Detection of Road from vehicle scene in different light conditions

Project report submitted for

Vth Semester Minor Project-I

in

Department of Computer Science and Engineering

by

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CERTIFICATE

This is to certify that the project titled "Detection of Road from vehicle scene in different light conditions" by "Divya Krishnani, Palak Arora, Khushboo Priya " has been carried out under my/our supervision and that this work has not been submitted elsewhere for a degree.

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Dr. SPM IIIT-NR

July-Dec, 2018

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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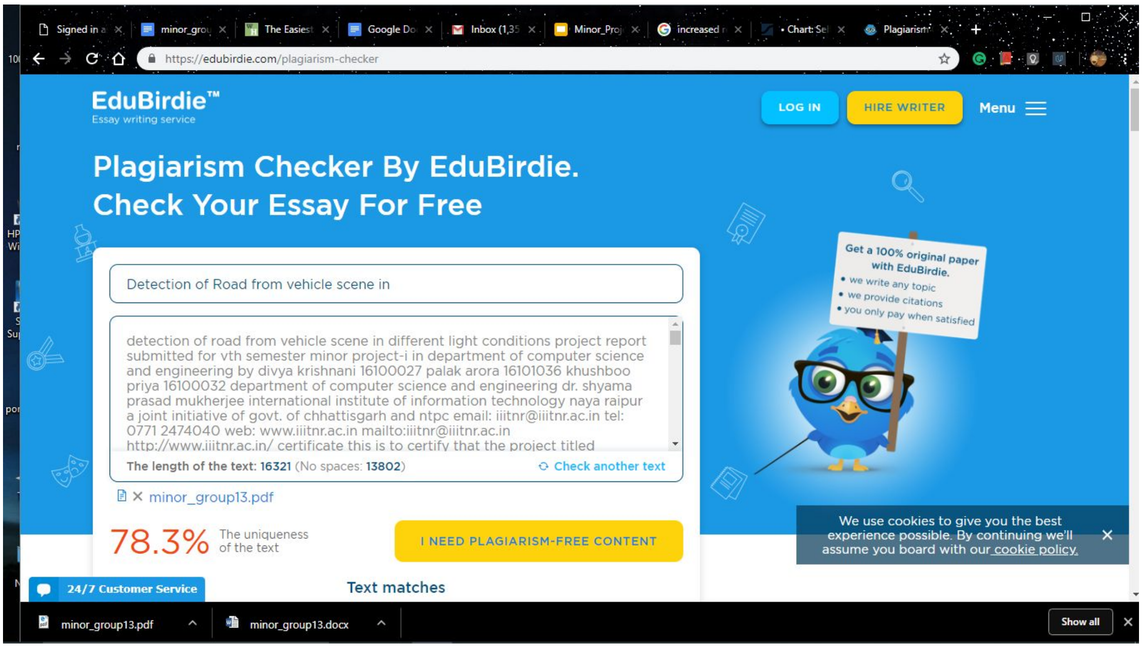
PLAGIARISM REPORT



APPROVAL SHEET

This project report entitled "Detection of Road from vehicle scene in different light conditions" by "Divya Krishnani, Palak Arora, Khushboo Priya" is approved for Vth Semester Minor-Project I.

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Dr. Ankit Chaudhary (Chair)

Date: _____________ Place: _____________

ABSTRACT

The aim of this project is to detect road area in front of the vehicle using Computer Vision techniques. Applied approaches include finding the edges in each frame and then applying Perspective Warp and Sliding Window Search to detect the lanes and then detecting out the area between them. The videos were shot all on our own using smartphones with good camera quality (iPhone 7 Plus: 4K video recording at 30 fps/1080p HD video recording at 30 fps or 60 fps/720p HD video recording at 30 fps/Optical image stabilisation for video). We have changed the frame rate to 12 fps for processing works.

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CHAPTER 1: INTRODUCTION

With increasing road network and traffic conditions in India and also, drivers leniency towards driving we need the application of intelligent transportation systems in India. Accidents in India are increasing gradually and also there are no measures taken up for managing the stray animals on major roads. However, road or lane detection becomes a challenging task when it comes to different curvatures and textures of the respective road and minimal development has been done in India towards this issue. Our aim is to make a working model for the road and apply the model to the real-time scenario.

