Research & Development Activities in Big data analytics & Artificial Intelligence at TIFAC-CORE in Automotive Infotronics, VIT, Vellore

Many real time applications can be solved using Machine learning and Artificial Intelligence based techniques. But these techniques demand large amount of samples with variety. If the data is more, then the accuracy will be better. For crunching this huge amount of data, we need various kinds of hardware platforms and software tools. The Big Data Analytics and Artificial Intelligence lab boasts the necessary hardware cum software infrastructure so that students can solve many real time problems related with Automotive, Biomedical, Consumer electronics, etc.

Hardware:

- DELL i5 with multi core CPUs: 21 Nos. (built a Hadoop big data platform)
- HP z238 with GPU: 3 Nos. (NVIDIA Quadro k620 2GB RAM - to solve compute intensive tasks using single computer
- Connoi with GPU: 2 nos. (NVIDIA Tesla C2050 3GB RAM – to solve real time problems involving real time performance)
- Jetson embedded GPU: 1 No. (NVIDIA Pascal - Portable hardware that can work with less power)
- Intel Movidius VPU: 3 Nos. (meant for low cost, non-critical applications)
- Depth Camera: intel Realsense D435 (stereo camera to get the third dimension information)
- Raspberry Pi (to work with simple proof of concept projects)

Different operating systems and programming languages are currently explored by Industry while working with deep and machine learning algorithms. Each of these operating systems and programming languages has got their own pros and cons. In order to expose our students to different operating systems and programming languages, we have installed the following operating systems and programming languages in this lab.

Software:

- Operating system: Ubuntu 16.04 (open source) , windows 7 and windows 10
- HADOOP Distributed file system (21 systems for multi cluster architecture)
- Deep learning: Matlab, Java, R, Tensorflow, Caffe, Keras, PyTorch, Cython, Embedded C++, C

Artificial Intelligence Based Real Time Applications

Artificial Intelligence systems try to create computers or machines as intelligent as humans. It includes various components such as reasoning, learning, perception, problem solving, language understanding, etc. A normal computer program can answer for specific questions whereas AI systems can address generic questions. In a normal program a slight change in the program will lead to change in its structure whereas in an AI program, one can modify a piece of information of a program without affecting its structure. AI concepts are used in gaming, natural language processing, expert systems, vision systems, speech recognition, handwriting recognition, intelligent robots, etc.

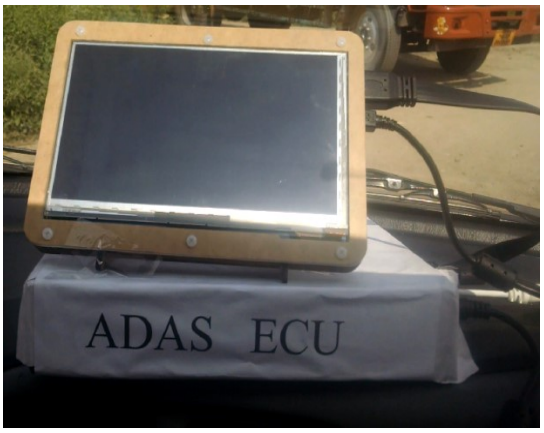
Machine learning is a subset of Artificial Intelligence system wherein the systems have the ability to automatically learn and improve from experience without writing explicit programs. They can learn from examples. Machine learning techniques involve various topics such as representation, evaluation, optimization, classification, regression, probability estimation, etc. It is widely used in areas such as credit risk assessment, disease diagnosis, face recognition, automatic steering, etc.

Deep learning is a subfield of machine learning wherein the algorithms are inspired by the structure and function of the brain called artificial neural networks. Deep learning is a key technology behind driverless cars, which can automatically recognize sign boards, identify pedestrians, understand lane boundaries, figure out moving objects such as cycles, motorbikes, autos, buses, Lorries, trucks, animals, etc. One can track these objects and figure out at what speed and direction they are moving. Subsequently, it is possible to estimate (predict) when they will approach our vehicle. Once proper estimation is done, we can automatically actuate the necessary sub systems such as steering, braking, acceleration, gear shifting, etc using conventional programming techniques (hard computing).

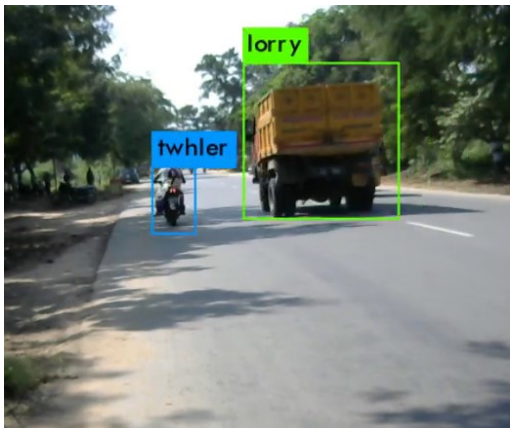
The center is focusing on such AI based systems for automotive, medical, and real life applications. We highlight some of the on-going research / consultancy works happening at our center in these emerging areas.

On-board Vehicle Detection System

In order to detect the various moving objects such as lorry, bus, two wheeler, pedestrian, etc in front of our vehicle, we have built a relevant AI model using our 21 node Hadoop cluster. The model built was ported to an on board embedded ECU which is turn is was interfaced with a video camera (used to acquire live video stream) and a speaker (to give an audio alert). The system was successfully fitted in a Maruthi Suzuki car and various alerts were tested at 80 km speed.



