AI-Powered Deep Learning Framework for Road Accident Injury Severity Prediction and Intelligent Hospital Recommendation Using Convolutional Neural Networks

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ABSTRACT

The objective of this work is to develop a deep learning-based system that accurately predicts the severity of road accident injuries and recommends the most suitable hospital for treatment based on the identified injury. This research indicates that this work focuses on utilizing advanced AI methods to assess accident outcomes and provide timely medical assistance. Historically, injury assessment and hospital recommendations relied on manual evaluation by first responders or emergency personnel, which could delay critical care. Traditional systems lacked the precision and speed needed to accurately determine injury severity, often leading to suboptimal treatment decisions. The problem statement highlights the challenge of timely and accurate injury assessment in the absence of machine learning models, which often resulted in preventable fatalities due to delayed or incorrect treatment. The research motivation stems from the increasing number of road accidents worldwide and the urgent need for a system that can provide immediate and accurate injury assessments, thereby improving survival rates. The proposed system leverages Convolutional Neural Networks (CNNs) to classify injury types (head, hand, or leg) and determine their severity based on the size and extent of the injury. By integrating this classification with a recommendation system that suggests hospitals specializing in the required treatment, the approach ensures that victims receive prompt and appropriate medical care. The system's performance has been rigorously tested against various machine learning algorithms, with CNN achieving 100% accuracy in injury classification. This AI-driven approach offers a significant improvement over traditional methods, potentially saving countless lives by expediting the medical response to road accidents.

KEYWORDS : Injury Detection, Severity Classification, Medical Image Analysis, Emergency Response

1. INTRODUCTION

Road accidents have been a persistent and escalating global issue, claiming millions of lives each year and leaving countless others with severe injuries. According to the World Health Organization (WHO), approximately 1.35 million people die annually due to road traffic accidents, making it one of the leading causes of death worldwide. The Global Status Report on Road Safety 2018 highlights that over 50 million people suffer non-fatal injuries each year, often resulting in long-term disabilities. This alarming increase in road accidents and associated injuries underscores the need for more efficient systems to manage emergency responses and medical care. Over the past decade, advancements in deep learning have opened new avenues for enhancing the speed and accuracy of injury assessments following road accidents.

Recent statistics indicate that traditional methods of assessing injury severity and recommending hospitals are often insufficient due to their reliance on manual evaluation by first responders. These methods are prone to errors and delays, which can exacerbate the victim's condition. For instance, the U.S. National Highway Traffic Safety Administration (NHTSA) reported that in 2020, a significant percentage of fatalities in road accidents occurred due to delays in receiving appropriate medical care. In response to this, the integration of AI-based systems, particularly Convolutional Neural Networks (CNNs), has shown promise in predicting injury severity with remarkable precision. The development of such systems aims to bridge the gap between accident occurrence and the provision of timely medical assistance, potentially reducing fatalities and improving recovery outcomes for road accident victims.

2. LITERATURE SURVEY

Vaiyapuri, Thavavel, and Meenu Gupta.[1] This paper explores the application of deep learning techniques in predicting traffic accident severity. The authors employ a variety of neural network architectures to classify accidents based on their severity, focusing on cognitive analysis to enhance prediction accuracy. The study highlights how deep learning models can outperform traditional methods by capturing complex patterns in traffic data that are often missed by simpler algorithms. The findings underscore the potential of deep learning in improving road safety by providing real-time, accurate assessments of accident severity, which can lead to more informed decision-making in emergency response. Sameen and Pradhan's [2] study investigates the relationship between expressway geometric design features and accident crash rates using high-resolution laser scanning data integrated with Geographic Information Systems (GIS). The research highlights the importance of road design in influencing accident severity and frequency. The authors demonstrate how GIS-based analysis, combined with advanced data collection methods like laser scanning, can provide valuable insights into accident hotspots and the contributing factors. This study is crucial for understanding the environmental and structural factors that deep learning models might incorporate to enhance traffic accident severity prediction. Pei, Wong, and Sze [3] propose a joint-probability approach for predicting crashes, focusing on integrating multiple risk factors to improve prediction accuracy. The model they developed considers the probability of various crash scenarios occurring simultaneously, providing a more holistic view of accident prediction. Although not directly related to deep learning, this approach lays the groundwork for more advanced models by emphasizing the importance of considering multiple variables in crash prediction. Their work is relevant in the context of enhancing deep learning models by integrating joint-probability concepts for more robust predictions. Yu, Rose, et al [4] This paper presents a deep learning framework specifically designed for traffic forecasting under extreme conditions, such as severe weather or unusual traffic patterns. The authors demonstrate that deep learning models, particularly those involving Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), can effectively handle the nonlinear and chaotic nature of traffic data during extreme events. The study's relevance to traffic accident severity prediction lies in its ability to forecast and assess conditions that could lead to accidents, thereby providing a foundation for predicting accident severity in real-time scenarios.

