Project proposal: Image processing using convolution and filtering on ARM-based devices

Group 5, Chris Wegter 1589741, Cézan von Meijenfeldt 1634496

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1 Project Description

Convolution and filtering are common concepts in signal analysis as well as in image processing. However, these concepts can be quite theoretical and hard to grasp for beginners and students. By creating a demonstrator utilising these concepts in OpenCV, this project will show how these concepts work visually. The demonstrator will use a predetermined video as input to show specific image processing techniques, which can be selected by the user. The resulting output video will show the user what effect each concept has on the input. In addition to presenting different image processing concepts, performance will be measured of this application for later quantification.

To establish a performance threshold, the demonstrator will be made to run on a low-power ARM-based device, in this case, the Raspberry Pi 2 Model B. This device will serve as a benchmark device for the demonstrator to run on, allowing quantification of the application speed in fps(frames per second) and serve as a baseline in comparison to more recent and more powerful devices such as the Raspberry Pi 4.

2 Goals

The goal of this project is to visualise convolution and certain widely used filters using a pre-selected video clip. The demonstrator application written in C++ will process this video using the OpenCV library running on a Raspberry Pi 2B. The application will also measure the performance, which will be presented to the user in frames per second.

Because multiple different image processing techniques are used, they will be divided into different operations. Each operation will be measured separately to establish the effect on the performance of the application.

The operations are as follows:

- Gaussian Blur (3x3)
- Box Blur
- Sharpening
- Edge Detection
- Low Pass Filtering
- High Pass Filtering
- Band Pass Filtering

In addition to the single image processing operations, some combinations will also be implemented. These combinations will not count towards the benchmark and are purely there for demonstration purposes. As combining operations will significantly decrease performance, these combinations might be implemented on a static image instead of the video.

The following combinations are selected:

- Blur, Low Pass Filtering
- Sharpening, Edge Detection
- Blur, Sharpening

The predetermined input video will run at 30 frames per second and have a resolution of 320 x 240 (also known as QVGA). Each operation will be compared to this 30 frames per second threshold. This indicates if the application is able to process the video content realtime. If it cannot meet this requirement, the output video will start to desync. The 30 frames per second threshold should be met running on the earlier mentioned Raspberry Pi 2B.

3 Challenges

The challenges for this project are: first of all, applying the knowledge gained about signal filters and convolution, in a 2D medium(images/video). Secondly, implementing the features mentioned under goals in OpenCV using C++. Finally, optimising these features to be able to run on a Pi 2 Model B at 30fps.

4 Deliverables

For this project, the following products will be delivered:

- An OpenCV demonstration application.
- A comprehensive report
- A video that shows the functionality of the application