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Review of Current Animal-Vehicle Collision (AVC) Studies

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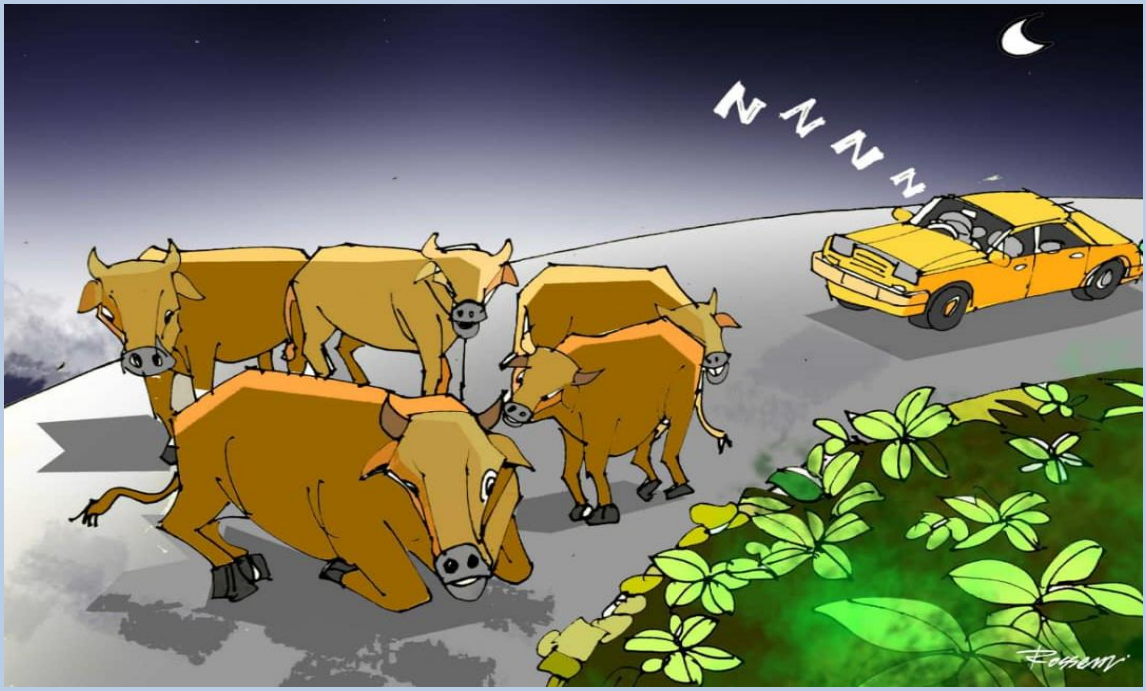

Animal-Vehicle Collision (AVC) is one of the widest and foremost research segments in the road safety research area. This paper aims to give a critical review of highlighted points and characteristics of different types of research that is within the AVC research segment. There are distinctively four categories of AVC research namely: trend and characteristic of AVC study, AVC spatial modeling study, human-animal behavioral study, and AVC mitigation study. Specific traits of each category are explored and related reported data are presented. In conclusion, each category of AVC research required further analysis especially on gathering comprehensive field data and records.

Rossem or his real name, Rosidi Semail, is a legendary cartoon artist currently based in Ketereh, Kelantan, Malaysia. He has a gallery named Balai Kartun Rossem and his Facebook page is www.facebook.com/rossem.sem.

Keywords: Animal-Vehicle Collision (AVC), spatial-modeling, human-animal behavioral, AVC mitigation

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The road system is paramount to a nation's social and economic growth. Nonetheless, some roadways have been built nearby or on animals' habitats; which resulted in a high risk of animal-vehicle collision (AVC) (Trombulak & Frissell, 2000). A large number of animals from a wide range of species have been involved in AVCs (Langbein & Putman, 2006; Glista et al., 2008) while death or serious injuries to drivers have incurred a great amount of economic damage and losses (Bissonette et al., 2008).

In Malaysia, data in 2016 have indicated that there are more than 1,914 accidents related to animal crossings on our roads and highways since 2011 (Bernama, 2016). A Malaysian Statistical Report on Road Accident in 2016 produced by the Royal Malaysian Police Department, indicates that 5.6% of total motorcycles accidents involve AVC, out of which 47 cases of death (Royal Malaysian Police, 2017).

