Digital image processing

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Homework 3

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Changes for the use of C++11

Because we wanted to use `C++11`, we added `set(CMAKE_CXX_FLAGS "${CMAKE_CXX_FLAGS} -std=c++11")` to the `CMakeClists.txt`.

Exercices

create Gaussian Kernel

```
Mat Dip3::createGaussianKernel(int kSize){

    float sigma = 0.3 * ((kSize - 1) * 0.5 - 1) + 0.8;
    int mean = kSize/2;
    Mat kernel = Mat::zeros(kSize, kSize, CV_32FC1);
    float sum = 0;

    for (int x = 0; x < kSize; x++) for (int y = 0; y < kSize; y++) {

        float scale = 1/(2 * M_PI * sigma * sigma);
        float e = -0.5 * (pow((x - mean)/sigma, 2.0) + pow((y - mean)/sigma, 2.0));
        float gaussXY =  scale * exp(e);

        sum += gaussXY;

        kernel.at<float>(x, y) = gaussXY;

    }

    // normalize kernel

    for (int x = 0; x < kSize; x++) for (int y = 0; y < kSize; y++) {
```

```
        kernel.at<float>(x, y) = (kernel.at<float>(x, y)/sum);
    }

    return kernel;
}
```

circShift

```
Mat Dip3::circShift(Mat& in, int dx, int dy){

    // sanitze input

    dx = dx % in.cols;
    dy = dy % in.rows;

    Mat out = Mat::zeros(in.rows, in.cols, CV_32FC1);

    for (int x = 0; x < out.rows; x++) for (int y = 0; y < out.cols; y++) {

        int newX = (x + dx) % out.cols;
        int newY = (y + dy) % out.rows;

        newX = newX < 0 ? out.cols + newX : newX;
        newY = newY < 0 ? out.rows + newY : newY;
        out.at<float>(newX, newY) = in.at<float>(x, y);

    };

    return out;

}
```

Frequency Convolution

```
Mat Dip3::frequencyConvolution(Mat& in, Mat& kernel){

    Mat tempA = Mat::zeros(in.rows, in.cols, CV_32FC1);
    Mat tempB = Mat::zeros(in.rows, in.cols, CV_32FC1);

    for (int x = 0; x < kernel.rows; x++) for (int y = 0; y < kernel.cols; y++) {
        tempB.at<float>(x, y) = kernel.at<float>(x, y);
    }

    tempB = circShift(tempB, -1, -1);

    dft(in, tempA, 0);
    dft(tempB, tempB, 0);
    mulSpectrums(tempA, tempB, tempB, 0);
    dft(tempB, tempA, DFT_INVERSE + DFT_SCALE);

    return tempA;
```

```
}
```

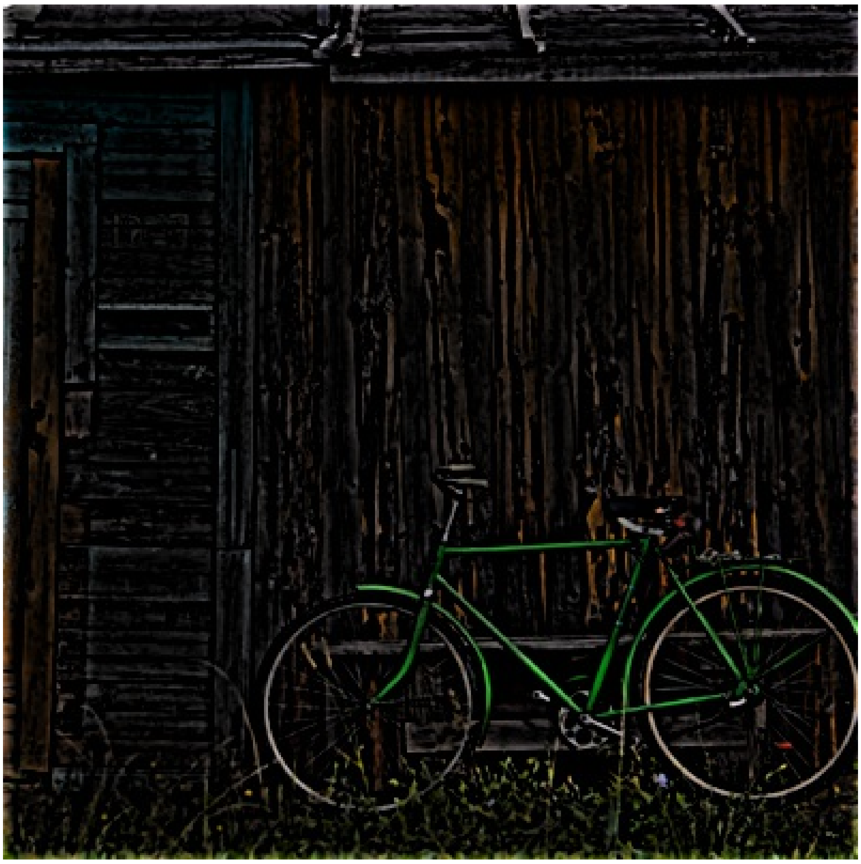
unsharp Masking

```
Mat Dip3::usm(Mat& in, int type, int size, double thresh, double scale){

    // some temporary images
    Mat tmp(in.rows, in.cols, CV_32FC1);

    // calculate edge enhancement

    // 1: smooth original image
    //    save result in tmp for subsequent usage
    switch(type){
       case 0:
          tmp = mySmooth(in, size, true);
          break;
       case 1:
          tmp = mySmooth(in, size, false);
          break;
       default:
          GaussianBlur(in, tmp, Size(floor(size/2)*2+1, floor(size/2)*2+1), size/5., size/5.);
    }

    subtract(in, tmp, tmp);

    for (int x = 0; x < in.rows; x++) for (int y = 0; y < in.cols; y++) {
       if (tmp.at<float>(x, y) > thresh) {
         in.at<float>(x, y) = in.at<float>(x, y) + tmp.at<float>(x, y) * scale;
       }
    }


    return in;

}
```

