ELL715
Assignment 1 Report

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1 Assumptions

In all parts, we have assumed the center of the image as origin and the usual coordinate axis direction.
We increased/decreased number of pixels in the image as per the required transformations. For instance, if a $x * x$ image is rotated 45 degrees, it's new size will be $x\sqrt{2} * x\sqrt{2}$. Thus, to have the complete image, and not a truncated one, we change the number of pixels in the image as required.
In part 2a, we have assumed that the image is rotated anti-clockwise and it has been flipped horizontally (w.r.t y-axis).
In part 2d, we have again assumed that the image is rotated anti-clockwise.
We have also scaled down images so as to fit them in the pdf appropriately. Scales are mentioned in the respective sections.

2 George Clooney

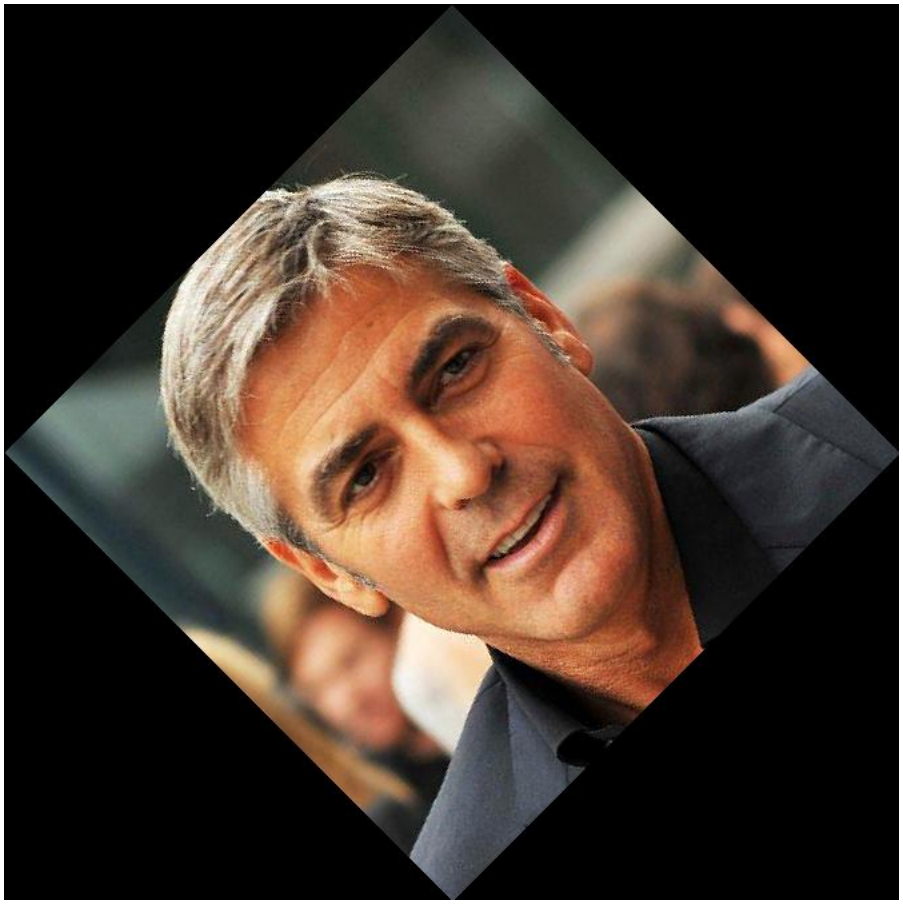
All images in this section are scaled by 0.5.

