Technique automatic for detection and segmentation of optic disc area in retinal image

by Erwin Erwin

Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Technique automatic for detection and segmentation of optic disc area in retinal image

To cite this article: Erwin *et al* 2020 *J. Phys.: Conf. Ser.* **1500** 012089

Technique automatic for detection and segmentation of optic disc area in retinal image

Erwin[1*]**, B Cania**[2]**, I K Larasati**[3]

Department of Computer Engineering, Faculty of Computer Science,
Universitas Sriwijaya, Indralaya, Indonesia.
erwin@unsri.ac.id, niabican@gmail.com, indah.larasati1997@gmail.com

Abstract. Optic disc (OD) is a part that must be observed in diagnosing retinal disease. In this paper an approach will be proposed for segmentation and detection of the OD area. Segmentation and detection are important steps in detecting a retinal disease automatically. Segmentation in this study was carried out using the Luminance Channel and Active Contours method, and for OD area detection was carried out using the Averaging Filter method and Image Histogram. Before segmenting and detecting the OD area begins with pre-processing as an increase in image quality and eliminating blood vessels. The detection results obtained an accuracy of 90% and 97.50% using the STARE and DRIVE dataset, while segmentation uses the DRIVE dataset with the acquisition of PSNR of 19.705 dB, accuracy of 86.45%, sensitivity 100% and specificity is 85.175%. The results of the research obtained can be used as a further step in diagnosing retinal disease.

1. Introduction

Retinal images can be as structural as the macula, optical disk, optical cup, and blood vessels. OD is the exit point of the retinal nerve fibers from the eye, and the entry and exit points for retinal blood vessels [1][2]. Locations on OD can be used to help estimate the fovea location and OD limits are very important for calculating cup-to-disc, which is an important indicator in connecting glaucoma [3]. OD is the location of the optic nerve and also as an entry point in the arteries, even though the contrast tends to be high from OD and the surrounding area in color fundal images, identifying OD areas is quite difficult, because image quality is greatly influenced by a number of factors such as lighting, focus the camera, this movement, and the disease that causes the location of OD and its limits work poorly [4]. OD segmentation is one very important step to help diagnose various types of eye diseases such as diabetic retinopathy and glaucoma. Circular transformation is able to detection OD centers and OD boundaries accurately and efficiently, circular transformations combine of detection and segmentation OD in the same way the work places the center and OD limits simultaneously [5]. However, OD and bright lesions can cause misclassification. Segmentation OD functions for the first step that is important for pathological screening as diabetes retinopathy or glaucoma [6]. Main steps of the method proposed for detection OD are presented a section consisting of preprocessing, segmentation, feature extraction and selection and classification [7].

Based on the above problems, then in this study above the proposed segmentation of OD using the luminance channel and active contour methods as well as the image histogram for detection in the OD area are available to provide information that can be used to install disease detection further eyes.

2. Related work

Optical disc (OD) is an important step in the process of diagnosing retinal disease automatically. OD detection and segmentation is needed to distinguish it from bright lesions (exudates) that have similar visual characteristics to OD. In research [8] proposed a method that automatically finds OD in retinal images by grouping the brightest pixels to determine the intensity of the desired area. In research [9] proposed the method is [10]segmented the area optic eye and optical cup in retinal image. And several other similar studies [11] [12] [13].

In [1] detection optical disks in fundus images automatically which are divided into line and curve segments. This method is also oriented to certain pixel angles and lengths. The proposed method gets an accuracy value of 87.65% from STARE dataset. However, this study failed for images that had lesions that were brighter or darker than OD areas. In [14] using the *Algorithms Committee* with *Weighted Voting method* to apply five advanced OD detection methods and make committee algorithms. Then the results are determined by voting. To determine weights use the part of the available image database in calculating the success rate of each method. This method produces an accuracy of 63.40% in the STARE dataset, and 90.83% in the DRIVE dataset.

In [15] proposed an Optic Disc via Deep Learning detection method for Fundus Images with CNN *(Convolution Neural Network)*. CNN an arevolutionary network structure that has demonstrated its strength in the field of computerization such as classification, object detection and segmentation. The results of the current experiment show that this method is quite accurate with an accuracy of 89% using the STARE dataset. But it still needs to be evaluated in more datasets to get more objective and comprehensive test results.

In [16] proposed a new method for low quality images based on exploitation of vascular convergence into OD. An integrated method is called the *Scale-Space algorithm* with *Vessel Transform* (SSVT). SSVT has been tested on retinal images of two databases with good and bad images of fuzzy convergence methods (FC) and modified circular transformations proposed by Lu. Absolute increase in SSVT sensitivity to FC and Lu up to 12.37% and 8.18%. Greater SSVT increases in predictive values of up to 37.46% and 30.84% respectively against FC and Lu.

In research [17] using the Group Sparse Regularization Extreme Learning Machine method to obtain an accuracy of 97.83% in the DiaretDB dataset. This method automatically selects effective hidden nodes through the sparse group regularization to achieve more accurate and efficient classification performance. The actual OD can be distinguished from the false candidate based on the highest output response criteria.

In [18] detecting OD especially its diameter along with the diameter of the optical cup can be used as a feature for diagnosing glaucoma. This study contains two main steps for optical disk shielding, namely detection of OD center points and determination of OD diameter. The OD center point is obtained by finding the pixel value based on average filtering.

After that, the diameter of OD is measured from the detected optical disc limit. But in this method there is no mention of the accuracy of the results of OD detection performed. And there are still many other studies that discussed OD detection [19][20][21].

3. Methodology

In this study, the authors propose the Luminance Channel and Active Contour methods to segment the retinal image while the detection proposes an Averaging Filter and Histogram Image method with the STARE and DRIVE dataset. Through several stages of pre-processing according to the block diagram that will be explained. The work steps that have been made in this study are sequentially based on the framework that has been made. In this study a framework is needed to assist in the preparation of research that has stages to obtain appropriate and structured results. The block diagram is shown in figure.1.

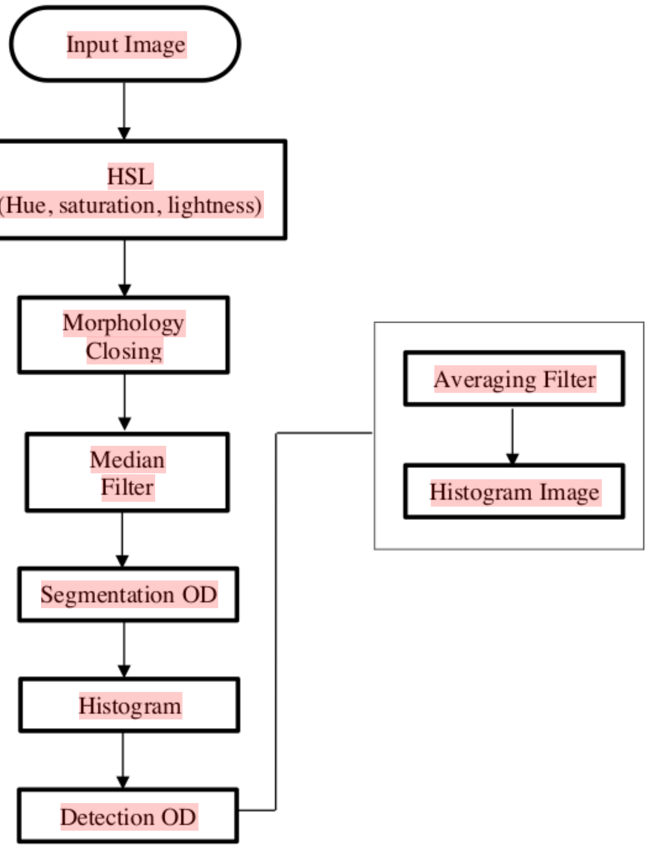


Figure 1. Stages of the Segmentation and Detection method

3.1. Segmentation

3.1.1 Input Image

In the initial stage, this is an input image process, in the form of a retinal image to be processed shown in figure 2.

Figure 2. Original Image

3.1.2 Pre Processing

At the preprocessing there are three stages in figure 3 bellow:

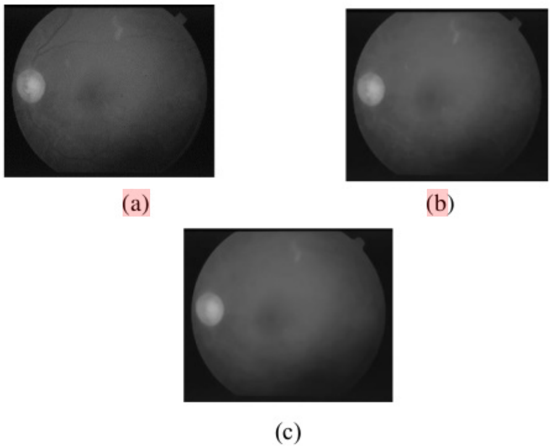


Figure 3. (a) Convert to HSL, (b). Morphology Closing, (c). Median Filter

(a) HSL

Pre-processing is the stage that is done before doing segmentation. The purpose of this stage is to normalize all previous images. At this stage, namely Convert to HSL, the retinal image changes to grayscale.

(b) Morfology Closing

At this stage, that is, after the process of converting through HSL is complete, then it removes the structure of blood vessels in the retina using morphology closing.

(c) Median Filter

At this stage it is used to reduce or eliminate noises, this stage is one of the suggested processes in the segmentation technique. Often images that will be processed can result in difficulty

Journal of Physics: Conference Series **1500** (2020) 012089 doi:10.1088/1742-6596/1500/1/012089

recognizing information in the image. The lack of good image can be caused by the amount of noise (noise) that appears in an image that must be reduced first, because it is done the median filter process to eliminate noises.

3.1.3 Histogram

After pre-processing, a histogram image will show in figure.4. Histogram is a diagram that draws the frequency of pixel intensity values in an image. The horizontal axis is the pixel intensity value and the vertical axis is the frequency or sum of pixels.

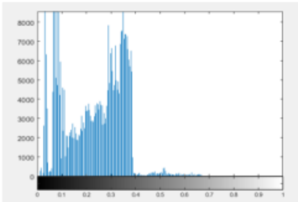


Figure 4. Histogram

3.1.4 Detection Optic Disc

At this stage, it is detecting or finding an optical disc that will be obtained as shown in Figure.5. below.

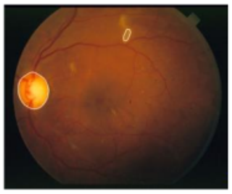


Figure 5. Detection of optic disc

3.1.5 Segmentation Optic Disc

At this stage is the final stage, namely segmentation on the optic disc, this stage is the core stage in the detection of optical disc segmentation in the eye retinal fundus image as shown in figure.6.

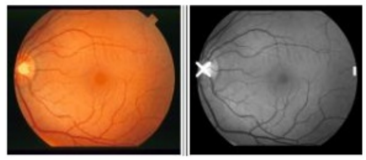
Figure 6. Segmentation of the retina

3.2 Detection

3.2.1 Input Image

Journal of Physics: Conference Series **1500** (2020) 012089 doi:10.1088/1742-6596/1500/1/012089

The dataset used for this experiment is the STARE and DRIVE dataset. In this study we will try 40 images from the dataset randomly and the results of this study will be compared with the available ground truth as in figure.7.

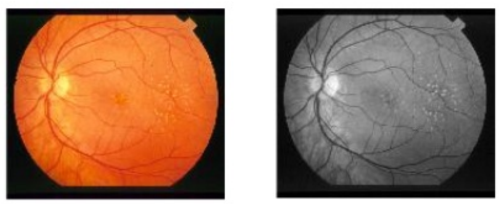


(a) **(b)**

Figure 7. STARE fundus image: (a). Original Image, (b) Ground truth

3.2.2 Green Channel

In this stage, the input image from the STARE dataset will be converted into a green channel image in shown figure.8.



