Benchmarking numpy / scikit-image / scipy vs clesperanto

In [1]:

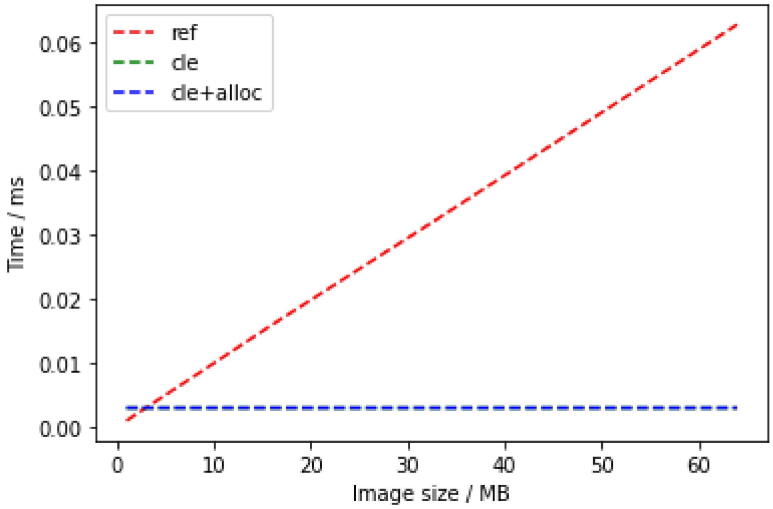
```
import clesperanto as cle
import numpy as np
import time
import matplotlib.pyplot as plt

num_iterations = 10

# measure execution time of a given method
def benchmark(function, kwargs):
    times = []
    for i in range(0, num_iterations):
        start_time = time.time()
        function(**kwargs)
        delta_time = time.time() - start_time
        times = times + [delta_time]
        # print(delta_time)

    # return median of measurements to ignore warmup-effects
    return np.median(times)



def benchmark_size(method_np, method_cle, method_cle_alloc):
    times_ref = []
    times_cle = []
    times_cle_alloc = []
    sizes = []
    for size in [1, 2, 4, 8, 16, 32, 64]:

        input1 = np.zeros((1024, 1024, size))
        cl_input1 = cle.push(input1)
        cl_input2 = cle.create(cl_input1.shape)

        time_ref = benchmark(method_np, {"image":input1})
        time_cle = benchmark(method_cle, {"image":cl_input1, "output":cl_input
2})
        time_cle_alloc = benchmark(method_cle_alloc, {"image":cl_input1})

        times_ref = times_ref + [time_ref]
        times_cle = times_cle + [time_cle]
        times_cle_alloc = times_cle_alloc + [time_cle_alloc]
        sizes = sizes + [size]

    plt.plot(sizes, times_ref,  'r--', sizes, times_cle, 'g--', sizes, times_c
le_alloc, 'b--');
    plt.ylabel('Time / ms')
    plt.xlabel('Image size / MB')
    plt.legend(("ref", "cle", "cle+alloc"));
    plt.show()


    print("\nSizes (MB)        " + str(sizes))
    print("Times ref (s)       " + str(np.round(times_ref, 4)))
    print("Times cle (s)       " + str(np.round(times_cle, 4)))
    print("Times cle+alloc (s) " + str(np.round(times_cle_alloc, 4)))
```

Thresholding

In [2]:

```
# RED: thresholding of a numpy array
def threshold_ref(image):
    thresholded = image > 100
    return thresholded

# GREEN: thresholding of a pre-existing opencl array (no push, pull or alloc)
def threshold_cle(image, output):
    cle.greater_constant(image, output, 100)

# BLUE: allocate result memory + thresholding
def threshold_cle_alloc(image):
    thresholded = cle.create(image.shape)
    cle.greater_constant(image, thresholded, 100)

benchmark_size(threshold_ref, threshold_cle, threshold_cle_alloc)
```

```
C:\Users\rober\Anaconda3\envs\cle\lib\site-packages\pyopencl\__init__.py:248:
CompilerWarning: Non-empty compiler output encountered. Set the environment v
ariable PYOPENCL_COMPILER_OUTPUT=1 to see more.
  warn("Non-empty compiler output encountered. Set the "
```