We are developing an Image Processing based model to solve major issues faced in autonomous driving systems, with the increasing traffic conditions. We are developing Road Detection which is crucial for smart navigation systems. In our framework for detecting lanes, we are using videos from real-time vehicle scenes. In early stages for detecting lanes in the video, we have used Edge Detection Algorithm and Hough Transform for finding lanes in front of a vehicle, which would be able to analyse whether the vehicle is moving in a particular lane. Further, we have implemented Road Detection by first using perspective warp and filter and then detect roads by poly-curve fitting and sliding window.
The overall framework is implemented using Python & OpenCV(Open Source Computer Vision Library).

The region of interest of each frame of video is a trapezium-shaped region, in front of the vehicle. We have captured the video using iPhone 7 which has got inbuilt Optical Image Stabilisation feature so that the video quality is maintained and better results can be obtained. The videos are of the Naya Raipur and during data preprocessing we have undistorted each frame of the video, i.e the curved details of the image can be made flat enough to increase detection of lines.

This system can be implemented using Deep Learning and CNN which will increase the efficiency of the system as a whole.

The result is highly dependent on the intensity of light during various times of the day. The basic colour space is RGB on which any video gets recorded or any image gets captured. RGB (Red, Green, Blue) describes what kind of *light* needs to be *emitted* to produce a given colour. In computer vision, you often want to separate colour components from intensity for various reasons, such as robustness to lighting changes, or removing shadows. Henceforth, HSV, HLS, CIELUV are much more beneficial than RGB.

The impact of this system is huge in terms of averting disasters mainly during the night time when the rate of accident increases. These systems are already being implemented in foreign countries in huge global car brands such as BMW, Mercedes etc, making a consumer-friendly and accessible system will have a huge impact on the growth and economy of India, as our model focuses more on the Indian roads.

CHAPTER 2: LITERATURE REVIEW

S. No.	Paper	Description	Year	Drawback
1.	Computer vision based Drivable Road Area Estimation	Proposed Approach: ● Intensity **k-means clustering** ● **Color Segmentation** to detect the road pixel cluster	2015	Unable to identify curves and accuracy of results
2.	Vision Based Road Detection using Road models	Proposed Approach: ● Based on **scene(road) classification** which provides the probability that an image contains certain type of road geometry (straight, curve to the left/right, etc.) ● **Classifier trained**, probability map learned for road geometry ● **Road probability map combined with the result of a pixel–based road detection method** to improve performance	2009	Light variant approach
3.	Real time Lane detection for Autonomous Vehicle	Proposed Approach: ● Noise reduction ● **Canny Edge Detection** ● **Hough Line Transform** ● Right & Left lane detection	2008	Canny edge detection is used and no fitting algo is used
4.	Illuminant-Invariant Model-Based Road Segmentation	Proposed Approach: ● Making an Illuminant Invariant Image space from the dataset	2008	No Line or curve transforms are used

		● Using the **segmented image to detect roads** in different weather too.		
5.	Combining prior , appearance and context for road detection(Data Based Approach)	Proposed Approach: ● Collecting prior information about the road using GIS database systems ● Using low and high level cues to detect horizon line, vanishing point, lane markings, 3-D scene layout, and road shape ● Output is a binary mask which is formed by combining Georeferenced onboard image and present scene analysis output	2014	Huge databases are used, which require huge processing which isn't our case
6.	Real time road detection with image texture analysis based vanishing point estimation	Proposed approach: ● Calculate texture orientation using sober filter ● Calculate vanishing point using texture ● Calculate left and right boundary ● Update vanishing point and thus road is detected.	2015	Only straight lanes can be detected and less efficiency was there
7.	Near Real-Time Ego-Lane Detection in Highway and Urban Streets	● using Hough Line transform ● using Perspective warp, Sliding Window Search	2017	No Sobel edge detection is used and only works for lanes
8.	Robust Inverse Perspective Mapping based on Vanishing Point	● vanishing point detection ● calculate the pitch and yaw angle ● inverse perspective mapping	2014	Didn't worked for curved roads

9.	Vision-based road boundary tracking system for unstructured roads	• Birds Eye View • Hough Transforms • Different Light Intensities	2017	Curved Lanes can't be detected
10.	Road detection technology based on Reverse perspective transform	• sobel filter • perspective transform	2016	It didn't worked for night videos

Table 2.1

CHAPTER 3: PROPOSED SOLUTION

1) Sobel Filter:

It is used to detect edges present in images by using gradient/derivative of the image along x or y-axis. We take derivative because taking derivative helps us to find the change in intensity along any direction. A high change in gradient indicates a major change in the image intensity.

A method to detect edges in an image can be performed by locating pixel locations where the gradient is higher than its neighbours (or to generalize, higher than a threshold).

