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Deep Learning-Based Pedestrians Controlling System on Zebra Crossing

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Abstract:

The 'Vision zero' goal represents the apex of the European Commission's road safety plan, and enhancing road safety is seen as a primary objective by governments and transport policymakers across the globe. Due to the greater death rate associated with crashes involving pedestrians, this vulnerable user group has been the focus of increased study. Consequently, there is a growing need for studies that examine pedestrian behavior and the implementation of Intelligent Transport Systems designed to aid pedestrians. Using a Countdown Signal Timer (CST) and some machine learning techniques, this research aims to forecast how pedestrians would behave at crossings. Presenting this case study is an analysis of a simulated environment model intersection with pedestrian traffic lights equipped with countdown signal timings. An X-Convolutional Neural Network (X-CNN) and a decision-making model were both employed to meet the requirements of the analysis. Both models demonstrated satisfactory performance, according to the results. To be more specific, the X-CNN model used a Mean Squared Error value to predict the pedestrians' crossing speed. By accurately predicting how pedestrians cross the street, we may learn more about the impact of countdown signal timers and how to improve infrastructure safety for this demographic so that they receive timely and relevant information through the speaker.

Keywords: Countdown Signal Timer (CST), Machine Learning, X-Convolutional Neural Network (X-CNN), Decision making.

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I. INTRODUCTION

As technology evolves over time, it has a tendency to drastically alter the world that contemporary people experience. These days, tech-dependent "smart cities" are rapidly rising in importance and are quickly becoming an absolute must. Every society revolves around its residents; they are the bedrock upon which decisions are built and infrastructure is structured to better meet human needs. Providing a great quality of life for the people who live in modern cities is their ultimate goal. The longevity of transportation networks and the state of various forms of transportation are important factors in determining people's quality of life. With the goal of implementing sustainable mobility, numerous researchers have performed various surveys pertaining to transportation issues and offered relevant services. In particular, they have studied traffic congestion under a wide range of scenarios, as well as public transportation operating conditions (such as service quality and the ratio of a mode's occupancy to its capacity), the rise in road accidents after their warning system went live, and every other aspect of transportation systems. Researchers and those in control have so used a wide range of technical instruments to solve related issues in the best possible way. These technical discoveries may play a pivotal role in establishing the parameters for sustainable mobility.

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Research utilizing cutting-edge methodologies and novel approaches has proliferated, especially in the transportation sector. Among the many important and intriguing approaches is the use of Artificial Neural Networks (ANN) in machine learning. Many academics are interested in this branch of AI because of the wide variety of uses for these models and their adaptability; they can handle a wide range of situations with relative ease. The excellent prediction accuracy rates offered by these models are a strong argument in their favor as a tool for accurate forecasting. Logistic Regression is another powerful machine learning method, particularly for categorization issues. This study set out to look at how well Deep Learning models work for transportation issues, specifically how well they can be used to enhance transportation systems through the use of their predictive capabilities. The most defenseless road users in densely populated regions are pedestrians; we addressed this issue by applying multiple deep learning models. The purpose of this study was to analyze pedestrian kinematic and crossing behavior at a crossroads equipped with a Countdown Signal Timer (CST). In addition to gathering valuable data for pedestrian behavior classification, the research sought to uncover promising results for enhancing pedestrian road safety. Here is the outline of the paper: First, we present some evidence on the novel and efficient application of ANN approaches in a variety of modern city mobility challenges by citing a brief literature review of previous research. Afterwards, the theoretical foundation is laid out to showcase some aspects of the models that were created for this study. Following that, the case study is examined, detailing the data gathering and processing steps, along with the creation of the models. Here we summarize the paper's findings and then draw some inferences. The development of intelligent transportation systems in recent years has aimed to alleviate many problems associated with traffic, including congestion in urban areas, injuries and fatalities caused by accidents, excessive fuel use, pollution, and so on. For a variety of uses, these systems draw on a wide range of technologies, such as the Internet of Things (IoT), neural networks, deep learning, image processing, and machine learning and data mining. Contrarily, tech and automotive behemoths like Google and Tesla are working on autonomous smart cars that can keep drivers and passengers safe even when they're nodding off, thanks to accident-prevention technology built into the vehicle. In order to avoid accidents, these vehicles need sensors that can detect their surroundings, identify nearby objects, and alert the driver. They need also have actuators that can respond in real-time when the driver is sleepy or distracted. The following are examples of some of the most significant challenges associated with producing autonomous vehicles:

- The inability to reliably detect people and barriers in a variety of lighting conditions and picture quality settings;
- The possibility of human mistake while detecting pedestrians and other obstacles in the way of autonomous vehicles
- The general public's mistrust of autonomous vehicles The unwillingness to entrust humans with the constant monitoring and control of urban and interurban roads
- The detrimental impact of bad lighting, snow, ice, fog, and rain on the quality and performance of in-car cameras, leading to less accurate detection of pedestrians and other obstacles
- The dearth of appropriate infrastructure to support intelligent transportation on all urban and interurban roads
- The exorbitant expense of establishing the communication networks required to link vehicles to each other (V2V) and vehicles to roadside infrastructure (V2I) Machine learning (ML) is a subfield of AI that relies on statistical methods to discover previously unknown patterns in data and draw conclusions about previously unseen records. A machine learner's primary responsibility is to construct a general model based on the distribution of training examples and to extrapolate that model to new, unknown examples. The accuracy of the presented facts is crucial to the educational process. A dataset with various attributes is used to illustrate the point. Unfortunately, not all tasks lend themselves well to feature extraction.

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- The goal of deep learning, a subfield of machine learning, is to find more complex representations of simpler ones. Artificial neural networks with several hidden layers of nonlinear processing units form the basis of deep learning methods. The term "deep" describes the use of multiple hidden layers to alter the presentation of data. Each hidden layer of a neural network uses feature learning to plot its input data in a new display. Each layer is able to absorb a higher level of abstraction than the one before it. The output of the machine learning task is mapped to the hierarchy of features learned at several levels in a single framework in deep learning systems. Unsupervised learning methods and supervised learning approaches, such as deep neural networks, make comprise the two main branches of deep learning architecture, much as ML methodologies. There are five parts to this study. Intelligent transportation systems are described in detail in the second part. Section 3 gives a high-level introduction to deep learning and its uses. In the fourth section, we outline the application of deep learning to smart city and intelligent transportation system pedestrian identification, discuss the work of different scholars in this area, and list the obstacles faced by each subfield. Lastly, we shall present the conclusion in the fifth section.

[1] In this study, Rajashekhar V. S. et al. suggest a new method for determining the degrees of freedom for a mechanism. One name for it is the zebra crossing technique. We make a zebra crossing diagram out of the mechanism we built. Counts of loops are computed. A good formula for determining degrees of freedom is selected according to the mechanism's kind and the amount of loops. It is used to determine the mechanism's degrees of freedom. This fast approach can be used for any mechanism, as far as the authors are aware. The zebra crossing method can be used to find fourteen mechanisms, some of which have degrees of freedom that cannot be found using methods already published in the literature. Consequently, the outcomes produced by this zebra crossing technique are precise.

[2] According to the research by Teklu Wodajo et al., a model was created to estimate the speed at which pedestrians cross roads by taking into account the factors that have a significant impact. The study evaluated the behavior of pedestrians on specific segments of roads. In addition, the author's pace at which pedestrians cross roads and the utilization of zebra-marked crosswalks were determined, taking into account both actual and potential human factors. Video cameras placed at strategic points on the chosen portions recorded the data author. After then, the creator of the video was taken out and examined. primary focus, and the significance of drivers' interactions with the demands of other road users. A large number of people are seen crossing the street without a permit. The cause could be due to design, human behavior, environmental variables, or a mix of these. Policymakers and road users can utilize this model to forecast how fast pedestrians will be crossing uncontrolled cry sections and segments in the middle of blocks. Further applications of the study's findings include urban planning, comparative analysis, and the determination of crossing speeds in future research.