(a) **(b)**

Figure 8. (a) Original Image, (b) Green Channel

3.2.3 Averaging Filter

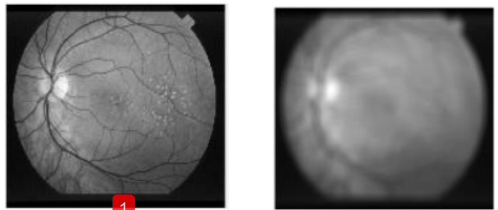
The next step is the *averaging filter* stage. In this stage the image which has been made a green channel leveled with averaging filter. Based on the line in general, filtering at M x N size images using the weighted averaging mask the size found in m x n (m, n odd) will be stated by equation (1) and (2).

$$R = \frac{1}{961}\sum_{i=1}^{961} Zi \qquad (1)$$

$$g(x,y) = \frac{\sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t)f(x+s,y+t)}{\sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t)} \qquad (2)$$

The following are the results of the averaging filter after going through the green channel stage in shown figure 9.

Journal of Physics: Conference Series **1500** (2020) 012089 doi:10.1088/1742-6596/1500/1/012089

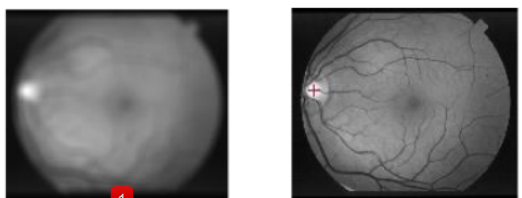


(a) **(b)**

Figure 9. (a) Green Channel (b) Averaging Filter

3.2.4 Detection Optic Disc (OD)

After image acquisition phase, green channel, and averaging filter, the last stage is the Optical disk detection (OD) stage. At this stage the results of the averaging filter will be detected using a histogram image in shown figure 10.



(a) **(b)**

Figure 10. (a) Averaging Filter, (b) Detection OD

4. Results and analysis

In this study, the results of the method will be used as many as 40 database images from STARE and DRIVE. This study contains two main steps for optical disk shielding, namely detection of OD centre points and determination of OD diameter. The OD centre point is obtained by finding the pixel value based on average filtering. After that, the diameter of OD is measured from the detected optical disc limit.

To find out the performance results of how well the system is made, the system was tested by comparing the results of detection of the system with groundtruth optical disks from A. Hoover's research and M. Goldbaum A. Hoover [22] which obtained the accuracy and sensitivity values with equations (3) , (4) and (5) below.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (3)$$

$$Sensitivity = \frac{TP}{TP+FN} \quad (4)$$

$$Specificity = \frac{TN}{TN+FP} \quad (5)$$

Based on TN values (True Negative), FP (False Positive), FN (False Negative), TP (True Positive), sensitivity and specificity will be obtained. TP is True Positive, which is the amount of ground truth data detected by the optical disc and detected correctly by the system.

TN is True Negative, which is the amount of ground truth data that is not detected by optical disc and the system also does not detect optical disc. FP is False Positive, which is the amount of data detected by the system with optic disc but in ground truth it is not detected. FN is False Negative, which is the amount of ground truth data detected by optical disc but in the system not detected.

The following is a several results of segmentation and detection and the acquisition of PSNR and Accuracy values in shown table 1, while present the evaluation result for the OD segmentation and detection approach in shown table 2.

