Artificial marker-based navigation using Aurora and OpenCV

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Abstract

This report serves as documentation for the source code developed. Two new plugins were added to the Aurora framework, which allow the use of a camera for a marker-based navigation system. The first plugin, used by the MarkerFollowing component, sets the new target of the robot's trajectory based on proximity to the marker, and ensures the robot does not change of target until it has completely arrived to the center point of the marker. The second plugin, used by the MarkerDetection component, detects the marker in the camera image and calculates the distance and orientation between the robot and the marker. The type of marker used is an arrow of an specific colour. OpenCV library was used to implement the image processing algorithms.

Marker detection

Introduction

The aim is to develop an artificial marker-based navigation using arrows of a certain colour to guide the mobile robot's trajectory. The robot is equipped with a stereoscopic camera that is used to detect arrows in the floor, and obtain for each one of them: distance to the robot, dimensions, center point, orientation.

The key assumptions will be:

- Any type of arrow can be detected.
- The robot only detects arrows of a specific colour that is defined in the configuration file of the component.

Finally, from all the arrows seen in the frame, the robot chooses as a target the one that is closest, and moves towards it until it is completely on top of its center point.

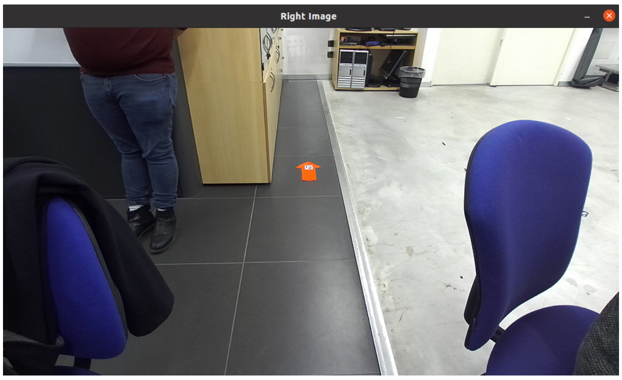

Figure 1: *Frame retrieved by the camera without processing*

Image preprocessing

Enhance image quality The aim of this step is to reduce noise by smoothing colours, but without blurring the edges. For this we use the cv::bilateralFilter from OpenCV. A previous transformation of the colour codification is required in order to be able to use the method from the library.

Apply colour filter In this step we eliminate all the colors of the image except from the arrow's one. As we will be only detecting arrows of a specific colour. We will define a mask (cv::Mat) that consists of a binary matrix of the same dimensions of the frame.

Cells set to 1 will correspond to those within a color range (where the color of the arrow will be, plus some tolerance due to changes in the illumination).

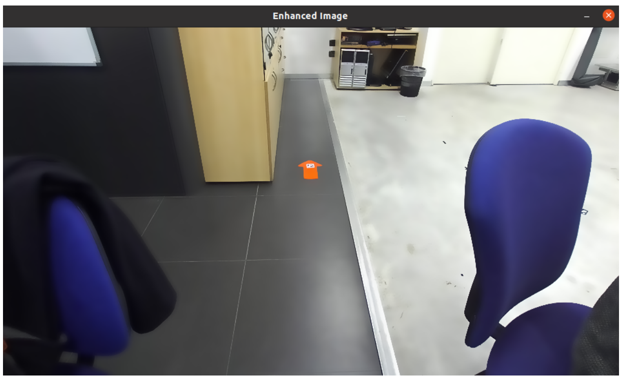

Figure 2: *Frame after applying bilateralFilter*

Figure 3: *Pure black and white image after applying the mask*

Figure 4: *Pure black and white image after applying the mask*

Then, we will simply define another matrix of the same dimensions of the frame, where each cell will store white colour (255, 255, 255) in BGR codification.

We multiply (bitwise_and operation) both of them and the result will be a pure black and white matrix, where the background will be black (0, 0, 0) and the arrow white.

Algorithm for detecting arrows

The algorithm for arrow detection in the frames can be decomposed in the following steps:

1. Detect the edges with Canny out of the pure black and white filtered image (Figure 4).

```
for (int i=0; i<iterations;i++)
{
do something
}
```

Methodologies

Sample Sites & Processing

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[1] Example footnote text.

