The 6th Conference on Mathematics in Engineering: Theory and Applications
Novi Sad, June 11-13th 2021

ANALYSIS OF SOME SHAPE DESCRIPTORS FOR DETERMINING STAINSPOTS CAUSED BY COVID-19

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Abstract. In this paper we investigate how shape descriptors can help to describe important features of human CT lungs images of people affected by Covid-19. The CT images are considered in binary format in order to segment stainspots caused by Covid-19 as much as better. We present a short statistical analysis of obtained results.

AMS Mathematics Subject Classification (2010): 68U05, 68U10, 94A08, 62P30

Key words and phrases: shape descriptors, Covid-19, tomography

1. Introduction

In this paper we use shape descriptors for detecting features of given set of real Computed Tomography (CT) images. Shape descriptors are well-used for observation and calculation numerical values of the properties for considered image. Image recognition, classification and identification are some of the problems which use shape descriptors. Shape descriptors we analyze are centroid, area, circularity, elongation, orientation, Hu moments, convexity and perimeter. About their definitions and proterties the reader can find in [6]. We attempt to notice some specific properties about stainspots caused by the effect of the corona virus.

In general, obtained information about features of given images could be used in tomography as a priori information. Tomography [11] represents an image reconstruction of object using projection data from different direction. As more projection direction it has, the reconstruction is better. But, it is important to reduce number od projection direction. The reason could be less radiation exposure in medicine, cheaper investigation or impossibility of obtaining more projection direction. So, using a priori information we could reduce required number od projection direction and still have good reconstruction results. This approach is used in many tomography reconstruction methods, see [7], [8], [9]. The application of shape descriptors in tomography reconstruction motivates us to research about features of stainspots.

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2. Shape descriptors and stainspots caused by Covid-19

Firstly, we found some chest CT images [1, 2, 3, 4, 5] and segmented area of interest which is stainspot caused by Covid-19. Those images were observed in binary format. Figure 1 shows CT lung image of patient affected by Covid-19 and the binary segmented area of interest. The white arrow shows exactly which stainspot we segmented.

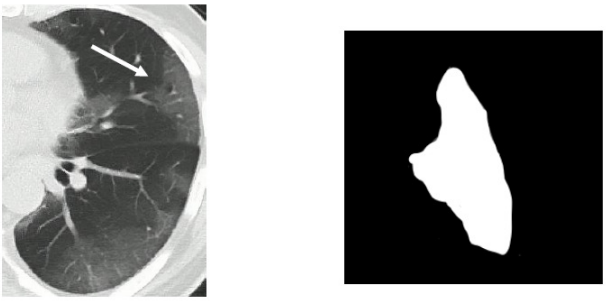

Figure 1: CT image showing human lung and stainspot caused by Covid-19 (left image) and the binary segmented stainspot (right image)

We analyze different shape descriptors and calculate their values for every test image. The results and short statistical observations are shown in this article. The main goal of this research is to give a contribution in recognition of corona virus caused stainspots in CT lungs images.

3. Experimental results

Figure 2 shows the binary test images used in experiment. As we said

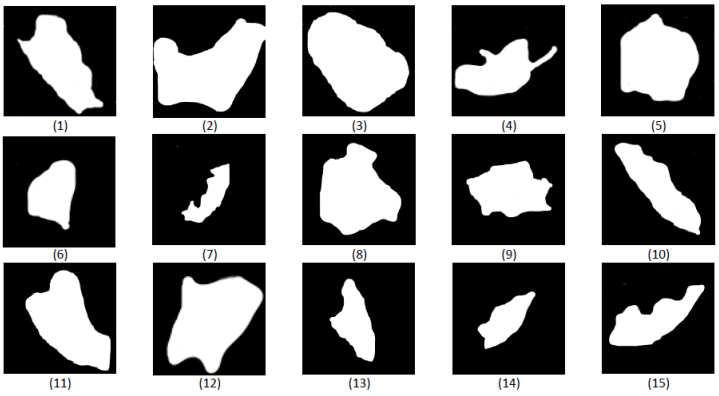

Figure 2: Binary images used in experiments obtained by segmentation of stainspots regions of CT images

in introduction, these images present binary segmented CT images showing

stainspots of human lungs caused by Covid-19. Using computing platform Matlab, we calculate for each test image values of following descriptors: centroid, area, circularity, elongation, orientation, Hu moments, convexity, perimeter. The exact definition of these descriptors the reader can find in [10]. Figure 3 shows a tabular presentation of the obtained results.

