Advanced Driver Security Application

Suhas N Bhargav, Rajani Katiyar

Abstract: The introduction of modern and more advanced vehicles has stretched their performance boundaries dramatically in terms of pace and maneuverability. It has also significantly enhanced the likelihood of people losing control of their vehicle, contributing to accidents. Within the past, several strategies have been suggested which resolve this issue by restricting the car's travel to just one specific path. To various road situations, this is achieved by applying lane identification utilizing algorithms such as canny edge identification, Hough transformations, vanishing point estimates, principal component analysis etc. Practical deployment of these programs, however, requires extremely powerful hardware such as TDA3x which can process in real time. This paper aims to introduce the usage of the Lane Detection and Alert System on a Texas Instruments Driver Assist 3x (TDA3x) board with a frame resolution of (1920*1080p) at 2 GHz relative to the current implementation, which has a resolution of only (480*270p) at 100 MHz.[16]. This system too makes use of canny edge detection and hough transforms to identify the lane points, and tracks the vehicle movement by extracting the corresponding polar co-ordinates.

Keywords: Lane Detection and Warning System (LDWS), Canny edge identification, Hough transforms, Vanishing point estimates, Principal component analysis, TDA3x

I. INTRODUCTION

There could be different causes for an on-road collision. Nonetheless, the split-second pause on the driver's part in reacting to an incident is what determines the condition between life and death. In most instances, accidents result when the driver has little time to react to an impending accident. This is attributed to the loss of synchronization between a driver's body and mind. There are also situations under which the crash is triggered by pure incompetence on the part of the vehicle driver. Whatever could be the cause, a careful rider's timely reaction is only one remedy that may potentially avert a crash and in effect save the lives of others.

Because humans are likely to commit mistakes intentionally or unknowingly, they cannot be expected to assume complete responsibility for maintaining fellow travelers' safety. Within the car an automated device will be built and introduced that can operate independently of the human driving the automobile. The purpose of this program is to control the driver's behavior constantly whilst maintaining track of the ambient environments at the same time. The benefit of putting up these devices inside the vehicle is that they can detect the driver's mistakes and anticipate future crashes as well. Not only does this warn the driver of his errors, but it would also help him resolve such errors by taking corrective steps on time.

In this article, Lane Detection and Warning System (LDWS) usecase would be addressed among the other uses that the autonomous systems will have. As the name itself indicates, this program essentially collects video frames from the camera on the front of the vehicle, and then extracts details about the lane lines on the route. The progress of the car will be monitored on the basis of the available details and an appropriate alert will be given to the driver beforehand. Not only does this warn the driver, but it will also help to prevent potential crash until it is too late for the driver to react.

Lane marks were identified on the path by evaluating the double edges of the lane markings[1]. On the captured image, canny edge detection operation was conducted to collect the details about the edges of the road. Then the essential features of the lane markers were derived by making use of this lane edge information and the lane field details. In the other side, [2] sought to concentrate the research in increasing the processor speed rather than on the precision of the usecase. Throughout this method, it was discovered that the usecase processing speed could be significantly improved by the resolution of the captured image, without any loss in precision or efficiency. [3] and [4] concentrated on the noise dimension of the picture by seeking to increase the efficiency and adaptability of the illumination to adjust to various lighting conditions on the route. However, there were drawbacks to their function in the presence of motorcyclists and pedestrians. [5] attempted to demonstrate the particular bottlenecks found in current procedures, such as obstructions created by the movement of cars, ambiguous lane markers, shadow obstructions attributable to houses, etc. and attempted to include several workarounds. [6] and [7] also based their research on solving the question of low road visibility in hilly regions due to the prevalent complex weather conditions including heat, fog, haze, etc. While they were able to obtain an output of 82% and 92% respectively, their job had some drawbacks near to the tight curves or in the midst of pedestrians. In [8], a binarization method was applied to the research regions, where each sample area was further divided into two parts: the foreground region and the context zone. This was achieved to make sure the context data did not impact the algorithm's overall output. [9] suggested a vision-based lane recognition algorithm to monitor the lanes while less lane markers were present on the route. The algorithm tried to map the lane in this method by utilizing the lane markers from just one side while the other half of the lane markings are totally erased. Also, in cases where both sides of the lane markers were

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removed, the algorithm sought to allow use of the lane markings from the previous moments and determined the lane points at the present time. Several other works [10–15] have sought to conduct vision-based lane recognition, utilizing methods such as perspective analysis, deep neural networks, vanishing point predictions and other mathematical models. Such techniques demanded huge computational costs and high computing capabilities were needed for their implementation.

All of these current works have attempted to conduct lane identification by concentrating on the specific dimension of the problem and have therefore progressed in gaining descent precision. Nonetheless, in order to incorporate these computationally complicated algorithms, ensuring that the execution time is held as short as possible is essential. These kinds of applications often include the use of highly engineered hardware which will allow the captured images to be processed in real time. Texas Instruments has created a hardware named “TDA3x” whose whole function is to support the ADAS framework implementation. This paper thus aims to shed some light on the board and discusses its usage in applying the LDWS usecase.

II. THEORY AND METHODOLOGY

As mentioned earlier, software would only be able to run in real time if the equipment it requires is adequately powerful to handle high-speed processing. Consequently, this paper utilizes the TDA3x hardware to execute the usecase addressed. Fig 1 depicts the interfacing diagram for the usecase.

![Fig. 1. Use case block diagram of LDWS (This figure indicates the interfaces that needs to be linked to the external I/O devices for the proper implementation of the proposed system)](image)

While canny edge detection helps to define the edges of the lane in the input picture, Hough transforms can help to establish a mathematical relationship between certain edge points, whether it is a straight line, a parabola or a circle. Hough transforms can also serve to derive the polar equivalents of the lane coordinates acquired to better map the direction of the lane and the test vehicle.

The government agencies who mark the lanes on the road must ensure they travel parallel to each other at all times. Yet in fact the way a camera looks at these lanes would be very special. When the camera is mounted parallel to the ground, it appears that the lines in front of the vehicle behave like a trapezoid, rather than rectangle. The Fig 3 represents this situation. The four extreme vertices of this trapezoid need to be defined first for usecase to classify the trapezoid. It is achieved by extracting the lane points details at the block’s Hough Transforms output. The Fig 4 demonstrates the pictorial image of the trapezoid.

![Fig. 2. Flowchart for use in LDWS (This figure depicts the sequence of operations that needs to be performed in the proposed usecase)](image)
When the 4 vertexes have been obtained, 2-point method can be used to produce a line equation and define the lane markings in effect. Suppose there are two points in space, \((x_1,y_1)\) and \((x_2,y_2)\). Therefore, the two-point formula for the line connecting those points can be supplied as shown in the equation (2):

\[ y - y_1 = \left( \frac{y_2 - y_1}{x_2 - x_1} \right) \cdot (x - x_1) \] ......(1),

where, \(\frac{y_2 - y_1}{x_2 - x_1}\) denotes the slope of the line.

The figure above, when generalized, represents the function of the related lane markings. This method can be used to further approximate or forecast the direction of the lane by substituting various values for \(x\) or \(y\) in the method above.

A perpendicular line needs to be constructed from the root to the line to separate the polar parallels (rho and theta) from the specified straight line, as shown in the Fig 5.

Then, using the trigonometric relationship between the angle and the duration of the side, the following equation can be obtained as shown in equation (2):

\[ \rho = (x \cdot \cos(\theta)) + (y \cdot \sin(\theta)) \] ......(2)

The definition mentioned above, when applied to both the lanes, results in Fig 6. There, “\(\theta_1\)” corresponds to the angle subtended by the left lane and “\(\theta_2\)” corresponds to the angle subtended by the right lane. Likewise, the magnitude of the perpendicular to the left lane is denoted by “\(\rho_1\)” and the magnitude of the perpendicular to the right lane is denoted by “\(\rho_2\)”. The car is said to be in normal condition when it stays within the limits of the current lane.

As the vehicle drifts to the left, the angles undercut by both lanes will decrease, while the magnitude of the perpendicular to the left lane rises and the magnitude of the perpendicular to the right lane drops, as shown in the Fig 7.
Similarly, as the vehicle drifts to the right, the angles undercut by both lanes will decrease, while the magnitude of the perpendicular to the left lane drops and the magnitude of the perpendicular to the right lane rises, as shown in the Fig 7.

The above principles will be used to get results for the suggested usecase of the LDWS.

III. RESULT AND DISCUSSION
Centered on the principles mentioned in the previous section, snapshots of the findings obtained are displayed, accompanied by a thorough review. The Fig 9 displays the snapshot of the lanes observed under normal conditions. The Fig 10 and the Fig 11 shows the snapshots obtained during the lane cross events.

The above experiment was also carried out using a sheet of cardboard and a cello tape to imitate the lane lines on the route. The data was evaluated for various camera parameter parameters, and the corresponding readings were tabulated, as seen in table I.
Once the collected readings from the tabular column have been evaluated, it can be inferred that the efficiency of the proposed application depends on the relative difference between camera height and road width. As the ratio of these two values begins to rise, it gets more harder for the usecase to accurately identify the lanes. Based on the same arguments, the lane markers on the path cannot be correctly measured when the ratio gets too small of a magnitude. This is because in both instances, the lanes in the shot picture stretch way outside the algorithm's processing range.

