REVA UNIVERSITY
Bengaluru, India

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REVA Academy for Corporate Excellence (RACE)

A Monocular Camera Depth Estimation Approximation using Deep learning

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M.Tech in Artificial Intelligence

Capstone Project Presentation
Year: I

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Agenda

Introduction

- Depth estimation is a crucial task in applications such as collision avoidance systems.
- Depth estimation is backbone of ADAS
- For depth estimate, the most prevalent methods nowadays are based on Radar , Lidar or ultrasonic or combination of these technologies and stereo camera are being used.
- Also, there is monocular camera method which is for know size of the object being used for is not so accurate and tend to wrongly estimate for the object of unknow size.
- Traditionally monocular camera depth estimate calculate distance for a know reference object.
- Depth using single camera is challenging since the camera image is subject to perspective distortions.

Literature Review

Paper title, Year	Key Insight
An Ultrasonic Sensor for Distance Measurement in Automotive Applications, 2001	Discuss Ultrasonic 40khz piezoelectric-transducer for depth estimate in automotive industry.
Lidar Sensor in Autonomous Vehicles Syed	Discuss object detection and Depth estimation using Lidar.
Automotive Radar Signal Processing: Research Directions and Practical Challenges, 2021	Provide a comprehensive signal model for the using MIMO.
Sensor Fusion of Laser & Stereo Vision Camera for Depth Estimation and Obstacle Avoidance, 2010	Demonstrates a technique of sensor fusion of information obtained from LRF and Stereovision camera systems to extract the accuracy and range
An Image Based Approach to Compute Object Distance, 2008	Relationship between the physical distance of an object and its pixel height detailed.
Depth Estimation Using Monocular Camera, 2011	**Discuss a method for depth estimation using camera parameters and also image geometry.**

Problem Statement

- Autonomous vehicles are the future
- Radar , Lidar, Stereo based depth estimate systems are expensive to deploy in small cars
- There are monocular camera depth estimate available, however, works only on predefined objects.
- No wide adaption of Deep Learning algorithm in Monocular depth estimation

Project Objective

- ✓ **Implementation of Depth Estimation Using Monocular Camera, 2011 research paper using basic deep learning concept**
- ✓ **Which predominantly uses camera parameters and also image geometry**
- ✓ **Selection of optimal DL model to balance between complexity of model and cost associated**

❖ **Developed as depth estimation module for a Race Autonomous vehicle**

Basic concepts in research paper

Driven by Camera properties include height of camera, focal length, angle of tilt of camera, pixel resolution.

These camera parameters are related to respective camera only.

The image captured is in the 2-D plane and the relation between 2-D image and the actual 3-D view of the image can be found out to estimate the distance.

There are two cues which can be used:

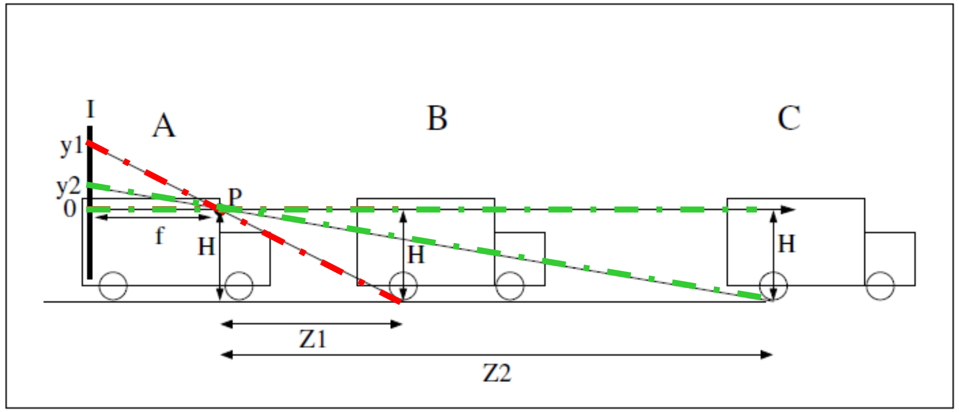
1. Size of the object and
2. Position of the bottom of the object.

Since the width of the object can vary, range estimate based on width will have only about moderate accuracy for e.g.: In case of a vehicle.

A much better estimate can be achieved using the road geometry and the point of contact of the vehicle with the road.

Depth estimate

Figure shows a diagram of a schematic pinhole camera comprised of a pinhole (P) and an image plane (I) placed at a focal distance (f) from the pinhole.



H = Height of the camera

Z1 = Distance of the rear of vehicle (B) from the camera

Y1 = The point of contact of vehicle and the road projects onto the image plane

f = focal length

Equation can be derived directly from the similarity of triangles.