[3] Ruth Madigan et al. describe the Previous studies have demonstrated that pedestrians using an eHMI are more likely to make an early decision to cross the street when faced with an AV. Little research has examined how different types of crossing infrastructure or the direction in which autonomous vehicles approach affect pedestrian behavior. A pedestrian crossing, the approach direction of an automated vehicle (AV), the yielding behavior of an AV, and a new external Human Machine Interface (eHMI) were all factors in this CAVE-based pedestrian simulator study that looked at how pedestrians made judgments at a four-way crossroads. A pedestrian simulator experiment, an online interview, and a brief questionnaire were the components of a multi-

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method study that thirty-eight individuals participated in. Whether or not a zebra crossing was present, as well as the availability of necessary infrastructure and clear channels of communication for potential AV applications, were the primary independent variables. The present study's findings expand upon previous one by indicating that pedestrians would gain the most from eHMIs in scenarios when they are unsure of what to do, there is no obvious right of way, and they will need to negotiate with drivers. Therefore, in real-world scenarios or near various types of intersections, future research should investigate how eHMIs could amplify the influence of kinematic signals, like edging or slow-moving behavior.

The study is structured into five parts. We present a comprehensive overview of ITS in the second section. A concise introduction to deep learning and its uses is given in Section 3. Section 4 details how smart cities and ITS make use of deep learning to detect pedestrians, summarises the work of several academics in the area, and lays out the obstacles to further study in each subfield. Next, in Section 5, we shall present the final verdict.

II. LITERATURE SURVEY

[4] Pedestrian crossing safety and the effects of several types of side road entry treatments have been the subject of several research, as recounted by Geoffrey R. Browne et al. Nevertheless, this study stands out by examining the broader behavioral impacts of treating only some side roads, rather than all of them. We hypothesized that people's lack of knowledge about these seemingly irrational road regulations could have unintended negative effects on walkability, and we tested that idea in this study. Two of the most significant takeaways from this study are 1) the widespread lack of rule knowledge among road users and 2) the widespread agreement among respondents that it would be beneficial to modify the laws such that drivers must yield to people crossing the street at stop lines. It is suggested by these two pieces of evidence, together with additional supporting evidence, that cars may mistakenly think they are exempt from giving way to pedestrians at T-intersections without zebras. It further implies that the treatment would be unnecessary if the regulations were changed in the manner stated above, since it would create a universal and clear responsibility to yield to pedestrians at T-intersections.

[5] The percentage of elderly people walking in the city and the area examined was drastically reduced, according to Tiziana Campisi et al., who explain that this was due to a combination of factors, including stricter regulations at the national and local levels, a rise in the number of COVID-19 positive admissions, particularly among the elderly, and stricter monitoring of the monitored population. Furthermore, the author saw a significant disparity across the four classes when it came to the issue of talking on one's phone while crossing the street, among other typical pedestrian crossing behaviors. According to estimates, this was the most effective in slowing people down, particularly younger ones and the elderly, when compared to other activities that could compromise their safety. In terms of walking speed, the monitoring showed that young people's speeds dropped by 0.44 m/s, while children's speeds dropped by 0.2 m/s, adults' speeds dropped by 0.07 m/s, and the elderly's speeds dropped by 0.01 m/s. Whether looking at trends between adults and youth or between children and the elderly, it is clear that all three tasks performed simultaneously while crossing the road exhibit very similar patterns. On the whole, pedestrians' speeds drop to 0.6 m/s when older persons cross the street while talking on the phone, while authors using headphones or similar devices see a similar drop to 0.69 m/s.The findings lay the groundwork for future studies on road crossing safety, which should lead to better crosswalk and surrounding area urban planning.

