LcAR – Low cost Augmented Reality for the Automotive Industry

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Abstract— **Currently, AR (Augmented Reality) technologies for the automotive industry are available mostly for high-end luxury vehicles in developed countries where the nature of the solution is such that it is very costly to install and the repair cost is high. However, for developing countries, there is a huge and ever-increasing population that drives at night in low-light conditions where vehicle accidents are almost usually fatal. For developed countries too, the fatalities due to animal crossings etc is high. This paper presents a mechanism to drastically improve the visibility in low-light conditions using Augmented Reality where the real-time video is analyzed, and augmented with the highlights indicating obstacles if any. Our system uses an IR camera with suitable range. This video is then processed to identify the obstacles via machine learning frameworks, classified appropriately and augmented by highlighting the obstacles in the driver's path either visually or audio feedback or both. Our system can build upon previous knowledge to enable constant learning and improvement in the detection accuracy.**

Keywords-automotive augmented reality; machine learning in AR; automotive AR

I. INTRODUCTION

Currently, AR (Augmented Reality) technologies for automotive are available only for high-end luxury vehicles in developed countries where the entire windshield and display are integrated and connected to on-board electronics (ECU etc). This is a very costly solution and needs to get replaced in case of a crack. However, for developing countries (eg India/China), where there is a huge ever-increasing car population that drives at night/low-light conditions, car accidents are almost always fatal or near-fatal. Some of the market research data indications are listed below:
Statistics [1] show that about 22.9% of all driving accidents in India happen at night killing a majority of the young people aged 15-29 years. Worldwide, on an average, 1.3 million people die every year on the road. Also, in developed markets like US, almost 200 deaths occur annually due to animal crossing, costing a whopping $4 Billion [2].

One of the solutions to avoid such accidents is to ensure proper illumination across vast stretches of national highways and roads across the country. This may or may not always yield the desired result since the high-beam lights from oncoming vehicles can severely impair the drivers' vision inspite of proper illumination. Moreover, such a solution has an inherent recurring cost and is highly labour intensive.

Our proposed solution to avoid such accidents is via a low-cost augmented reality solution that captures the IR imagery via a suitable camera for the specified range and adds a dedicated low-cost controller for the video processing. This will project the augmented image with obstacles highlighted in red, onto a specific portion of the windshield display.

The system will also learn, via an embedded neural network, to identify and recognize the objects – based on training inputs. Finally, the augmented image/video is projected using a pico-projector with the desired lumen rating. A standard glass windshield is used with a low-cost surface mat if required for projection of the scene imagery. This system can be plugged into existing cars independent of car model or size with minimal modifications. The main advantages would be increased safety and minimizing highway accidents at night, apart from reduction in recurring costs incurred by the road infrastructure providers. The road visibility at night becomes very similar to the road visibility during the day, irrespective of the illumination infrastructure present on the roads.

II. AUGMENTED REALITY SOLUTION ARCHITECTURE

Figure 1 depicts the high-level component architecture of the solution:-

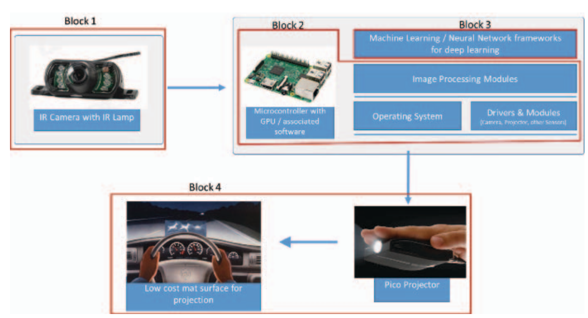

Figure 1: LcAR Component Architecture

An IR camera, together with an IR lamp for illumination (Block 1), captures the series of images/video and sends it to the microcontroller with GPU with associated software (Block 2). We perform image segmentation to extract the number of regions in the image. We then apply particular focus to the regions directly in the vehicle's path (both on the road as well as just above the road/lower than the height of the vehicle).

Using Machine Learning (Block 3), we attempt to classify the objects in the focus regions as follows:-

Harmless: If the vehicle proceeds on course, the vehicle or the object or both would not suffer any damage, whatsoever.

Non-harmless: If the vehicle proceeds on course, the vehicle or the object or both may possibly suffer significant damage, possibly loss of life.

We further classify this set of non-harmless objects as follows:-

Harmful: If the vehicle proceeds on course, the vehicle or the object or both will definitely suffer significant damage, possibly loss of life.

Possibly harmful: If the vehicle proceeds on course, the vehicle or the object or both may possibly suffer significant damage, possibly loss of life.