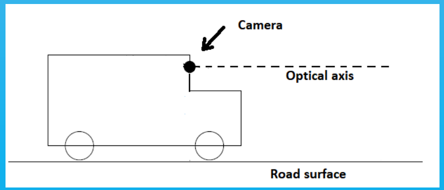
Distance to vehicle

$$Z = \frac{fH}{y}.$$

Typical intended setup

Technical | Functional

- ✓ Our proposed approach assumes a **planar road surface** and a camera mounted so that the **optical axis is parallel to the road surface**.

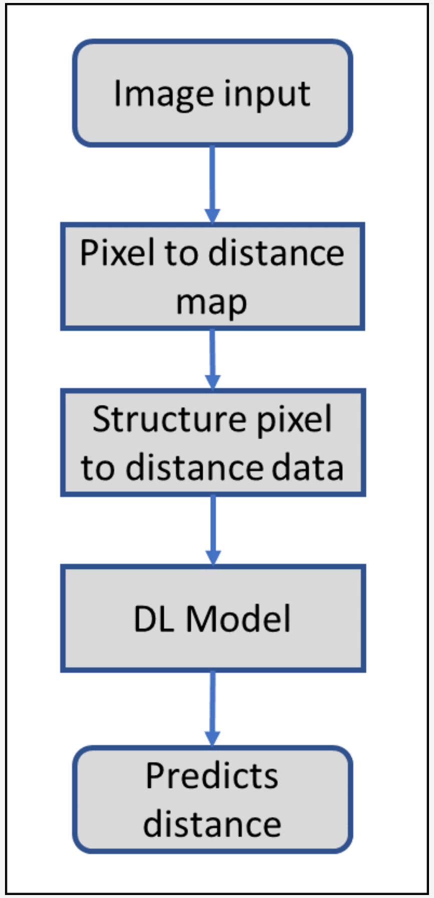


Race 2nd floor which planar and suitable for this approach

- ✓ The paper presents a novel approach to estimate the in-path and oblique distances of the objects using a single forward-looking camera mounted on the dashboard based on the **camera properties** and **geometry applied to the input images** relation between 2D and actual 3D view of the image is estimated.

Project Methodology

Conceptual Framework | Research Design



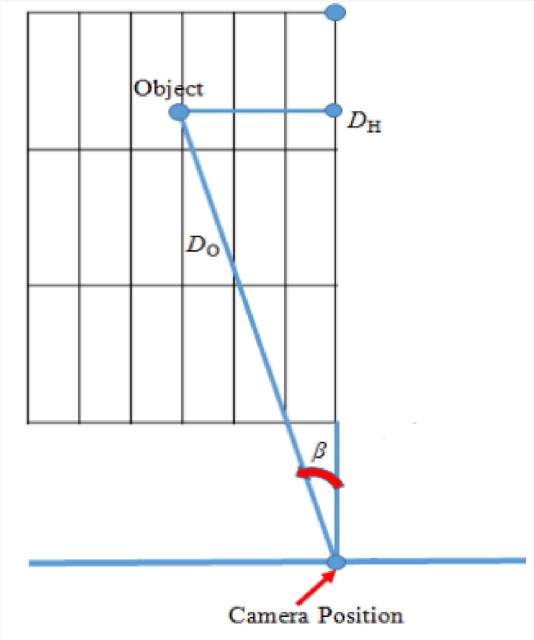
Technical Resources

- Python environment with required libraries,
- Pandas for creating a data frame from dataset
- Numpy for array operation
- Sklearn for data split as train and test
- Tensorflow for loading and deploying deep learning models
- Matplotlib to run varies data representation.

Project Methodology

Conceptual Framework | Research Design

Properties	Input variables
Input	Horizonal pixel position
	Vertical pixel position
Output	Depth estimate



