EDITORIAL

Road traffic accident trauma: A model for road safety management utilizing the artificial intelligence with geo-mapping and geospatial data in Pakistan

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Trauma from road traffic accidents (RTA) is the leading cause of mortality among children and adults up to the age of thirty. Currently, almost one and a half million annual deaths are attributed to RTA trauma with over 90% of the deaths being reported from low- and middle-income countries.[1] In Pakistan, almost 26,000 casualties from 50,283 RTAs have been registered in the past five years, however a much larger number was reported by the World Health Organization (WHO) in 2016, which estimated 14.3 annual deaths per 100,000 population.[2,3]

Seemingly, a higher number of mortality from RTAs in the developing countries can be attributed to factors such as lack of adherence towards traffic rules, violation of speed limits, vehicular overloading, low-quality vehicles with less safety features, increased traffic density due to abundance of motorcycles, and inadequate post-accident trauma care. In addition to this, faulty road infrastructure and poor road designs including the malfunctioning signals, crossings, turns, intersections and curves are a frequent cause of recurring RTA mishaps at particular locations. Therefore, road safety management is becoming a global concern with the ever-growing population, increasing number of motor vehicles and vulnerable road users. The WHO's estimated cost of RTAs in low- and middle-income countries is around 3% of the gross domestic product which is alarming for the authorities.[1] Also, the burden of RTA trauma on the healthcare system of Pakistan is enormous, which is struggling with myriad of issues.

Despite being a public health concern, road safety has been a neglected domain in Pakistan and the current road infrastructure safety management is far from the international standards.[4] Developed countries in contrast, have revolutionized the road safety and infrastructure management through effective utilization of computer technology and data science which plays a major part in road safety through data driven and evidence-based guidelines, intelligent systems and processes. Artificial intelligence (AI) is one such advanced form of data computation which enables the machine to learn from the available data and perform cognitive functions like reasoning and interpretation with autonomous decision-making. Such intelligent systems and algorithms are designed to handle colossal amounts of information gathered from multiple sources i.e. the big data. These are being utilized in the developed parts of the world for the improvement of road safety and prevention of RTA fatalities.[5]

Machine learning (ML) is the subclass of AI which specifically deals with the processes by which machines learn from certain datasets to make future predictions or decisions on their own. There are two main methods by which a machine can process large datasets to identify and learn the underlying patterns. Supervised ML is the one which involves prior training of the machine with structured and labeled input data that is directed towards a predefined outcome. This trained machine can then recognize the underlying patterns in new input data to generate the predetermined outcome. Unsupervised ML in contrast, uses unlabeled data without a preset outcome and is aimed at data classification, structuring, feature extraction and dimensionality reduction in the fed data.[6] Deep learning (DL) is a subtype of ML with multiple layers of deep neural networks (DNN) which can process vast amounts of information to find links and patterns without any prior programming or training. These DNNs work just like human neurons and have numerous connections with many other "neurons" within different layers of the system. DL involves big data and does not need any prior training or assumptions. Once fed, DL determines the number of computational DNN layers (including the input, output and the hidden layers) and the patterns for analysis in the data by itself.[7] Therefore, DL is the robust of all AI subtypes and more accurate method of big data analysis in medical sciences which is otherwise impossible to handle with conventional analysis methods.[8] Having said that, DL requires larger sets of cleaned data gathered from multiple sources with numerous independent variables in order to be useful in autonomous decision-making and accurate predictive modeling.

With the current advancements in information technology, it is possible to prevent RTA trauma and fatalities by the accurate prediction of when or how a catastrophic event may occur, along with the identification and mitigation of associated factors.[9] It is high time that the developing countries like Pakistan also inculcate modern and

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intelligent systems and techniques into road safety management in order to make it efficient. The first step in this regard is to devise a mechanism to secure multidimensional data from both the catastrophic and near-miss events.[9] The data collection framework should encompass; 1) crash-related data, 2) driver- and driving behaviour-related data, 3) vehicular data and traffic dynamics, and 4) post-crash trauma care, service and in-hospital management data. Crash-related data will include geospatial data i.e. the data from the specific location and time of the incident. This will also include data like the road design and geometrics, road curvatures, traffic density and flow, roadside visibility as well as weather and environmental conditions at the time of the crash. Driving behaviour will include data like traffic rule or signal violations, wrong turns or lane violation and over speeding etc, while driver-related data will cover functional disabilities like driving under influence of alcohol or drugs, visual impairment or any other organic disease that could impair the driver's driving abilities. Similarly, vehicular data will correspond to the vehicle-related safety factors like the emergency brakes deployment, air-bags functioning, overloading, seat belts and structural frame stability etc. Post-crash trauma care related data will include factors relating to first aid response time, initial stabilization and transfer to the trauma care center, access to the nearest trauma care facility, quality of services provided in the hospital and nature and the extent of injuries.

