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Using a Deep Convolutional Neural Network to Identify Vehicle Driver Activity

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Abstract

Driver actions and judgments are the most critical aspects influencing passenger safety in a vehicle. Common things that drivers do include: driving safely, talking on the phone, texting, eating, reaching behind, altering hairstyle or makeup, operating the radio, and operating mobile phones. The first four are considered typical driving duties, whereas the latter seven are considered distractions. The strategy is to take in the live feed from the dashboard camera, process the frames with pre-trained convolutional neural network (CNN) models, and then refine it with the transfer learning method to identify the driver's activities. An activity recognition system for drivers is developed utilising deep Convolutional Neural Networks in order to monitor their actions (CNN). A warning is sent to the driver based on the identified driver's actions. In addition to activating the warning lights, the system gently slows down the vehicle or forces the driver to shift to the side lane and come to a complete stop in order to protect everyone in the vehicle and the surrounding area.

Keywords: Identify Vehicle Driver Activity, Image classification, Convolutional neural network, Machine learning, Deep learning.

Introduction

Everyone has experienced the frustration of a green light followed by a stationary vehicle. Another example might be a normally ordinary car suddenly losing speed and veering off the road. What are you expecting to see when you go past the driver who caused the accident? The sight of a driver engrossed in texting, social media, or a vigorous hand-held phone discussion is seldom shocking [10]. A distracted driver is responsible for one out of every five automobile accidents, according to the CDC's Motor Vehicle Safety Division. Distracted driving tragically claims the lives of 3,000 individuals annually and injures 425,000 more [11]. By examining whether dashboard cameras can automatically identify drivers participating in distracted behaviours, State Farm aspires to improve these concerning numbers and enhance their clients' insurance coverage [12]. State Farm has issued a challenge to Kagglers, asking them to categorise the actions of each driver based on a collection of 2D photos captured by dashboard cameras [13]. Is the person behind the wheel paying attention, fastening their seatbelt, or snapping selfies? Experimental photos are collected using real-world data from drivers using a cheap camera. Training an activity identification Convolutional Neural Network model follows raw image segmentation, which isolates the driver's body by removing noise and background using a Gaussian mixture model [14].

A warning is sent to the driver based on the identified driver's actions. When a driver engages in an activity that is deemed distracting, the duration of time that the driver continues to do so is documented [15]. When the time goes over the threshold you selected, an alert will go off. In addition to activating the warning lights, the system gently slows down the vehicle or forces the driver to shift to the side lane and come to a complete stop in order to protect everyone in the vehicle and the surrounding area [16-19]. Computing systems that are eerily reminiscent of the biological neural networks seen in animal brains are known as artificial neural networks (ANN) or connectionist systems. Such systems "learn" to execute tasks by analysing samples, typically without having task-specific rules encoded into them [20]. Visual imagery analysis is one of the most prevalent uses of Convolutional Neural Networks (CNNs), also known as ConvNets. Because of its shared-weights architecture and translation invariance qualities, these artificial neural networks are also known as shift-invariant or space-invariant (SIANN). Financial time series, medical image analysis, image classification, recommender systems, natural language processing, and picture and video identification are some of their many potential uses [21-24]. CNNs are multilayer perceptrons with regularisation applied to them. In multilayer perceptrons, all of the neurons in one layer are linked to all of the neurons in the following layer. With their "fully-connectedness," these networks are more likely to overfit data. Convolutional neural networks (CNNs) use a different strategy for regularisation; they build more complex patterns out of smaller, simpler ones by capitalising on the hierarchical pattern in the input. Thus, CNNs are at the bottom of the complexity and connectedness scale [25-33].