[6] A study that looked at how often people used zebra crossings in Malaysian cities was described by Walid Abdullah Al Bargi et al. Pedestrians' comprehension of and adherence to zebra crossing facilities varies greatly depending on a number of circumstances, including the unique qualities of each place. The necessary data for this study was gathered through user surveys and the observation

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of pedestrian movement at twelve separate locations. According to the results, reasons for the low level of pedestrian zebra crossing utilization include the width of the crossing, the number of lanes, and the absence of a guardrail. Providing this facility should take into account the location of the zebra crossing and guardrail, as well as the width of the roadway (greater than two lanes), in order to promote a high utilization rate. Researchers hope that by informing policymakers, drivers, and pedestrians about the study's findings, they can help make crossings safer for everyone.

[7] This study was carried out by Azlina Ismail et al. to analyze pedestrian behaviors at unsignalized zebra crossings on campus. In addition, the results of this study provide light on how pedestrians view the efficiency of the crossing. This study's findings show that the unsignalized zebra crossing at UMP Gam bang campus is adequate. In terms of efficiency, security, and connection, the majority of respondents to the author's survey felt that the crossing facility had fulfilled its functional requirements. Based on these results, it appears that the user's responses and their actual crossing behavior are fairly consistent. Results show that 98% of pedestrians use the appropriate zebra crossing when crossing the street.

[8] In their explanation of image processing concepts, Chen Zhu, Dong-Yuan Ge, and colleagues use a suite of algorithms that, once thresholded, allow for near-automatic processing of incoming images with minimal human intervention. In this study, the zebra crossing is detected using the principle of VP detection by CHT. From an experimental standpoint, it is clear that the CHT algorithm outperforms the HT method when it comes to detecting straight lines and VP, both in terms of speed and accuracy. Simultaneously, the VP can be employed to remove the interference line segment, lending credence to the precision of zebra-crossing detection. For some use scenarios, this approach provides a reference for road detection by obtaining zebra-crossing location information without ROI extraction. Using ROI to extract a detection target that includes VPs and the entire zebra crossing region will undoubtedly enhance detection efficiency.After that, the author will dig deeper into ways to make the algorithm faster and more accurate at detecting objects, as well as ways to remove noise from images.

[9] Walking for transport and walkability are gaining traction in urban development plans, according to T. Bozovic et al., but there are two big problems: first, there isn't a universal agreement on what makes people least likely to walk, and second, there's a pressing need to prioritize retrofitting, particularly in areas that are heavily populated by cars and may not be considered walkable. By combining first-hand accounts of obstacles to walking with objective measurements and technological suggestions and guidance, this study provides a potential next step toward a more realistic approach. Using three criteria—cornering radii, complexity, and traffic volumes—the results give a baseline for what constitutes a non-signalized crossing that is considered unwalkable. A more complex approach to crossings that takes into account the interaction between many elements is suggested by a critical evaluation of the guidelines. However, it is also suggested that there should be "non-walkability guidelines" to assist professionals responsible for walkability in identifying the most important non-walkable features.It is also proposed the methods used here be extended to other elements of walking environments that are viewed as impediments to walking, such as narrow/obstructed sidewalks, car-dominated streets or roads with inadequate natural surveillance, or insufficient lighting. To further characterize hazardous non-signalized crossings, future study should take into account the perspectives of persons of varying ages and abilities residing in various car-dominated cities.

[10] In a real-world, naturalistic investigation, 269 crossing events were observed at a pedestrian crossing that included a ground-mounted lighting intervention. Additionally, a small sample of crossing users provided experiential data. This information is provided by Madeline Hallewell et al. Using a coding approach developed from prior research, we examined the observational data for possible influences on crossing behaviors. It

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appears that these activities and contextual factors had no effect on the behavioral reactions of people whose crossing habits were the subject of the investigation. While the survey findings are from a smaller sample, the information gathered from users is still valuable. Although perceptions of the lights may have been influenced by varying ambient lighting conditions, many individuals appreciated and comprehended the crossing's safety-related purpose. It follows that the lighting intervention may encourage safer conduct at crossings and keep it up. To determine effectiveness, though, additional testing is required. Limitation\Looking Ahead: Additionally, the work adds to the broader conversation on pedestrian surveillance techniques. constraints on what could be observed in this study were present, and many of these constraints were outside the control of the researcher. One must choose between collecting data on a finer level of detail and a broader field in order to conduct a low-cost, short-timescale investigation. Some technological solutions to these problems have been proposed for use in future studies.