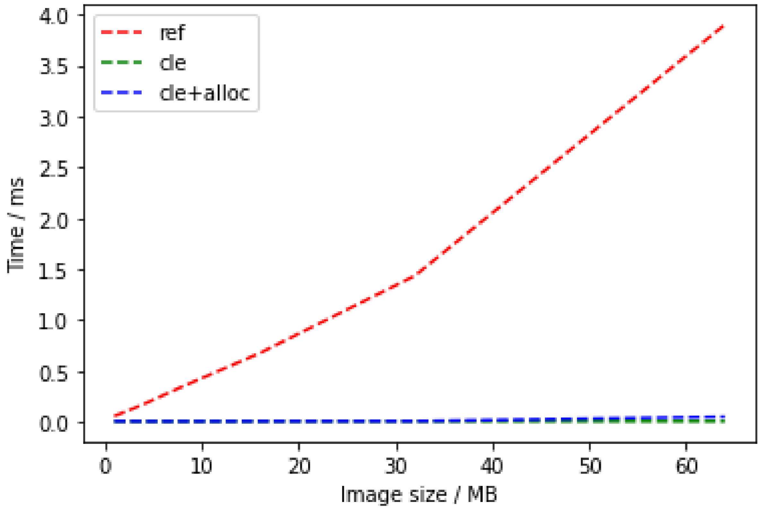


```
Sizes (MB)        [1, 2, 4, 8, 16, 32, 64]
Times ref (s)       [0.001  0.002  0.004  0.008  0.016  0.0314 0.0628]
Times cle (s)       [0.003 0.003 0.003 0.003 0.003 0.003 0.003]
Times cle+alloc (s) [0.003 0.003 0.003 0.003 0.003 0.003 0.003]
```

Gaussian blur radius 2

In [3]:

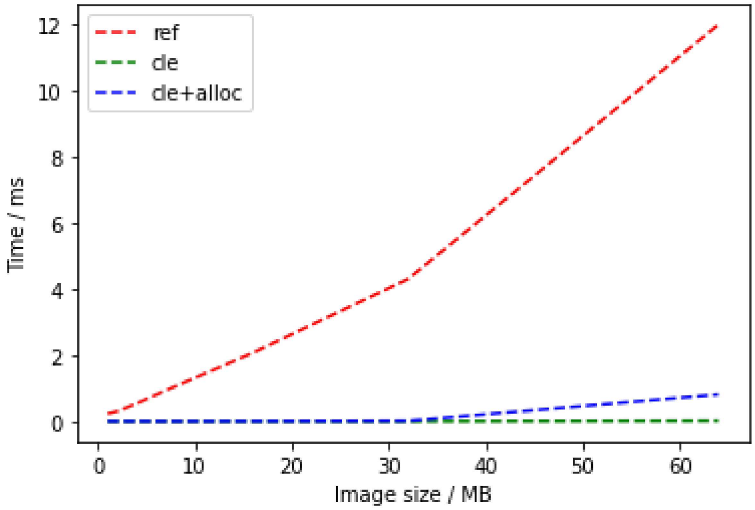
```
from skimage.filters import gaussian

radius = 2

def gaussian_blur_filter_ref(image):
    filtered = gaussian(image, sigma=radius)
    return filtered

def gaussian_blur_filter_cle(image, output):
    cle.gaussian_blur(image, output, radius, radius, radius)

def gaussian_blur_filter_cle_alloc(image):
    filtered = cle.create(image.shape)
    cle.gaussian_blur(image, filtered, radius, radius, radius)

benchmark_size(gaussian_blur_filter_ref, gaussian_blur_filter_cle, gaussian_bl
ur_filter_cle_alloc)
```



```
Sizes (MB)        [1, 2, 4, 8, 16, 32, 64]
Times ref (s)       [0.0598 0.0967 0.1746 0.3481 0.6767 1.4357 3.9001]
Times cle (s)       [0.008 0.008 0.007 0.007 0.008 0.009 0.009]
Times cle+alloc (s) [0.008  0.008  0.007  0.007  0.008  0.0095 0.0531]
```