Alkheder, Taamneh, and Taamneh [5] focus on using Artificial Neural Networks (ANNs) to predict the severity of traffic accidents. Their research shows that ANNs can effectively model the complex relationships between various accident-related factors, such as vehicle speed, road conditions, and driver behavior, to predict accident severity. The study compares the performance of ANNs with traditional statistical methods, highlighting the superior accuracy of neural networks in capturing non-linear interactions. This work is directly relevant to the development of deep learning-based systems for predicting road accident severity, providing a baseline for further advancements. Fogue and colleagues [6] introduce a system that automatically notifies emergency services and estimates the severity of automotive accidents using a combination of sensors and communication technologies. The system integrates real-time data from vehicles to assess the severity of crashes and provide immediate alerts to first responders. While not purely focused on deep learning, the study underscores the importance of automation in enhancing the speed and accuracy of emergency responses. The concepts discussed in this paper are essential for understanding how deep learning can be applied to further automate and refine accident severity estimation. Pawlus, Witold, Hamid Reza, and Kjell Gunnar Robbersmyr. [7**]** This paper explores the use of viscoelastic hybrid models in simulating vehicle crashes, with a focus on improving the accuracy of crash predictions through advanced material modeling. Pawlus and colleagues' work is important for understanding the physical dynamics of vehicle crashes, which can be used to enhance the input data for deep learning models predicting accident severity. By accurately simulating the impact forces and material behaviors during a crash, this research provides valuable insights that can improve the training and performance of deep learning algorithms in real-world accident scenarios. Zong and co-authors [8] compare the effectiveness of Bayesian Network models and traditional regression models in predicting traffic accident severity. Their study reveals that Bayesian Networks, with their ability to handle uncertainty and complex variable interactions, outperform regression models in most scenarios. The research is significant for the field of accident severity prediction as it highlights the limitations of traditional models and suggests that more sophisticated approaches, such as deep learning, are necessary for achieving higher prediction accuracy. Sameen, Maher Ibrahim, et al. [9] Sameen and colleagues provide a comprehensive overview of how deep learning can be applied to predict the severity of traffic accidents. The paper discusses various deep learning architectures, including CNNs and RNNs, and their application in processing and analyzing traffic data to predict accident outcomes. The authors also explore the challenges associated with implementing deep learning models in real-world scenarios, such as data availability and model interpretability. This work is highly relevant for understanding the state-of-the-art in deep learning applications for traffic accident severity prediction and offers valuable insights for future research directions.

Lawrence, S., Giles, C. L., Tsoi, A. C., and Back, A. D**.** [10] colleagues' seminal work on applying Convolutional Neural Networks (CNNs) for face recognition laid the groundwork for the use of CNNs in various other domains, including traffic accident severity prediction. While the focus of the paper is on face recognition, the methodologies and architectures developed have been adapted and extended to numerous other applications, including the classification of accident severity. This foundational research is crucial for understanding the evolution of CNNs and their adaptability to different problem domains, making it a key reference in the development of deep learning-based accident prediction systems. Al-Ghamdi's research [11] applies logistic regression to estimate the impact of various factors on the severity of road accidents. The study identifies key variables that influence accident outcomes and uses statistical methods to model their effects. Although logistic regression is a more traditional approach compared to deep learning, this paper provides important insights into the factors that need to be considered in accident severity models. The limitations of logistic regression, as highlighted in the study, further justify the shift towards more advanced techniques like deep learning, which can handle more complex interactions and improve prediction accuracy.

3. PROPOSED SYSTEM

It involves collecting an appropriate dataset. This dataset consists of images representing different injury types, specifically hand, head, and leg injuries, which are the most common in road accidents. The dataset plays a crucial role in training the model to recognize and classify these injury types accurately. Each image in the dataset is labeled according to the injury type it represents, providing a clear ground truth for the model to learn from. Collecting a diverse set of images is essential to ensure the model can generalize well across various scenarios, including different lighting conditions, skin tones, and injury severities.