[11] The eleventh A zebra crossing is a traffic marking that indicates a pedestrian crossing path, according to Dina Uzlifatul Firdaus et al. Directly across from the line borders, zebra crossings indicate that automobiles must come to a complete stop. Motorists and pedestrians alike are expected to be aware of and compliant with the current traffic signs, as the zebra crossing serves as a crossing area. Worldwide, 270,000 people lose their lives as pedestrians each year, making up around 22 percent of all fatalities caused by traffic accidents, according to statistics compiled by the World Health Organization (WHO). To tackle this issue, a system was designed using an ESP32-Cam microcontroller, an E18-D80NK Infrared Proximity Sensor, water spray, and buzzer techniques. The inventor of the prototype development method was also involved in the process. When a crossing infraction is detected by the infrared proximity sensor, the water spray will be activated, and a buzzer will be sounded to signal that traffic is to be obeyed. If a crossing violation has happened, the ESP32-Cam will automatically send a picture to the Telegram Bot. The research results were tested using the confusion matrix test, which yielded an accuracy, precision, and recall value of 83.33%, 83.33%, and 88.23%, respectively.

[12] According to Ratih Puspadini et al.the Laplacian of Gaussian (LoG) method was effectively utilized in this study to identify damaged zebra crossings in images. This allowed users in the Langkat district highway area to assess the need for zebra crossing repairs. Tests of image textures utilizing the Laplacian of Gaussian (LoG) Method have shown excellent results, making it considerably simpler, faster, and more accurate for users to assess the zebra cross highway's health. The significance of a computerized system for detecting crucifixions on roadways is illuminated by this research, which informs the people and authorities of Langkat district.

[13] In The current study, narrated by Mr. Wawale S. N. et al., examined pedestrian behaviour at a signalised crossing that made use of a CST device. To get to the point, inside the project's framework, an X-CNN model was created to estimate the pedestrians' crossing speed. This model took into consideration several factors, including gender, age, the indication of the CST device at multiple instances, and more. Furthermore, an effort was made to categorize pedestrians based on their crossing behavior. This was done by utilizing a trained model that utilized the input data of the X-CNN model, along with speed data. Both models performed admirably, according to the results.

[14] In their description of the use of the X-G boost deep learning model to quantify the effect on the power grid, Shubham Gade et al. highlight the model's strength in picture classification and its ability to provide the necessary predictions. The XG boost model and the fuzzy classification procedure are both utilized by the author.

[15] The degree of zebra crossing usage in Malaysian metropolitan roadways is explained by Walid Abdullah Al Bargi et al. Pedestrians' comprehension of and adherence to zebra crossing facilities varies greatly depending on a number of

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circumstances, including the unique qualities of each place. According to the results, reasons for the low level of pedestrian zebra crossing utilization include the width of the crossing, the number of lanes, and the absence of a guardrail. Providing this facility should take into account the location of the zebra crossing and guardrail, as well as the width of the roadway (greater than two lanes), in order to promote a high utilization rate. Researchers hope that by informing policymakers, drivers, and pedestrians about the study's findings, they can help make crossings safer for everyone.

III. METHODOLOGY

Following the detailed procedure outlined below, the Pedestrian Controlling System approach is brought to life. The methodology's system overview is shown in figure 1, which is up there.