An AI function that attempts to mimic the way the human brain processes data and generates patterns for decision-making is called deep learning, deep neural learning, or deep neural network. Deep learning is a branch of AI's machine learning that uses networks with the ability to learn unsupervised from input that is neither structured nor labelled [34-39]. A deluge of data in every shape and from every corner of the globe has coincided with the rise of deep learning in the digital age. Sources of this data, also referred to as big data, include online cinemas, social media, search engines, and e-commerce platforms. Thanks to financial tools like cloud computing, this massive data set is easily shareable and accessible [40]. The goal of the machine learning (ML) research topic known as transfer learning (TL) is to apply the skills and information learned to solve one problem to another, similar but distinct, in the future [41]. Reusing or transferring information from previously performed tasks to learn new tasks can dramatically improve the sampling efficiency of a reinforcement learning agent, which is a practical advantage. One method of machine learning is transfer learning, which involves taking a model that has been trained for one task and applying it to another, similar task. The terms "domain adaptation" and "transfer learning" describe the process of using knowledge gained in one context to enhance generalisation in another. By optimising for transfer learning, we can model the second task more quickly or with better performance. The process of improving one's learning for a new task by transferring knowledge from one related task to another is called transfer learning [42-53].

Although deep learning has mostly focused on transfer learning, it is not the only field to address issues like concept drift and multi-task learning [54]. However, due to the massive resources needed to train deep learning models or the big and difficult datasets used to train deep learning models, transfer learning is popular in deep learning [55]. To be effective in deep learning, transfer learning relies on generalizability of the model features learnt in the initial task [56]. The process of transfer learning begins with training a base network on a common dataset and task. The learned features are then either reused or transferred to another network that will be trained on a different dataset and task. If the characteristics aren't task-specific and can be applied to both the base and target tasks, then this approach will be successful. In deep learning, this method of transferring knowledge is known as inductive transfer. Here, utilising a model fit on a related but distinct job helps to advantageously reduce the scope of viable models (model bias) [57-65].

Objective

Using transfer learning and deep convolutional neural networks, we want to create a system that can identify driver activity. A warning is sent to the driver based on the identified driver's actions. When a driver engages in an activity that is deemed distracting, the duration of time that the driver continues to do so is documented. When the time goes over the threshold you selected, an alert will go off. In addition to activating the warning lights, the system gently slows down the vehicle or forces the driver to shift to the side lane and come to a complete stop in order to protect everyone in the vehicle and the surrounding area.

Literature Survey

Xing Yang and colleagues [1] When it comes to driving safely, driver decisions and actions are paramount. This research presents a driver actions identification system built on top of deep convolutional neural networks (CNN) for the purpose of driver behaviour understanding. In particular, seven typical driver behaviours are highlighted: regular driving, checking the mirrors to the right and left, using the in-car radio, texting, and answering the phone. The first four are considered typical driving duties, but the third set of actions constitutes a distraction. Using a budget camera, ten drivers participate in the naturalistic data gathering process, and the experimental photographs are captured. Prior to training the CNN model for behaviour detection, the raw images are segmented using the Gaussian mixture model to isolate the driver's body from the background. The first step is to detect driving actions using a fresh method based on deep learning. In contrast to previous research that relies on intricate algorithms to predict drivers' state, the suggested programme only requires colour images as input and produces data on drivers' actions as output. Automatic feature learning can take the position of human feature extractors with the help of deep CNN models. Secondly, the pre-trained deep convolutional neural network (CNN) models are fine-tuned using transfer loss. These models can handle both multiple and binary classifications because to their training. This technique provides a workable way to detect drivers' actions without being too intrusive. The study also demonstrates that transfer learning is effective in applying domain knowledge acquired from large-scale datasets to small-scale driver behaviour recognition tasks. Lastly, the raw photos are processed using an unsupervised GMM-based segmentation algorithm, which separates the driver's body from the background. The results show that the detection accuracy of the driving activities recognition is improved when a segmentation model is applied before the behaviour detection network.