1. We calculate two derivatives:
    1. **Horizontal changes**: This is computed by convolving I with a kernel G_x with odd size. For example for a kernel size of 3, G_x would be computed as:
    2. $$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * I$$
    3. **Vertical changes**: This is computed by convolving I with a kernel G_y with odd size. For example for a kernel size of 3, G_y would be computed as:
    4. $$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * I$$
2. At each point of the image we calculate an approximation of the *gradient* in that point by combining both results above:
3. $$G = \sqrt{G_x^2 + G_y^2}$$
4. Although sometimes the following simpler equation is used:

5. $G = |G_x| + |G_y|$

Figure 3.1 Result of Sobel Filter edge detection

The overall steps implemented are:

1) Convert to HSL color space
2) Apply a threshold to the S channel
3) Return a binary image of threshold result

2.) Perspective Warp

The perspective transformation converts a 3d image/video into a 2D image space. Many studies have shown that using a bird's eye view is more helpful in detecting curved road areas than that in original camera space. This is achieved by applying the perspective transformation to the image.

The idea behind performing a perspective warp is that if we can project different lanes in a road area on a flat 2D image surface, we can find a polynomial that can represent road lanes in front of the vehicle. This will be achieved in further steps by fitting a curve on the lane edges extracted.

If we want to transform the a points (xi,yi) to the another point (ui,vi) for *i*=0,1,2,3, i=0,1,2,3, we can use a perspective transform of the form:

$$u_i = \frac{a_0 x_i + a_1 y_i + a_2}{c_0 x_i + c_1 y_i + 1} \quad ; \quad v_i = \frac{b_0 x_i + b_1 y_i + b_2}{c_0 x_i + c_1 y_i + 1}$$

The eight unknown coefficients $a0,a1,a2,b0,b1,b2,c0,c1$a0,a1,a2,b0,b1,b2,c0,c1 can be calculated by solving the following linear system:

$$\begin{bmatrix} x_0 & y_0 & 1 & 0 & 0 & 0 & -x_0u_0 & -y_0u_0 \\ x_1 & y_1 & 1 & 0 & 0 & 0 & -x_1u_1 & -y_1u_1 \\ x_2 & y_2 & 1 & 0 & 0 & 0 & -x_2u_2 & -y_2u_2 \\ x_3 & y_3 & 1 & 0 & 0 & 0 & -x_3u_3 & -y_3u_3 \\ 0 & 0 & 0 & x_0 & y_0 & 1 & -x_0v_0 & -y_0v_0 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & -x_1v_1 & -y_1v_1 \\ 0 & 0 & 0 & x_2 & y_2 & 1 & -x_2v_2 & -y_2v_2 \\ 0 & 0 & 0 & x_3 & y_3 & 1 & -x_3v_3 & -y_3v_3 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ b_0 \\ b_1 \\ b_2 \\ c_0 \\ c_1 \end{bmatrix} = \begin{bmatrix} u_0 \\ u_1 \\ u_2 \\ u_3 \\ v_0 \\ v_1 \\ v_2 \\ v_3 \end{bmatrix}$$

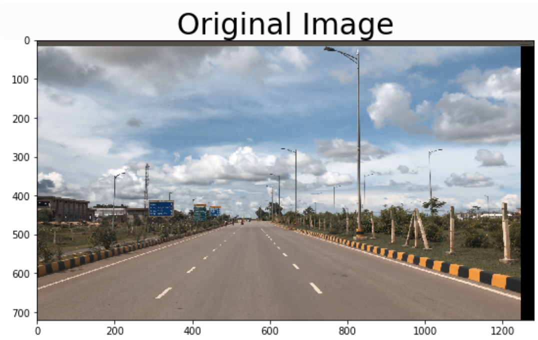
This is how perspective transformation works. In this work we have used perspective transform to achieve a bird's eye view of the image to obtain a specific ROI(Region of interest), a top view of the image. 4 points on the input image are mapped to 4 corresponding points on the output image represented as source(src) and destination(dst) points.