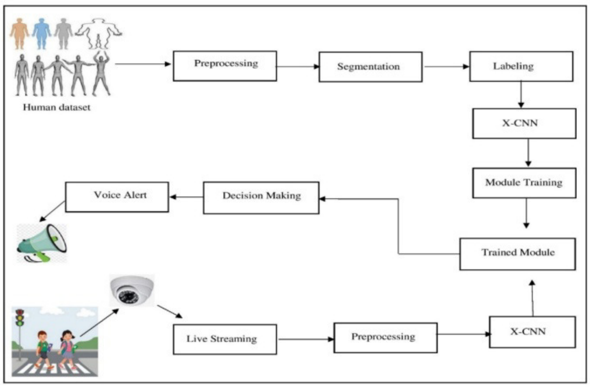

Figure 1: System Overview

Step 1: Data collection and Preprocessing: The following URL can be used to obtain a dataset that has been properly labelled as either human or non-human:https://www.kaggle.com/datasets/constantinwerner/human-detection-dataset/data. Both human and non-human sorts of photos are abundant in this dataset. You can find these dataset images labeled as "test" or "train" in directories that are numerically organized. The photographs are resized according to their folder hierarchy using the python programming language once they have been classified. Here, the paths to the directories are obtained by recursively traversing them. The resulting path's photos are scaled to 128 by 128 pixels using OpenCV's CV2 object. For accurate training, the scaled picture objects are transformed into grayscale. To get the right dataset for training the X-Convolution neural network, the photos are re-stored in the same directory after being resized and grayscaled.

Step 2: Training through X- convolution neural network: The first step in training a human dataset is to establish the test and train routes. In the end, all 32 batches and 10 epochs make use of the 921 test and train images. The depth ratio of the image data generator object is 1:255, which is used to create test data objects and train data objects. The pixels will be analyzed to their farthest depth using the specified ratio. The necessary parameters have been put into the test and train data objects with dimensions of 128 x 128 and a batch size of 23, using a grayscale color mode. Class mode with a categorical value is loaded as the last argument. To represent the grayscale color channel, denoted as 1, in 128 x 128 images, a convolutional neural network model is constructed using a sequential neural network. The first layer of the model is then filled out using 32 3 X 3 kernels. Then, a second convolutional layer with 64 3X3 kernels is added to the second layer. An activation function called "Relu" powers the first and second layers, respectively. The following step is to incorporate a 2D maxpooling layer with a 2 X 2 kernel size into the model in order to gather the neurons into a 2D matrix. A dense layer with a dropout rate of 25% ends this max pooling 2D layer.A max-pooling 2D layer with a 2X2 kernel size and 128 3x3 kernels activated using the "Relu" function make up the third layer. The fourth layer follows the same pattern until it reaches a dropout percentage of 25%. Once this complete neural network has been flattened, the neurons will be collected using a dense layer with a size of 1024 and a dropout ratio of 50%. Activation function "Softmax" is used to acquire trained data for both human and non-human classes. Using an optimizer named "Adam," the losses are evaluated during data training using categorical cross entropy. After twenty iterations, the model is called using the fit generator function, and the resulting.h5 file contains the trained data. The signal dataset for the three classes of traffic light states, such as RED, YELLO, and GREEN, is

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trained using the same architecture. In figure 2, we can see the convolution neural network architecture.

LAYER	ACTIVATION
conv 2D 32 (3X3)	Relu
conv 2D 64 (3X3)	Relu
MaxPooling 2D 2X2	
DropOut 0.25	
conv 2D 128 (3X3)	Relu
MaxPooling 2D 2X2	
conv 2D 128 (3X3)	Relu
MaxPooling 2D 2X2	
DropOut 0.25	
Flatten	
Dense 1024	Relu
DropOut 0.5	
Dense 2	Softmax
Optimizer	Adam
batch_size	32

Figure 2: X- CNN network Architecture

Step 3: Pedestrian controlling on Zebra crossing: Here, the Python software uses the mobile phone's camera to record video and, by extension, the frames. It does this by utilizing the Droid Cam app, which is compatible with both laptops and mobile phones. When the green and yellow lights are on in the live streaming frames, we may utilize the trained model file.h5 of Human and Traffic light states to detect a person crossing the Zebra. We extract their upper left rectangle positions from this file. Pedestrians are warned to promptly return from the Zebra crossing in order to avoid serious injury or death, as this location keeps an eye on the steadiness of human presence for both green and yellow lights.

