover on the pie charts and graph to see more details of the data such as the total number vehicle crash cases. The legend of the pie chart also can be clicked to filter the data according to the user selection. Figure 2 shows the final form of the interactive map and data dashboard.

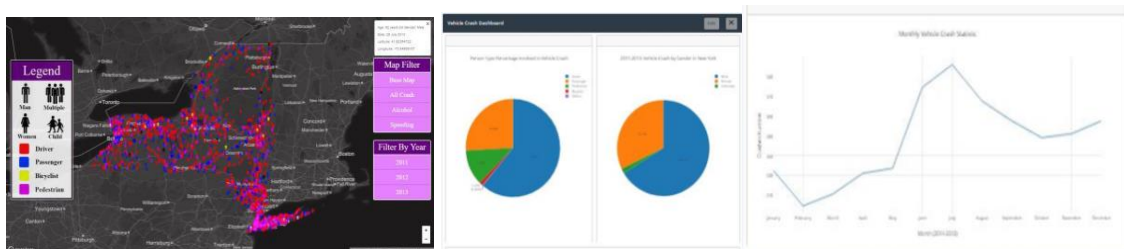


Figure 2. Final form of the interactive map and data dashboard

**4. RESULTS AND DISCUSSION**

Reviews from the experts are necessary to gain insights regarding the data visualisation technique used in this project to evaluate the suitability of the data models. Three experts that have more than 20 years in the field of transportation and trafficking system have identified. Expert panels involvement in evaluation phase is very critical to avoid any misconception about how the interactive map and data dashboard can help government and non-governmental organisation (NGO) in handling a large amount of vehicle crash data to reduce vehicle crash cases. Interview session is conducted to measure the suitability of the map and data dashboard in interpreting vehicle crash data. The procedure for the evaluation session divided into three (3) phases. The first phase is to give a brief introduction about the project description and the objectives. The second phase involved the expert's engagement toward the interactive map and data dashboard, and the last phase is where interview session conducted to evaluate overall of the project product. A set of question prepared for the interview session. The questions divided into two (2) categories of question and every category has five (5) questions. The first category question used to evaluate the interactive map and the data dashboard in term of the interface design, performance and the usability of data models. Among the questions

includes; do you find it easy to use the interactive map and data dashboard?, are the user-interactive functions working correctly?, do you find the map legend is helpful?, do you agree that these data models are effective in visualize vehicle crash data?, dan these data models potentially increase road safety awareness to the public?.

Positive responds and feedback received on the map interface and usability of the interactive map. Good comments were also received from the map filtration function and the pop-up information features that tied with each of the point markers. The second panel, commented on the dark map background should be changed to light background colour. Some explanations are given to her regarding the dark web base style. The dark background colour is chosen to highlight the data point marker on the map by making map background less appealing and contra. However, the user can opt to deactivate the map base layer by clicking on the "Map Base" button under the first user-interaction column. The second panel satisfied with the justification made. The evaluators are not having problem while using the interactive map and data dashboard because the interface is user-friendly and straightforward. The user-interactive function worked as expected. The map navigation features including zooming control, mouse hover function, and the cursor control also worked smoothly. Panels also can easily distinguish between the point marker based on the data element by referring to the legend provided.

The second category question is prepared to evaluate the usefulness of interactive map and data dashboard in visualise vehicle crash data, in particular on the decision-making activities of the organisation. Based on the result, all three panels claim that the interactive map and data dashboard are efficient and suitable for the future implementation in handling vehicle crash data. On the other hand, only the second panel agreed that if the interactive map and data dashboard are published for the public people, it can increase the awareness to drive safely on the road. The first and the third panel disagree because they could not see any correlation between the issues. One of the panels said that law road reinforcement is more effective approaches to educate people to drive safely such release summons if the driver disobeys the law. The second panel agrees that the interactive map can educate people to know which area is high-risk accident area so that they can pay more attention while driving in that particular area.

The other question highlighted on the way that interactive map and data dashboard can benefit in reducing vehicle crash. Automated System and speed trap camera categorised as one of the effective methods in reducing traffic light violence and controlling vehicle speed limit on the road. Thus, Automated System and speed trap camera implemented to capture the drivers that violate the road law. High-density area of vehicle crash can be identified easily through the interactive map. So, the high potential area to implement Automated System and speed trap camera can be detected and minimised the effort in decision making. All panels agreed that the interactive map could help in finding suitable location in implementing Automated System and speed trap camera. Thus, the interactive map and data dashboard models could help in assisting decision making.

The last question in this category justifies on the importance for the government to release vehicle crash data for the public use. As mentioned, only selected government bodies and research institute can get access to the statistical report and road accidents data. The panels agreed on the fifth question which supported the idea of making the statistical data available for the public use that can benefit in reducing vehicle crash cases in Malaysia.

All in all, the experts gave good feedback on the selected data visualisation model for this study consist of interactive map model and data dashboard. It proved that the interactive map and data dashboard could benefit the related organisation in many ways including decision-making process. It is hoped that the interactive and data dashboard modelling will help transportation professionals to spend less time and energy to analyse the large amount of vehicle crash data which will ultimately help the transportation system safer.

## 5. CONCLUSION AND FUTURE WORKS

This study described a study on the design and development of an interactive map and data dashboard for vehicle crash. The interactive map and data dashboard are suitable methods in describing vehicle crash data. Transportation safety organisation can extract and access more accurate and reliable information regarding the critical accident areas that need their attention. Thus, through the interactive map also they can analyse and identify the suitable area for promoting road safety awareness program or campaign. The information of interactive map can be adjusted based on the available filters such as vehicle contributing factors or by specific year. The flow of the information can control by the users within a few scrolls and clicks.

Future works include connecting the interactive map and data dashboard to database system and equipped with live data that will frequently be updated by the related transportation safety organisation. This will result in more efficient and accurate mapping system.

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