image	centroid		area	circularuty	elongation	orientation [°]	Hu moments		convexity	perimeter
	Cx	Cy					I1	I2		
1	132.38	132.53	21279	0.72	4.74	104.95	0.22	0.02	0.89	862
2	143.36	128.20	32409	0.74	2.80	21.67	0.22	0.01	0.81	993
3	129.20	122.27	34373	0.90	2.30	136.73	0.18	0.01	0.97	924
4	151.21	110.60	12759	0.71	4.04	20.44	0.22	0.02	0.78	872
5	128.00	128.13	26582	0.98	1.13	110.75	0.16	0.00	0.95	770
6	132.50	115.73	12254	0.88	1.98	73.93	0.18	0.00	0.93	548
7	142.04	132.27	6182	0.49	9.05	57.18	0.32	0.07	0.41	562
8	134.62	120.93	26025	0.93	1.29	107.50	0.17	0.00	0.90	836
9	129.50	128.49	16322	0.89	2.25	176.62	0.18	0.01	0.88	706
10	124.05	130.86	15772	0.49	13.88	131.07	0.33	0.08	0.90	816
11	138.92	150.12	24649	0.76	3.35	124.10	0.21	0.01	0.89	858
12	130.28	135.04	30894	0.87	2.18	48.32	0.18	0.01	0.89	954
13	138.39	122.50	10299	0.66	5.20	104.95	0.24	0.03	0.88	594
14	132.22	121.77	8227	0.70	5.57	45.79	0.23	0.02	0.91	534
15	132.09	118.14	14452	0.56	7.72	27.13	0.28	0.05	0.84	780
a	134.58	126.51	19498.53	0.75	4.50	86.08	0.22	0.02	0.86	773.93
min	124.05	110.60	6182.00	0.49	1.13	20.44	0.16	0.00	0.41	534.00
max	151.21	150.12	34373.00	0.98	13.88	176.62	0.33	0.08	0.97	993.00
sd	7.03	9.47	9167.54	0.16	3.47	47.79	0.05	0.03	0.13	152.03
rsd	5.22	7.48	47.02	20.82	77.11	55.52	23.78	115.67	15.49	19.64

Figure 3: Obtained results for test images presented in Figure 2

The format of all considered images is 256×256. In table there are shown values of avarage (a), minimum , maximum, standard deviation (sd) and relative standard deviation (rsd) for every descriptor. The data were also analyzed in statistical package Minitab.

As we see, centroid of stainspots is close to centroid of whole image which is a consequence of maner of stainspots segmentation.

Average area of stainspot is approximately 19500, while area of whole image is 65536. Therefor, stainspot is approximately a third of whole image. However, there are stainspots different areas, so deviation is quite big, about 47%.

For circularity, there are two images with values 0.49 and 0.56. Other values are approximately similar, they are mostly from 0.7 to 0.9, i.e. they have high values of circularity. This results are shown in Figure 4 in box plot. The box plot is a graphical display that describes several important features of a data set, such as center, spread (deviation), departure from symmetry, and identification of unusual observations or outliers.

The results for elongation is not representative for considered test images because deviation is high, 77%. There is object whose elongation is 1.13 and also object whose elongation is 13.88.

Orientation has quite big deviation because some images are from right lung and some are from left lung, which is shown at Figure 4.

After separation data in two groups, stainspots from left lung L and stainspots

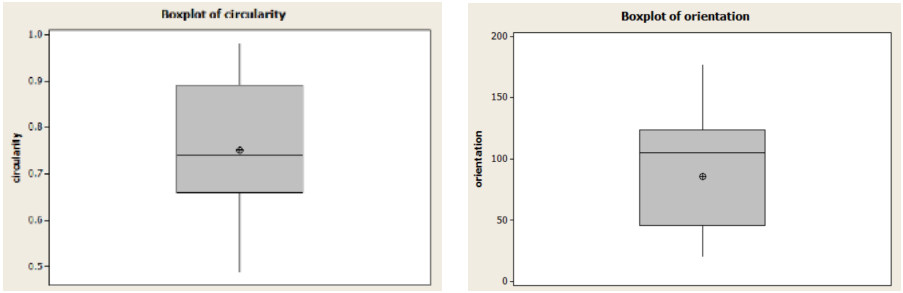

Figure 4: Box plot for circularity (left) and orientation (right)

from right lung R, we analyze deviation of these groups. Deviations of data sets L and R are less then deviation of all data together, but still there are outlayers. Mean and deviation are respectively approximately 118 and 36 for L and 50 and 31 for R. At the Figure 5 are shown box plots of these data sets.

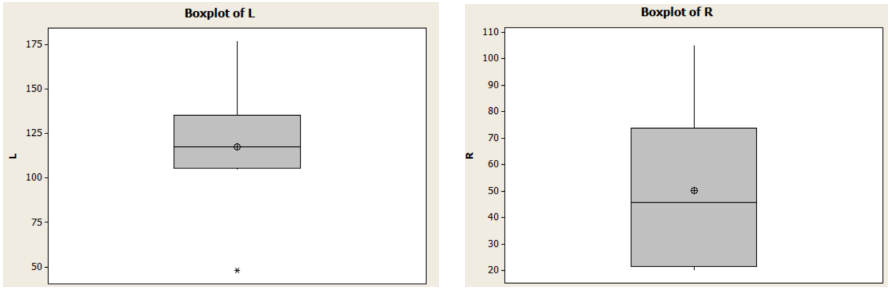

Figure 5: Box plots for data sets L (left box plot) and R (right box plot)

First Hu moment is inversely proportional to circularity, so results are similar. The relative standard deviation is 23.78%, almost all values are around 0.22.

Specially, look at convexity. We can notice that mostly values are around 0.85. Data are shown at box plot (Figure 6).

We can see that deviation is not large (0.0169), the mean is 0.85. In percent deviation is about 15%, which is smallest relative standard deviation in this research. Also, we see one outlayer (presented like star at boxplot) that disturbs our results. That is value for the ninth image.

Results for perimeter show also a small deviation (19%). Average perimeter of object is 773, while relative standard deviation is 19.5%.

4. Conclusion

In this paper we analyze shape descriptors to verify properties of the specified test image set. The images we used are binary segmented images given by CT scanning lungs of patients affected by Covid-19. We wanted to check

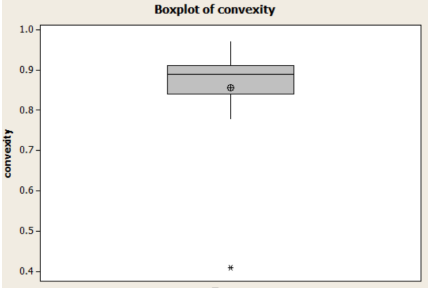

Figure 6: Box plot for convexity

is there any common information in these images, regarding to consider shape descriptors. The results show a small deviation in convexity, which means almost all images have convexity around 0.85. Seemly results are obtained for circularity, where mean is 0.75 with deviation of 0.16.

The further steps for researh should be collecting more images or finding new descriptors which describe this problem better then consider descriptors. We belive that the results can be applied in medicine as a priori information about stainspots caused by Covid-19.

Acknowledgement

Authors acknowledge for support within the project "Teorijska i primenjena matematika u tehničkim i infromatičkim naukama" of the Department of Fundamental Sciences, Faculty od Technical Sciences, Novi Sad.

References

[1] Imaging technology news: *h*ttps://www.itnonline.com/article/ct-imaging-2019 -novel-coronavirus-2019-ncov-pneumonia

[2] M. K. Kalra, F. Homayounieh, C. Arru, O. Holmberg and J.Vassileva, *"Chest CT practice and protocols for COVID-19 from radiation dose management perspective"*, European Radiology, vol. 30, 2020.

[3] T. C. Kwee and R. M. Kwee, *Navigating Radiology, Chest CT in COVID-19: What the Radiologist Needs to Know*, Radio Graphics, vol. 40, 2020

[4] Katedra za Radiologiju, *"Radiološke manifestacije promena u plućima kod COVID-19"*, Medicinski fakultet Univerziteta u Beogradu, 2020.

[5] Business insider, *https://www.businessinsider.es/-pacientes-coronavirus-tienen-vidrio-esmerilado-pulmones-600589*

[6] J. Žunić, *Shape Descriptors for image analysis*, Internal report, SANU, Beograd, 2010.

[7] T. Lukić and P. Balázs, *"Binary tomography reconstruction based on shape orientation"*, Pattern Recognition Letters, Vol. 79, pp. 18-24, Elsevier, 2016

[8] T. Lukić and P.Balázs, *"Shape circularity assisted tomography reconstruction"*, Physica Scripta, IOP Publishing, Volume 95, Number 10, pp. 105211, 2020.

[9] T. Lukić and P. Balázs, *"Limited-view binary tomography reconstruction assisted by shape centroid"*, The Visual Computer, Springer, Vol. 12, pp. 1-11, 2021.

[10] T. Kopanja and T. Lukić, *"Geometrical moment and shape descriptors"*, The 6th Conference on Mathematics in Engineering: Theory and Applications Novi Sad, 2021

[11] G. Herman, *Fundamentals of Computerized Tomography: Image Reconstruction from Projection*, 2nd edn. Springer, Berlin, 2009.