Kevin Yuen and colleagues [2] An important part of driving safely in an autonomous vehicle is keeping an eye on the hands to make sure the driver is prepared to take over if the computer asks them to. Here, we zero in on the very first stage of the procedure: finding the hands. A system of this kind needs to be able to function in the face of constantly changing, extremely bright lighting. Our own day-time naturalistic autonomous driving dataset is used to retrain the network with fewer parameters. It is then used to estimate joint and affinity heatmaps for the driver's and passenger's wrists and elbows for eight different joint classes, as well as part affinity fields between each pair of wrists and elbows. Because it relies on a single CNN model, the produced fuzzy values are not as precise. The suggested localised learning method has the potential to achieve better classification results when compared to various global and local approaches. Learning online also has the potential to lessen the computational effort. The method processes data in real-time at a rate of 40 frames per second, including a number of drivers and passengers. In rigorous quantitative and qualitative evaluations, the system demonstrates a detection performance of at least 95% for joint localization and arm-angle estimation. Low recognition efficiency is a drawback of the proposed technology that causes false driver activity recognition.

Much research interest has been focused on human activity and posture recognition using sensor data in various biomedical engineering and human health applications (Youssef et al., 2014). Human activity recognition (HAR) data often presents difficulties, such as class imbalance and ambiguity, which are addressed in this study. A new hybrid localised learning method of K-nearest neighbours least-squares support vector machine (KNN-LS-SVM) is suggested to mitigate the impact of imbalance and ambiguity in HAR situations. Various imbalanced and ambiguous synthetic and real-world datasets are fed into the classifier. This research is the first to tackle the HAR issue using a hybrid localised learning technique. The model is able to identify the driver's demeanour based on the hue of their skin. Because it just uses one CNN model, the produced fuzzy values aren't as precise. The suggested localised learning method has the potential to achieve better classification results when compared to various global and local approaches. Learning online also has the potential to lessen the computational effort. Prior to training the CNN model for behaviour detection, the raw images are segmented using the Gaussian mixture model to isolate the driver's body from the background. The pre-trained CNN models are fine-tuned using the transfer learning method to lower the training cost. In order to identify the driver's actions, the model takes into account the driver's skin tone. Due to the usage of a single CNN model, the resulting fuzzy values are not as accurate.

Zheng Yukun et al. [4] Hand gestures provide a more organic means for people to engage with computers in a wide range of contexts. Nevertheless, hand gesture recognition algorithms can be impacted by factors including the intricacy of hand gesture patterns, variations in hand size, hand position, and ambient lighting. The efficiency of picture identification systems has been substantially enhanced by the latest developments in deep learning. When compared to more traditional machine learning approaches, deep convolutional neural networks have shown to be far more effective at both representing and classifying images. This method uses the input video to directly detect when the driver is drowsy. The driver's facial landmarks are not taken into account by this model. For the purpose of hand gesture identification in American Sign Language, this paper suggests a two-method comparison using a deep-convolution neural network and transfer learning with the pre-trained model mobilnetv2. The driver's activities can be deduced from the photos by classifying them based on facial expressions and eye movement. The model's usage of a semi-supervised machine learning approach makes it time and money efficient. Incorporating differences in scale, lighting, and noise, the two models are trained and evaluated utilising 1815 color-segmented images with a black background and its static hand movements for five volunteers. The outcomes demonstrate that the suggested CNN model attained a recognition accuracy for classifications of 98.9%. This model outperforms the 97.06 percent convolutional neural network model enhanced with transfer learning by 2%.

In their study, Haojie Li and colleagues demonstrated [5] A major safety concern is that drivers take their hands off the wheel when they engage with the vehicle. This research offered a solution to this problem by collecting the driver's image and recognising multi-features in their face. The system relies on the driver's head-eye moving behaviours to facilitate natural interaction. The infrared camera mounted ahead of the driver in the vehicle first gathers 2D headshots and 3D point cloud data. To identify faces in two-dimensional infrared images, we use the SDM minimization nonlinear least square function to extract facial features. By utilising the coordinates of the feature points, pictures of the ocular area can be obtained. To extract the pupil and feature points of the Purkinje image from the eye image, the C-V extension model based on feature search was employed. At the same time, the driver's head posture was determined by transforming the spatial coordinates of the points in the three-dimensional point cloud using the index of facial feature points. The driver can then utilise the decision tree model to engage with the vehicle based on the mapped head-eye behaviours, which include analysing the acquired eye feature vectors and head position data and mapping them to the gazing object. Low recognition efficiency is a drawback of the proposed technology that causes false driver activity recognition. The experimental results demonstrate the rapid and accurate identification of the driver's intents to interact with the vehicle using the method suggested in this study. To determine the driver's status, we first need to identify their skin tone, and then we can use transfer learning to compare the picture to our database of samples.

Suzuki Satoshi and colleagues [6]. Preschool is a pivotal time for the physical-psychological and social-participatory development of gross motor skills. There are a number of standardised assessments for children's gross motor skills, but they are underutilised in Japan due to a lack of time and qualified teachers. The current authors have been researching a labor-saving artificial intelligence evaluation system that relies on recognition of gross motor actions in an effort to rectify the problem (GM-AR). Thanks to stratified 8-fold cross-validation, the enhanced GM-AR was able to categorise the acquired dataset (which included thirteen different types of GM capabilities) with an accuracy of 82.3%. A system that monitors the driver's actions and automatically shifts lanes based on their speed and level of attentiveness.

(Liu Tianchi et al., 2007) The driver's activities can be deduced from the photos by classifying them based on facial expressions and eye movement. The model's usage of a semi-supervised machine learning approach makes it time and money efficient. The foundation of building a driver-centered driver assistance system and the heart of many distraction countermeasures is real-time driver distraction detection. However, lowering the astronomical expense of gathering labelled data remains an obstacle, even when data-driven approaches show encouraging detection performance. To reduce the burden of categorising training data, this research investigated semi-supervised approaches to driver distraction detection in real-world driving scenarios.

Kim Whui et al. [8] Nowadays, driver attention, exhaustion, and lethargy are major contributors to traffic accidents, making driver condition identification a crucial responsibility. In order to identify the driver's actions, the model takes into account the driver's skin tone. Because it just uses one CNN model, the produced fuzzy values aren't as precise. We present a technique to identify distracted drivers in this research. One Convolutional Neural Network model, like Inception ResNet or MobileNet, is used to identify drivers who are distracted. The two models may be trained using the same pre-trained checkpoints and a short dataset as our experiments. The dataset used for training was the ILSVRC2012 dataset. Even though we only have photographs of two subjects in our training dataset, our method consistently produces trustworthy results when applied to other subjects as well.

According to F. Y. Wang et al. [9], the transportation and vehicle control systems of today face a formidable threat from the growing number of autonomous and connected vehicles. The goal of this study is to present Parallel Driving, a new unified approach to linked automatic driving that uses a cloud-based cyber-physical-social systems (CPSS) paradigm. Intelligent machine systems based on CPSS and ACP are initially introduced in this study. The cyber-physical-social space is the setting for the proposed parallel driving, which takes into account the interplay between data, human drivers, and automobiles. The framework includes the development and simple review of parallel testing, learning, and reinforcement learning. Additionally, progress on the intelligent horizon U+0028 horizon U+0028 and its potential uses in relation to the parallel horizon are detailed. For future road transportation networks, the suggested parallel driving provides a sufficient means of facilitating safe, efficient cooperation among linked autonomous cars operating at varying degrees of automation.

Proposed Model

The suggested setup captures the driver's actions in real time using an inexpensive camera. After that, the system receives the separated frames. With the help of the pre-trained data, the system is able to divide the driver's actions into 10 distinct categories. Two convolutional neural networks are used to identify the data; these networks classify pictures using transfer learning and produce fuzzy values. Classification of the photos is followed by the recording of the amount of time the driver spends on each activity. When the time reaches the threshold you've chosen, an alert will go off.

