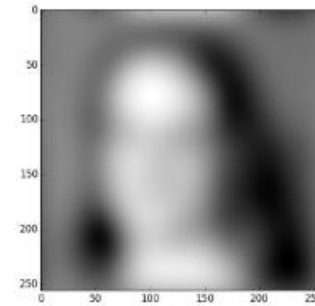# Image Processing, Retrieval and Analysis

Project 2

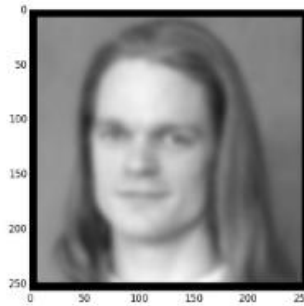Alina Arunova

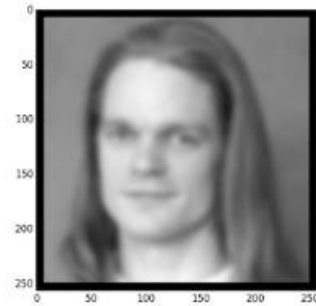Alexey Karpov
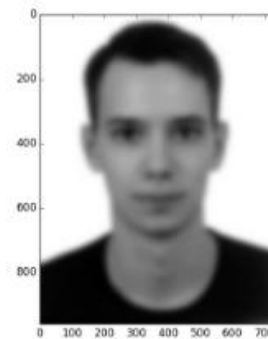
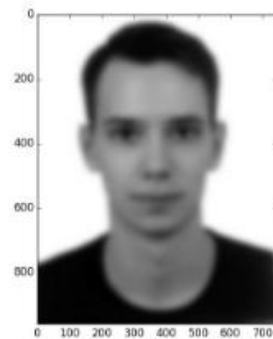Maxim Maltsev