Figure 2 depicts the machine learning workflow:

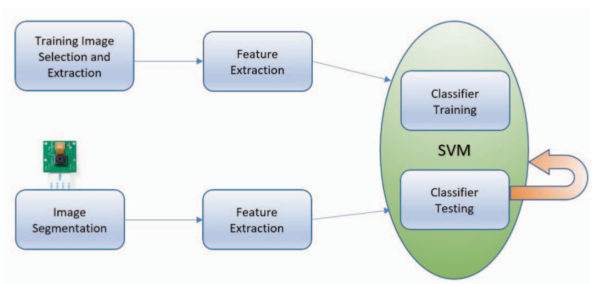

Figure 2 : LcAR ML Workflow

We selected and processed a small set of training images for feature extraction. These images go through a linear SVM classifier training for harmless and non-harmless objects. The captured test images are segmented and the regions are processed for feature extraction. The window around a candidate region is given as an input to a pre-trained CNN for feature extraction. The feature-extracted regions are fed back to the linear SVM classifier as done for the training images. The resulting binary map from the linear SVM classifier would have a list of harmless and non-harmless objects.

We use semi-supervised learning as the use of unlabelled (testing) data together with a small amount of labelled (training) data can improve accuracy considerably and is a plausible model for human learning.

The above classification enables us to highlight the object and warn the driver in low-light conditions. An audio feedback (similar to reverse parking audio feedback) can also be provided.

The above solution is tested in a trial run on a diverse sample of drivers.

III. Comparison with Existing Solutions

Some of the current solutions are HUDs (Heads-Up-Display) in various forms, ranging from a screen that projects various information onto the windshield glass (or a dashboard-top box that projects onto a glass surface). The current solutions available in the market do not solve the problem of obstacle identification/feedback via constant learning, whilst being expensive.

The following table depicts the main differences of our solution with respect to HUDs :

HUDs	LcAR
HUDs process the imagery around and display it along with the info present on the dashboard	Our solution is highly focused on obstacles and determining the nature of the obstacle
HUDs are more expensive and offered as a luxury alternative	Our solution is very low-cost and can be fitted onto any vehicle
Currently, HUDs do not have too much intelligence built-in	Our solution constantly learns and has the ability to enable learning / scale to millions of images.

Moreover, [3] contradicts the safety assertion of HUDs, claiming that, in practice, HUDs are distracting and "a threat to safety" because they force drivers to focus on two different things at once: the road ahead and the windshield. To alleviate this concern, we have an adhesive surface mat that can be fixed onto any small area of the windshield at the driver's convenience. The projection mechanism will only highlight the obstacles in bright blinking colors. When there is no obstacle, the projection area will be the same as the road-view. Thus, our solution displays the obstacles on the road without forcing the driver to shift the focus constantly.

IV. Experimental Setup

The experimental setup consists of:-

Hardware:

- A Raspberry Pi 3 board with Quad core 1.2 GHz BCM2837 64 bit CPU
- 1 GB RAM
- Micro SD 32 GB

Software:

- Linux (Ubuntu)
- OpenCV image processing framework
- Keras framework for ML with back-end as Tensorflow/Theano.

The machine learning training was performed offline using a standard Intel i5-6300U CPU running at 2.4 GHz with 8 GB RAM.

V. Conclusion and Future Work

The proposed solution integrates image/video processing with machine learning to highlight obstacles in the vehicle's path. Constant learning via the SVM feedback loop improves the efficacy of the solution.

In a smart city ecosystem, using AR solutions for automotive [4] can greatly enhance the driving experience for the passenger and heavy vehicle industry. It is possible to package our solution with the insurance industry as an additional revenue potential. During an accident, the image/video data can also be recorded (subject to prevailing privacy laws) and synced to the cloud to ascertain more details. It can also help to reduce the cost for the various business partners within the cloud ecosystem.

Our future work would involve coupling this solution with input from OBD (speed, turn radius/angle etc), thereby giving a significant improvement to the solution in terms of obstacle identification and highlighting the correct obstacle(s).

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References

[1] National Statistics of road traffic accidents in India, Journal of Orthopedics, Traumatology and Rehabilitation (JOTR), http://www.jotr.in/article.asp?issn=0975-7341;year=2013;volume=6;issue=1;spage=1;epage=6;aulast=Ruikar

[2] Insurance Journal, Car and Deer Collisions Cause 200 Deaths, Cost $4 Billion a Year, 2012. http://www.insurancejournal.com/news/national/2012/10/24/267786.htm

[3] Y.Sun, S.Wu, I.Spence. The Commingled Division of Visual Attention. PLoS ONE 10(6): e0130611. doi: 10.1371/journal.pone.0130611. 2015

[4] Augmented Reality in the Car Industry : https://www.completecar.ie/features/post/302/Augmented-Reality-in-the-Car-Industry