Problem Statement

The system is able to identify the driver's movements based on the live feed photographs. We are gathering photos of drivers who are attentive and alert while driving, as well as photos of drivers who are not distracted. We gather all these pictures, sort them into folders according on how distracting they are, and then store them. There are nine different types of distractions, thus we can organise them into nine classes: c1, c2, c3, c4, c5, c6, c7, c8, and c9. The class c0 represents safe driving and its associated drivers [66-74]. What follows is a statistical breakdown of the photographs that were gathered. The challenge is in applying the pre-trained data to identify the driver's present activity. Using convolutional neural networks (CNNs) and transfer learning, we can identify the driver's actions in each input image by generating fuzzy values for each class. Along with pictures of drivers who are attentive and careful on the road, we are also gathering data on potential drivers' distractions. After gathering all of these photographs, we sort them into folders according on how distracting they are [75-87]. There are nine different types of distractions, thus we can organise them into nine classes: c1, c2, c3, c4, c5, c6, c7, c8, and c9. The class c0 represents safe driving and its associated drivers [88]. Incorporating convolutional neural network (CNN) training into development: An easy convolutional neural network (CNN) to identify the driver's actions will be constructed and trained using the acquired photos. The model will assign him or her to the appropriate distracted category if that happens. There are a total of eight layers in the basic CNN model [89-96].

Implementation

The requirements research, specifications, and list of resources are all part of it. The interface, project processing sequence, packages, and input/output/system requirements are all detailed in the requirements study and specification. An infrared camera serves as the interface to our processing unit, which is in turn linked to a microcontroller (Arduino or Raspberry Pi) and, to speed up computing, to a graphics processing unit (GPU). For the model to work, the system needs a high-quality, low-noise image as input [97-105]. After that, the input image is subjected to additional noise reduction using the Gaussian approach in order to isolate the human body. The system notifies the driver and indicates the type of distraction if the driver's activity falls into the distracted class, which is determined by the fuzzy value. The output is dependent on the fuzzy value. The hardware and software that were utilised to construct and train the model are the primary focus of the resource demand. There is an in-depth explanation of the gear and software that were utilised to train and construct the model [106-115]. There is a clear explanation of the processor and GPU that are used. Clear explanations are provided for the software libraries and packages that were used. All of the project's resources are defined and demonstrated in detail. The project's success depends on these, and failing to use them could result in subpar performance [116-123].

The system's design lays out all the specifics of its structure, operations, and components. The parts that follow provide a comprehensive breakdown of our suggested model's design. Here we can observe the processing unit receiving frame-by-frame video data processed from the infrared camera [124-131]. This is where the CPU with the trained CNN model determines if the driver is multitasking; if the amount of time spent multitasking exceeds a certain threshold, the driver is alerted and instructed to either brake or reduce their speed. Because of their interdependence, it is critical that the various components of the system communicate with one another. The underlying operating system takes care of the communication mechanism since it is unimportant [132-141]. The technique is straightforward; it captures the driver's footage, frames by frames, transforms them, and then analyses each one. A warning will go out if the motorist is preoccupied [142].

Implementation

The driver's video is captured using an infrared camera and then rendered into frames. The Convolutional Neural Network receives these frames as input. The GPU is responsible for running the Convolutional Neural Network. The graphics processing unit (GPU) is a computer running the designed model, typically an Aurdino or Raspberry Pi. The CPU regulates the transfer of data from the camera to the graphics processing unit. State Farm provides the sample images used to train the CNN [143-151]. Every single frame is examined by the Convolutional Neural Network. As an image output, the trained CNN generates fuzzy values. The GPU-based CNN sends its fuzzy values to the CPU. There is a collection of fuzzy values associated with each class in each image. We select the image with the highest generated fuzzy value, assign it to a specific class, and then determine the type of distraction. At a predetermined interval, you can enable various types of distractions [152-159]. The central processing unit keeps track of how long the driver is actively participating in the task at hand. The central processing unit triggers the warning system whenever the driver exhibits a certain form of distraction for longer than the predetermined threshold duration. The primary goal of the alert system is to keep the driver's attention on the road, which significantly lowers the likelihood of an accident. So that the driver can stop the car and resume driving after the activity in which they are participating is over, the alert system either tells the driver to slow down or tells them to move to the side lane.

Package Diagram

Classes and modules in Java are organised into packages and sub-packages. Consequently, a package diagram is essential. Safe driving drivers are also included in our collection. We gather all these photographs, sort them into folders according to how distracting they are, and then store them separately. There are nine different types of distractions, thus we can organise them into nine classes: c1, c2, c3, c4, c5, c6, c7, c8, and c9. The class c0 represents safe driving and its associated drivers. Building and training a basic CNN using the gathered photos will allow us to detect the driver's actions. The model will assign him or her to the appropriate distracted category if that happens.

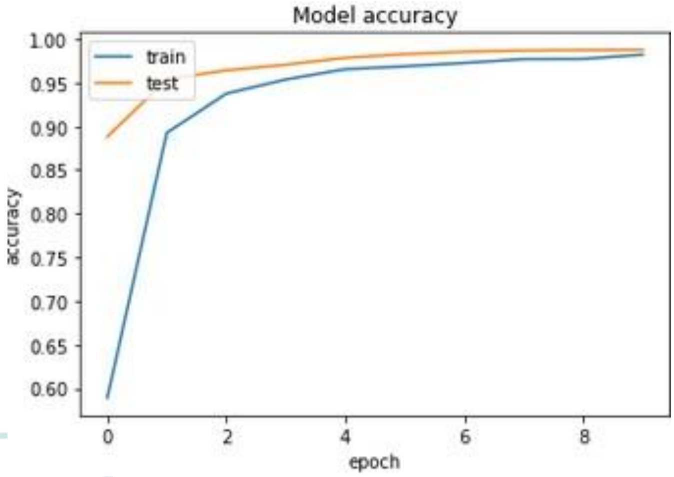
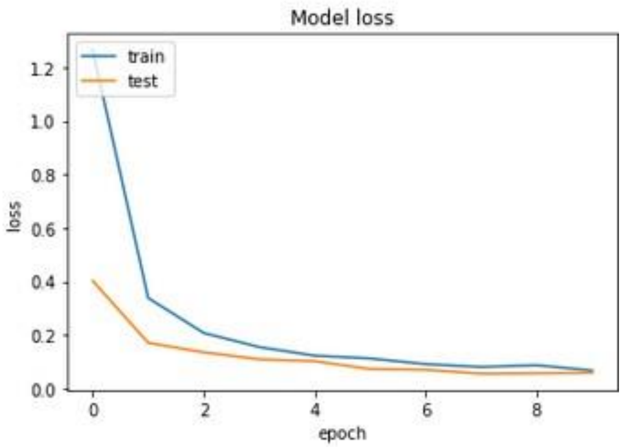


Figure 1: Model accuracy for the CNN

The first set of layers in a convolutional neural network (CNN) model includes the processing layer, which is responsible for sending the picture to the activation function ReLu after transforming it into a 32x32 2D matrix. Reducing noise for effective mathematical computation is the goal of batch normalisation. Once more, the identically sized image matrix is used to feed the picture into the convolution layer. To prevent overfitting the model, the output of each node in the max pool layer is merged and supplied as an input to future layers. Batch normalisation is repeated



here (Figures 1 and 2).

Figure 2: Model loss for the CNN

The model outperforms the state-of-the-art systems with an accuracy of 0.98 (98 percent).

Conclusion

A driver activity detection system that is based on a two-layer deep convolutional neural network model is proposed in the model that was shown earlier. The model employs two layered convolutional neural networks to identify driver activity. These networks are based on sample data that has been learnt in advance. We use the fuzzy values that are created in this way to assess the activity that the driver is engaged in. This allows us to either warn the driver or take preventative actions in order to limit the number of accidents that occur on the road. Receiving the live video feed from the dashboard camera, analysing the frames with CNN models that have been pre-trained, and then fine-tuning it with the transfer learning method in order to detect the type of activity that the driver is engaged in is the concept behind the approach. The purpose of the project is to watch the actions of drivers, and in order to accomplish this, a driver activity identification system is constructed with the help of deep convolutional neural networks (CNN). An warning is sent to the driver based on the conduct of the driver that was noticed. In addition, the system will automatically activate the hazard lights and will either gradually slow down the speed of the vehicle or will force the driver to move to the side lane and come to a complete stop in order to minimise the risk of injury or death to the driver, passengers, and people in the surrounding area.

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