IV. RESULTS AND DISCUSSION

The proposed method for Deep Learning-Based Pedestrians Controlling on Zebra Crossing.was developed using the Anaconda framework, Python, and the Spyder IDE. The development computer has 1 terabyte of secondary memory and 8 gigabytes of main RAM. A number of factors have been considered in order to determine how feasible the proposed plan is. In this part, we detail the results of the experimental study.

Figure 3 shows the results of the human dataset training in terms of accuracy and loss.

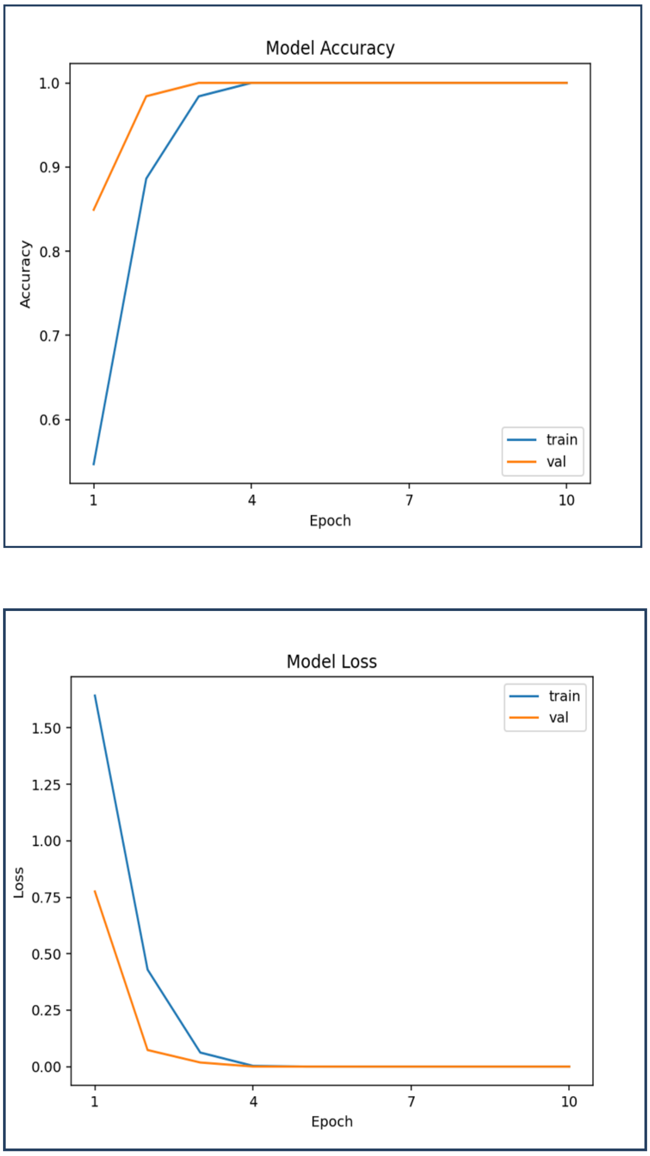

Figure 3: Accuracy and loss for X-CNN

V. CONCLUSION AND FUTURE SCOPE

The purpose of this study was to examine the conduct of pedestrians at a signalised crossing that made use of a CST device. Moving on, the project's architecture included the development of an X-CNN model that attempted to estimate the pedestrians' crossing speed by considering several attributes, like gender, age, the indication of the

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CST device at many instances, etc. Furthermore, an effort was made to categorize pedestrians based on their crossing behavior. This was done by utilizing a trained model that utilized the input data of the X-CNN model, along with speed data. Both models performed admirably, according to the results. Specifically, the X-CNN model demonstrated optimal training by not exhibiting overfitting or underfitting. In addition, the model's predictive power was evaluated using the MSE metric, which indicates that the pedestrians' speed can be anticipated with a high degree of accuracy. Implementing real-time traffic lights is something the system can improve upon. the system's functionality can be improved to accommodate various traffic signals through the use of cloud-based live frame streaming.

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