Pylyp Matyash

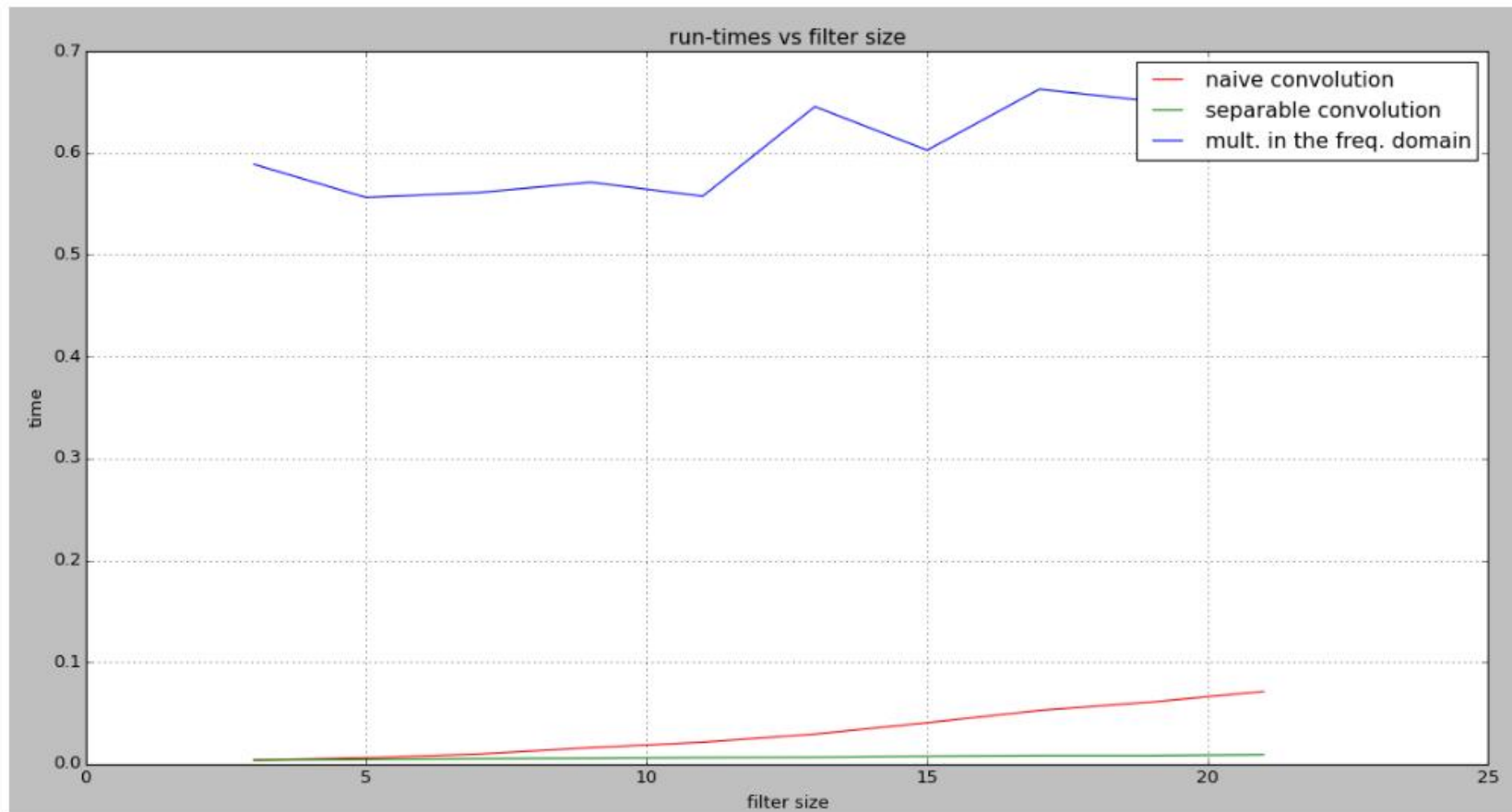Maksym Radomskyi

Andrei Zhukov.

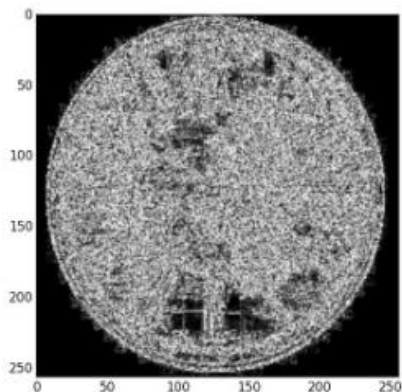# Task 2.1: Smoothing images

15 x 15, $\sigma = 2.7$

50 x 50, $\sigma = 9.5$
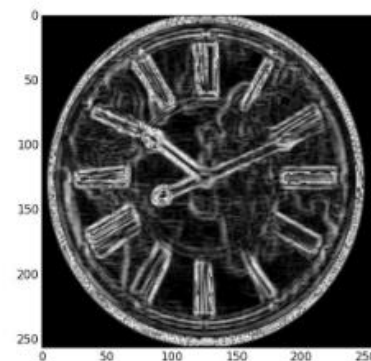
Task 2.1: Smoothing images

run-times vs filter size

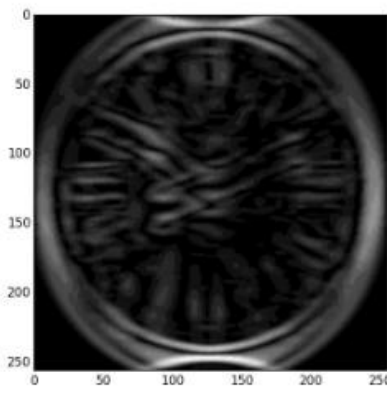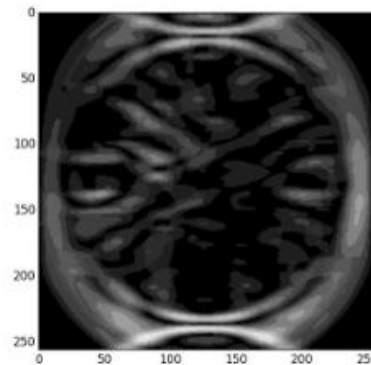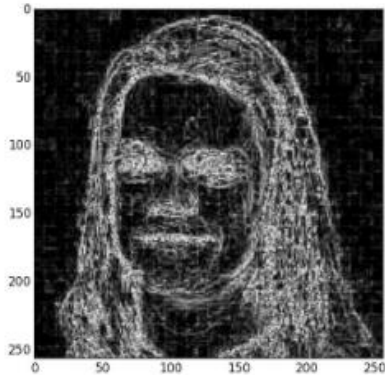# Task 2.2: Computing gradient images

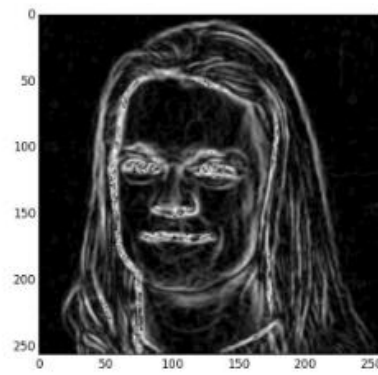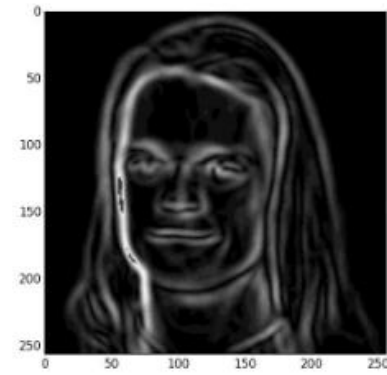

3x3
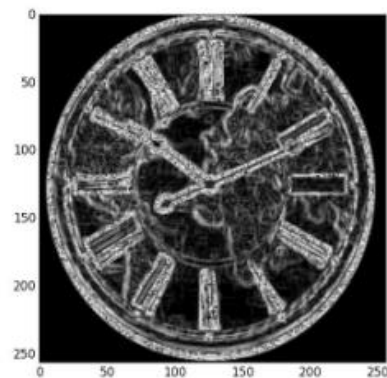
7x7

9x9
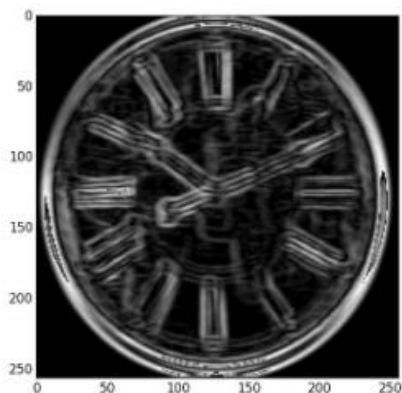
15x15

33x33

49x49

Task 2.2: Computing gradient images

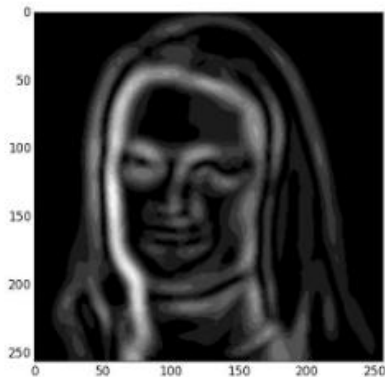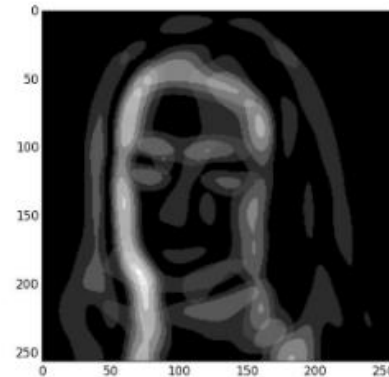3x3

9x9

15x15

27x27

45x45
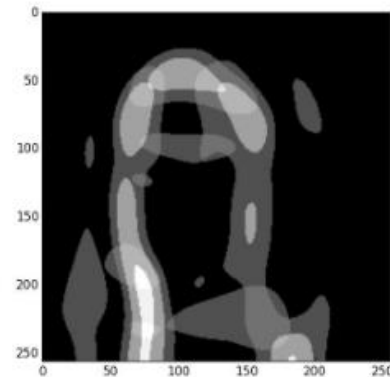
69x69

Task 2.3: Implementing a recursive filter
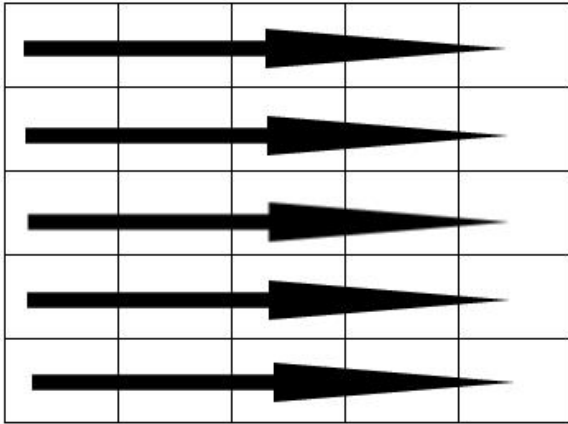
1) X[m,:]
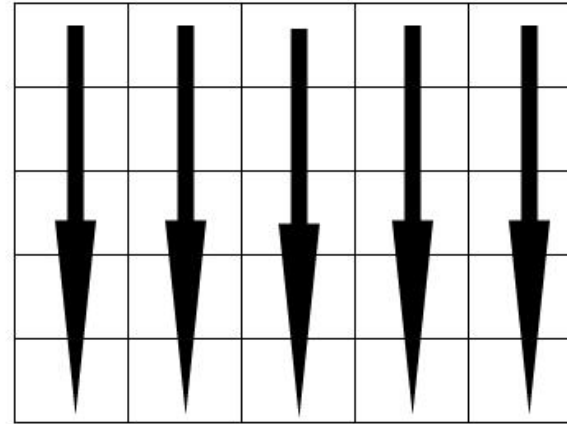
2) X[:,n]

$$Y[n] = \frac{1}{\sigma\sqrt{2\pi}} \left(\sum_{m=0}^{3} a_m^+ x[n-m] - \sum_{m=1}^{4} b_m^+ y^+[n-m] + \sum_{m=1}^{4} a_m^- x[n+m] + \sum_{m=1}^{4} b_m^- y^-[n-m] \right)$$

Causal filter

Anticausal filter

Task 2.3: Implementing a recursive filter

$\sigma = 0.2$

$\sigma = 0.8$

Task 2.3: Implementing a recursive filter

$\sigma = 0.1$

$\sigma = 0.5$

$\sigma = 0.9$

$\sigma = 1.1$

Task 2.3: Implementing a recursive filter

Influence of border

$\sigma = 1.2$ $\sigma = 1.2$ $\sigma = 0.2$

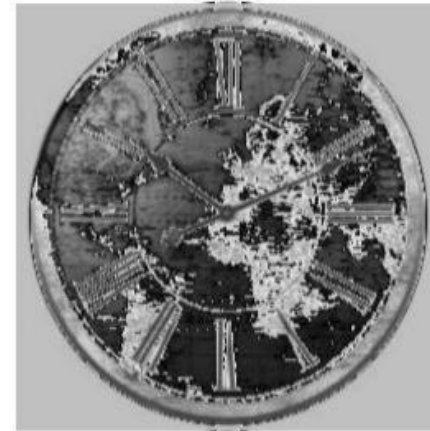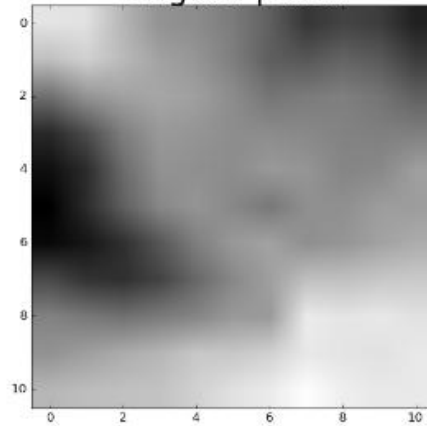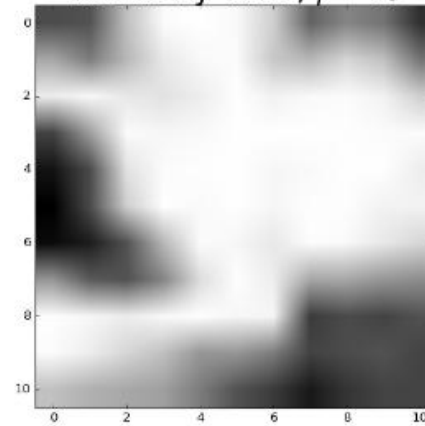# Task 2.4: Implementing a bilateral filter

$$h[x,y] = \gamma \cdot \sum_{i=-\frac{m}{2}}^{\frac{m}{2}} \sum_{j=-\frac{m}{2}}^{\frac{m}{2}} G_\rho \Big[f[x-i,y-j] - f[x,y] \Big] G_\sigma[i,j] \, f[x-i,y-j]$$