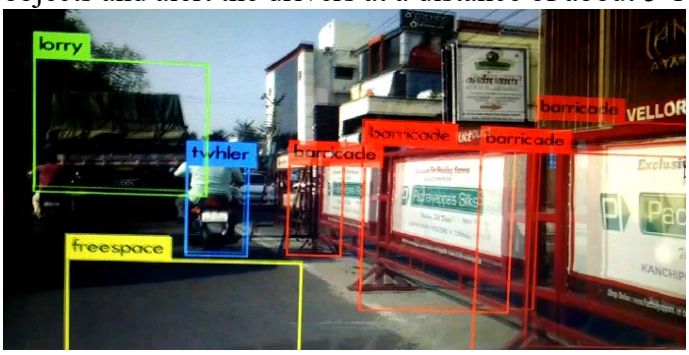
ADAS ECU and display used in the car



Various objects detected & alerted

Detection of stationary objects

In a country like India, various stationary objects such as barricades and road diversion sign boards are installed at different times and places. Lot of accidents are happening due to the presence of these objects without proper sign boards. Many novice drivers especially when drive at high speed loses their control when they see these objects all of a sudden. These lead to a number of accidents in highways. We have built a deep learning algorithm that can detect these objects and alert the drivers at a distance of about 5-10 meters ahead.

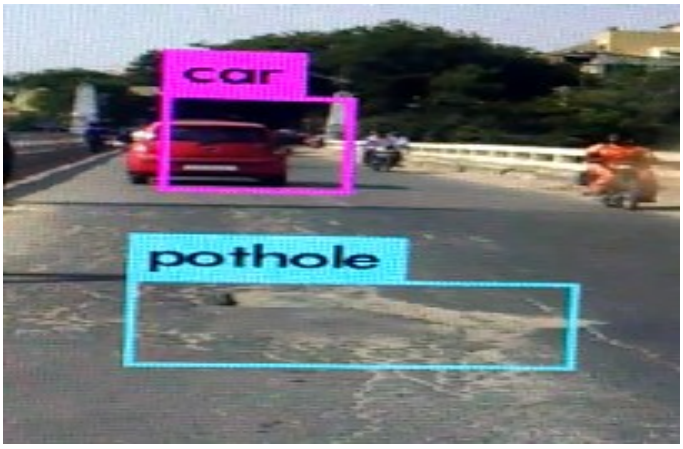


Live Road barricade detector and alert system

In recent times we see that lot of accidents in Indian roads are mainly happening due to the presence of speed breakers and potholes. There is no standard followed while laying these speed breakers (their height and width varies from place to place). Often the white markers on the speed breakers fade away. The sign boards are broken, occluded by advertisements, bent, etc. Hence a speedy driver when applies a sudden break creates nightmare to other vehicles behind them, leading to accidents. We have developed an appropriate machine learning algorithm to detect them and alert the same in real time while driving even at a speed of 60+ km.

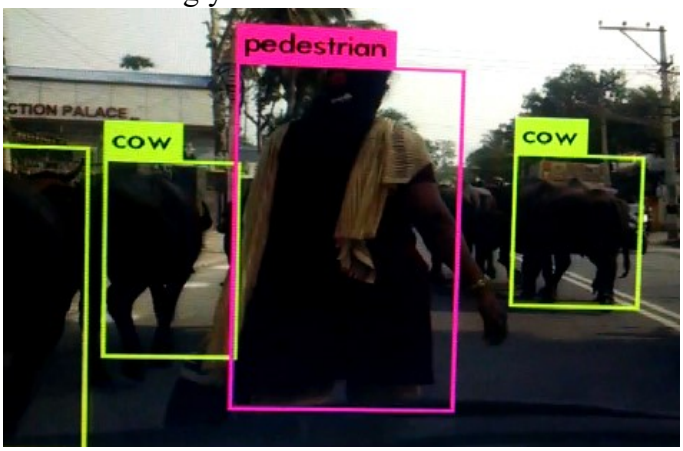
Live Speed breaker identification and alert system

Our Indian roads are often not laid with International standards or at times not properly maintained. Especially during the rainy season, due to poor water drainage system, the roads erode and lot of potholes is created. Generally they are not fixed immediately. For many drivers, it is a nightmare. Often they drive in a zigzag way which in turn causes confusion to the drivers who are behind them. Hence detection of live potholes and alert the drivers in advance will help them to reduce the speed and use proper indicators so that other vehicles following us will be aware of what is our intent. We have built an efficient pothole detection algorithm using our NVIDIA GPUs. The built model can detect the presence of potholes and alert the driver in real time.



Live Onboard Pothole detection and alert system

In our Indian roads, we often see various animals such as dogs, pigs, etc are crossing the road. The pedestrians also cross the roads all of a sudden. Some of them walk slowly without even worrying about what objects are approaching them. Drivers need to identify and asses them. We have built a machine learning cum deep learning algorithm that can detect these slow moving objects on the road and give an appropriate alert well advance so that the drivers can react accordingly. This in turn can reduce the accidents, if not totally avoid accidents.



Slow moving objects identification and alert system

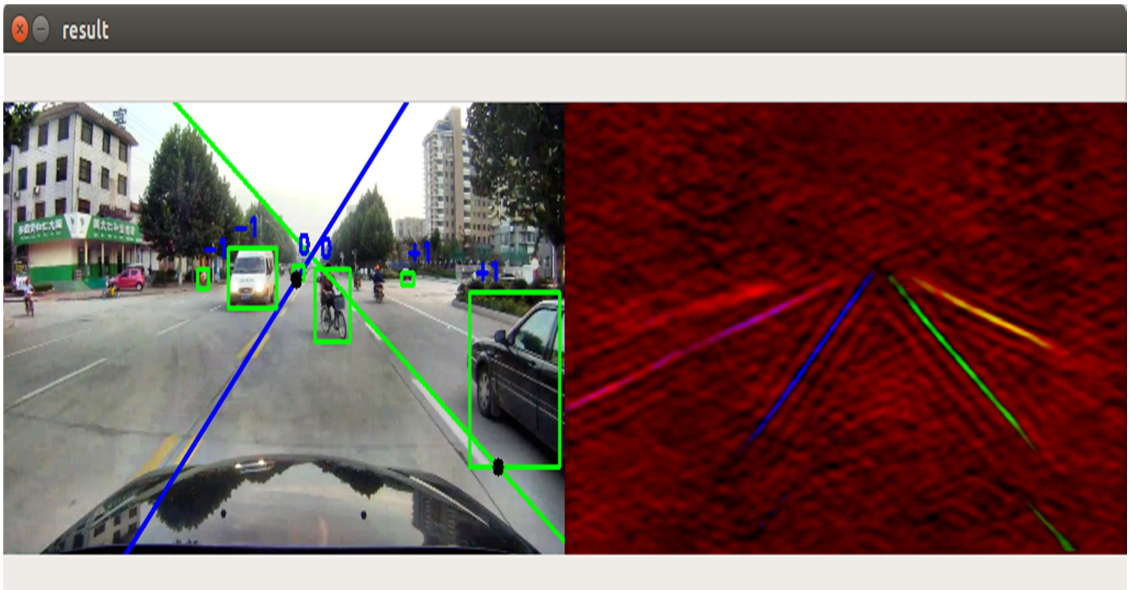
AI based security alert system for schools

Many private nursery and primary schools in our country are located near the roads. These schools often do not employ professional security personnel. There are many instances, wherein due to the negligence of the security, the children ran away from the school premises into the (main) roads as soon as the bell rings. Many times people report minor accidents to the children. We have built an AI based deep learning model that can process the CCTV footages and identify whether the children leave the school with an accompanying adult (care takers such as parents or auto / van drivers). Whenever a child leaves the school alone, our system will raise an audio alarm so that the security or fellow caretakers will prevent these children in crossing the school gates.

System alarming a lone child crossing gate. Detect children accompanied with adult

Lane departure warning system

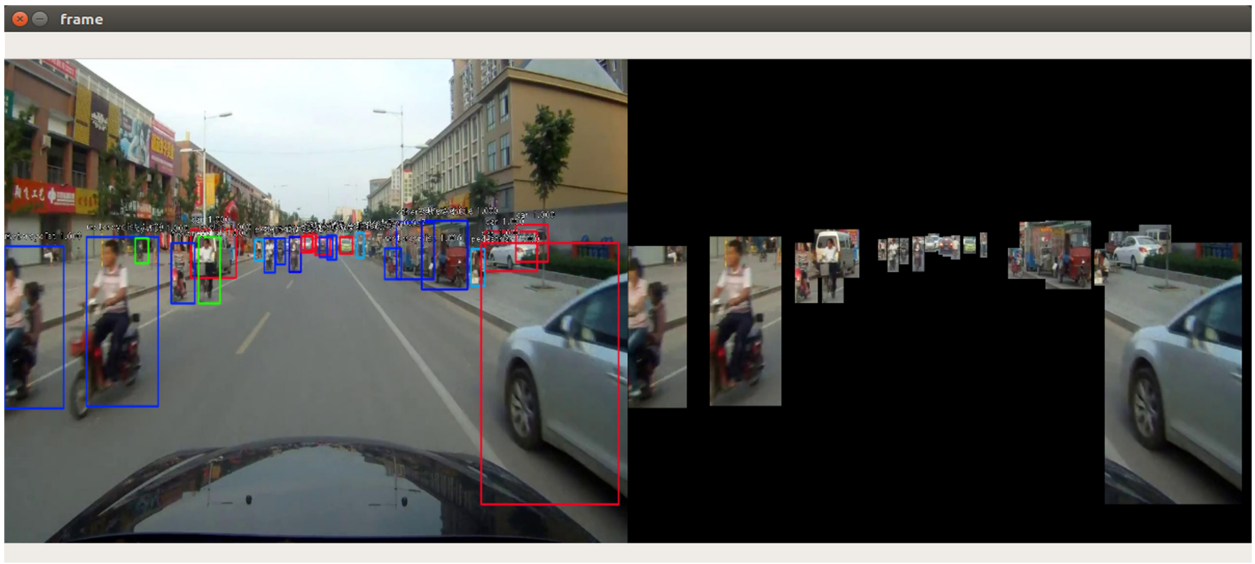
In highways, where there are multiple lanes, the drivers are expected to follow the lane discipline meaning they should use the same lane depending on the speed of the vehicle. Whenever they want to overtake another vehicle, they are supposed to watch both the mirrors and steer to the right or left. But at times driver changed the lane casually leading to accidents. In order to avoid this, we have built an AI based algorithm that can identify the road markers and track them continuously using live video stream and whenever we are about to cross the lane boundary, it will trigger an audio alarm to alert the driver. In developed countries, the road markers are well laid and visible. But in India, they often fade and erode. Hence we have built an AI algorithm that can take care of these partial information while detecting the algorithm.



Live Lane departure warning system Detection of multiple lanes and tracking

Efficient, Automatic 2D Marking Tool

In order to train the deep learning algorithm, one has to capture a large amount of images / videos and identify the various objects and label them manually (as our algorithms are supervised ones). This involves considerable amount of human efforts. In order to overcome this we have built our own Automatic 2D marking tool. Using this tool one can load their raw video files. The user can specify what kind of objects he wants to identify such as 2 wheelers, cars, pedestrians, etc. The underlying AI model will automatically identify the various objects and draw bounding box as well. With minimal human intervention, one can change the labels of objects which are misclassified. Using instance segmentation technique, we remove unwanted objects and collect only the objects of our interest which can be used later for improving our algorithm. Our tool is very efficient because what a human annotator does in a day, we will be able to do it in less than a minute.



Automatic marking of objects using our tool. Instance segmentation of selected objects

Our tool also provides lot of editing options once the objects are identified and labeled. While training our system we need a number of parameters such as whether an object is moving or not, if moving, in which direction it is moving, at what speed it is moving, which side of the object we are looking at, in which lane it is going, lighting condition, is the object is occluded or not. This information will make our AI algorithm to be more intelligent. This will also help the autonomous vehicles to take appropriate action such as steering, braking and accelerating, etc.

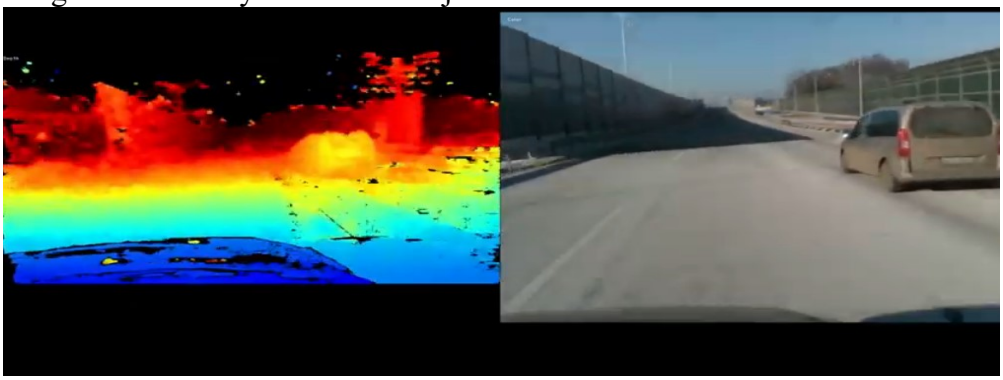
Manual Property Editing options for detected vehicles

Manual Property Editing options for 2 wheelers vehicles

Manual Property Editing options for pedestrians

Vehicle detection in night time

The statistics says that there is lot of road accidents happening at night time due to poor illumination. One needs to build an appropriate AI algorithm that can process the infrared images and identify the various objects on the road and alert the driver accordingly.



Infra red images of roads & vehicles Objects seen by the normal camera

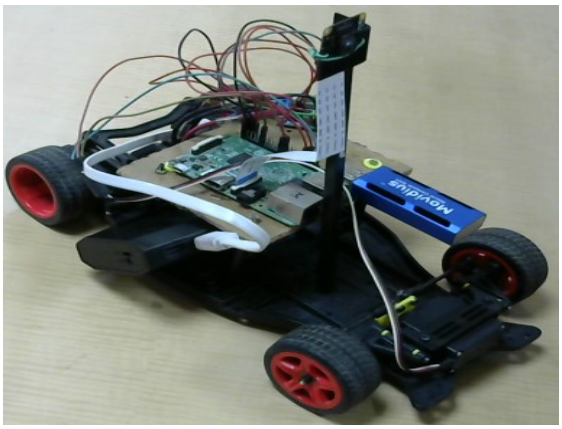
Accident prevention system for night drives

In India, vehicle owners illegally change the head lights with powerful lamps. Due to this, the vehicle drivers who are coming in the opposite direction become blind for a fraction of a second. Hence often they are unable to identify the objects in front of them. These lead to a number of night time accidents. To overcome this, we have built an AI based algorithm that can work with stero / 3D images and identify at what distance the various objects are there. When we approach the closest object, it will trigger an audio alarm. Hence the driver can reduce the speed and avoid the accident

AI algorithm to alert a driver in night time when he approaches an object

Self-driving toy car

We have trained a toy car in the controlled in door environment to follow a specific path using relevant AI algorithm. Once trained, the model can be loaded on the toy car and can maneuver insider the room. The work is still under research.


Autonomous toy car for indoor navigation

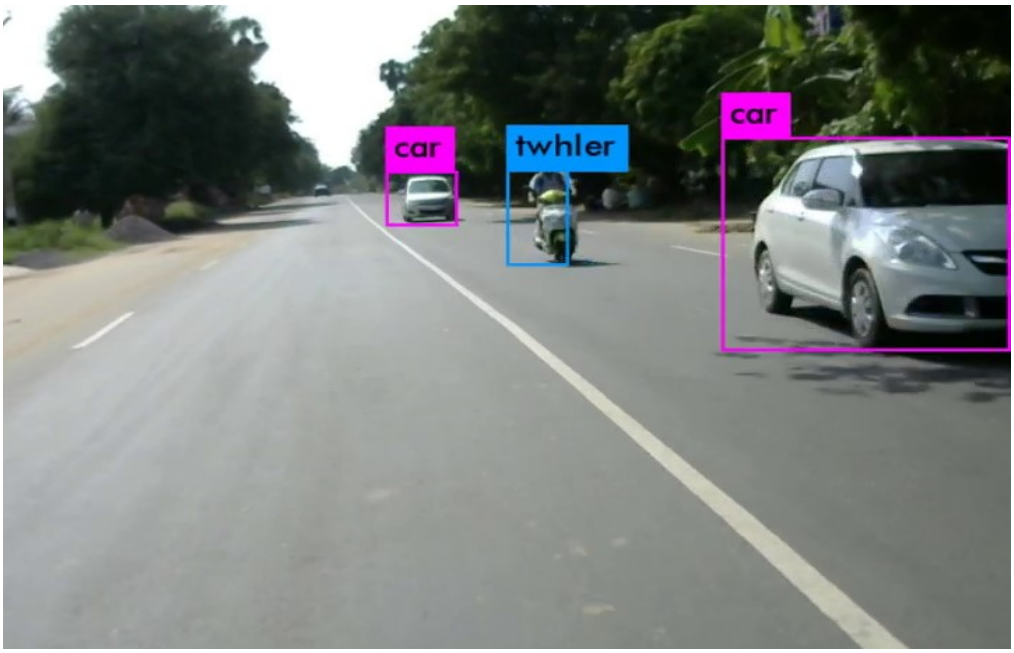
Driver face emotion recognition

When the drivers drive for a long time or while driving in dense traffic condition, they lose their temper and become angry / sad. The proposed machine learning algorithm identifies the mood of the driver. If he is angry / sad, it automatically spray fragrance or play his favorite music.