Unless at all the consumer also needs to be able to accurately identify the lanes at higher ratios, the device will be tilted downwards by a slight angle such that it is no longer parallel to the road surface. However, the optimal ratio the code should operate at, though, is in the range 0.3 to 0.8.

**IV. CONCLUSION AND FUTURE SCOPE**

Existing lane detection techniques on the Xilinx Zynq-7000 APSoC platform allow only a resolution of (480 × 270p) at 100MHz [16]. This paper tries to implement the proposed usecase by making use of a highly efficient and user-friendly hardware, the TDA3x board that allows maximum HD quality (1920 × 1080p) at 2GHz. As a consequence, the lane markers from the recorded video streams will be clearer and the sensed edges will be very precise. Also, the hardware level requirements for powering up this board makes it the most suitable one for setting up inside the vehicles. The availability of multiple cores in the hardware help to solve the computationally complex processes with ease. Overall, this paper is successful in providing a solution for a real-time implementation of the proposed safety application.

However, the proposed approach may be of some value when the driver is completely awake. In situations, when the driver drowses off, there is no significance of these warnings.

Also, these warnings will become a nuisance to the driver when he is deliberately wanting to change the lane. To addresses these minor issues, a more intelligent system can be developed in the future.

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**REFERENCES**


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Table I: Readings for various parameters of the camera

<table>
<thead>
<tr>
<th>SL. No</th>
<th>Height of the camera from ground (inches)</th>
<th>Width of the road (between the lane markings) in inches</th>
<th>Camera banking angle (w.r.t. Horizontal axis) in degrees</th>
<th>Ratio between Camera height and road width</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 (least height)</td>
<td>13.6</td>
<td>0 (parallel to the ground)</td>
<td>0.22</td>
<td>Lane detected</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>13.6</td>
<td>5 ↓</td>
<td>0.22</td>
<td>Lane detected</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>13.6</td>
<td>10↓</td>
<td>0.22</td>
<td>Lane detected</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>13.6</td>
<td>30↓</td>
<td>0.22</td>
<td>Lane not detected</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>13.6</td>
<td>0</td>
<td>0.73</td>
<td>Lane detected</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>13.6</td>
<td>20↓</td>
<td>0.73</td>
<td>Lane detected</td>
</tr>
<tr>
<td>7</td>
<td>15.8</td>
<td>13.6</td>
<td>0</td>
<td>1.161</td>
<td>Lane not detected</td>
</tr>
<tr>
<td>8</td>
<td>15.8</td>
<td>13.6</td>
<td>20↓</td>
<td>1.161</td>
<td>Lane detected</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>13.6</td>
<td>0</td>
<td>1.25</td>
<td>Lane not detected</td>
</tr>
<tr>
<td>10</td>
<td>17</td>
<td>13.6</td>
<td>20↓</td>
<td>1.25</td>
<td>Lane detected</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>25.3</td>
<td>0</td>
<td>0.11</td>
<td>Lane not detected</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>25.3</td>
<td>0</td>
<td>0.39</td>
<td>Lane detected</td>
</tr>
<tr>
<td>13</td>
<td>10</td>
<td>25.3</td>
<td>10↓</td>
<td>0.39</td>
<td>Lane detected</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>25.3</td>
<td>20↓</td>
<td>0.39</td>
<td>Lane detected</td>
</tr>
<tr>
<td>15</td>
<td>17</td>
<td>25.3</td>
<td>0</td>
<td>0.67</td>
<td>Lane detected</td>
</tr>
<tr>
<td>16</td>
<td>17</td>
<td>25.3</td>
<td>20↓</td>
<td>0.67</td>
<td>Lane detected</td>
</tr>
<tr>
<td>17</td>
<td>24.5</td>
<td>25.3</td>
<td>0</td>
<td>0.968</td>
<td>Lane not detected</td>
</tr>
<tr>
<td>18</td>
<td>24.5</td>
<td>25.3</td>
<td>15↓</td>
<td>0.968</td>
<td>Lane detected</td>
</tr>
<tr>
<td>19</td>
<td>30</td>
<td>25.3</td>
<td>0</td>
<td>1.18</td>
<td>Lane not detected</td>
</tr>
<tr>
<td>20</td>
<td>30</td>
<td>25.3</td>
<td>25↓</td>
<td>1.18</td>
<td>Lane detected</td>
</tr>
<tr>
<td>21</td>
<td>35</td>
<td>25.3</td>
<td>30↓</td>
<td>1.38</td>
<td>Lane detected</td>
</tr>
</tbody>
</table>

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