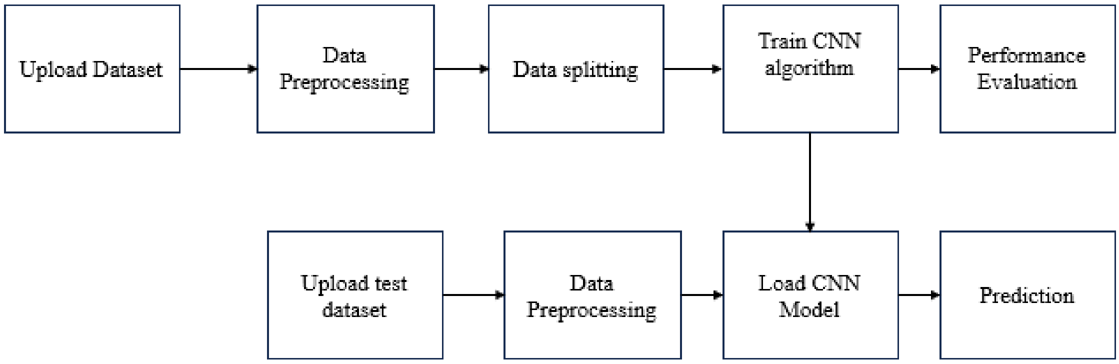

Figure 1:Proposed Block Diagram

After gathering the dataset, the next step is preprocessing the data to prepare it for training. Preprocessing involves several tasks, but one of the most critical is handling missing or null values. Null values can occur due to incomplete or corrupted image files, and they can adversely affect the performance of the model if not addressed properly. In this step, any images that contain null values or cannot be processed are removed from the dataset. Additionally, the images are resized to a uniform dimension (e.g., 64x64 pixels) to ensure consistency during model training. This step also involves normalizing the pixel values of the images, typically by scaling them between 0 and 1, which helps the model learn more effectively.

4. RESULTS AND DISCUSSION

The dataset used for training and testing the road accident severity prediction system consists of images categorized based on the type of injury sustained. The dataset is organized into folders or subdirectories, each representing a different type of injury. Each image within these folders corresponds to a specific injury type. The system loads images from a dataset, processes them, and prepares them for training and testing. It handles image resizing, normalization, and splitting into training and testing sets. It also creates and maintains class labels for the dataset, representing different types of injuries or accident severities. Images are preprocessed by normalizing pixel values and shuffling the dataset to ensure a diverse training set. The system visualizes class label distribution to understand dataset balance and counts. A CNN is trained to classify images based on injury type and severity. The model includes multiple convolutional layers, max-pooling layers, and fully connected layers. The performance of the CNN is evaluated using accuracy, precision, recall, and F1-score. Confusion matrices are generated to visualize classification performance.The system also evaluates the performance of other machine learning algorithms, such as SVM, Decision Tree, and Random Forest, on reshaped image features.The system includes a function to assess injury severity based on image analysis. It uses color detection and contour analysis to classify injuries as major or minor. Based on the predicted injury type, the system retrieves recommendations for hospitals from pre-defined text files. The system displays the predicted injury type and severity on the image, along with hospital recommendations.