getPerspectiveTransform function is used for the implementation purpose which calculates the 3×3 matrix of a perspective transform so that:

$$\begin{bmatrix} t_i x'_i \\ t_i y'_i \\ t_i \end{bmatrix} = \texttt{map\_matrix} \cdot \begin{bmatrix} x_i \\ y_i \\ 1 \end{bmatrix}$$

where,

$$dst(i) = (x'_i, y'_i), src(i) = (x_i, y_i), i = 0, 1, 2, 3$$



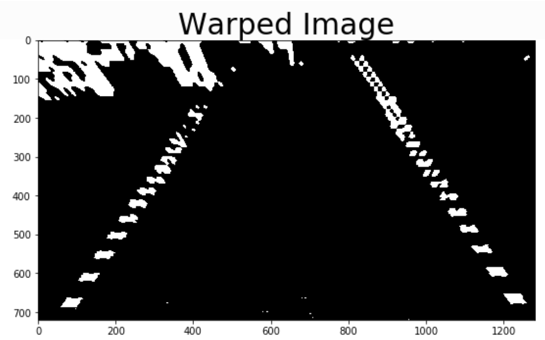
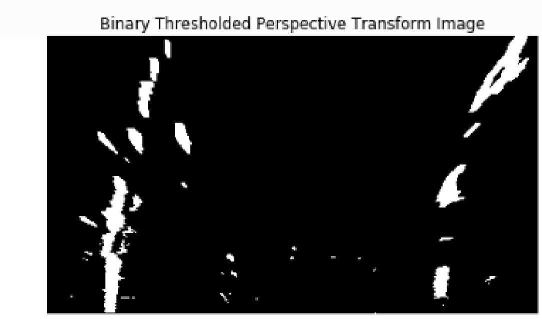


Figure 3.2 Original Image [2]

Figure 3.3 Warped Image

3) Histogram Peak



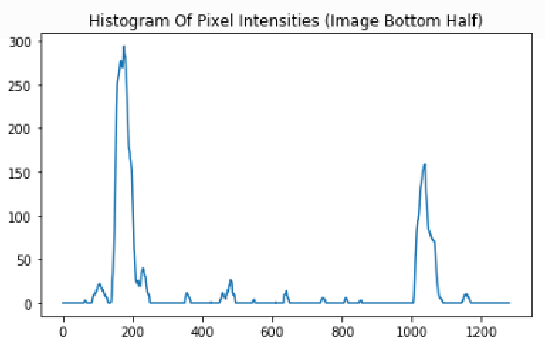


Figure 3.4 Binary Thresholded Image

Figure 3.5 Histogram of Pixel Intensities

This is a histogram plot of a bird's eye view representation of a lane. Histogram plots of these binary thresholded images are taken in the y-direction so as to identify the pixel intensities which are highest in x-direction.

4) Sliding Window Search

Sliding Window is used to classify the objects and to find where an object resides in an image. In this project Sliding windows are required to detect the lines on the road using the histogram to differentiate on the basis of intensities. A sliding window is a rectangular region which slides across the image to detect the required object is present or not in the image.

It is used to find the lane pixels and the increase the accuracy in detecting the curvature of the road. It is done by fitting the curve to a polynomial using numpy's poly fitting curve to find the coefficients that best fit the left and right lane of the curve.

Sliding window detects the desired object in the frame using a shrink and slide mechanism.

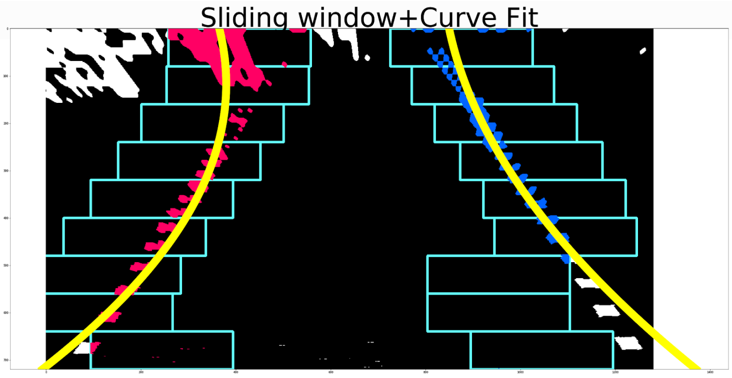


Figure 3.6 Sliding Window

5.) Curve Fitting

Curve fitting is the process of constructing a curve, or mathematical function, that has the best fit to a series of data points, possibly subject to constraints.

Polynomial Regression Curve fitting is used to achieve right and left curves of the road.

A general polynomial regression model of order k can be represented as:

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \cdots + \beta_m x_i^m + \varepsilon_i \ (i = 1, 2, \ldots, n)$$

where ε is the unobserved random error with mean zero and the coefficients of the polynomial regression model are **β**0, **β**1, **β**2...**β**m. The model can be represented in the form of system of linear equations as follows:

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} 1 & x_1 & x_1^2 & \dots & x_1^m \\ 1 & x_2 & x_2^2 & \dots & x_2^m \\ 1 & x_3 & x_3^2 & \dots & x_3^m \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & x_n & x_n^2 & \dots & x_n^m \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \vdots \\ \beta_m \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \vdots \\ \varepsilon_n \end{bmatrix},$$

Polynomial Regression of 2nd Order is performed on left and right lane boundary pixels differentiated in the previous step.

