**Assignment 3**

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In this project we will build a code that detect the movement of the objects between two pictures using Lucas-Kanade optical flow technique.

We start by importing all the necessary libraries:

Graphical user interface, text, application, email

Description automatically generated

First, the two consecutive images from the video sequence are read from the folder.

Graphical user interface

Description automatically generated

1. **Choose two consecutive images from a video sequence. Convert images to grayscale.**

Graphical user interface

Description automatically generatedHere the images that are read are converted to gray scale using convert function from PIL with “L” as an argument.

1. **Smooth the two images using Gaussian filters.**

Graphical user interface

Description automatically generatedThe gaussian filtering over the images are applied using the open cv function called GaussianBlur with kernel size of 3x3.

1. **Graphical user interface, text, application

   Description automatically generatedCalculate the spatial derivatives *Ex = ∂E/∂x* and *Ey = ∂E/∂y***

The spatial gradient along X and Y direction are computed using Convolve2D function from SciPy. For spatial derivative along X axis, the kernel ¼\*[[-1 1][-1 1]]is used while for along Y axis, the kernel ¼\*[[-1 -1][1 1]] is used.

1. **Calculate the time gradient by the difference between consecutive frames, simply subtracting the two frames as *Et=I(x, y, t + 1) − I(x, y, t)***.

The time difference is computed using subtraction of image frames.

1. **Graphical user interface

   Description automatically generatedDisplay the original image and the spatial and time gradients.**

The first image is the original gaussian smoothen image, the top right image is the spatial gradient along X-axis, the bottom left is the spatial gradient along Y-axis, and bottom right is the time gradient of two images.

Graphical user interface

Description automatically generatedBefore computing the flow vectors, I will select the good features or the significantly important features from the image. Then only calculate the flow vectors of those features rather than calculating flow vector of each pixel. Since, the calculation with all the pixel was also carried out however the computational time was very high thus only the good features are taken into consideration and thus demonstrated.

1. **Compute the flow vectors u and v. To compute these parameters, you need to select a neighborhood size and then solve the optical flow equation using points in the neighborhood.**

A picture containing text

Description automatically generated

1. **Display the computed flow vectors over the original image.**

Graphical user interface, application

Description automatically generated

1. **Discuss your results.**

As can be seen from the above figure, the two balls on left are moving from left to right and ball on the right is moving from right to left. While the bottle and everything are stationary in the image sequence. As a result, the algorithm has been clearly able to estimate the motion of the different pixels of the balls movement. Since each balls have the corresponding flow vectors pointing its motion direction. The plot has been made more explainable by plotting the flow vectors with different color depending on the magnitude of the vector. So higher magnitude (> 10) the flow vector has yellow color is the arrow of that pixel. So, if the magnitude is low (between 2 and 10) the flow vector color is blue. And, if the magnitude is less than 2 then we do not plot the vectors because those flow vectors do not have significant value. The thresholding of small value is done to avoid very small motion of pixels which are not the object motion but are some random movement and noise.

Even though when we chose many points for evaluating the flow vector, the algorithm has been able to estimate motion and movement of direction of the moving parts from the images i.e., three balls and the corresponding ropes holding the balls

From the above figure of flow vectors, we can also extrapolate the information that the magnitude of speed of ball at right is more than the balls on the left. Since there are high number of yellow arrows there.

There are some other flow vectors been plotted in the bottom which are supposed to be the stationary objects; however, they are shown because there was some motion seen in them which the algorithm computed. Nevertheless, the algorithm has done the good job of highly estimating the flow vectors of the motion parts only.