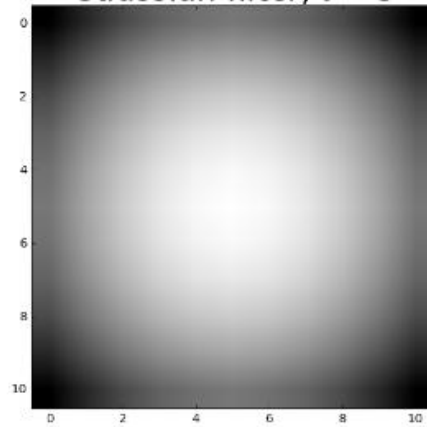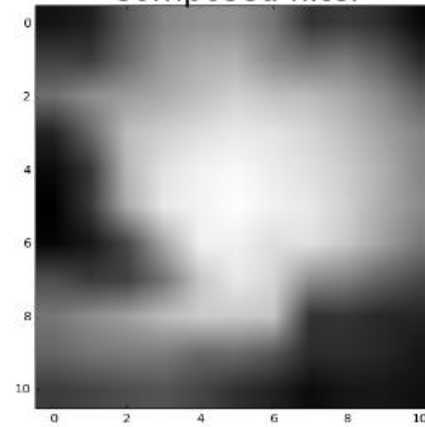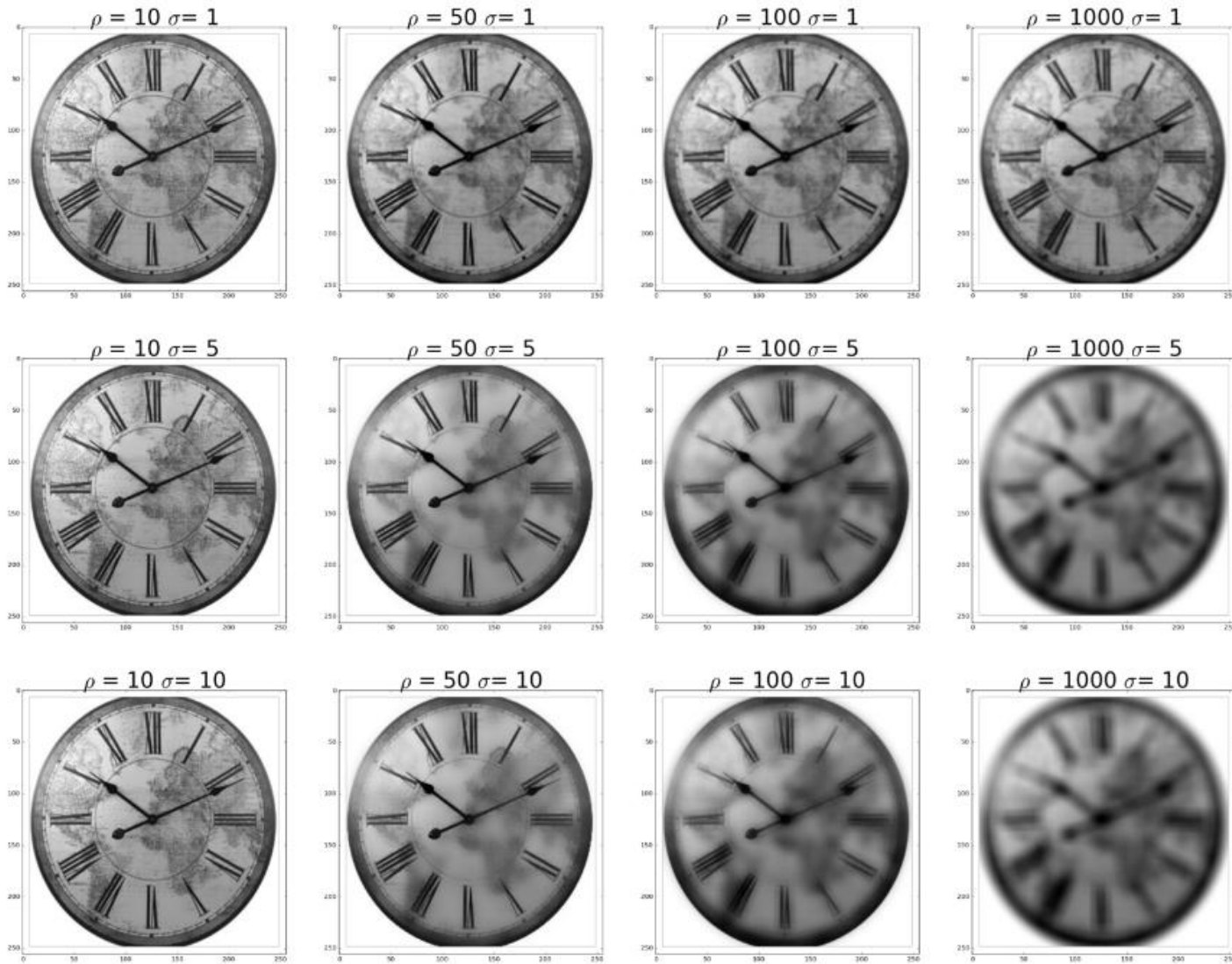Intensity filter   Gaussian filter   Pixel intensity