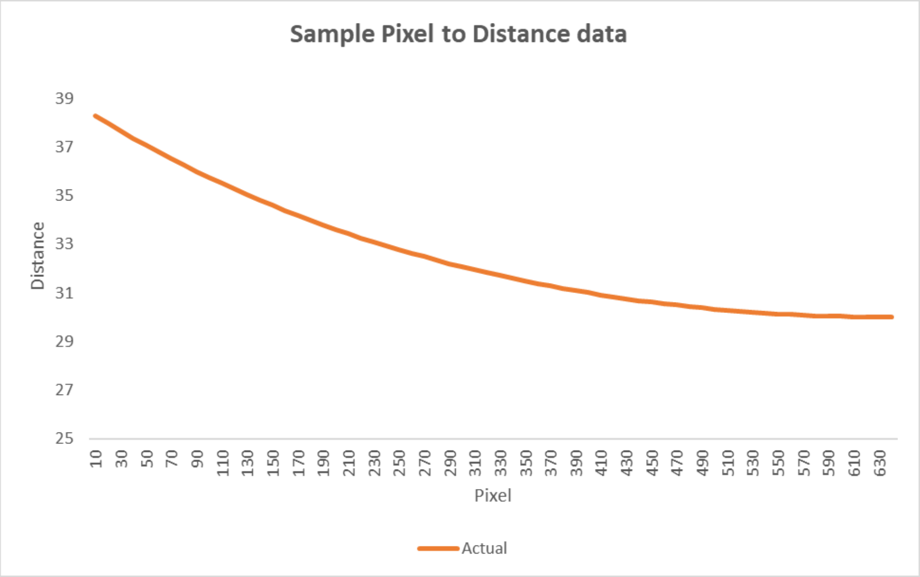
$$D_O = \frac{D_H}{\cos(\beta)}$$

Resource Specifications

Data Resources

- ✓ Data for the proposed implementation is simulated using camera parameters like focal length, vertical view angle, horizontal view angle and pixel density in both vertical and horizontal.

Sample data



Implementation

Demo | Application | Use cases

Data
- Structured pixel and distance data

Split data
- Split the data in to test and train
- 30% for test

Model train & test
- Train and test data with DL model

Validation
- Check the model accuracy with MSE, MAE, MAPE and RMSE

	Node at Layer 1	No. of hidden layers	No. of nodes in hidden layer
Model 1	13	1	10
Model 2	13	4	10
Model 3	50	1	100
Model 4	50	4	100

Testing and Validation

Test Results | Learnings

	MAE		RMSE	
	Train	Test	Train	Test
Model 1	2.0245	1.8609	2.6184	2.4958
Model 2	0.5060	0.5226	0.6550	0.6694
Model 3	0.1605	0.1675	0.2327	0.2494
Model 4	0.0623	0.0630	0.0837	0.0839

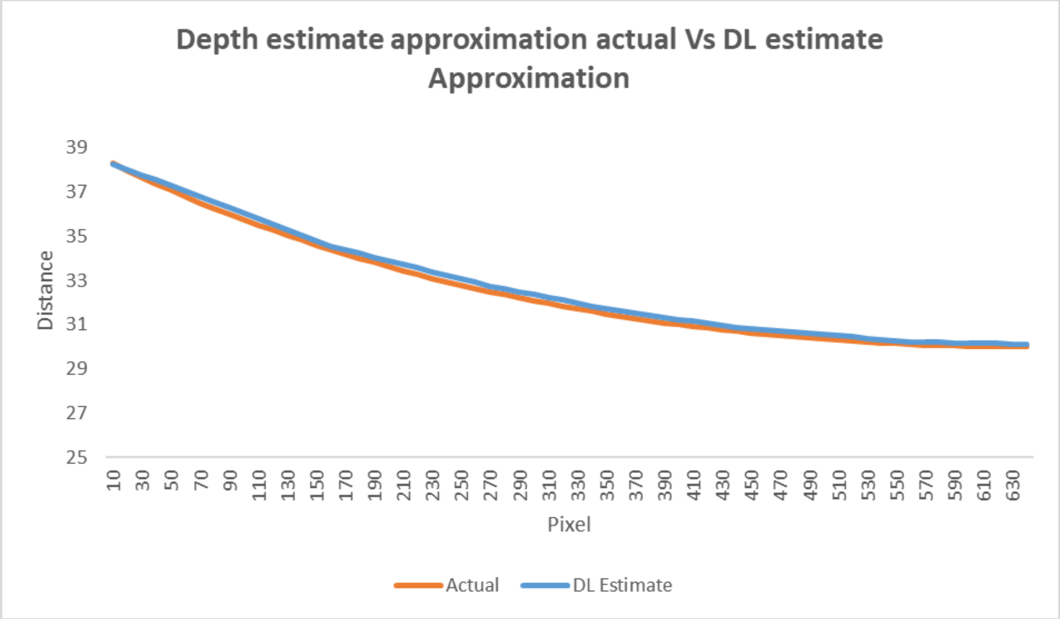
Implementation

Demo | Application | Use cases

DEMO

Analysis and Results

Key Findings | Insights



- ❖ Model 1 is taken as baseline model and all other models are compared with baseline model. It can be observed that model 2, MAE/RMSE is 75% less than baseline model
- ❖ Similarly additional layers and neurons will reduce this to almost zero in model 4, but the cost of building the complex model is very high

Suggestions and Conclusion

Insights | Next Step | Future Scope

Insights

- You can equip your car with this device to help you avoid collisions
- Works for camera optical axis is parallel to the road surface

Future Scope

- With a higher-resolution camera, the same method can be applied to considerably greater distances.
- Additionally, the approach can be improved for steep grades and winding routes
- Rare camera can be added for rare collision detection.

References

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Annexure

Additional Information | Plagiarism score

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