Gaussian blur radius 10

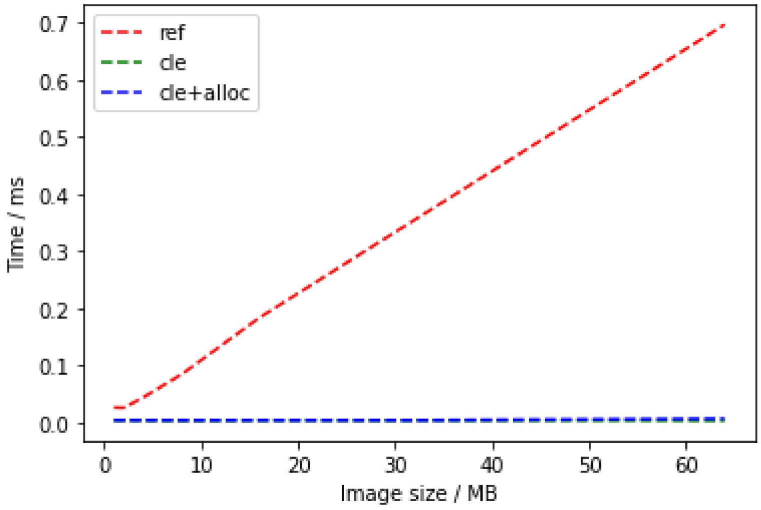
```
In [4]: radius = 10
        benchmark_size(gaussian_blur_filter_ref, gaussian_blur_filter_cle, gaussian_blur_filter_cle_alloc)
```



```
Sizes (MB)        [1, 2, 4, 8, 16, 32, 64]
Times ref (s)       [ 0.2414  0.314   0.5521  1.0736  2.0839  4.308  11.9929]
Times cle (s)       [0.009  0.008  0.0085 0.008  0.008  0.01   0.0264]
Times cle+alloc (s) [0.009  0.008  0.009  0.008  0.0116 0.0234 0.8208]
```

Binary erosion

In [5]:
```
from skimage.morphology import binary_erosion


def binary_erosion_ref(image):
    filtered = binary_erosion(image)
    return filtered

def binary_erosion_cle(image, output):
    cle.erode_box(image, output)

def binary_erosion_cle_alloc(image):
    filtered = cle.create(image.shape)
    cle.erode_box(image, filtered)

benchmark_size(binary_erosion_ref, binary_erosion_cle, binary_erosion_cle_allo
c)
```

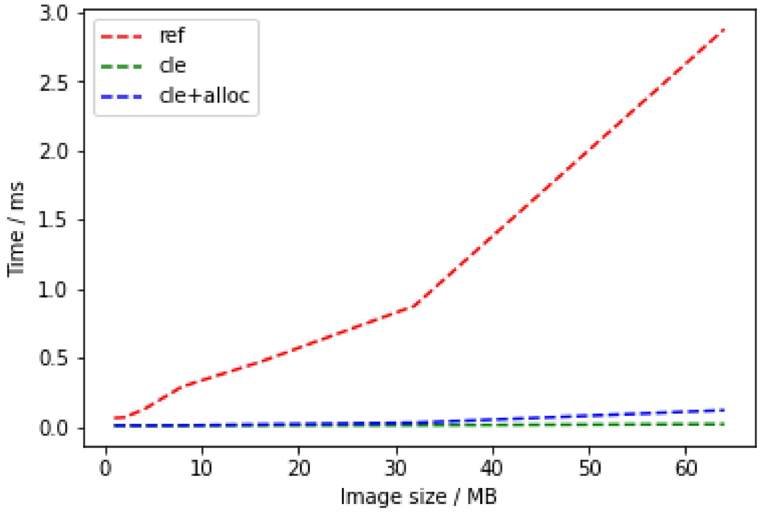


```
Sizes (MB)        [1, 2, 4, 8, 16, 32, 64]
Times ref (s)       [0.0264 0.0259 0.0439 0.0848 0.1835 0.3545 0.6966]
Times cle (s)       [0.004  0.004  0.004  0.0035 0.004  0.004  0.0035]
Times cle+alloc (s) [0.004 0.004 0.004 0.004 0.004 0.004 0.007]
```

Mean filter radius=2

In [6]:

```
import scipy.ndimage.filters as spf


radius = 2
def mean_filter_ref(image):
    # todo: not sure if size is a radius or a diameter. Check documentation
    # https://docs.scipy.org/doc/scipy/reference/generated/scipy.ndimage.uniform_filter.html#scipy.ndimage.uniform_filter
    filtered = spf.uniform_filter(image, size=radius)
    return filtered

def mean_filter_cle(image, output):
    cle.mean_box(image, output, radius, radius, radius)

def mean_filter_cle_alloc(image):
    filtered = cle.create(image.shape)
    cle.mean_box(image, filtered, radius, radius, radius)

benchmark_size(mean_filter_ref, mean_filter_cle, mean_filter_cle_alloc)
```



```
Sizes (MB)        [1, 2, 4, 8, 16, 32, 64]
Times ref (s)       [0.0653 0.0698 0.1247 0.2922 0.4697 0.877  2.8813]
Times cle (s)       [0.011  0.011  0.011  0.011  0.012  0.0135 0.0209]
Times cle+alloc (s) [0.011  0.0115 0.0105 0.012  0.0184 0.0304 0.1217]
```

In [ ]: