CS 763: LAB2

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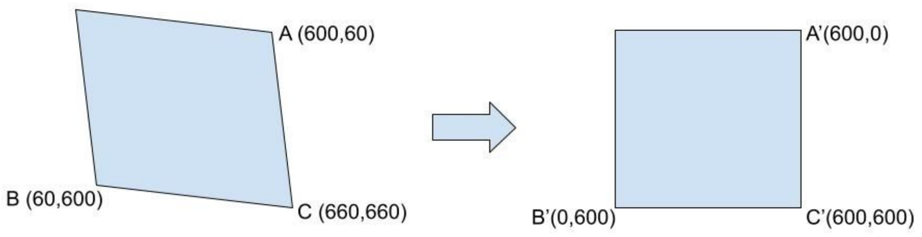
1. Geometric Transformations

1.1. Affine Transformations -



- Computing Transformation Matrix Manually:
  To get the original image transformation matrix used is a combination of X-Shear and Y-Shear transformation matrix.

$$\begin{vmatrix} 1 & sh\_x \\ sh\_y & 1 \end{vmatrix}$$

sh_y is computed using coordinates of A(600,60) and its corresponding coordinates after transformation will be A'(600,0)-

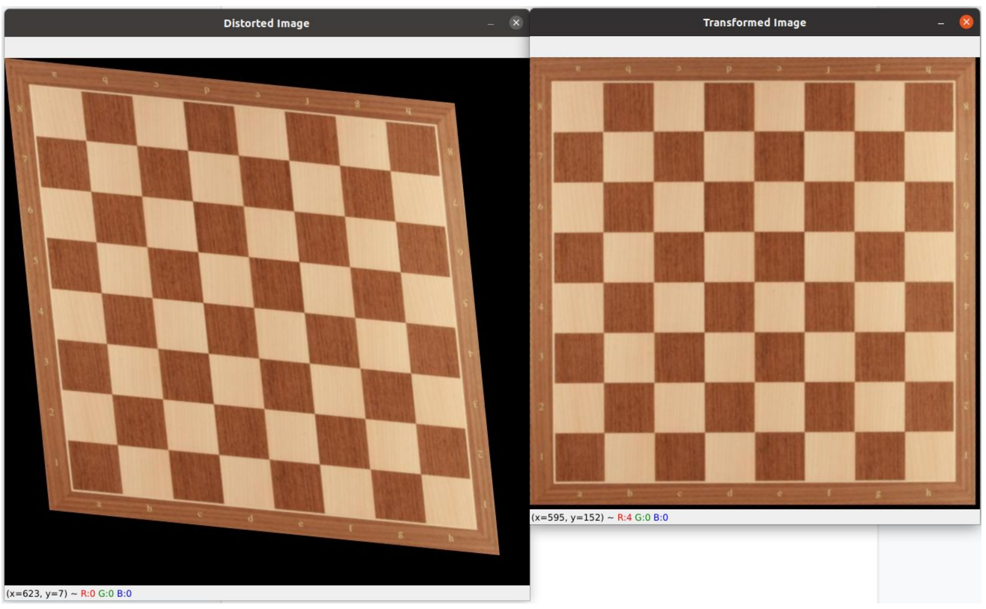
$$Y' = Y + sh\_y * X$$
$$0 = 60 + sh\_y * 600$$
$$sh\_y = -0.1$$

Similarly, sh_x is computed using B(60,600) and its corresponding coordinates after transformation B'(0,600). Shear matrix -

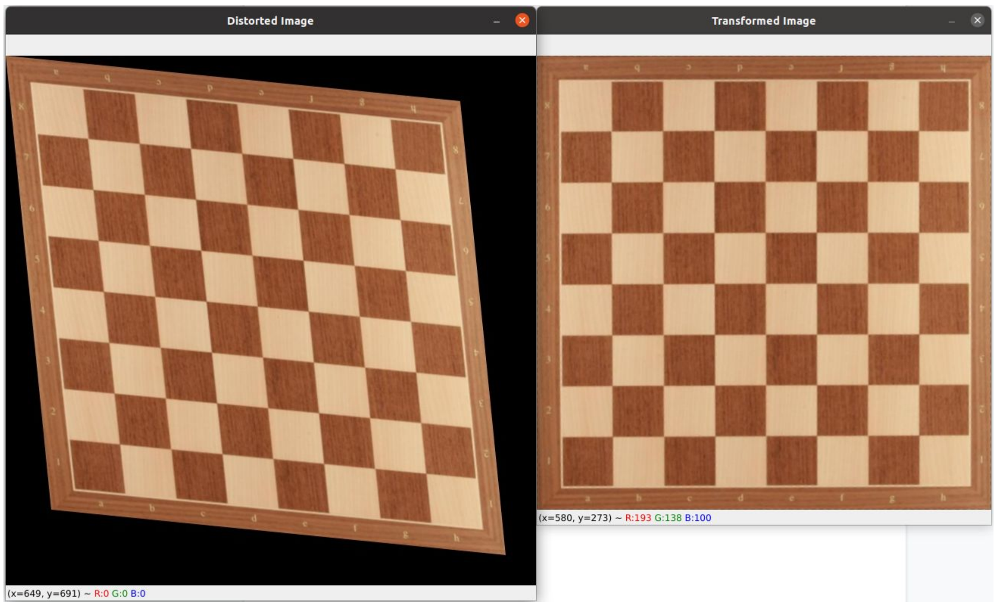
$$\begin{vmatrix} 1 & -0.1 \\ -0.1 & 1 \end{vmatrix}$$

This shear matrix is then used to get the undistorted image using cv2.warpAffine() method.

Result after applying manually computed transformation matrix -



- Computing Transformation Matrix using API:
  Points used for transformation matrix are A(600,60), B(60,600), C(660,660).
  Result after applying transformation matrix computed using API -


Distorted Image
Transformed Image
(x=649, y=691) ~ R:0 G:0 B:0
(x=580, y=273) ~ R:193 G:138 B:100

Observed difference between the results is that in the manually computed matrix (max_x , max_y) for chessboard is (593,593) whereas for the matrix computed using api is (599,599). This difference is observed because api uses scaling as on applying scaling of 600/593 in manually computed matrix both give identical result.

1.2. Perspective Transformations

Q. In what way does 3D geometry enter into the picture here?
- If we consider the map dimensions as X and Y, the depth along which the obelisk is placed introduces the 3rd dimension.
Several other clues can be observed, like:
• The farther side of the map seems shorter than the nearer one, although we know that physically they measure the same.
• The angles of the map aren't preserved either.
• Physically parallel lines aren't being projected as parallel lines in the image plane, etc.

Q. How many point correspondences did you use?
- We used 4 point correspondences.

For getting the required view 2, we used the opencv function getPerspectiveTransform() along with manually found point correspondences and saved the 'view 2' image in the compliant form: a 512 x 385, front facing orthographic projection.

Output Image (view 2)

Animation:
To generate the intermediate views of the map, we generated arrays of interpolated coordinates between 'view 1' and 'view 2' and used them to get the respective projective transformations.
While displaying each intermediate view, we first cropped the frame (using boundingRect() function) in a rectangle bounding the transformed map in that view and then created a mask for the map points using the function drawContours(). And used the mask to get rid of the background and replace it with the white background.
Here is the link to the animation recording.

Q: Is the way to go from view 1 to view 2 unique?
- No. As perspective transformation involves a series of transformations like rotation and translation along the 3 axes and scaling, which can be performed in different orders and still result in the same final view; the way to go from view 1 to view 2 is not unique.
For example, in the animation the map transforms incrementally in the anticlockwise direction but it could also work out in the clockwise direction. Also if we decompose the projective transformation into rotation and translation that could provide numerous more ways that finally result into 'view 2' from 'view 1'.

2. Document Scanner

Here we have implemented two different versions of a document scanner. The first one performs the task by manually identifying the correspondence points while the second approach is automatic. The detailed explanation for both these approaches with its brief technical explanation along with the corresponding results can be found in the following sections.

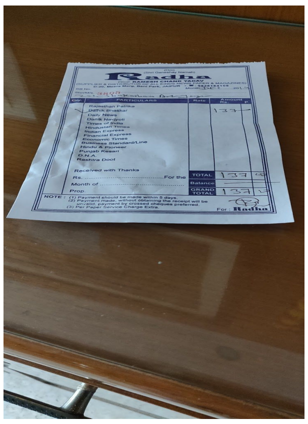
2.1. Manual Document Scanner

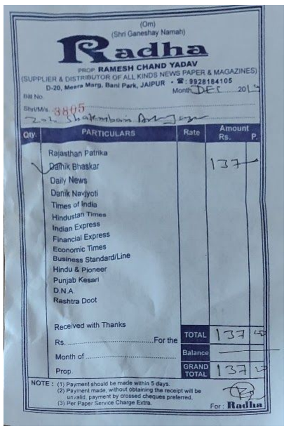
The manual version of the document scanner utilizes the correspondence points received from the user to perform the task. Once the original image is shown on the screen we expect the user to left click on the four corner points of the document to be scanned. These left mouse clicks are registered in order to identify the coordinates of the correspondence points.
Followed by this once the user presses the ESC key the warped and transformed image is displayed on the screen.

Behind the scenes of this, we implement this manual approach by recording the left clicks on the four corners of the document as provided by the user to extract the requisite correspondence points to calculate the perspective transform matrix. We then obtain the perspective transform matrix by utilising the function cv2.getPerspectiveTransform. It is then employed to get the final output image using the function cv2.warpPerspective.
Even though the width and height of the target image can be calculated explicitly, for the sake of easiness in the implemented code we have kept the target width and height fixed as 400 and 600 respectively.

The following are the input images and the corresponding results obtained for the manual document scanner.

Result 1 (Default input from the folder)





(Om)
(Shri Ganeshay Namah)
Radha
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	D.N.A.			
	Rashtra Doot			
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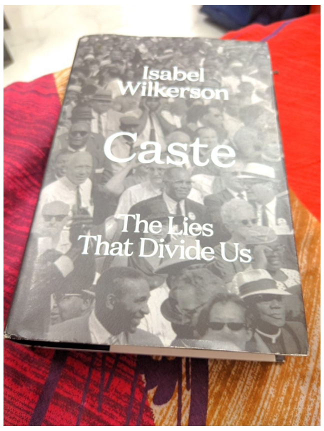
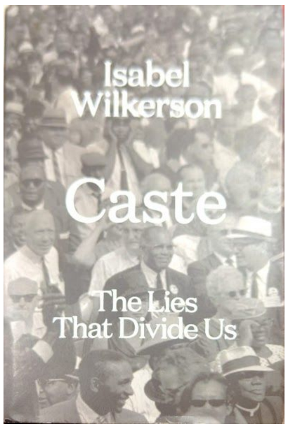
(2) Payment made, without obtaining the receipt will be unvalid. payment by crossed cheques preferred.
(3) Per Paper Service Charge Extra.

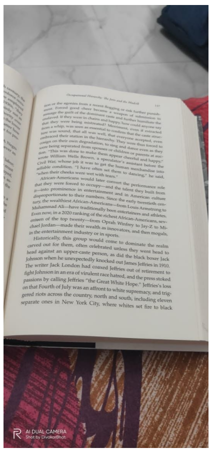
[illegible]
For : Radha

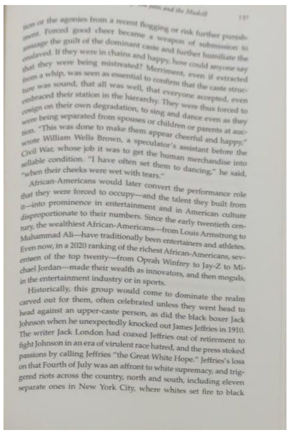
Result 2





Result 3





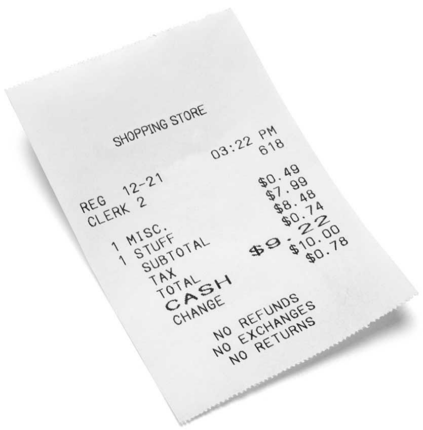
[illegible] and the Mudsill 137

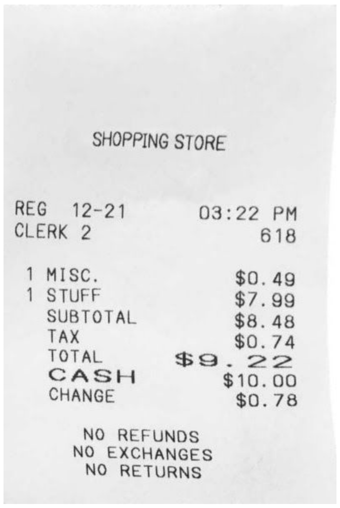
tion or the agonies from a recent flogging or risk further punishment. Forced good cheer became a weapon of submission to assuage the guilt of the dominant caste and further humiliate the enslaved. If they were in chains and happy, how could anyone say that they were being mistreated? Merriment, even if extracted from a whip, was seen as essential to confirm that the caste structure was sound, that all was well, that everyone accepted, even embraced their station in the hierarchy. They were thus forced to cosign on their own degradation, to sing and dance even as they were being separated from spouses or children or parents at auction. "This was done to make them appear cheerful and happy," wrote William Wells Brown, a speculator's assistant before the Civil War, whose job it was to get the human merchandise into sellable condition. "I have often set them to dancing," he said, "when their cheeks were wet with tears."

African-Americans would later convert the performance role that they were forced to occupy—and the talent they built from it—into prominence in entertainment and in American culture disproportionate to their numbers. Since the early twentieth century, the wealthiest African-Americans—from Louis Armstrong to Muhammad Ali—have traditionally been entertainers and athletes. Even now, in a 2020 ranking of the richest African-Americans, seventeen of the top twenty—from Oprah Winfrey to Jay-Z to Michael Jordan—made their wealth as innovators, and then moguls, in the entertainment industry or in sports.

Historically, this group would come to dominate the realm carved out for them, often celebrated unless they went head to head against an upper-caste person, as did the black boxer Jack Johnson when he unexpectedly knocked out James Jeffries in 1910. The writer Jack London had coaxed Jeffries out of retirement to fight Johnson in an era of virulent race hatred, and the press stoked passions by calling Jeffries "the Great White Hope." Jeffries's loss on that Fourth of July was an affront to white supremacy, and triggered riots across the country, north and south, including eleven separate ones in New York City, where whites set fire to black

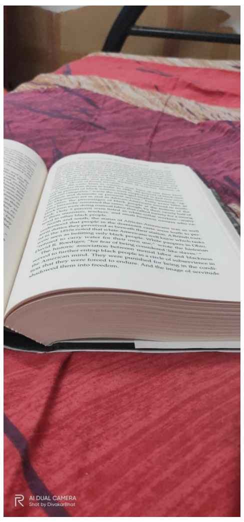
Result 4

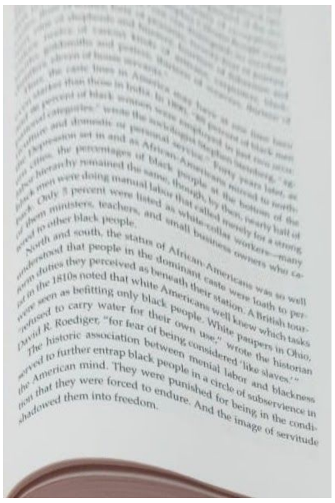




```
        SHOPPING STORE

REG   12-21          03:22 PM
CLERK  2                  618

 1 MISC.                $0.49
 1 STUFF                $7.99
   SUBTOTAL             $8.48
   TAX                  $0.74
   TOTAL             $9.22
   CASH                $10.00
   CHANGE               $0.78

        NO REFUNDS
       NO EXCHANGES
        NO RETURNS
```

Sample of output for which the transformation fails





[illegible] the caste lines in America may have at one time been [illegible] starker than those in India. In 1890, "85 percent of black men [illegible] 96 percent of black women were employed in just two occu[illegible] categories," wrote the sociologist Stephen Steinberg, "ag[illegible] and domestic or personal service." Forty years later, as the Depression set in and as African-Americans moved to north[illegible] cities, the percentages of black people at the bottom of the [illegible] hierarchy remained the same, though, by then, nearly half of black men were doing manual labor that called merely for a strong back. Only 5 percent were listed as white-collar workers—many of them ministers, teachers, and small business owners who ca[illegible] to other black people.

North and south, the status of African-Americans was so well understood that people in the dominant caste were loath to perform duties they perceived as beneath their station. A British tourist in the 1810s noted that white Americans well knew which tasks were seen as befitting only black people. White paupers in Ohio, refused to carry water for their own use," wrote the historian David R. Roediger, "for fear of being considered 'like slaves.'"

The historic association between menial labor and blackness served to further entrap black people in a circle of subservience in the American mind. They were punished for being in the condition that they were forced to endure. And the image of servitude shadowed them into freedom.

2.2. Automatic Document Scanner

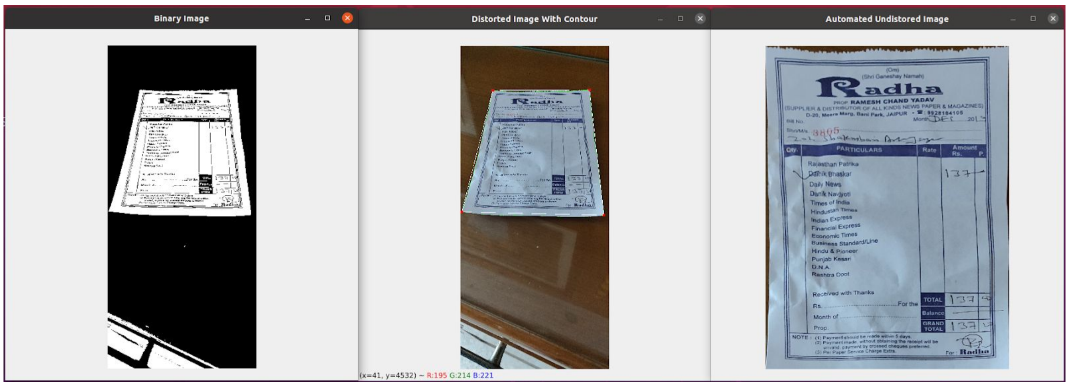
The automated version of the code identifies the correspondence points using contour detection. To have better accuracy of the cv2.findContour() method, the image is first converted to a binary image using cv2.threshold() method. As cv2.findContour() returns a list of contours so, to select document contour, contour covering maximum area is identified using cv2.contourArea() method. Then a polygon is fit to the contour using cv2.approxPolyDP() method to identify the corner points of the document. I identified points that are used to compute the transformation matrix using cv2.getPerspectiveTransform() and un-distort the image using cv2.warpPerspective().

In the results of automated document scanner
Image1 - Input image converted to binary image
Image2 - Selected Contour, polygon and points are marked on the input image
Image3 - Undistorted Image

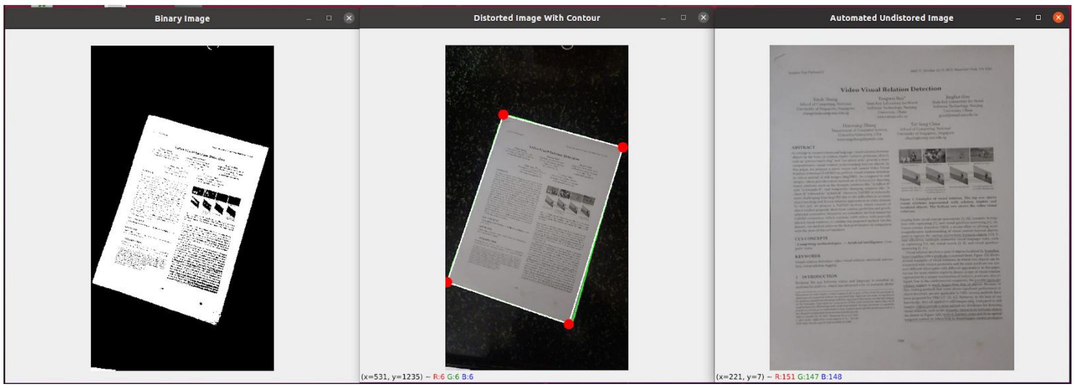
Observation-

1. On comparing result4 and result5 it is observed the code fails to fit quadrilateral if a bright light spot touches the edges of the document.
2. From result6 it is observed that the background of the document also affects the results as the final image is still distorted because of wrong polygon fitting.

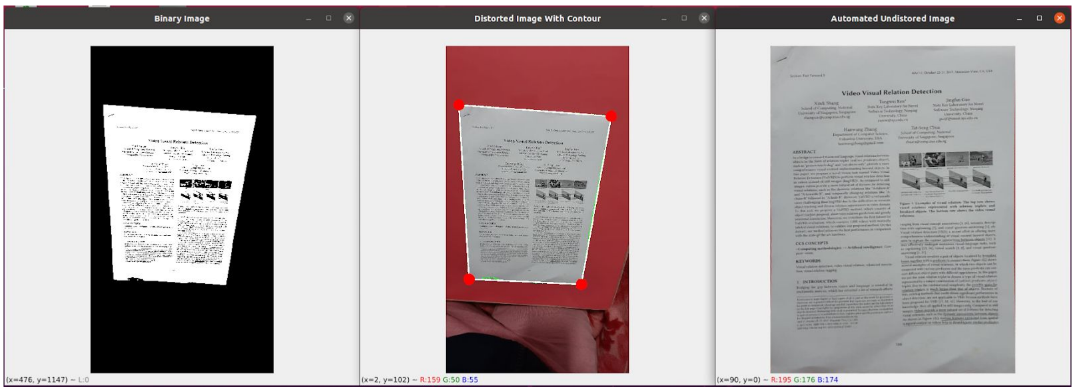
Result1 - (For given sample input)


Binary Image
Distorted Image With Contour
Automated Undistored Image
(x=41, y=4532) ~ R:195 G:214 B:221

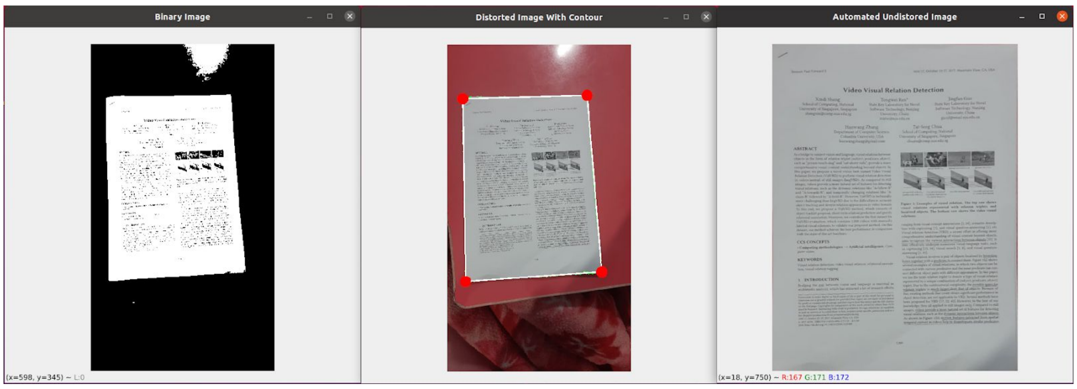
Result2 -


Binary Image
Distorted Image With Contour
Automated Undistored Image
(x=531, y=1235) ~ R:6 G:6 B:6
(x=221, y=7) ~ R:151 G:147 B:148

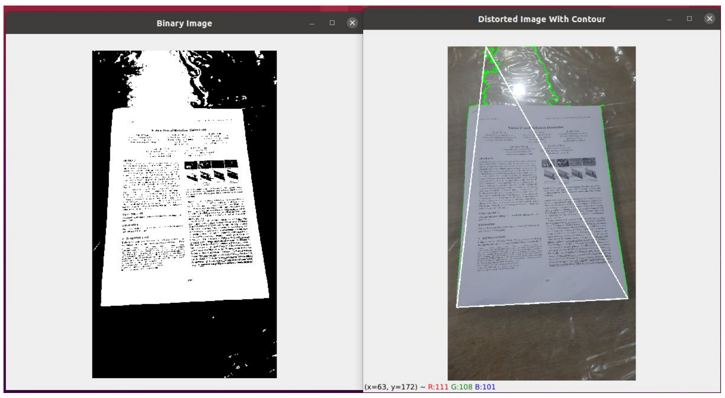
Result3 -


Binary Image
Distorted Image With Contour
Automated Undistored Image
Video Visual Relation Detection
(x=476, y=1147) ~ L:0
(x=2, y=102) ~ R:159 G:50 B:55
(x=90, y=0) ~ R:195 G:176 B:174

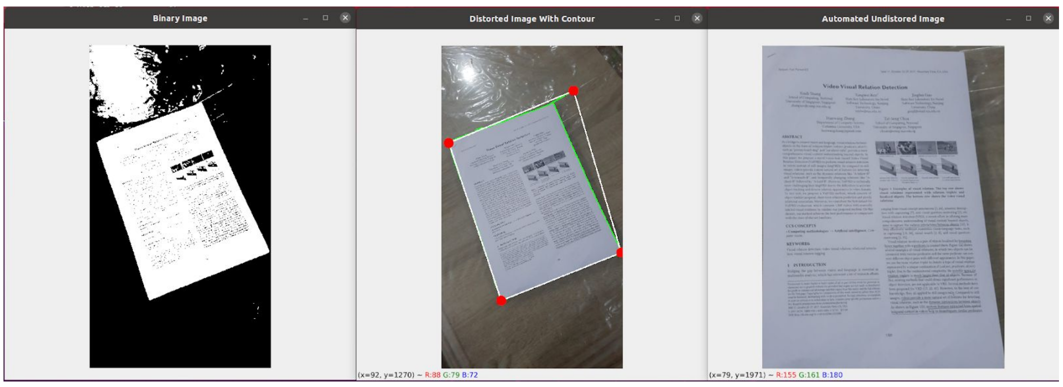
Result4 -


Binary Image
Distorted Image With Contour
Automated Undistored Image
Video Visual Relation Detection
(x=598, y=345) ~ L:0
(x=18, y=750) ~ R:167 G:171 B:172

Result5 -


Binary Image
Distorted Image With Contour
(x=63, y=172) ~ R:111 G:108 B:101

Result6 -


Binary Image
Distorted Image With Contour
Automated Undistored Image
Video Visual Relation Detection
(x=92, y=1270) ~ R:88 G:79 B:72
(x=79, y=1971) ~ R:155 G:161 B:180

Acknowledgement:

- https://medium.com/analytics-vidhya/opencv-perspective-transformation-9edffefb2143
- https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_geometric_transformations/py_geometric_transformations.html
- https://stackoverflow.com/questions/48301186/cropping-concave-polygon-from-image-using-opencv-python/48301735
- https://stackoverflow.com/questions/54734538/opencv-assertion-failed-215assertion-failed-npoints-0-depth-cv-32
- https://docs.opencv.org/3.4/d6/d6e/group__imgproc__draw.html#ga746c0625f1781f1ffc9056259103edbc
- https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_contours/py_contour_features/py_contour_features.html#contour-features
- https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_geometric_transformations/py_geometric_transformations.html
- https://www.pyimagesearch.com/2015/03/09/capturing-mouse-click-events-with-python-and-opencv/
- https://www.pyimagesearch.com/2014/08/25/4-point-opencv-getperspective-transform-example/
- https://stackoverflow.com/questions/17241830/opencv-polylines-function-in-python-throws-exception