2.1 Polar Transformation

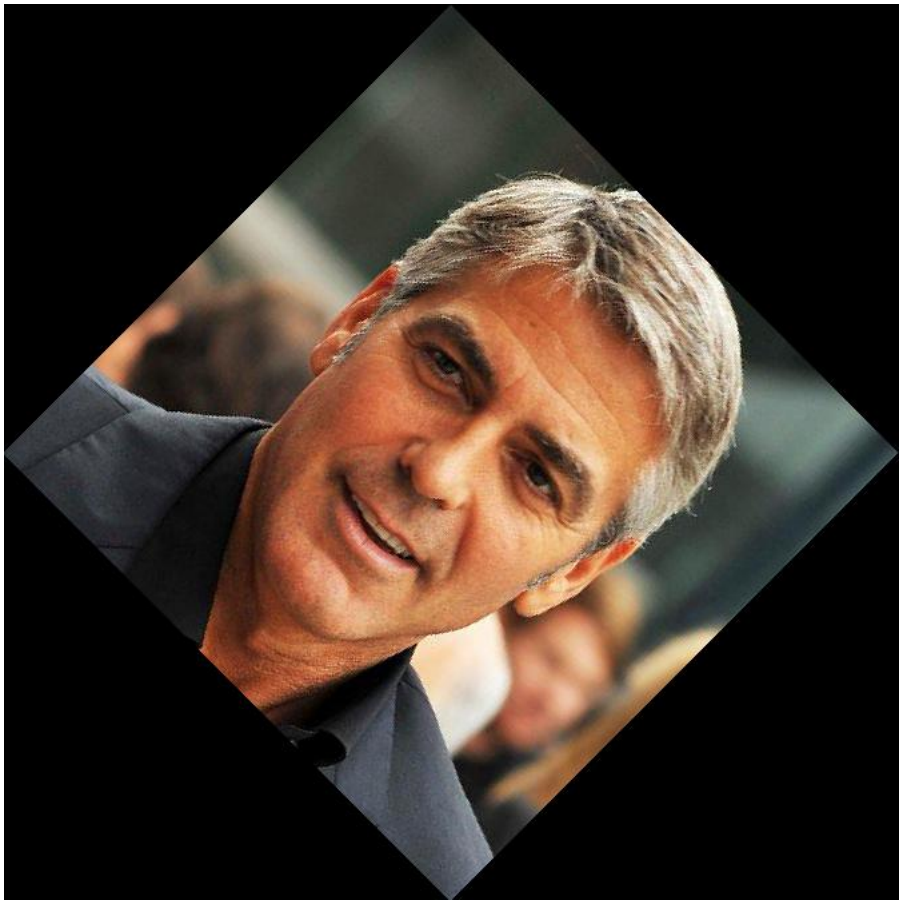
Initial image size = $475 * 475$, Transformed image size = $360 * 335$

2.2 Rotation, Flip

- Rotate (45 degrees):
  Initial image size = $475 * 475$, Transformed image size = $671 * 671$

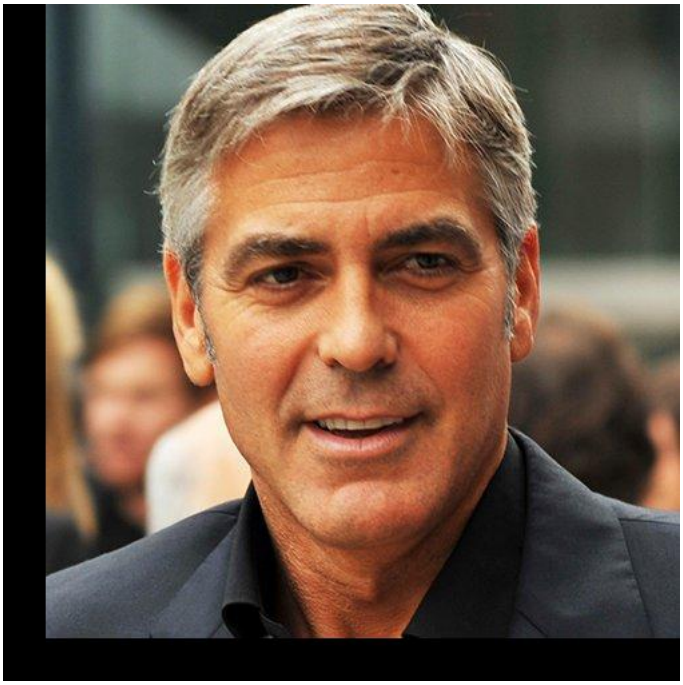


- Rotate + Flip:
  Initial image size $= 475 * 475$, Transformed image size $= 671 * 671$



