1 Report Shape Recognition

1.1 The algorithm

Our approach to this problem was a bounding circle. For every 100x100 image the algorithm visits every pixel. Then it checks if the pixel is black, if so the algorithm adds one to the sum of black pixels. Furthermore the algorithm calculates the distance (radius) to the center of the 100x100 image and always keeps the radius of the point furthest away. After visiting every pixel the algorithm calculates the circle area with the radius of the point furthest away and computes the ratio between this area and the number of black pixels, e.g. the area of the shape itself. For a better distinction between stars and triangles we looked at the increase and decrease of black pixels per line and used that as a second feature.

1.2 Pre-Processing

For Pre-Processing we implemented a median filter to remove noise. The filter produces excellent results – the filtered image shows no signs of noise and recognition ratio on the filtered image is as good as on the same image without any noise. Alas our current implementation of the median filter uses four for-loops and is therefor really time-consuming and could therefor be improved. To solve the problem with fuzzy edges we tried to blur the image with a Gaussian filter, extract the edges of that image and added them up to the original image. Unfortunately the recognition rates on those images were not satisfying.

1.3 Results

The algorithm yields perfect results on clean images. Furthermore we achieved acceptable results with salt and pepper noise when we applied a median filter. The biggest problem with our algorithm are unsharp edges. We were not able to clean those edges with pre-processing. We tried applying a gaussan blur and the re-binarize the image but the recognition was the same or even poorer. This is why we decided to add another feature extraction, since we saw that most of the time it was the star that got confused with the triangle. We were able to improve the recognition but not to perfect results.

1.4 Validation Results

`Shapes_Border_Easy_Test`

```
(2, 'circle', 'square', 0.9261972617454015)
(3, 'triangle', 'star', 0.4316282056652202)
(15, 'circle', 'square', 0.923098669932993)
(30, 'circle', 'square', 0.9468857264095434)
(32, 'triangle', 'star', 0.4098239784616305)
(34, 'circle', 'square', 0.8941288937746931)
(36, 'triangle', 'star', 0.4141942166530882)
(39, 'circle', 'square', 0.9346770487461609)
(42, 'circle', 'square', 0.9426384847284335)
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(49, 'triangle', 'star', 0.4324500145897431)
(50, 'triangle', 'star', 0.45067637350774326)
(55, 'triangle', 'star', 0.4099934639486959)
(56, 'circle', 'square', 0.9196070053651606)
(60, 'circle', 'square', 0.8869758626244955)
(62, 'circle', 'square', 0.9414907610647222)
(68, 'circle', 'square', 0.871286184809646)
(72, 'circle', 'square', 0.9219441781178188)
Recognition Ratio: 0.7875

Confusion-Matrix:

            star        circle      triangle    square
star        1.000       0.000       0.000       0.000
circle      0.000       0.214       0.000       0.786
triangle    0.286       0.000       0.714       0.000
square      0.000       0.000       0.000       1.000

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Shapes_Border_Heavy_Test

(0, 'triangle', 'star', 0.39985444129604264)
(2, 'square', 'star', 0.5735881117371278)
(4, 'triangle', 'star', 0.3865978202439811)
(7, 'circle', 'square', 0.8899944417698789)
(10, 'circle', 'square', 0.9350591734594668)
(12, 'triangle', 'star', 0.41275007615077125)
(13, 'circle', 'square', 0.930404142730654)
(15, 'circle', 'square', 0.9418484303520382)
(16, 'triangle', 'star', 0.41810890089711705)
(18, 'triangle', 'star', 0.42994377827884245)
(19, 'circle', 'square', 0.9234523475843083)
(21, 'triangle', 'star', 0.3991778032142672)
(24, 'triangle', 'star', 0.4274577524648896)
(25, 'circle', 'square', 0.9332096898470662)
(26, 'circle', 'square', 0.9476740655574768)
(27, 'triangle', 'star', 0.4041759188958083)
(32, 'triangle', 'star', 0.42226375938807353)
(37, 'square', 'star', 0.5844049014478427)
(38, 'circle', 'square', 0.9114681163993545)
(39, 'triangle', 'star', 0.4290141209362065)
(40, 'circle', 'square', 0.857447255907586)
(41, 'triangle', 'star', 0.43394082443014736)
(45, 'triangle', 'star', 0.44492648535467627)
(48, 'circle', 'square', 0.9191433399863305)
(50, 'triangle', 'star', 0.40262933024549585)
(53, 'circle', 'square', 0.8772620463225271)
(54, 'triangle', 'star', 0.41370726348451836)
(56, 'triangle', 'star', 0.4280943163165674)
(57, 'circle', 'square', 0.9327664251796315)
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(62, 'triangle', 'star', 0.4166412841450254)
(68, 'circle', 'square', 0.9482414352619072)
(69, 'circle', 'square', 0.9290141633930458)
(70, 'triangle', 'star', 0.41121028283019107)
(71, 'square', 'star', 0.5995460326826458)
(72, 'circle', 'square', 0.8928556217899072)
(73, 'circle', 'square', 0.8619924655050097)
(74, 'circle', 'square', 0.9148906791571845)
(78, 'triangle', 'star', 0.41569380185784144)
Recognition Ratio: 0.525

Confusion-Matrix:

            triangle    star        square      circle
triangle    0.000       1.000       0.000       0.000
star        0.000       1.000       0.000       0.000
square      0.000       0.130       0.870       0.000
circle      0.000       0.000       0.944       0.056

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Shapes_Border_Medium_Test

(4, 'circle', 'square', 0.8887212022251436)
(5, 'triangle', 'star', 0.4167910672969798)
(6, 'circle', 'square', 0.8433571211261258)
(7, 'circle', 'square', 0.9489965758638831)
(8, 'triangle', 'star', 0.4416142277601055)
(9, 'triangle', 'star', 0.42424422728635797)
(11, 'triangle', 'star', 0.42333104700016627)
(12, 'circle', 'square', 0.9433601473107684)
(14, 'circle', 'square', 0.902215919438133)
(15, 'circle', 'square', 0.8259592736320777)
(16, 'circle', 'square', 0.9312676847111611)
(19, 'triangle', 'star', 0.4246085835956889)
(20, 'circle', 'square', 0.949668338118582)
(26, 'triangle', 'star', 0.4505309158293653)
(28, 'triangle', 'star', 0.4278084870310147)
(31, 'circle', 'square', 0.9311384557180475)
(32, 'triangle', 'star', 0.43537527994606373)
(37, 'circle', 'square', 0.9451597511536516)
(39, 'circle', 'square', 0.8947088692733575)
(40, 'circle', 'square', 0.9250030880554599)
(41, 'triangle', 'star', 0.4189028446904913)
(43, 'triangle', 'star', 0.425068876100489)
(44, 'triangle', 'star', 0.41457921761498595)
(46, 'circle', 'square', 0.853521199236182)
(47, 'triangle', 'star', 0.41597852139471614)
(49, 'circle', 'square', 0.9317117609709072)
(50, 'circle', 'square', 0.947936910612361)
(52, 'square', 'star', 0.5934302899473447)
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(56, 'triangle', 'star', 0.4127891262867502)
(61, 'circle', 'square', 0.9395709185666293)
(62, 'circle', 'square', 0.8994236641634511)
(64, 'triangle', 'star', 0.42013387739948943)
(65, 'triangle', 'star', 0.4329231728472375)
(67, 'triangle', 'star', 0.42084510615803833)
(68, 'triangle', 'star', 0.41907465099249586)
(69, 'triangle', 'star', 0.4121032409129629)
(78, 'square', 'triangle', 0.579346021220325)
Recognition Ratio: 0.5375

Confusion-Matrix:

            star        square      circle      triangle
star        1.000       0.000       0.000       0.000
square      0.059       0.882       0.000       0.059
circle      0.000       0.895       0.105       0.000
triangle    0.947       0.000       0.000       0.053

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Shapes_Clean_Test

Recognition Ratio: 1.0

Confusion-Matrix:

            circle      square      triangle    star
circle      1.000       0.000       0.000       0.000
square      0.000       1.000       0.000       0.000
triangle    0.000       0.000       1.000       0.000
star        0.000       0.000       0.000       1.000

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Shapes_Noise_Easy_Test

(44, 'circle', 'square', 0.9498367003724313)
(51, 'triangle', 'star', 0.49728412407580885)
(53, 'triangle', 'star', 0.492256180864152)
Recognition Ratio: 0.9625

Confusion-Matrix:

            square      star        circle      triangle
square      1.000       0.000       0.000       0.000
star        0.000       1.000       0.000       0.000
circle      0.036       0.000       0.964       0.000
triangle    0.000       0.105       0.000       0.895

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Shapes_Noise_Heavy_Test
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(3, 'circle', 'square', 0.8556403362555106)
(5, 'triangle', 'star', 0.4552109545861825)
(9, 'circle', 'square', 0.9415947215041072)
(12, 'triangle', 'star', 0.4600370029280667)
(16, 'circle', 'square', 0.915140922778398)
(24, 'circle', 'square', 0.8134585980252428)
(29, 'triangle', 'star', 0.447464376743987)
(41, 'circle', 'square', 0.8848430781072347)
(54, 'circle', 'square', 0.8841941282883075)
(59, 'circle', 'square', 0.9349281396708825)
(60, 'triangle', 'star', 0.4485096601735714)
(61, 'circle', 'square', 0.9432841749105015)
(63, 'circle', 'square', 0.8906836264775794)
(77, 'circle', 'square', 0.9000135759509738)
(78, 'triangle', 'star', 0.478729971907577)
Recognition Ratio: 0.8125

Confusion-Matrix:

            square      triangle    circle      star
square      1.000       0.000       0.000       0.000
triangle    0.000       0.792       0.000       0.208
circle      0.714       0.000       0.286       0.000
star        0.000       0.000       0.000       1.000

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Shapes_Noise_Medium_Test

(1, 'triangle', 'star', 0.4609932893512116)
(15, 'circle', 'square', 0.9331914224217474)
(19, 'circle', 'square', 0.9409498324689758)
(21, 'circle', 'square', 0.9212262588377942)
(53, 'circle', 'square', 0.9456132716386758)
(56, 'circle', 'square', 0.9309474068525934)
(61, 'circle', 'square', 0.9021711138800256)
(63, 'circle', 'square', 0.9345578258356094)
Recognition Ratio: 0.9

Confusion-Matrix:

            triangle    square      star        circle
triangle    0.947       0.000       0.053       0.000
square      0.000       1.000       0.000       0.000
star        0.000       0.000       1.000       0.000
circle      0.000       0.350       0.000       0.650

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Total Recognition Ratio: 0.789285714286
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