# Module 2: Industry / Scholarly Review and References

## Literature Review: Accident Severity Prediction Using Machine Learning:

### **Current Industry trends:**

* Estimating the severity of traffic accidents accurately is crucial for both public health and traffic safety. Advanced prediction models are needed because of heavy vehicle traffic, variable weather, and complicated road conditions. By analyzing weather, road conditions, and driving behavior, machine learning—from simple algorithms to deep learning—can predict the severity of accidents (Çelik & Sevli, 2022; Zheng et al., 2018). Fourteen scholarly papers evaluate the trends, issues, and potential advancements in accident severity prediction.
* Current developments in CNNs, Decision Trees, and Logistic Regression can pinpoint the causes of accidents (Çelik & Sevli, 2022; Zheng et al., 2018). Predictive models are improved by include demographic and real-time meteorological data (Labib et al., 2019; Pińskwar et al., 2024). The field finds it difficult to adjust to changes in the world (Becker et al., 2022). This study discusses ways to improve and obstacles to impact research on accident severity prediction algorithms for road safety.

### **Machine Learning Techniques for Accident Severity:**

* As machine learning (ML) can handle complex parameter interactions, it is effective for analyzing large datasets to find trends in accident severity (Çelik & Sevli, 2022). Çelik and Sevli (2022) investigated the use of machine learning models (ML) to classify traffic accidents according to severity, including XGBoost, Random Forest, K-Nearest Neighbors, and SVM. At 88%, Logistic Regression was the most accurate model they had, demonstrating how simple models can detect accident severity factors (Çelik & Sevli, 2022).
* Although Logistic Regression is a simple model, Çelik and Sevli (2022) also looked at ensemble models that manage big datasets and nonlinear interactions well, such as XGBoost and Random Forest. Although Logistic Regression was not outperformed by these models in this study, their use indicates an increasing trend towards the use of complicated machine learning techniques in traffic safety evaluations (Çelik & Sevli, 2022). By mixing decision tree strengths, ensemble approaches such as Random Forest improve models (Labib et al., 2019). In order to determine the best dataset-aware accident severity prediction technique, the study focuses on testing several machine learning algorithms (Çelik & Sevli, 2022).
* Using machine learning techniques including Decision Tree, Naïve Bayes, KNN, and AdaBoost, Labib et al. (2019) categorized traffic incidents into groups such collision, fatal, grievous, and simple injury. Predictive accuracy can be increased by combining weak learners, as demonstrated by the superior performance of the ensemble learning model AdaBoost (Labib et al., 2019). AdaBoost's effectiveness demonstrates the need for many strategies in handling complex accident data connections. By looking at more factors than single-model approaches, ensemble learning enhances model prediction (Labib et al., 2019). This finding provides ensemble models for data on traffic accidents, which frequently include variables like weather, kind of vehicle, and driving style (Labib et al., 2019).

### **Deep Learning Approaches for Enhanced Prediction:**

* Accident severity projections were improved by recent advances in deep learning. Zheng et al. (2018) state that CNNs are particularly good at identifying intricate patterns in large datasets. In greyscale accident data, Zheng et al. (2018) used CNNs to identify complex feature associations. Deep learning has applications in road safety research because the Traffic Accident Severity Prediction-CNN model outperformed traditional techniques (Zheng et al., 2018).
* The prediction of accident severity is a novel application of CNNs, which are generally used for image processing (Zheng et al., 2018). According to Zheng et al. (2018), CNNs are able to visualize the relationship between accident severity and traffic density, road type, and weather. Zheng et al. (2018) found that deep learning enhances model performance for complicated datasets by automatically creating hierarchical representations from raw data.

### **Comparative Analysis of Machine Learning Models:**

* The optimal crash severity prediction methods were found by researchers by examining a variety of machine learning models (Malik et al., 2021). Six algorithms for predicting accident severity were analyzed by Malik et al. (2021): Random Forest, Decision Tree, Bagging, KNN, SVM, and Naïve Bayes. As demonstrated by their superior performance, Random Forest and Decision Tree techniques enhance traffic safety evaluations (Malik et al., 2021).
* In Random Forest, many decision trees decrease overfitting and increase accuracy (Malik et al., 2021). For the study of accident data on big datasets with lots of variables, this approach is perfect (Malik et al., 2021). Input variables and catastrophic consequences are explained by straightforward yet powerful decision trees (Malik et al., 2021). Malik et al. (2021) propose matching techniques to dataset attributes to improve severity forecasts.
* Behboudi et al. (2024) looked at machine learning-based improvements to traffic accident analysis. Model prediction is improved by include weather, traffic density, and road data (Behboudi et al., 2024). Several datasets aid models in understanding the complexity and seriousness of traffic accidents (Behboudi et al., 2024). Behboudi et al. (2024) emphasized that larger datasets and the integration of several data sources are essential for improved prediction in future models.

### **Influence of Weather Conditions on Accident Severity:**

* Traffic accident incidence and severity are significantly impacted by weather (Pisano et al., 2008). 24% of U.S. roadway crashes were caused by weather, per Pisano et al. (2008). The large share illustrates how driving safety is impacted by weather (Pisano et al., 2008). The severity of accidents is increased by weather-related impairments to visibility, traction on the roadway, and vehicle operation (Pisano et al., 2008). Road safety measures and risk assessment are enhanced by the use of real-time weather data in severity prediction algorithms (Pisano et al., 2008).
* In a different investigation, Pińskwar et al. (2024) looked at the effects of air pressure and temperature on road accidents in Wielkopolska, Poland. Research challenges the notion that "good weather" makes driving safer, demonstrating how temperature and pressure variations have a significant impact on road safety (Pińskwar et al., 2024). To increase accuracy across geographies and weather patterns, Pińskwar et al. (2024) suggest integrating extreme temperatures and pressure fluctuations in predictive models.

### **The Effects of Snowfalls and Rain:**

* Rain and snowfall have been researched in great detail because they make accidents more severe (Eisenberg & Warner, 2005). According to Eisenberg and Warner (2005), snowy days increase non-fatal and property damage accidents. Early snowfall increases risk, particularly for elderly drivers who might not be as accustomed to unexpected road conditions (Eisenberg & Warner, 2005). The findings highlight the need for preemptive actions and public awareness during the winter months, and they recommend that prediction algorithms take seasonal variations into account to increase accuracy (Eisenberg & Warner, 2005).
* According to Eisenberg's (2004) research, dry intervals increase the likelihood of rain and traffic accidents. A 1 cm rainfall two days and twenty days after the last rain raised the fatal crash rates by 3 and 9 percent, respectively (Eisenberg, 2004). According to these studies, complex weather patterns have an impact on traffic safety. Forecast models ought to incorporate precipitation incidence and timing in order to more accurately predict accident severity (Eisenberg, 2004).

### **The Risks of Warm Nights and Wet Days:**

* Research has been done on road safety during warm evenings and rainy days (Nazif-Munoz et al., 2021). According to Nazif-Munoz et al. (2021), these circumstances significantly increase the likelihood of crashes in Boston and Santo Domingo. While wet roads lower tire grip, particularly in unfamiliar regions, warm nights can impair driver awareness and vehicle performance, increasing the chance of an accident (Nazif-Munoz et al., 2021).
* According to Nazif-Munoz et al. (2021) the study recommends including climate data in accident severity models. Using seasonal trends, precipitation, and temperature data, these models forecast hazardous conditions and help transportation authorities implement safety precautions (Nazif-Munoz et al., 2021). Predicting accident severity may be improved by using traits that are suited to the climate (Nazif-Munoz et al., 2021).

### **Regional Variations and Driver Demographics:**

* When assessing the severity of an accident, regional variations and driver demographics are important considerations (AAA Foundation, 2015). Age-related data should be incorporated into prediction algorithms since, according to the AAA Foundation (2015), drivers who were 80 years of age or older and those who were 16–17 years old had higher crash rates. Age demographics can be added to models to improve targeted treatments, as evidenced by the result that driver experience, age, and behavior greatly affect accident likelihood and intensity (AAA Foundation, 2015).
* Crash severity is influenced by various local elements such as weather, traffic, and road infrastructure (Becker et al., 2022). Through the use of generalized additive models (GAM), Becker et al. (2022) discovered that single-truck crashes are more impacted by snow than single-car crashes are by rain. Multi-car collisions are much worse by sun glare, particularly on high-speed highways (Becker et al., 2022). According to Becker et al. (2022) these results imply that for better analysis, spatial and environmental factors should be included in accident severity models.

### **Best Practices for Road Safety Management:**

* Data-driven analysis is necessary to prevent traffic accidents. According to Labib et al. (2019), machine learning algorithms have the ability to forecast the severity of accidents in real time, which enables traffic management authorities to decide when and where to prevent accidents.
* Alghnam et al. (2022) recommended using datasets related to driver behavior, road attributes, traffic density, and weather for prediction models. According to Alghnam et al.'s (2022) research, a thorough examination of accidents can enhance the precision of models and the effectiveness of interventions. This, in turn, can enable traffic authorities to implement preventive measures, such as updates to road infrastructure.

### **Conclusion:**

* According to research, the severity of traffic accidents can be predicted using deep learning and ensemble machine learning models (Çelik & Sevli, 2022; Labib et al., 2019; Zheng et al., 2018). CNNs, Random Forests, and Logistic Regression can evaluate the severity of accidents using large datasets. Accuracy of the model is increased by including regional differences, driver demographics, and weather (Pińskwar et al., 2024; Becker et al., 2022).
* To enhance models, location-specific features and real-time data are required (Alghnam et al., 2022). In order to enhance accident severity prediction models and lower traffic accidents by implementing more effective traffic control strategies, future research should integrate a variety of data sources.

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