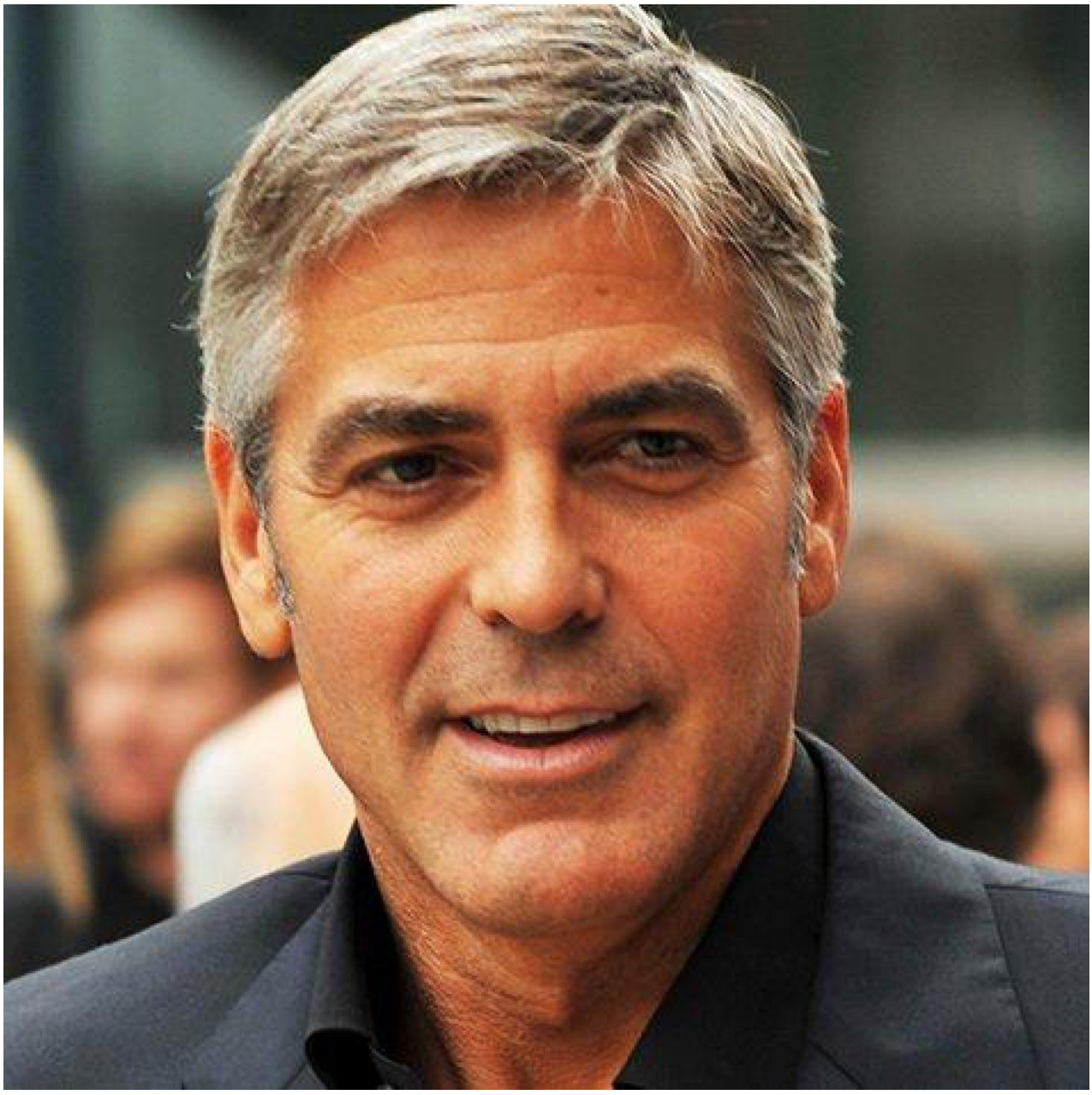
2.3 Translation

Initial image size = $475 * 475$, Transformed image size = $507 * 507$



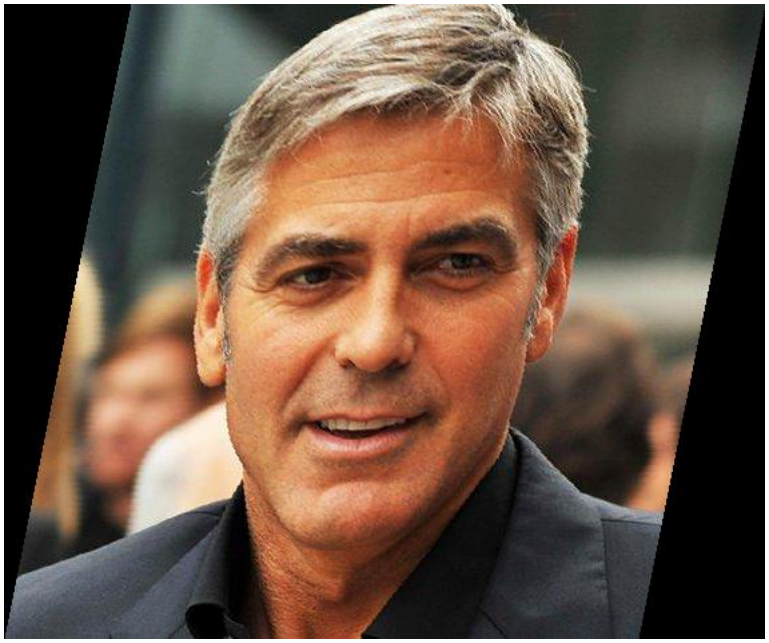
2.4 Scale

Initial image size = $475 * 475$, Transformed image size = $950 * 950$

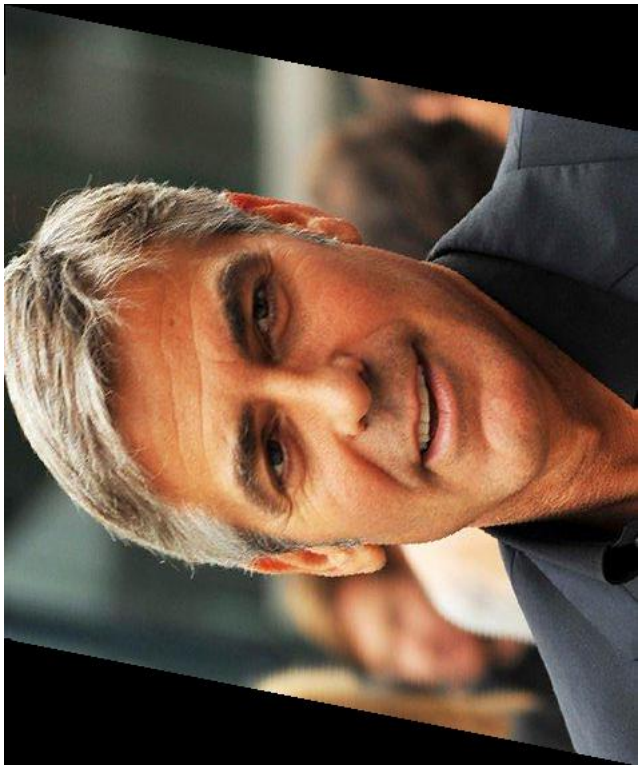


2.5 Shear, Rotate, Scale

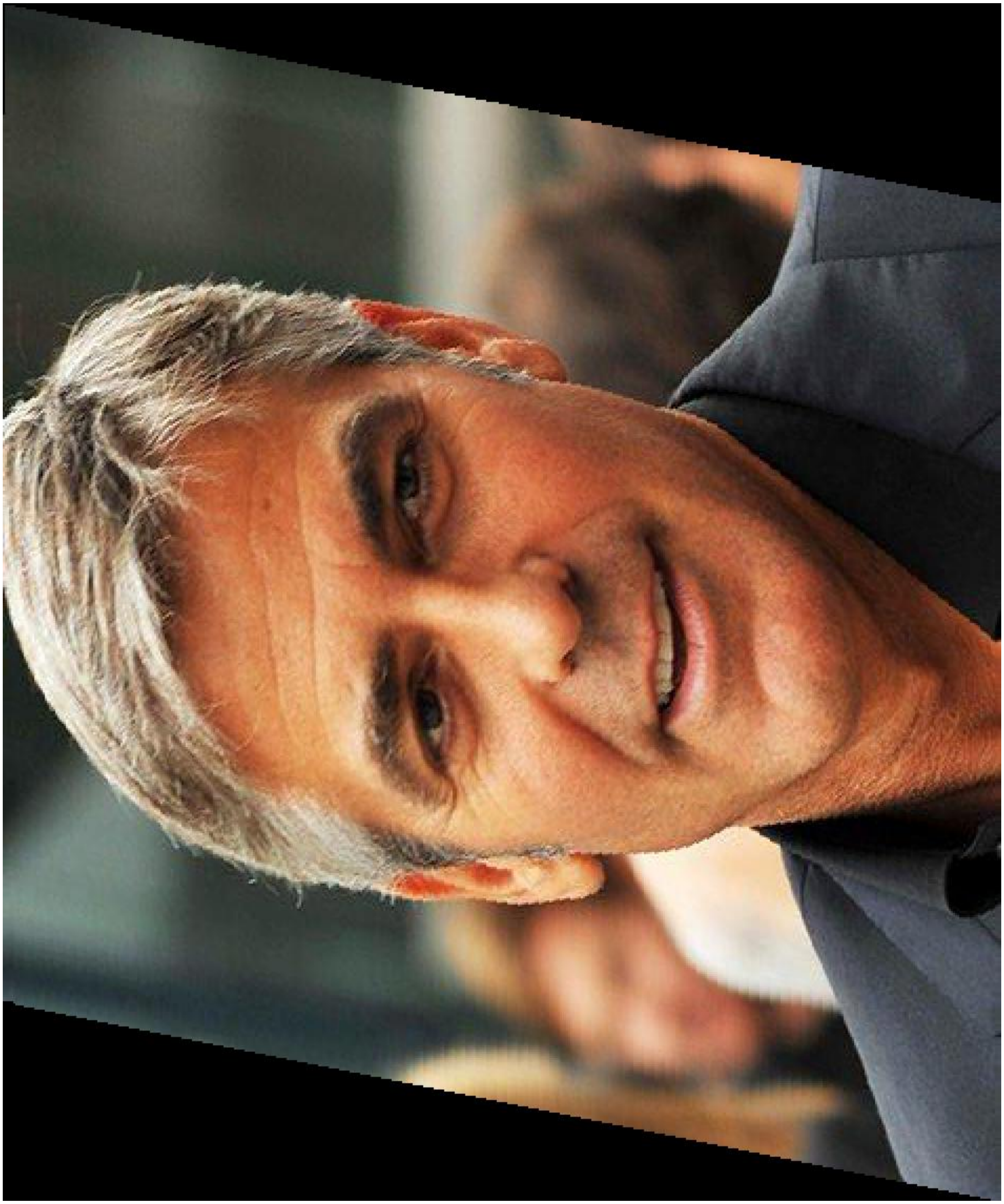
- Initial image size = $475 * 475$, Transformed image size = $570 * 475$



- Initial image size = $475 * 475$, Transformed image size = $475 * 570$



- Initial image size = $475 * 475$, Transformed image size = $950 * 1140$



3 Additional Images (Extra Credits)

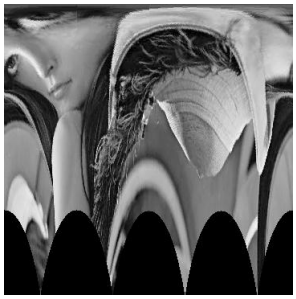
All the images below correspond to the optional experiments we did.

4 Lenna

All images in this section are scaled by 0.3.

4.1 Polar Transformation

Initial image size = $512 * 512$, Transformed image size = $362 * 360$



4.2 Rotation, Flip

- Rotate (45 degrees):
  Initial image size = $512 * 512$, Transformed image size = $724 * 724$

- Rotate + Flip:
  Initial image size = $512 * 512$, Transformed image size = $724 * 724$

4.3 Translate

:
Initial image size = $512 * 512$, Transformed image size = $3544 * 544$

4.4 Scale

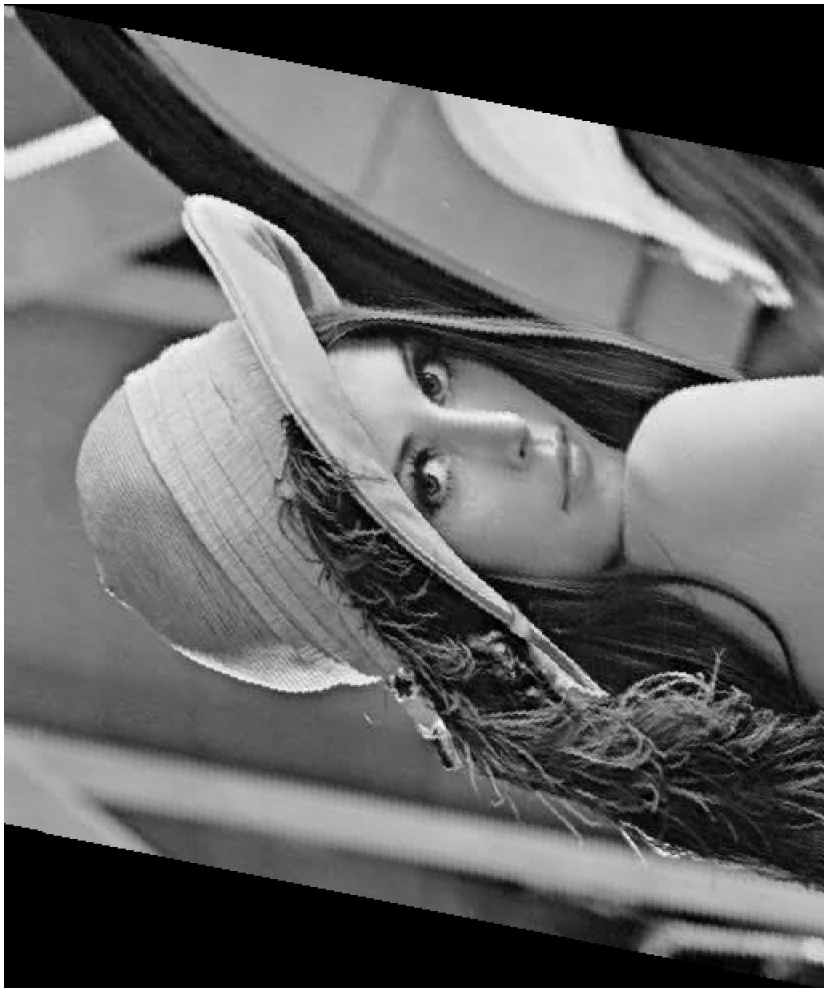
Initial image size = $512 * 512$, Transformed image size = $1536 * 1536$