Algorithm to identify the driver's emotion

Alerting drivers at safe distance

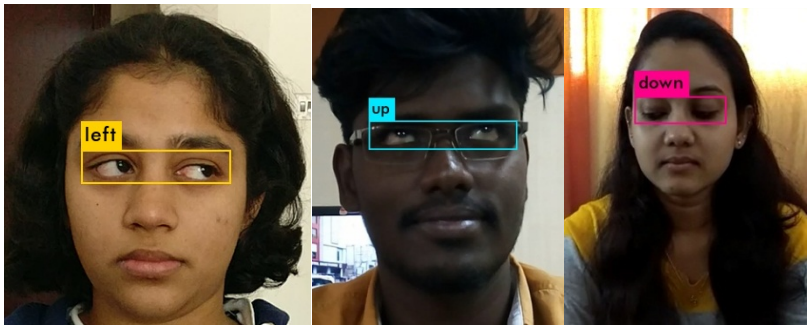
Often drivers go near the other vehicles and minor accidents. This is often due to the negligence of the driver or wrong estimation of the driver about the distance of the other vehicle. It is possible to use AI algorithms not only to identify the objects ahead but also estimate at what distance they by using appropriate are tracking algorithm. If we program it based on our driving pattern, it is possible to give an audio alert to a driver whenever he is very close to other moving vehicle. This can avoid minor accidents. Our proposed AI| model can track multiple moving objects ahead of our vehicle using live video footages and alert the driver when he is very close to them.



Tracking of multiple, moving objects in our lane and alerting for safe distance

Driver's attention monitoring and alert system

When driver's take a long drive, often they watch the scenes on either side of the car. Some drivers often look at their mobiles for messages and directions in their GPS map. These incidents often lead to accidents. Particularly, when the driver has diverted his attention on sideways and some vehicle from behind overtake them, they lose their control and often it leads to accidents. In order to avoid this, one has to watch the eye movement of the driver using an onboard camera and process the video in live. Whenever the driver's attention is not on the road ahead, it should give an audio alarm. We have built a CNN based model to track the eyes and whenever his eyes move sideways or up and down for few pre-defined time intervals, the on-board system will actuate the buzzer to caution the driver.



Eye gaze detection, monitoring and alert system

Vehicle Logo Detection System

Whenever an accident happens, in a country like India, often people fled away from the scene due to legal issues. If the injured person is immediately taken to the hospital and treated, his life can be saved. But during subsequent police investigations people describe about the color of the vehicle / vehicle type / vehicle brand name. But often they forget the memorize and remember the license plate number. We would like to build an AI based system that can automatically find what is the color, type and brand name of the vehicle by finding the logs which are present at the front and rear side of the vehicle. This will be useful for police investigation to find the culprits or criminals and take necessary action on them.

Identification of Vehicle manufacturer (brand name) using video footages

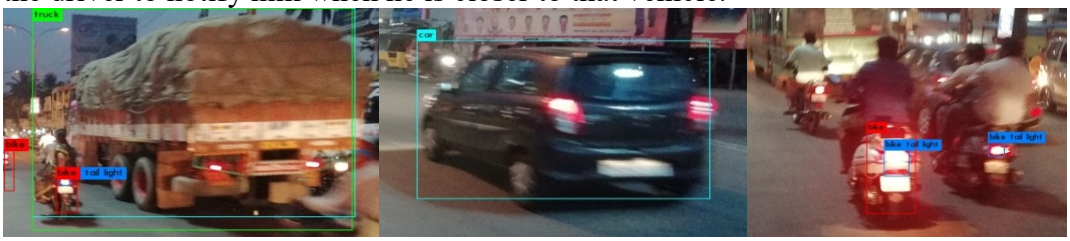
License Plate Detection System

There are many practical applications wherein the license plate detection plays an important role. For example, if we want to automate the toll collections system, the very first information required is to capture the number of the vehicle when it enters into the tool booths. But there are problems in detection of these number plates. Unlike in western countries, no standard format, font type, color, size of number plate etc are followed in India. In some states of the country, it is even displayed in vernacular languages. Decoding it automatically is a tough job. Thanks to deep learning techniques it is possible to train the AI system with good amount of samples of all variants. We have built an AI based license plate detection system.

AI based rear, front side number plate detection in cars & 2 wheelers

Vehicle detection at night time using tail lamps

Tracking vehicles ahead using normal cameras is a nightmare. Particularly, when we want to overtake a vehicle ahead of us, one should know whether it is a car, bus, lorry, truck, etc. The worst scenario that at times, two 2 wheelers going in parallel will look like a car to a driver. Often these kind of wrong detection, leads to accidents. In order to overcome this, we have implemented night time vehicle detection algorithm using neural networks and machine learning techniques. Based on the position, location and distance between the 2 tail lamps, we classify whether the vehicle in front of us is a car, bus, lorry or truck. Appropriate audio alert is given to the driver to notify him when he is closer to that vehicle.



Identification of heavy vehicles, light vehicles and 2 wheelers using tail lamp

Traffic Sign Board Detection

When we drive long distances, particularly in new terrains, we have to consciously watch for traffic sign boards and we need to drive accordingly. But at times, the drivers miss the sign boards and in turn leads to traffic violations, minor accidents, etc. To overcome this we have built a deep neural network based algorithm that can capture the live video and process them instantaneously and identify the type and kind of sign boards and accordingly give an audio alert to the driver. We have built 2 separate algorithms one for day time and the other for night time detection.

Live Signboard detection in day light and night light

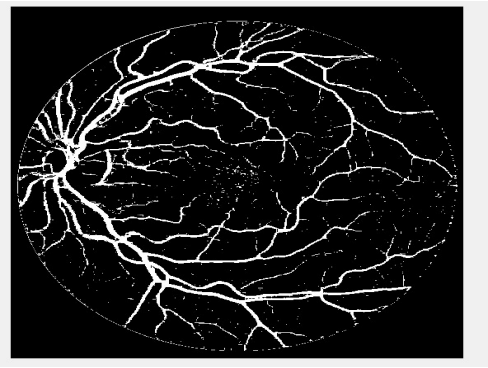
Milestone detection and alert system

In a country like India where different vernacular languages are used for reading and writing becomes a big problem for people who cross the state boarders. Biggest problem is for the lorry and truck drivers who deliver goods from one part of the country to the other. They have to cross different states. The worst part of it is that many milestones on the roads are written in vernacular language. Reading and decoding it becomes a tough task if the driver do not know those languages. Using deep learning and AI techniques, we capture the live mile stones and decode them (depending on the language) and read them to the driver in English. This will be also useful for hoppy drivers.

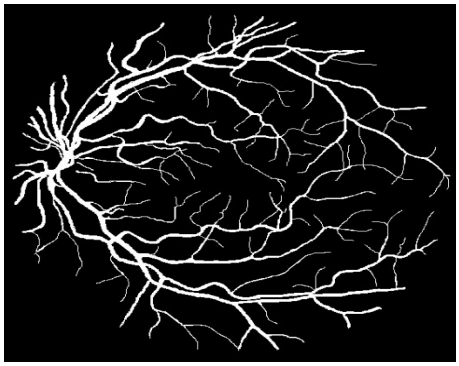
Decoding the milestones on the fly

Blood Vessel Segmentation in Retinal Fundus Images -Diagnosis of Diabetic Retinopathy

Retinal Fundus images show poor contrast between retinal structure and background. We use only green channel image as it contains maximum contrast between background and blood vessels. Using morphological opening operator, we remove Vessel central light reflex to get a uniform grey level profile. Subsequently we used background homogenization using Contrast Limited Adaptive Histogram Equalization to get a sharpened image and Vessel enhancement techniques. Then we calculated 11 features for each pixel of which 5 are grey level features and 6 are due to Zernike moment based. We used these dominant feature sets to train the images of DRIVE and STARE datasets. The model built using PatternNet classifier was used for classifying our images with better precision and accuracy.



PatternNet Trained Image



Ground Truth Image

Classification of pre-feature extracted images with Deep convolutional neural network in Facial emotion recognition of Vehicle driver

The pre-feature extraction technique and deep learning methods have presented excellent accuracies in many pattern recognition and classification problems. This paper delivers a study on pre-feature extraction with different Convolution Neutral Networks (CNN) models and shows its benefits by using the Face Emotion classification problems. The pre-feature extractions techniques are Gaussian filter with canny edge detection, most significant bit (MSB) plane slicing and Gabor filter with element-wise maximum feature extraction. We show and analyze the impact of different pre-feature extraction techniques on the performance of three CNNs techniques, LeNet, Alexnet and VGG16. In our studies the Gabor filter with element-wise maximum feature extraction has a high stateof-the-art accuracy and less execution time in Face Emotion classification problems with all CNN techniques in CPU based system.

	A	D	F	H	N	S	U	Avrg
Lenet (JAFFE) normal	95	97	**98**	94	94	95	92	95
Lenet (JAFFE) Canny	96	94	94	94	96	94	94	94.6
Lenet (JAFFE) MSB	96	96	**98**	94	**97**	95	93	95.6
Lenet (JAFFE) Gabor_EM	**99**	**98**	**98**	**98**	94	**99**	**98**	**97.7**
	A	D	F	H	N	S	U	Avrg
alexnet (JAFFE) normal	94	94	98	95	97	95	92	95
alexnet (JAFFE) Canny	96	95	96	94	94	94	95	94.8
alexnet (JAFFE) MSB	**98**	**96**	95	96	97	97	94	96
alexnet (JAFFE) Gabor_EM	**98**	95	**99**	**98**	**98**	**99**	**96**	**97.5**
	A	D	F	H	N	S	U	Avrg
VGG16 (JAFFE) normal	**99**	**99**	97	99	**99**	98	95	98
VGG16 (JAFFE) Canny	96	96	98	94	97	95	93	95.5
VGG16 (JAFFE) MSB	97	98	**99**	99	**99**	98	97	98
VGG16 (JAFFE) Gabor_EM	**99**	**99**	**99**	**100**	**99**	**100**	**99**	**99.3**
	A	D	F	H	N	S	U	Avrg
Lenet (FER2013) normal	**95**	92	**97**	93	94	92	89	93
Lenet (FER2013) Canny	92	**98**	90	95	91	95	90	93
Lenet (FER2013) MSB	91	92	93	95	94	96	91	93
Lenet (FER2013) Gabor_EM	**95**	96	96	**98**	**95**	**98**	**92**	**95.7**
	A	D	F	H	N	S	U	Avrg
alexnet (FER2013) normal	91	96	**93**	95	**94**	96	93	94
alexnet (FER2013) Canny	92	**98**	91	96	**94**	96	**94**	94
alexnet (FER2013) MSB	**97**	96	92	96	93	95	93	**94.5**
alexnet (FER2013) Gabor_EM	92	92	92	**97**	93	**98**	92	93.7
	A	D	F	H	N	S	U	Avrg
VGG16 (FER2013) normal	90	92	93	96	94	92	95	93
VGG16 (FER2013) Canny	92	**98**	95	95	90	90	91	93
VGG16 (FER2013) MSB	**96**	91	93	94	**95**	91	92	93
VGG16 (FER2013) Gabor_EM	94	94	**96**	**97**	**95**	**98**	**98**	**96**

Image Processing Techniques for Extracting Features from Ocean SAR Images

Here we have proposed suitable techniques for enhancement, speckle filtering, vessel detection and wake detection of ocean SAR images which are captured from PALSAR – 2/ ALOS – 2. We have evaluated the image information using Edge Preservation Index (EPI) after the statistical operations of enhancement and despeckling. Vessels are detected using morphological operations with proper dilation and erosion in the SAR images. In a given region of interest, we are not only identify and count the vessels but also measure the size of vessels classify them based on size and measure the distance between them. Using image tiling, we enhance the speed of detection by roughly 4 – 5 times. Line and wake detection techniques of Radon and Hough transform are used for detecting the wakes behind the ship. Ship wakes are often used as the primary means to estimate the direction of movement of the ship and the velocity of the ships. Our algorithm consumes less time for processing, has high accuracy to detect the small vessels and estimates the velocity of moving target.

Cloud computing, Big Data analytics and mobile based applications

Apart from working in the areas of deep and machine learning, we also work on Big data analytics, cloud and mobile based applications as well. Some of the interesting projects done at our center are highlighted here.

Face detection and recognition in large dataset using Hadoop

Due to the tremendous growth of data, it is essential to develop a framework that detects and recognizes a given image in a large data set at a faster rate and with a better accuracy. It should also provide useful information about the object. The proposed framework detects and identifies the given image of a person in the large dataset and shows the related information about him from social media links. This system was successfully tested in VIT, Vellore campus.

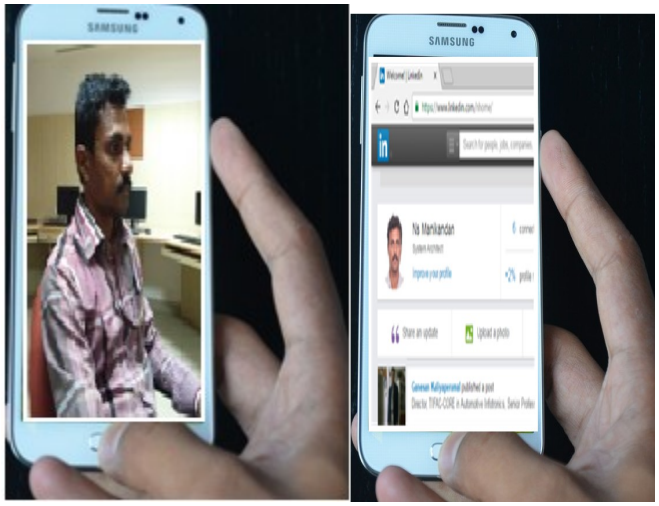
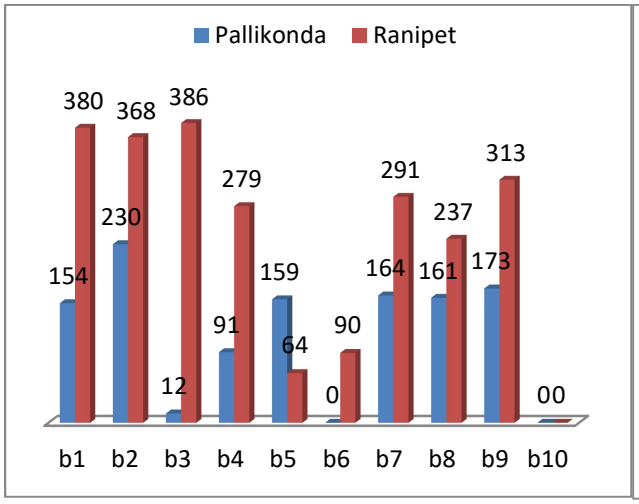


Image captured and social media information about the person is displayed.

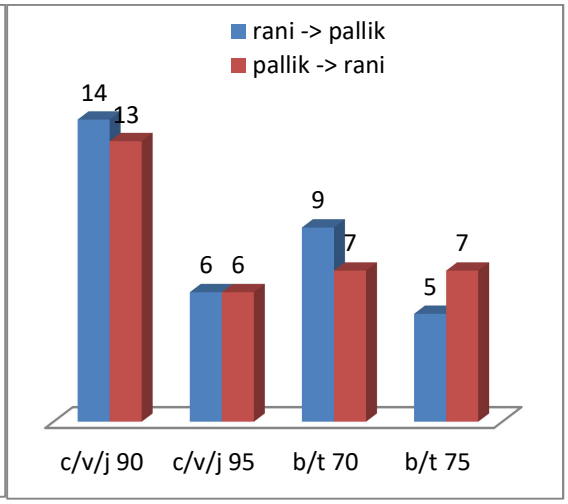
Low cost over speed detection system

Thanks to 6 way lanes between Krishnagiri to Ranipettai (in Tamilnadu state), a number of drivers were overspeeding. This in turn led to a number of accidents. To mitigate this we were requested to find a simple, low cost solution. We installed cameras near the tool booths and whenever a vehicle crossed it, we captured the number plate and decoded it. We stored this information along with the geolocation and time stamp (date and time of passing the toll gate) in to a cloud. Using an appropriate analytics software the information was analyzed and filtered and pushed into servers of all nearby tollgates. Whenever the vehicle crossed the next toll booth again the number plate was extracted. The geo-location, date and time stamp was added and the information was injected into the cloud system. An analytics software at the cloud, was able to find out the distance between the 2 tool gates using geo-location information. The time taken to cross the toll gates was calculated using the date and time stamp information. These data were sufficient to find the average time taken for the vehicle to cross the toll gates. Based on the road geometry between the 2 toll gates, the average time that should have been taken is computed. When the vehicle travel time is more than this scientific travel time, they were tagged as overspeeding vehicles. The live testing was done twice between Pallikonda to Krishnagiri and twice between Pallikonda to Ranipattai. The results were validated by the RTOs.

Testing of overspeeding vehicle detection system at Pallikonda &Ranipet Toll plazas



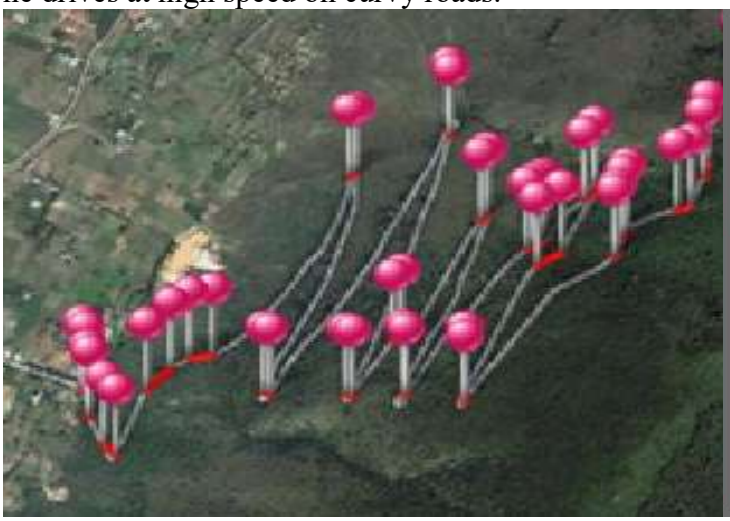
Booth wise vehicle passed



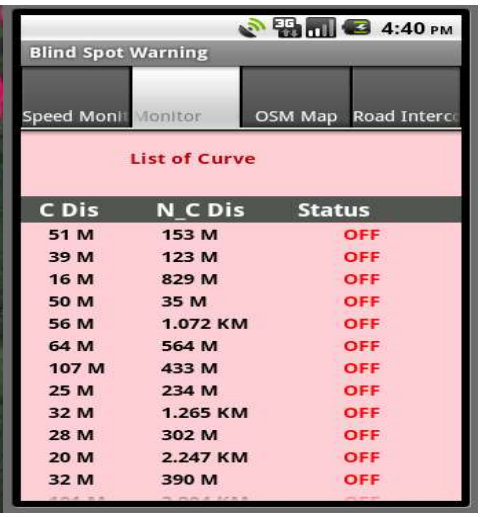
No. of vehicles overspeeded in each type

Speed Monitoring and Alert System

When we drive in hilly roads, the chances of having curvy roads are very high. For safe driving and avoid accidents one has to strictly adhere to speed limitations. But due to negligence, many drivers drive casually. To overcome this, we have come out with an off-line GPS map analysis based system wherein the present GPS location of the vehicle will automatically find what kind of road is ahead of us and what its curvature is using the on-board Electronic Control Unit system. Using in-vehicle networking techniques our ECU will verify whether the speed of the vehicle is exceeding that of the suggested speed. If so, it will give an appropriate buzzer sound to caution the driver to reduce the speed. Even though the proposed system is very useful for hilly roads, it can also be used in normal roads. The system will assist and caution the driver, if he drives at high speed on curvy roads.



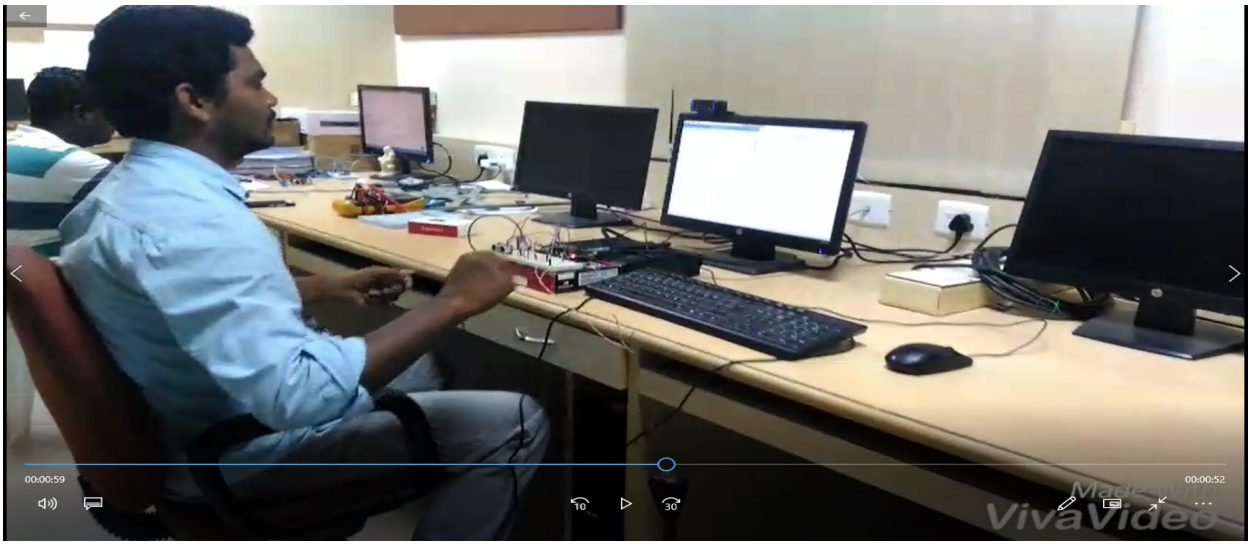
Identification of all hairpin bends using off-line map



Curve detection algorithm

Driver Fatigue Detection System

Many of us hire the vehicle and / or driver when we go for long journey during vacations / pilgrimage tours. During this time, for want of time the passengers insist the driver to drive for prolonged hours (more than 8 hours a day). Even the drivers for want of money overstretch themselves and drive for longer hours. Due to stress and tiredness these drivers become fatigue. The statistics says that these continuous, long drive leads to many accidents. To resolve this problem, we have implemented a system wherein we install few sensors inside the car and they are connected to an on-board Electronic Control Unit (ECU) which in turn is interfaced with the in-vehicle networking system to sense whether the vehicle is moving or not and what gear is engaged. The ECU is also interfaced with a sound system so that whenever the same driver drives the vehicle continuously (with small breaks) for more than 8 hours, it will trigger an alarm to caution him. The data can also be stored in the on-board ECU's data base. It will be useful for police in case of investigations.



Intelligent Interactive Voice Assistant System

At present people use IVRS (Interactive Voice Response System) for providing better services to a wide variety of services to their customers for 24 x 7. But in this system, the end user has to listen to the voices, remember them and finally press a number using their phones. Depending on the number pressed by the customer, services will be provided. To improve this system, we have used a Natural Language Processing based Interactive Voice Assistant System using Alexa device. In our system, the end user (customer) will ask the questions in a natural way. As our system is trained with all possible ways of asking a question it will figure out using NLP techniques what the user wants and accordingly provide the necessary services. In our work, we have trained the system to answer all questions related with a project work. When somebody presents his work in the conference / exhibition / seminar, the system will be able to answer the queries of participants. This is very useful wherein many people ask similar kind of questions. One can even depute somebody also to answer the queries of participants. This can act as a useful supplementary tool for video lectures.

interactive-voice application.mp4