This is a bullet point list:

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Data Analysis

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Table 1: *Example single column table.*

Location		
East Distance	West Distance	Count
100km	200km	422
350km	1000km	1833
600km	1200km	890

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Results

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Figure 5: *Anther of thale cress (Arabidopsis thaliana), fluorescence micrograph. Source: Heiti Paves, https://commons.wikimedia.org/wiki/File:Tolmukapea.jpg.*

Referencing a figure using its label: Figure 5.

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International Support

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Table 2: *Example two column table with fixed-width columns.*

Location		
East Distance	West Distance	Count
100km	200km	422
350km	1000km	1833
600km	1200km	890

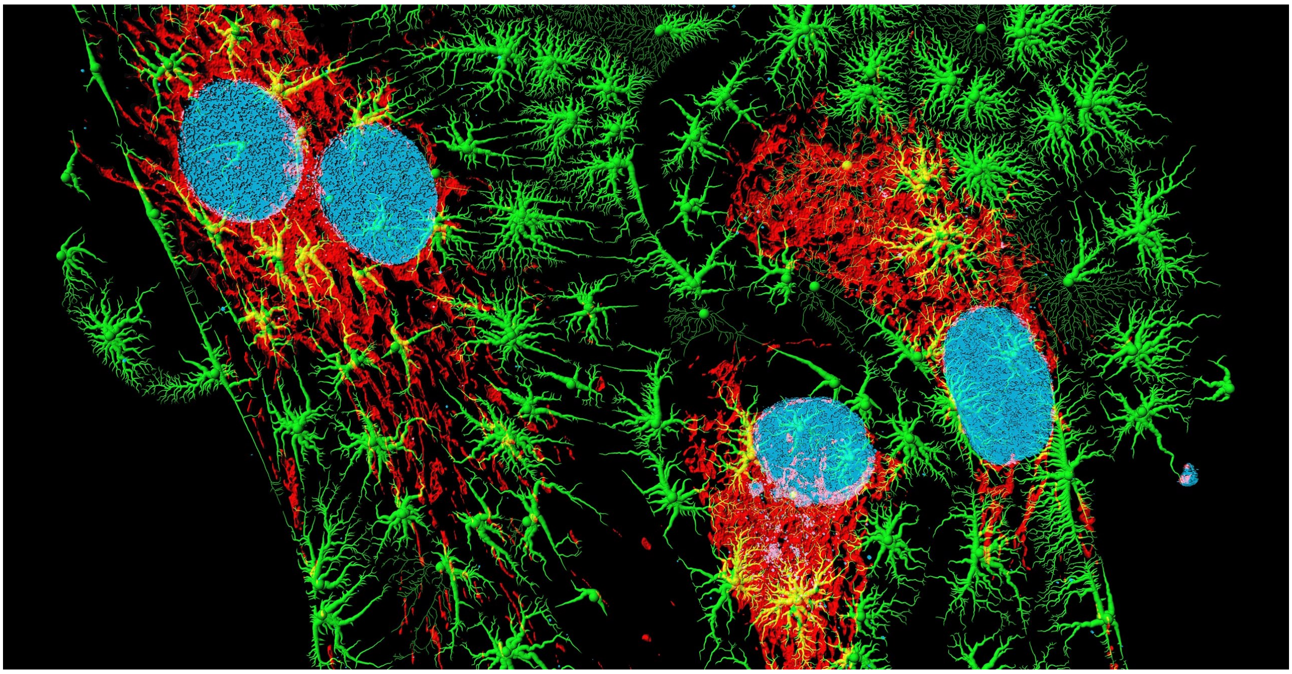

Figure 6: *Bovine pulmonary artery endothelial cells in culture. Blue: nuclei; red: mitochondria; green: microfilaments. Computer generated image from a 3D model based on a confocal laser scanning microscopy using fluorescent marker dyes. Source: Heiti Paves, https://commons.wikimedia.org/wiki/File:Fibroblastid.jpg.*

Links

This is a clickable URL link: LaTeX Templates. This is a clickable email link: vel@latextemplates.com. This is a clickable monospaced URL link: `https://www.LaTeXTemplates.com`.

Discussion

This statement requires citation [1]. This statement requires multiple citations [1, 2]. This statement contains an in-text citation, for directly referring to a citation like so: Jones and Smith [2].

Subsection One

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Subsection Two

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References

[1] J. M. Smith and A. B. Jones. *Book Title*. 7th. Publisher, 2023.

[2] A. B. Jones and J. M. Smith. "Article Title". In: *Journal title* 13.52 (Mar. 2024), pp. 123–456. DOI: `10.1038/s41586-021-03616-x`.