4.5 Shear, Rotate, Scale

- Shear $(*0.2, x - axis)$:
  Initial image size $= 512 * 512$, Transformed image size $= 614 * 512$

- Shear + Rotate (90 degrees):
  Initial image size $= 512 * 512$, Transformed image size $= 512 * 614$

- Shear + Rotate + Scale (*2):
  Initial image size $= 512 * 512$, Transformed image size $= 1024 * 1228$

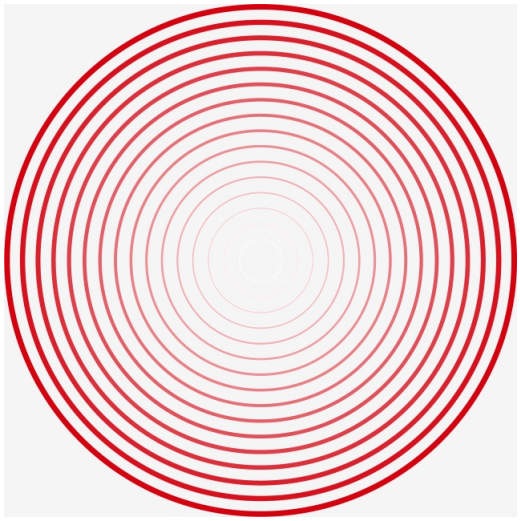


5 Verification

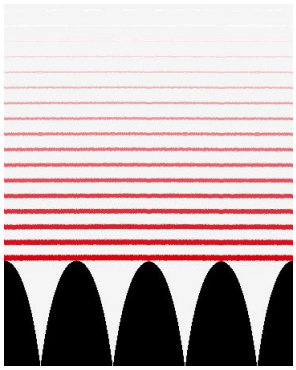
The images in this section are used to make sure our code works for all kind of images.

5.1 Polar Transformation

In polar transformation, we start from center and start arranging pixels according to their radius and the angle they are at w.r.t. the x - axis. So, if we take a the image of concentric circles, we should get straight lines if our algorithm is indeed correct.
The images are scaled down to 0.3.
Input Image:



Output Image:



5.2 Rectangular Images

In order to make sure that our code works for images of different dimensions too (and not only for square images), we tested those on $333 * 187$ image.
All the images in this subsection are scaled down to 0.5. The input image is:

The outputs are shown below:

- Rotation:

- Rotation + Flip:

- Translation:

- Scale:

- Shear:

- Shear + Rotation:

- Shear + Rotation + Scale:

6 Explanation

In each part we mapped the coordinates of the pixels of new image to the coordinates of the old image by which we are able to extract the intensity value at each pixel in the new image
For mapping coordinates we constructed a matrix(say, M) corresponding to each transformation and then we constructed the inverse matrix of M(say M^{-1}) and multiplied it with the homogenised coordinate vector of each of the coordinates of new image.
Let's say the coordinate vector of each of the coordinates the old image is x_i and new image is y_i then we got x_i corresponding to each y_i as $x_i = M^{-1}.dot(y_i)$ For each sub-part of second part , M is as follows:

- Rotation:

$$M = \begin{bmatrix} cos\theta & -sin\theta & 0 \\ sin\theta & cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

- Translation:

$$M = \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix}$$

  where t_x and t_y are translation in x and y direction respectively

- Scale:

$$M = \begin{bmatrix} s_x & 0 & 0 \\ 0 & s_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

  where s_x and s_y are scale factors in x and y direction respectively

- Shear :

$$M = \begin{bmatrix} 1 & k & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

  where k is shear factor in x direction

  For polar transformation, we mapped the x an y coordinates (let's say r and θ) of the new image to the coordinates of the old image (let's say x_{old} and y_{old}) as follows:

$$x_{old} = r * cos(\theta)$$
$$y_{old} = r * sin(\theta)$$