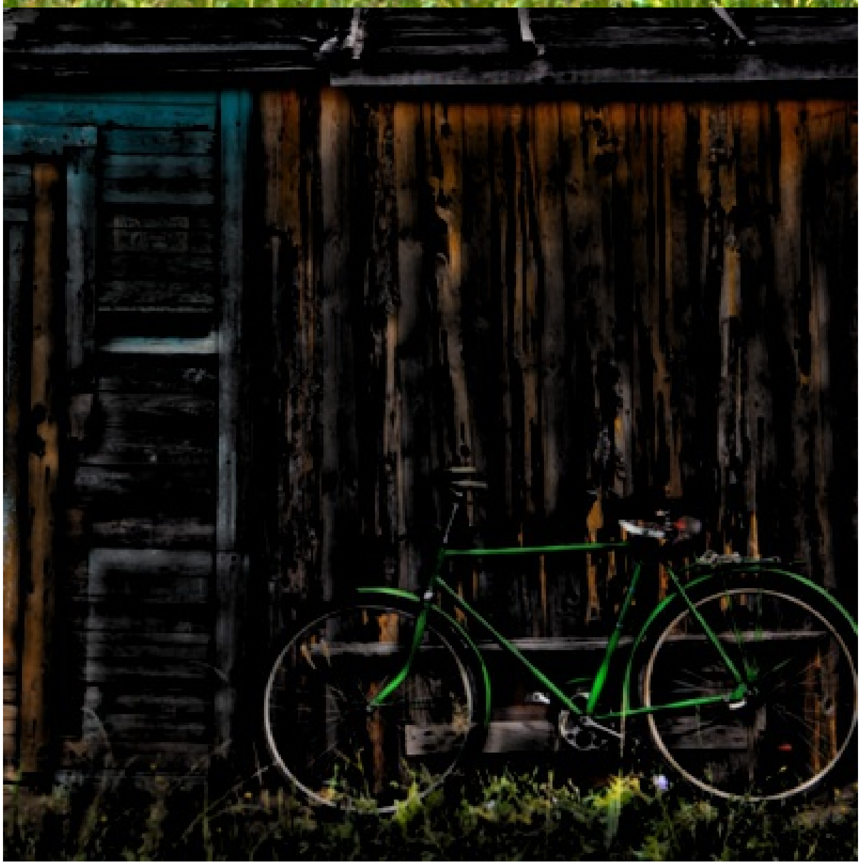
Image results

Here are the examples with a size of 400x400 and a kernel-size of 17

created with spatial convolution



created frequency with frequency convolution



Runtime

What we can see in those graphs, that the runtime is affected by the kernel size when doing spatial convolution, but not in frequency convolution. This is due to the fact, that in frequency convolution the convolution is simple a multiplication of matrices that are always the size of the initial image (the kernel needs to be enlarged to fit the image size). So despite how large we choose the kernel - we always enlarge it to fit the size of the image. In spatial convolution the kernel-size directly affects the size of the matrices that are multiplicated.