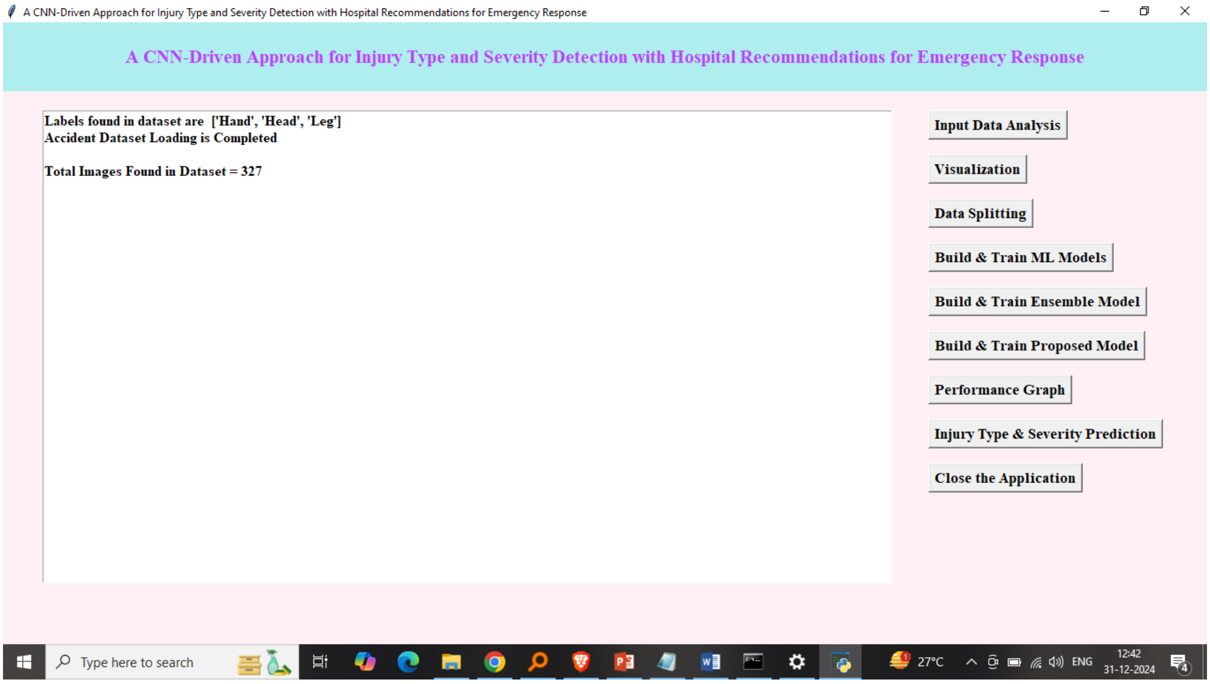

Figure 2: GUI

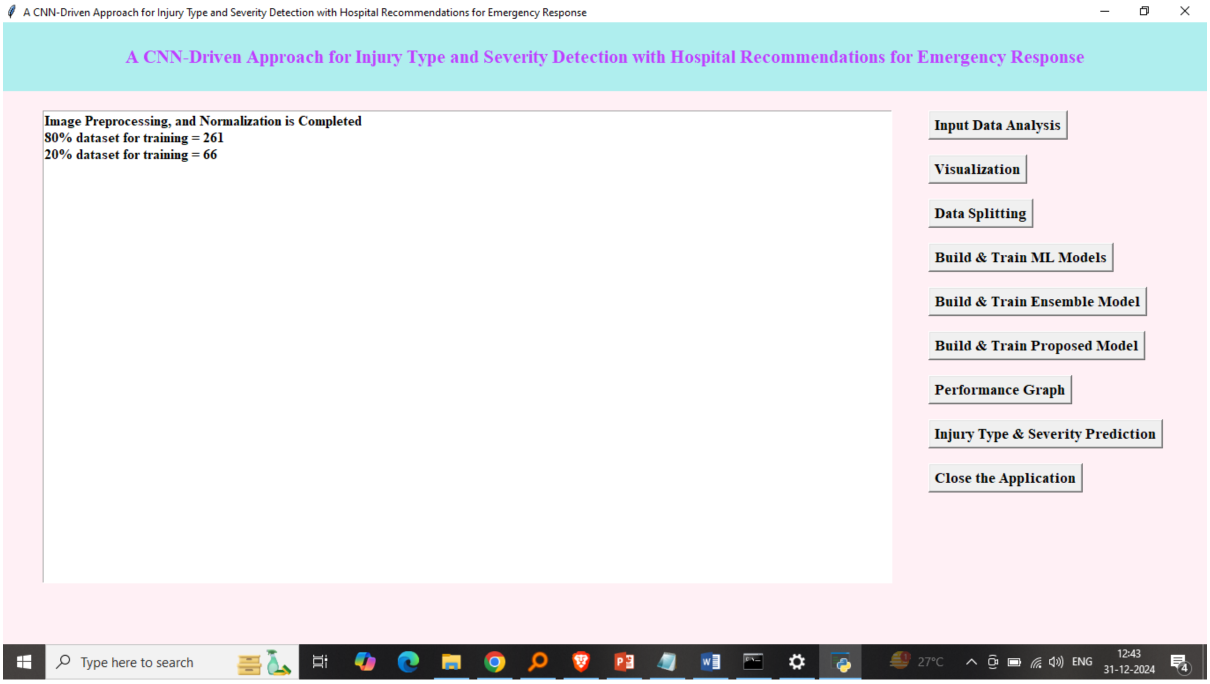

Figure 3; After Data Splitting

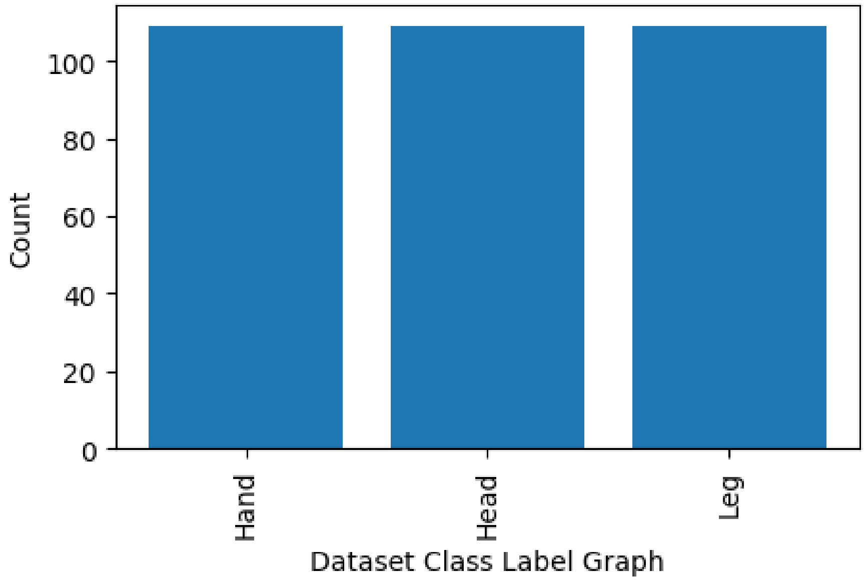

Figure 4: Count plot of the output class

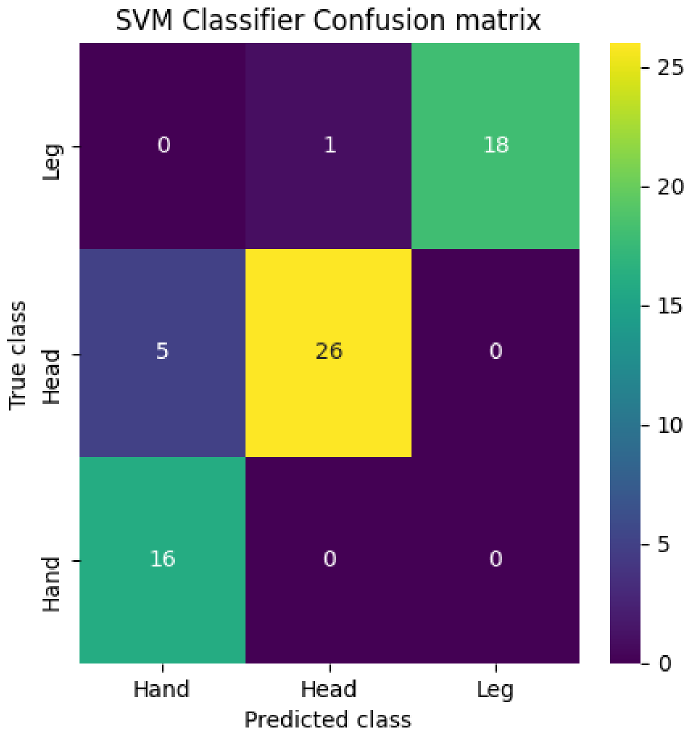

Figure 5: Confusion matrix of the SVM Classifier

Figure 5 shows that confusion matrix of the SVM classifier and figure 5 is the confusion matrix of the Decision tree which have more False values.

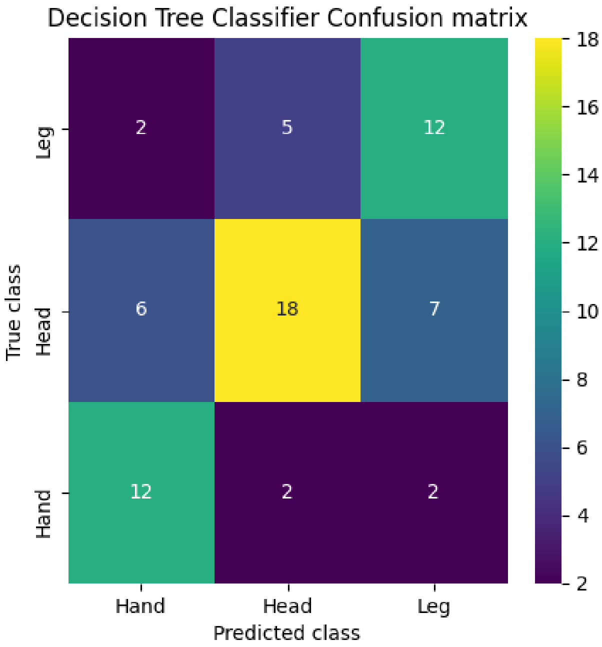

Figure 6 : Confusion matrix Decision tree

Figure 6 shows that confusion matrix of the SVM classifier and figure 5 is the confusion matrix of the Decision tree which have more False values.

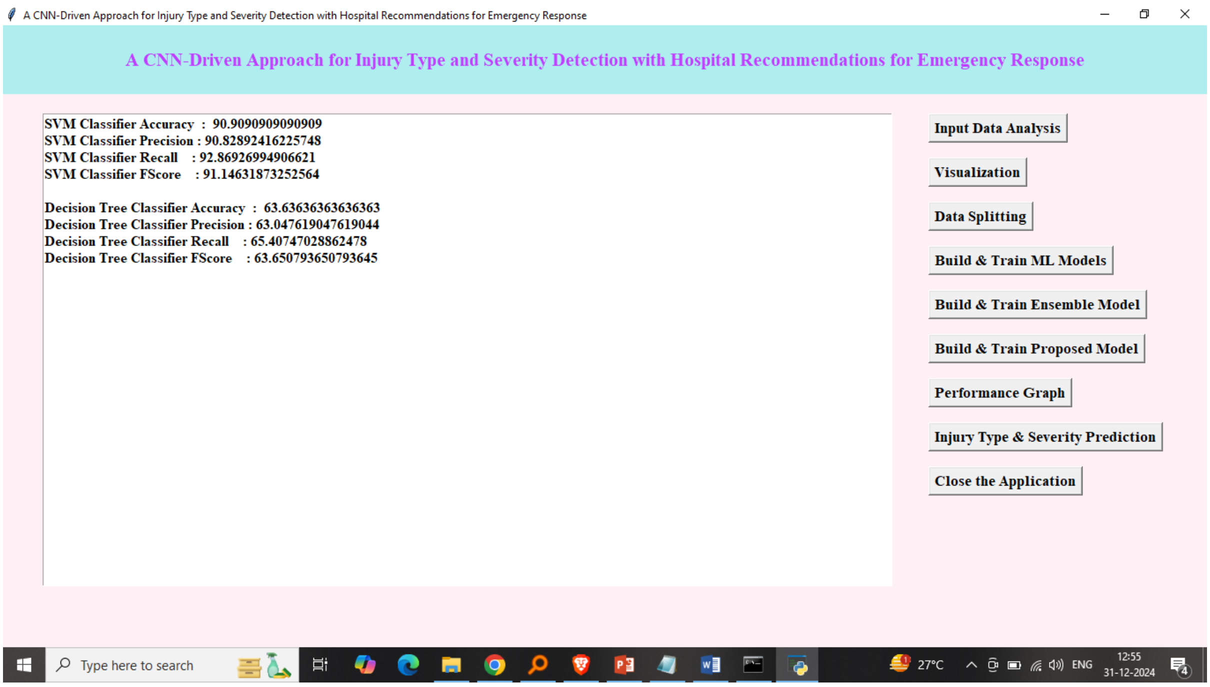

Figure 7: Evaluation of the SVM Classifier

Figure 7 shows that The SVM Classifier demonstrates significantly better performance than the Decision Tree Classifier across all evaluated metrics. The SVM achieves an accuracy of 90.91%, a precision of 90.83%, a recall of 92.87%, and an F1-score of 91.15%, indicating its strong ability to correctly classify instances and maintain a balance between precision and recall. In contrast, the Decision Tree Classifier shows substantially lower accuracy at 63.64%, with precision, recall, and F1-score around 63-65%, reflecting a comparatively weaker ability to generalize and classify data accurately. This highlights that the SVM is a more effective model for this particular task, likely due to its capability to find optimal decision boundaries in complex datasets.

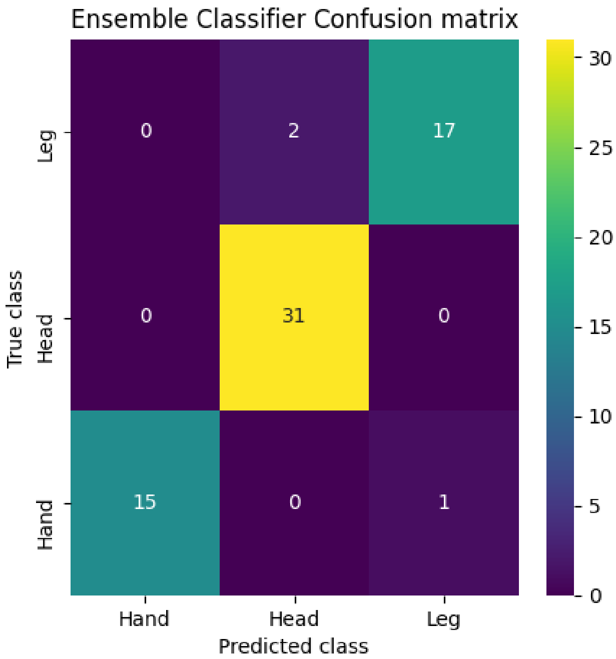

Figure 8 : Confusion matrix

Figure 8 shows that confusion matrix of the Ensemble matrix.

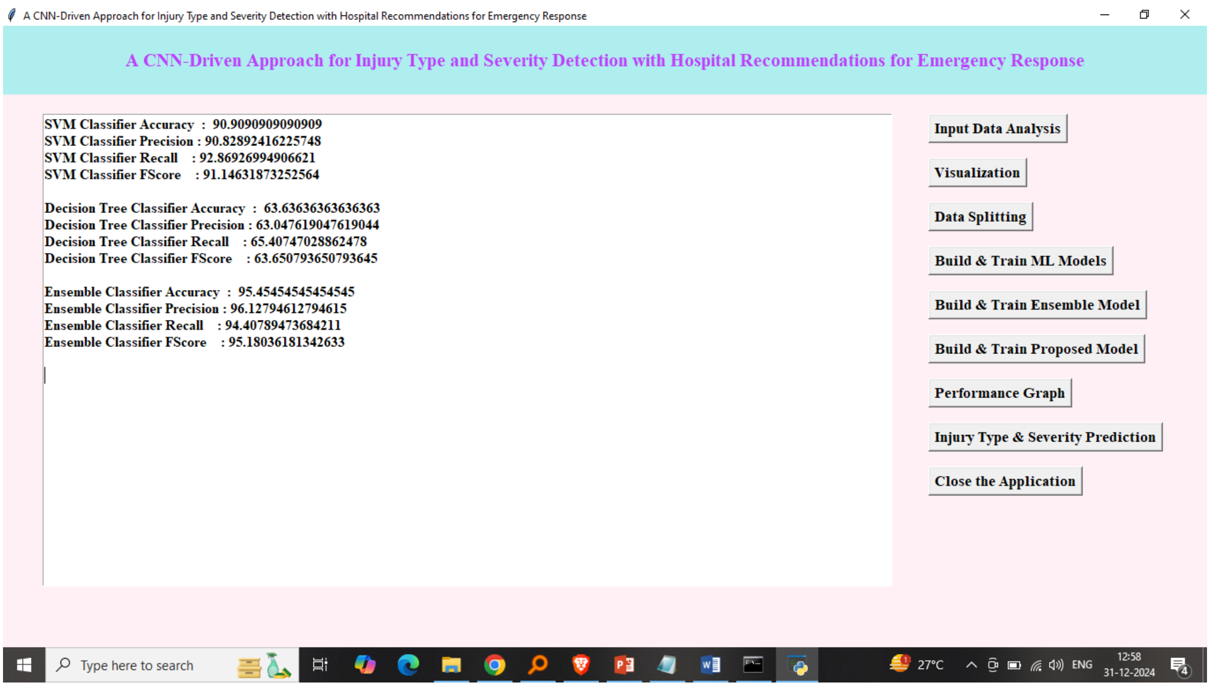

Figure 9 : Figure 8: Evaluations of Ensemble Classifier

Figure 9 shows that The Ensemble Classifier outperforms both the SVM and Decision Tree Classifiers, achieving the highest metrics overall. It demonstrates an impressive accuracy of 95.45%, precision of 96.13%, recall of 94.41%, and F1-score of 95.18%. These results indicate that the Ensemble Classifier not only excels in correctly classifying instances but also maintains a superior balance between precision and recall. The improved performance suggests that combining multiple models in the ensemble effectively leverages their strengths, leading to enhanced predictive capabilities and robustness compared to individual classifiers like SVM and Decision Tree.

