# 3D-PIV application for autonomous vehicles using monocular vision

Eduardo Afonso[1] and Researcher[2]

***Abstract*—**

## I. INTRODUCTION

Monocular vision has been demonstrating a flourishing field in autonomous vehicles.
Several applications has presented excellent solutions to problems presented nowadays. Therefore, this research contributes with an innovation, using Particle Image Velocimetry (PIV)[2] and Pearson's Correlation Coefficient (PCC)[6].
The proposal is to follow objects in scene and stipulate its relative velocity using the both techniques cited above. These parameters are calculated in 2 and 3 dimensions, and generated a coefficient relative to velocity of approaching and departure of objects.

Matlab is software used to validation of algorithm. PIV was the most important point of the beginning this project, considering numerous applications [7], [9].
Generally, this technique is utilized to calculate the field of velocity in fluids. Thus, it's possible to figure out the velocity of any objects that moves in scene. PIV was adjusted for situation to autonomous vehicles, using PCC and bank of dates of KITTI[4].

## II. THEORETICAL FUNDAMENT

### A. PEARSON CORRELATION COEFFICIENT - PCC

PCC is used in different fields, like: statistical analyses, pattern recognition and computer vision. Applications include disparity measurement, object recognition and comparing two images. The followed equation describes PCC for monochrome digital images[3]:

$$r_i = \frac{\sum_i (x_i - x_m)(y_i - y_m)}{\sqrt{\sum_i (x_i - x_m)^2}\sqrt{\sum_i (y_i - y_m)^2}}$$

Where $x_i$ is the intensity of the i th pixel in image 1, $y_i$ is the intensity of the i th pixel in image 2, $x_m$ is the mean intensity of image 1, and $y_m$ is the mean intensity of image 2 [6].

[1] Eduardo Afonso is coursing Control and Automation Engineering, Federal University of Lavras, Lavras - MG, Brazil. eduardo.afonso@engautomacao.ufla.br
[2] Researcheris with the Department of Electrical Engineering, Wright State University, Dayton, OH 45435, USA b.d.researcher@ieee.org

### B. PARTICLE IMAGE VELOCIMETRY - PIV

PIV is a method of determining velocity fields from images of seeded flows[2]. This technique is used to measure velocities of part or entire image. Its results is given by field of vector, demonstrating direction, sense and intensity of velocity in each particles. Therefore, it is possible to calculate the velocities of any part of image with two frames, for example.
PIV is powerful technique, and current researches support the vast applications [6], [7], [9] mainly involving fluids.

## III. SYSTEM DESCRIPTION

The purpose of this algorithm is tracking objects, producing added informations about the followed target. The algorithm developed takes inputs, such as: sequential frames and ROI(region of interesting). They are important to define the parameters used to generate tracking of objects and more details: relative velocity and factor of approaching or departure.
With ROI determined, the system enters in looping to follow the target as shown in the fig. 1.

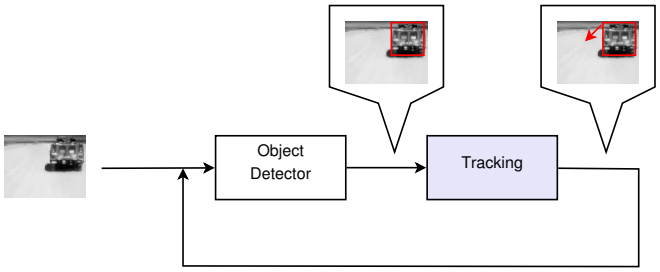


Fig. 1. Operation of algorithm in looping

In 2 dimensions, the objects are tracking and given information about its horizontal or vertical relative velocity. When the target moves in 3 dimensions, outputs are the relative velocity and the factor of approaching or departure. So that, there isn't the factor in 2 dimensions, since approaching or departure don't exist in this situation.

## IV. ALGORITHM DESCRIPTION

### A. MULTI-RESOLUTION MATCH CRITERIA

There are two method to find an object in the image in this algorithm. One is a search in axis x and y and other includes axis z. In the first way, the parameters of ROI are used to define the window of search (WOS) and the search is made pixel by pixel for whole WOS. The ROI and image selected are compared and verified if they are similar in each iteration. The new place of object is found from the

image of the highest coefficient calculated by PCC.
Other method to figure out the image includes axis z. In this way, the search is made in different layers and, consequently, the WOS changes beginning of the smallest (0.8 of size of ROI) until the biggest (1.2 of size of ROI) WOS with increment of 0.05 in each iteration.

*1) MULTI-PLAYER 3D APPROXIMATION:*

*2) FACTOR OF APPROACHING - RELATIVE VELOCITY:*

### *B. RENEW ROI CRITERIA*

## V. NUMERICAL RESULTS

## VI. CONCLUSIONS

PIV has presented satisfactory results. Different kinds of information that can be concluded, like: estimate collision, tracking of objects in 2 or 3 dimensions and factor of approaching and removal. The simulations in Matlab has given promissories results: (TABLES and GRAPHICS).

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