Most data regarding in-hospital management and information about the crashed vehicle is routinely registered in the major cities of Pakistan as a part of regular documentation. The panoramic geospatial data from the crash-related or a near-miss event and the data pertaining to driving behaviour can be procured by installation of roadside high-resolution closed circuit television (CCTV) cameras with specialized sensors. However, mass installation of such high-resolution surveillance equipment across every highway, avenue or intersection is impractical, especially for the low-income countries. The recently published National Road Safety Strategy 2018-2030 by the government of Pakistan has set forth the plan to install cameras for the surveillance of highways and roads, but in the capital cities only.[10] This is rather inequitable distribution of resources and a policy that is neglecting rural populations and non-capital cities where the documentation of RTAs and the availability of trauma care services are extraordinarily sub-standard.

Keeping in mind the aforementioned disparity and lack of resources to collect such huge amount of precise and accurate data, we present a data-driven strategy for the road safety management which utilizes intelligent systems to guide the resource-allocation process. This will ensure that resources and effort are only invested in areas where they are genuinely in need and can make a significant difference in road safety as a public health concern.

The model entails a preliminary identification of sites and locations, through the geo-mapping, where RTAs are rife, also referred to as "hotspots" (Figure). This can be achieved by employing a smartphone application for the rescue team or first responders where they can pin the location of the attending RTA or crash site with the aid of a global positioning system (GPS). Most modern vehicles also have an inbuilt GPS tracking system which can also provide accurate data. Through this simple and cost-effective mechanism, hotspots or sites of frequent crashes can be identified with great ease and accuracy. Various geostatistical methods are present in the literature which can identify the hotspots with accuracy by combining all the crash-related data.[11,12] Similarly, the hotspot identification can also be done by utilizing previous data from the government registries and crash records like the insurance claims etc. For this purpose, AI algorithms like natural language processing (NLP) and text mining can be utilized.[13] These are trained models for reading through and recognizing patterns from the written or spoken words and sentences, thereby simplifying the data extraction from sources like police papers, insurance claims, incident and media reports and medicolegal documentation by forensic experts.

Following the identification of crash hotspots, surveillance CCTV cameras with specialized sensors can be installed on selected high-risk road sections. This focused surveillance of high-risk locations will provide a huge amount of geospatial data related to future crash and near-miss events as well as the normal traffic flow patterns. Convolutional neural networks (CNN) are the type of DNNs which perform computational functions dealing with the visualization of imagery i.e. the detection of patterns from images and videos. Several CNN models have been developed and tested in other countries as well, which can process high-resolution imagery data with precision and accuracy to detect RTAs as well as identifying the spatio-temporal patterns and predictors for crash-events.[9,12]

As the data compilation goes on, this "big data" can be fed to the DL algorithms which will then identify the patterns and predictors of crash events and factors leading to fatalities from RTAs. Such DL techniques have also been tested to predict real-time traffic conflicts with accuracy.[14,15] It has also been reported in the literature that by combining two or more ML techniques in the traffic accident analysis, more accurate predictions can be generated.[16] Through identifying the patterns and predictors, ramifications like setting up new speed limits, imposing penalties for certain traffic rule violations,

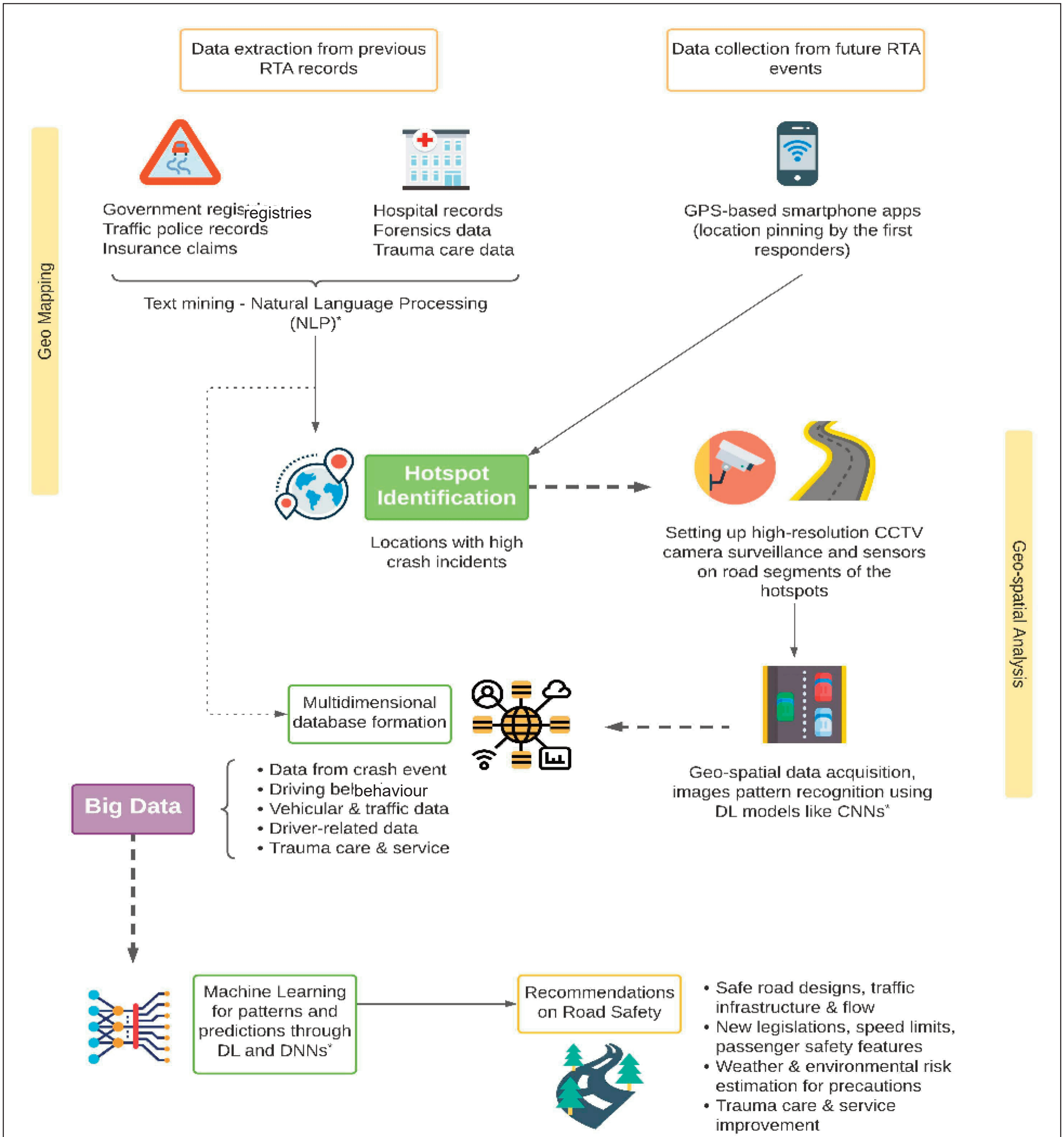

Figure: Model for road safety management utilizing the artificial intelligence with geo-mapping and geospatial data. CNN-convolutional neural network, DNN-deep neural network, NLP-natural language processing (Icons made by Freepik from @flaticon).

performing road safety legislation, upgrading trauma services and setting up new trauma centers can be made. Also, the faulty road infrastructure and malfunctioning designs can be rectified. Even so, artificially intelligent systems still cannot be relied on as a perfect solution to all RTA-related outcomes. Some variables like driver distraction are difficult to ascertain and leave a void in the risk assessment for RTAs. Although these systems have their own limitations, better results can still be obtained with the development of a vast database and high-resolution surveillance.

Geo-mapping followed by the focused surveillance of the crash hotspots will not only render the prediction modeling and risk factor evaluation, it will also encourage adherence to the traffic rules and regulations at particular locations. This intervention will be an effective measure to counter RTA incidents by imposing heavy fines and penalties on the violating road users. Such intervention is the need of the hour especially for resource limited countries like Pakistan where RTA trauma is a significant burden on the healthcare system and the numbers are still inflating with the growing population and vulnerable road users. Implementation of such intelligent systems will also help in achieving the targets set out by the United Nations General Assembly on Global Road Safety to halve the number of RTA deaths worldwide by 2030.[17]

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