Following depicts the results after applying curve fitting.

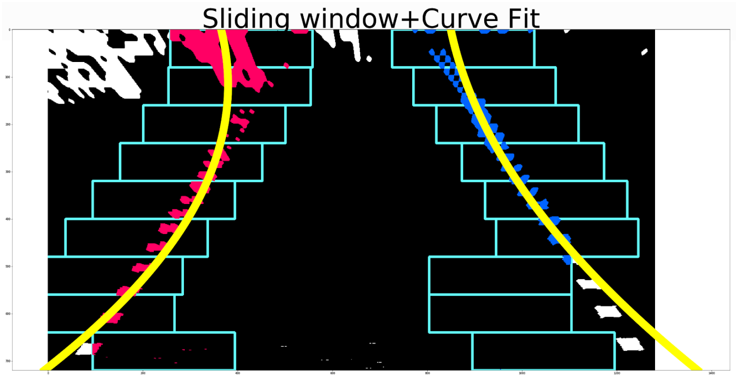


Figure 3.7 Curve Fitting

6.) Overlaying the curve on original image/video

The detected road area is overlaid on the image/video. The detected curves in the above perspective transformed image are mapped to the original image by performing inverse perspective transformation, i.e. mapping the destination points after perspective transformation back to the original source points. Hence the road detected is displayed on the image/video.

Figure 3.8 Resulting Image[2]

CHAPTER 4 : RESULTS

The proposed method is applied on videos of three different light intensities.

- Road on a sunny part of the day with bright light falling on the roads
- Road at the time of morning without bright sunlight.
- Road at evening with dark intensity.

Curved road lane is detected on all the different demo videos falling into above categories.

$$Accuracy = (No\ of\ frames\ with\ correct\ road\ lane\ being\ detected \div Total\ No.\ of\ frames) \times 100$$

The accuracy is measured in terms of total frames. Frame rate is 12 fps.

Light Intensities	**Accuracy**
Bright	81%
Without bright sunlight	95%
Evening	95%

Table 3.1 Accuracy and Results

Figure 4.1 False Detections[1]

Figure 4.2 True Detections[1]

CHAPTER 5: CONCLUSIONS

The project involved detection of road accurately so that the system can be helpful for driver and serve as a technological purpose for huge companies. We have managed to detect the road areas with medium accuracy with a huge dependency on the intensity of light and the time of the day. We followed a five step procedure involving Sobel Edge Detection, Perspective Warp, Sliding Window Search, Curve Fitting using Poly-Fitting curve and Inverse Perspective Warp. The advantages here are that not only lanes, instead curves can also be detected using Numpy's Poly-fitting curve.

The future scope of this project involves detection of the road on huge datasets using better technologies such as Deep Learning and CNN so that the detection can be done with high accuracy thus avoiding disasters.

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5. J.M. Alvarez, A. Lopez and R. Baldrich "Illuminant-Invariant Model-Based Road Segmentation"
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7. David E. Hernandez ; Sebastian Blumenthal ; Erwin Prassler ; Su Bo ; Zhang Haojie, "Vision-based road boundary tracking system for unstructured roads",

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8. 2016 8th International Conference on Intelligent Human-Machine Systems and Cybernetics “A road detection technology based on reverse perspective transformation”
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10. Daimang Zhang,Bin Fang,Weiben Yang, “Robust inverse perspective mapping based on vanishing point”.

Videos:

1) Downloaded from Internet
2) Shot on Naya Raipur

URLs

- https://www.learnopencv.com/
- https://scilab.io/computer-vision-perspective/
- https://www.pyimagesearch.com/2015/03/23/sliding-windows-for-object-detection-with-python-and-opencv/
- https://www.scipy-lectures.org/intro/scipy/auto_examples/plot_curve_fit.ht

APPENDIX

INCREASING ACCIDENTS WITH INCREASE IN TRAFFIC in INDIA

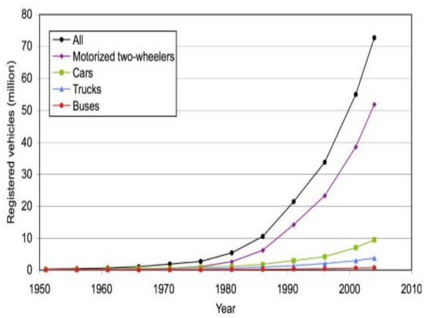


Figure 2. Registered vehicles, 1951 through 2004 (Department of Road Transport and Highways, 2008a).