The Wildlife and National Parks Department on Conservation and Biodiversity (PERHILITAN) stated that road accidents that result in the death of animals occur in 2016 involving 378 foxes, 170 wild boars, 65 leopards, and 33 tapirs (BERNAMA, 2016). Some of the animals in Malaysia are endangered species, which must be protected and nurtured (Jantan et al., 2020).

The objective of this paper is to present an outlook into the current research works that have been published in the AVC research segment. There are distinctively four categories of AVC research, namely: trend and characteristic of AVC study, AVC spatial modeling study, human-animal behavioral study, and AVC mitigation study.

Trend and Characteristic Study of AVC

Trend and characteristics study of AVC involves analysis of big data to produce useful patterns and relationships; which can improve understanding of AVC problem. An analysis performed by Sullivan (2011), a 10-year span of AVC data that were gathered from two sources – Fatality Analysis Reporting System (FARS) and General Estimates System (GES) – were processed and patterns were produced to see the effect of seasons, maximum vehicle speed regulation, deer populations and also hourly changes, to the number of AVCs. The results show that an increasing trend with an average increase of 104% for the ten-year data. For the relationship aspect, they found out that the likeability of terminal AVC and non-terminal AVC that occurs during nighttime, increases by 2.3% with every mile-per-hour maximum vehicle speed regulation (Sullivan, 2011).

A work using spatio-temporal analysis by Morelle et al. (2013) exhibits an analysis on the spatial and temporal analysis of AVC in Wallonia, Belgium. The spatial analysis involves mapping the AVC data and the use of a statistical tool to measure risk rating on AVC occurrences. The temporal analysis aims to examine AVC data in relation to time: yearly, monthly, weekly, etc. In the work by Morelle et al. (2013), spatial and temporal analysis is

applied to AVC data involving wildlife animals from 2003 to 2011 in a region of a high-density road grid. Based on the temporal analysis, the pattern of increasing AVC can be seen after dusk; indicating night as AVC prone period. Wildlife seasonal-related activities such as mating, migrating and hunting can be shown to affect the AVC tabulation. Spatial analysis is applied focusing on four common wildlife, which are wild boar, roe dear, red deer, and red fox. Mapping of the AVC data is performed using Kernel density estimation to detect the location of AVC hotspots. From the result, relevant authorities can have better decision-making in terms of regional planning and development.

Trend analysis is also applied to a study by Cherry et al. (2019), which focuses on the settings and parameters that influence the number of AVC in the National Park Service (NPC) in the United States for data between 1990 to 2013, using the statistical method – Pearson's chi-square. The work successfully points out that the seasonality pattern is the main condition that affects the number of AVC in NPC. However, more type of data is needed, especially in relating to the animal species in order to comprehensively capture the right condition for each unique environment of NPC.

AVC Spatial Modelling Study

Spatial Modelling in AVC study is used to obtain the statistical or mathematical relationship between AVC incidents and influencing parameters and also to obtain risk value for better road and development management. For example, the work of Lao et al. (2011) introduces a new statistical model that includes conditions of the vehicle drivers, animals, road parameters, and surroundings. The probability of AVC occurrences is the main output parameter of the modeling while the influence of parameters such as the maximum vehicle speed regulation, locality, animal population are examined.

The work of Hothorn et al. (2012) demonstrates a modeling work that circumvents the problem of lack of data on deer population, where the aim is to produce deer-vehicle collisions risk measurement including all influential parameters in Bavaria, Germany. Risk value for specific locations for two types of animals, which are Central European and North American white-tailed deer are produced. AVC data from 2006 to 2009, are examined using a new method of modeling that utilizes non-linear dear-surrounding and analysis of location uniformity, to produce a local risk of collision model. Measurement of risk was created named as "deer-vehicle collision index".

Yang et al. (2019) applied statistical analysis technique of Negative Binomial (NB) model and Generalized Negative Binomial (GNB) to differentiate the location of high-risk collision and effect of some specific parameters for two different types of reported data: carcass removal and AVC record. Empirical Binomial (EB) values are produced and the results show that further variables, such as types of road, are needed to increase the accuracy of the analysis.

Human-Animal Behavioral Study in AVC

In this category of research, there are two focuses of study: human reaction and animal reaction.

For the case of focusing on animal reactions, a lot of work is currently being done on analyzing animal reactions before the occurrence of an accident or near-miss accident. Figure 1 shows the general framework of animal behavior towards an approaching object.

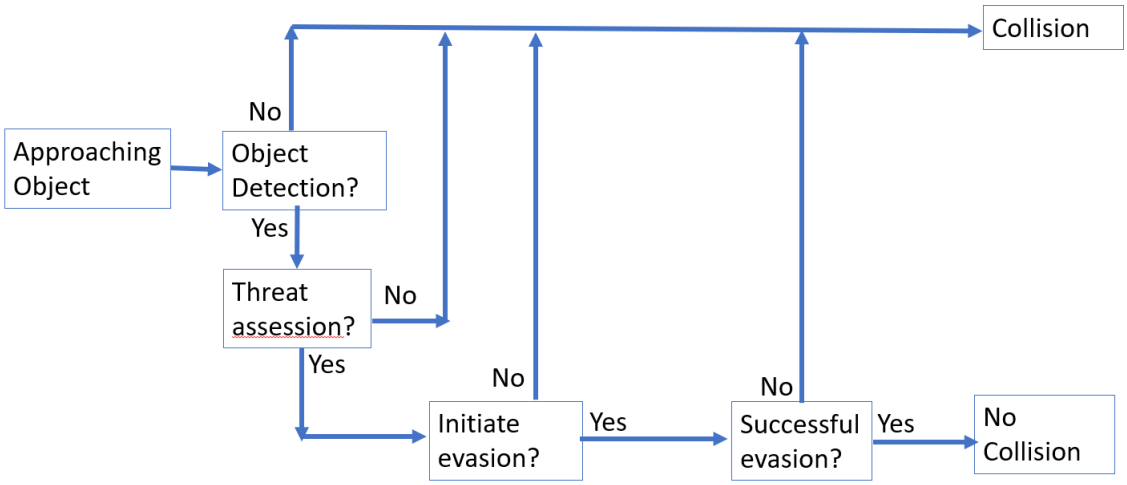

Figure 1: General stages of animal behavior towards an approaching object (Lima et al., 2015)

Any stages that resulted in a "No" response will produce AVC. Only if the process involves detection by the animal sensory system, threat assessment by the animal cognitive process, evasion initiation, evasion attempt will end with no collision. The main source of data is from experience details from drivers who involve in AVC. Unavoidably, some important parameters and conditions are missing from the data. Some researchers opt for the experimental method to study animal behavior towards incoming objects. However, this method has restrictions to mimic the real situation of AVC, such as the difference of indoor lab environment to the real outside environment.

For research that focuses on human reactions, involves study on drivers' attitudes, awareness, decision-making processes, and perception towards animals crossing the road. One work by Kioko et al. (2015) analyzes drivers' understanding and viewpoint towards accidents involving animal crossings. Figure 2 describes the results of the survey done by Kioko et al. (2015) that gathers drivers' views on the causes of AVCs.

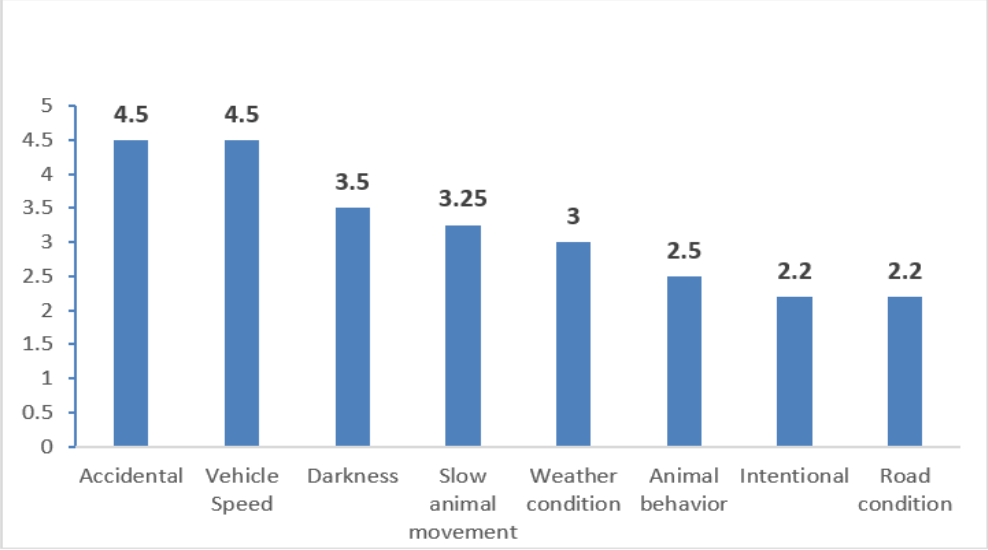

Figure 2: Survey on drivers' view on the causes of AVC (Kioko et al., 2015)

The result shows here that most drivers have the perception that AVC is mostly accidental and due to the high vehicle speed and darkness. Other than that, the study also reveals most drivers did not have any exposure to awareness programs relating to animals living close to roads.

AVC Mitigation Study

AVC mitigation study is a study that concerns the methods or processes to reduce or prevent AVC. There are four types of AVC mitigation study, depending on the focus or highlight of the method employed: (1) Mitigation method that aims to influence drivers' behavior; (2) Mitigation method that that aim to influence animal behavior; (3) Mitigation methods that seek to aim wildlife population size; and (4) Mitigation methods that aim to create a barrier between animal and roads (Huijser et al., 2008).

(i) Mitigation method that aims to influence drivers' behavior

This method primarily focuses on developing drivers' attitudes to prevent AVC (Huijser et al., 2008). Some of the methods are: (1) Public knowledge and awareness; (2) Warning signs; (3) In-vehicle alert systems; (4) Improvement on drivers' vision; (5) Decrement in traffic volume; (6) Decrement in speed limit; and (7) Animal crossing guards.

Public knowledge and awareness are important in curbing AVC through imparting general messages and campaigns through mainstream media, hardcopy materials, social media and other channels. Warnings signs are effective in eradicating or reducing the severity of AVC. As most drivers will be more attentive once they come across warning signs and may lower their driving speed; this will curb AVC or reduce the impact of the accidents. The in-vehicle alert system is an intelligent system to sense the presence of animals (of a certain size) at some specified range from the vehicle. The system is anchored by an interlinked GPS-communication system with the onboard controller inside a vehicle (Huijser et al., 2006).

The study from Green (2000) has shown that drivers need time - 0.7 to 1.5s - to brake or maneuver appropriately when drivers see an animal on the road. Hence, if the driver's vision is improved, it will give more space for drivers to react. Some ways that have been applied to increase the visibility of animals to drivers are – better roadway lighting, clearing vision blockages at the roadsides, among others. Decrement in traffic volume can be applied by managing the routes through different routing and temporary road closures. This, understandably can be applied only to rural roads which are close to wildlife habitats. Decrement in the speed limit in some ways can reduce the AVC. However, some data have shown other ambiguity to the method. Data from Biota Research and Consulting (2003) indicates no decrease in the number of vehicle collisions with deer when the posted speed limit is decreased to 56 km/h. In some roads within national parks, trained wildlife crossing guards are employed to control animal crossings by leading the animals to a safe path.

(ii) Mitigation method that aims to influence animal behavior

Mitigation method that use method to influence animal behavior without major facility changes involves the use of mirrors, light, sound, chemical fume, dummy and vegetation control to deter animals to come close to roadsides. Some of the well-known methods are the use of deer reflectors and mirrors, ultrasonic devices, olfactory repellants, deer flagging dummy, water

sprays, chloride-based salts, and removal of wildlife vegetation at the roadsides (Brown et al., 2000; Shipley, 2001; Baker et al., 2005; Huijser et al., 2008).

(iii) Mitigation method that aims to reduce animal population size

Reducing population size is an effective way to decrease AVC, as reported by (Doerr et al., 2001; Knapp, 2004). In the work, it is shown that the AVC in Minnesota, United States is reduced by 46% when AVC is reduced by 30% (Knapp, 2004). However, further comprehensive field tests to show the effectiveness of animal population size are still needed in this research area. Some of the approaches been taking by authorities in reducing animal population size are: (1) Animal culling; (2) Animal relocation; (3) Anti-fertility treatment; and (4) Animal habitat modification.

(iv) Mitigation method that aims to create a barrier between animals and roads

This wide category of approaches attempts physically detach animals from the roads. Structure or designed objects are placed to block any animal encroaching into roadways. In this research area, the positive and negative effects of the method need to be studied (Huijser et al., 2008). Some of the methods used are: (1) Fencing; (2) Big rocks in the animal crossings; (3) Tunnels and bridges; and (4) Animal underpasses and overpasses.

Conclusion

The distinct areas inside animal-vehicle collision research areas have been identified and their characteristics have been highlighted. Trend and characteristics study involves the analysis of big data to produce a useful pattern and criteria that can improve understanding of the AVC problem. Spatial Modelling in AVC study is used to obtain the relationship between incidents and influencing parameters and also to obtain risk value for better road and development management. The human-vehicle behavioral study depends on incidents anecdotes and limited experiments. A mitigation study is any study related to prevent or reduce the occurrence of AVC.

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