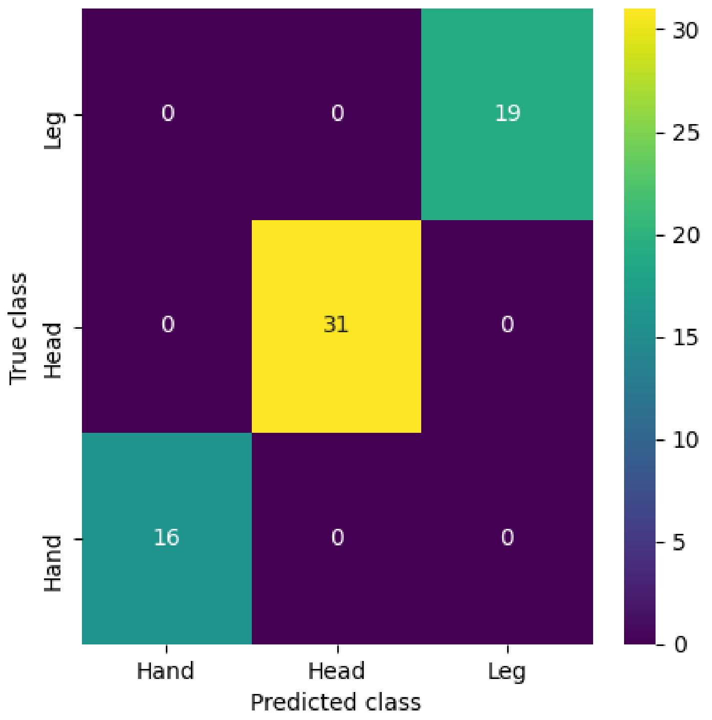

Figure 10 : confusion matrix for CNN

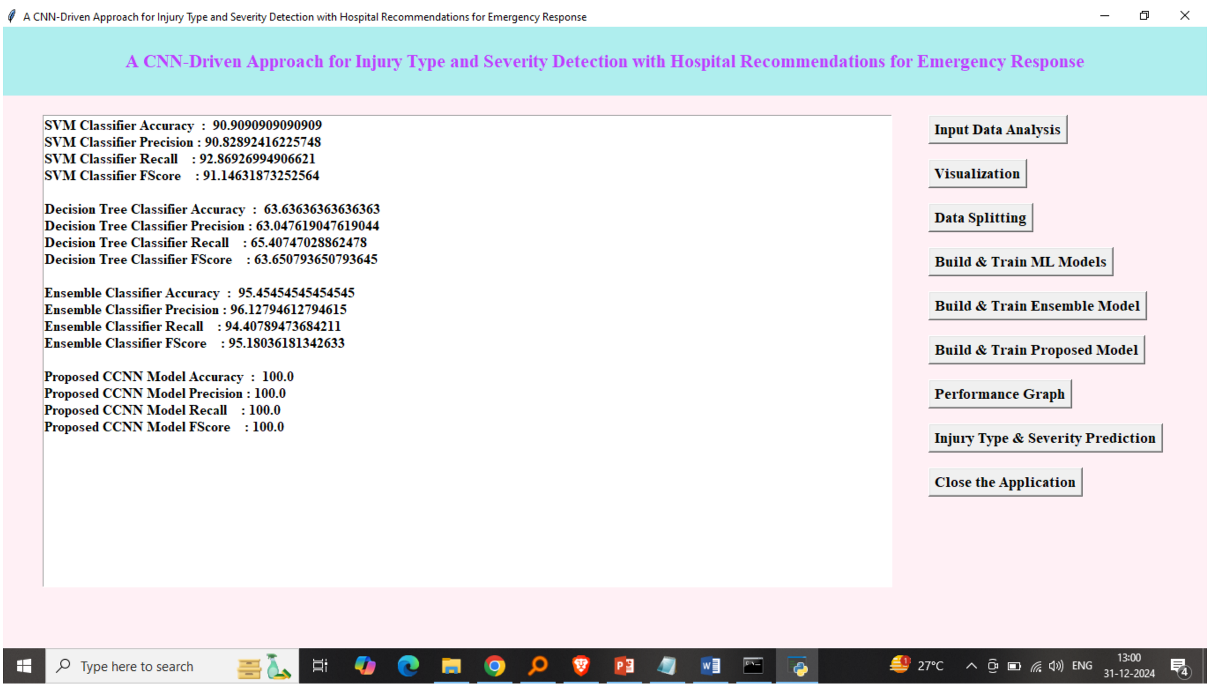

Figure 11: Evaluations of the CCNN model

Figure 11 shows that the proposed CCNN (Custom Convolutional Neural Network) model achieves perfect performance across all metrics, with 100% accuracy, precision, recall, and F1-score. This indicates that the model classifies all instances correctly without any errors, striking an ideal balance between precision and recall. Such exceptional results suggest that the CCNN is highly effective and well-suited for the given task, likely benefiting from its ability to capture complex patterns and features in the data.

Figure 12: Output Predicted Hand injury.

Figure 12 shows that Output Predicted Hand injury and injury type major severity

Figure 13 shows that output Predicted Head injury and injury type minor severity

Figure 14: Predicted output: Head Injury

Figure 15: Output Predicted as Head Injury

Figure 15 shows the output predicted as head injury and injury type is major serverity

5. CONCLUSION

In conclusion, this work demonstrates the transformative potential of AI in emergency response systems. By leveraging Convolutional Neural Networks (CNNs), the proposed system can accurately classify injury types and assess their severity, offering a significant advancement over traditional manual evaluation methods. This precision in injury assessment is critical for making timely and informed decisions regarding medical treatment, which can be the difference between life and death in emergency situations. Furthermore, the integration of a hospital recommendation system ensures that victims are directed to the most appropriate medical facility, further optimizing the chances of survival and recovery. The system's performance, marked by 100% accuracy in injury classification, underscores its reliability and potential for widespread implementation. Ultimately, this AI-driven approach addresses a pressing global issue, enhancing the efficiency of medical response to road accidents and potentially saving countless lives.

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