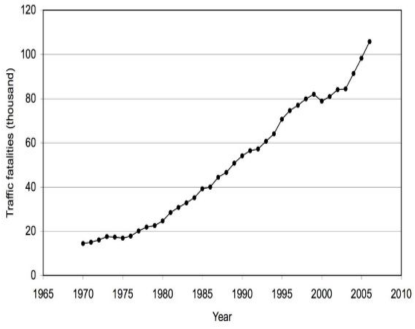
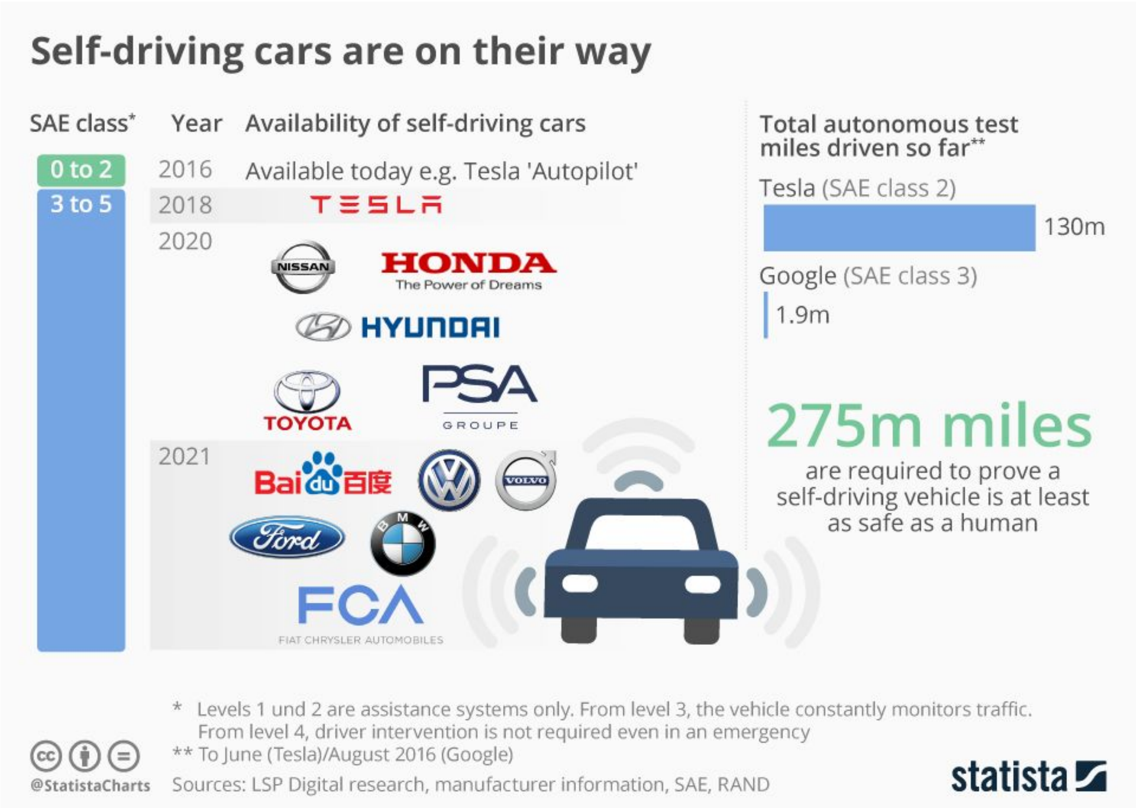


Figure 1. Traffic fatalities, 1970 through 2006.

The cause of accidents are:

1. Distraction
2. Speeding
3. Drunk Driving
4. Recklessness

Accidents can be reduced significantly by making a system that will alert the drivers if they are going outside their lane.



Strategy consultants have gotten to grips with the world of autonomous vehicles to reveal the companies planning to release an autonomous vehicle. The number of companies with such aspirations for the next five years is rather high with the likes of VW, Ford and BMW all planning a self-driving vehicle. The level at which the technology is expected to be performing is also impressive. From 2018 to 2021, twelve producers are looking to have cars that operate between level 3 and level 5 on the Society of Automotive Engineers (SAE) scale of autonomy.