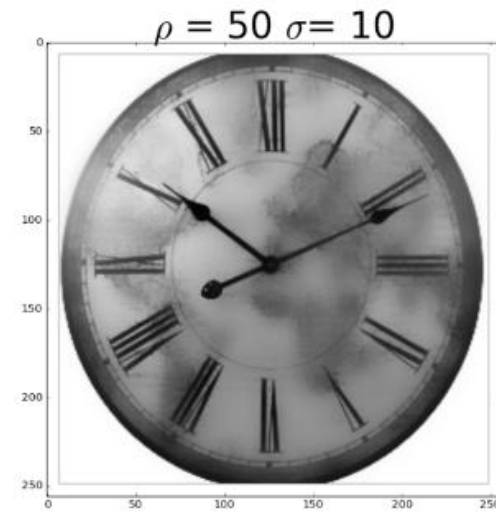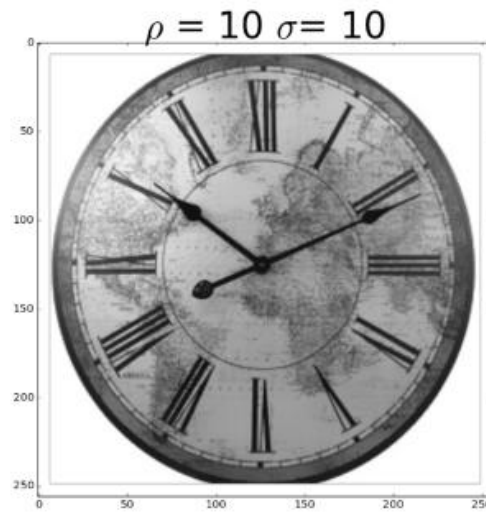Original patch   Intensity filter, $\rho = 20$

Gaussian filter, $\sigma = 5$ Composed filter

Task 2.4: Implementing a bilateral filter

$\rho = 10\ \sigma = 1$	$\rho = 50\ \sigma = 1$	$\rho = 100\ \sigma = 1$	$\rho = 1000\ \sigma = 1$
$\rho = 10\ \sigma = 5$	$\rho = 50\ \sigma = 5$	$\rho = 100\ \sigma = 5$	$\rho = 1000\ \sigma = 5$
$\rho = 10\ \sigma = 10$	$\rho = 50\ \sigma = 10$	$\rho = 100\ \sigma = 10$	$\rho = 1000\ \sigma = 10$

Task 2.4: Implementing a bilateral filter

$\rho = 1$ $\sigma = 5$

$\rho = 10$ $\sigma = 5$

$\rho = 50$ $\sigma = 5$

$\rho = 1$ $\sigma = 10$

$\rho = 10$ $\sigma = 10$

$\rho = 50$ $\sigma = 10$

Task 2.4: Implementing a bilateral filter