* + 1. **Second approach – HOG (Histogram of Oriented Gradients)**

The first approach was not successful, so decision was to use another feature description algorithm – Histogram of Oriented Gradients. HOG combined with SVM is widely used to object detection. Firstly, there was used ready HOG algorithm from OpenCV package to check if chosen approach make sense. Finally, HOG algorithm was implemented and used with SVM model.

* + - 1. **HOG algorithm**

The main idea of HOG is to use histograms of gradients directions as a feature descriptor. Algorithm steps:

1. Find Intensity Gradient of the Image:

Filter smoothened image with a Sobel filter in both horizontal and vertical direction to get first derivatives Gx and Gy. Then count edge gradient magnitude G and direction θ for each pixel as follows:

1. Calculate histograms of gradients in chosen cells.

Divide image to equally size cells. In our case 64x64 px images where split to 64 8x8 cells. Now in each cell calculate histograms of gradients values with respect to gradients degrees. There were chosen 9 splits on angles 0, 20, 40, 60, 80, 100, 120, 140 and 160 degrees. Example:

A graph with numbers and a line

Description automatically generated

Gradient magnitude in first pixel is 2 and direction is 80 degrees so whole value (2) is attached to 80 degrees in histogram. On the other hand, in pixel number 4 there is magnitude=4 and direction=10 therefore value 4 is split equally between angles 20 and 40 in the histogram.

1. Block normalization.

Initialize block size as a multiplicity of cell size. In our case it is 16x16 px. Now for all histograms obtained in previous step, their values are normalized within block. Results are attached to final feature list. Afterwards block slides about one step (in our case 8 pixels) and operation is repeated. Whole process is running in a loop for a whole image. Results are returned as a final feature vector. Example:

A person running in a race

Description automatically generatedA person running in a yellow shirt

Description automatically generated

In the first image block covers 4 cells, histograms of those cells are normalized and obtained values are added to final results list. In the second image we can see that window slided about one step and whole operation is repeated.