Table 1. Segmentation and Detection

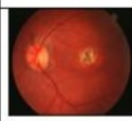
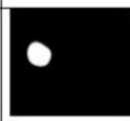
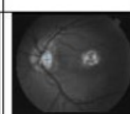
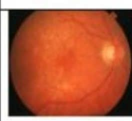
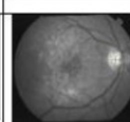
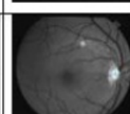
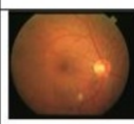
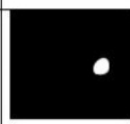
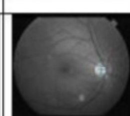
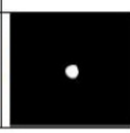
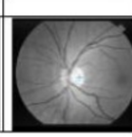
No	Raw Image	Segmentation	Detection	PSNR
0011				22.31
0015				21.07
0016.				16.85
0031				22.90
0163				20.13

Table 1 above is the result of several segmentation and detection experiments that have been tested based on 40 images from the STARE and DRIVE datasets. While in table 2 is a comparison of the results of several previous studies.

Table 2. Performance comparison.

Dataset	Methods	Accuracy
STARE	**Proposed method**	**90.00 %**
	Reza et al [1]	87.65%
	Silva et al [14]	63.40%
	Xu et al [15]	89.00%
	Gui et al [23]	86.40%
	Alghamdi [24]	86.71%
	Reza [25]	81.48 %
	Sinthanayothin et al [26]	50.00 %
	Walter [27]	75.00 %
DRIVE	**Proposed method**	**97.50 %**
	Reza [25]	97.50%
	Zhu [28]	90.00 %
	Sinthanayothin [26]	60.00 %
	Walter [27]	80.00 %

The accuracy level obtained through the STARE dataset is 90% and the DRIVE dataset is 97.50%, while segmentation uses the DRIVE dataset with an average value of PSNR 19.705 dB, accuracy of 86.45%, sensitivity of 100% and specificity 85.175% obtained through average results 40 images are the same as detection. From the results of the approved PSNR, the highest PSNR value was 24.60 dB while the highest PSNR was 11.59 dB. This reduces the quality of the original image.

5. Conclusion

From the results of experiments conducted, it was concluded that in this study using the luminance channel method and segmentation active contour. In the active contour after the installation of circle that will be done in the position of the head contained in the optic nerve, then the segmentation process is carried out further to obtain the shape of the optic nerve head that comes closer to its original form using an active contour model.

While the detection of results from research is still strongly influenced by the quality of images and conditions of the retina so that if the image quality is very bad and many other features with lesions that are brighter than optic disks such as exudates, this can cause detection errors. The Histogram image method is used to get the area that is likely to be an optical disc. OD will be very appropriate if you find a good retinal image and a little noise.

References

[1] M. N. Reza and M. Ahmad, "Automatic Detection of Optic Disc in Fundus Images by Curve Operator," 2015, no. December, pp. 6–11.

[2] T. Devasia, P. Jacob, and T. Thomas, "Automatic Optic Disc Localization and Segmentation using Swarm Intelligence," *World Comput. Sci. Inf. Technol. J.*, vol. 5, no. 6, pp. 92–97, 2015.

[3] V. R. Patil, M. Computer, and S. Iii, "Detection Of Optic Disc In Retina Using Digital Image Processing," vol. 2, no. 1, pp. 20–23, 2015.

[4] L. Wang, H. Liu, Y. Lu, H. Chen, J. Zhang, and J. Pu, "A coarse-to-fine deep learning framework

for optic disc segmentation in fundus images," *Biomed. Signal Process. Control*, vol. 51, pp. 82–89, 2019.

[5] S. Lu, "Accurate and efficient optic disc detection and segmentation by a circular transformation," *IEEE Trans. Med. Imaging*, vol. 30, no. 12, pp. 2126–2133, 2011.

[6] S. D. Bharkad, "Automatic Segmentation of Optic Disk in Retinal Images Using DWT," *Proc. - 6th Int. Adv. Comput. Conf. IACC 2016*, pp. 386–391, 2016.

[7] M. Arsalan, M. A. Khan, and M. A. Khalil, "PT US CR," *Expert Syst. Appl.*, 2018.

[8] P. Choukikar and R. S. Mishra, "Segmenting the Optic Disc in Retinal Images using Thresholding Segmenting the Optic Disc in Retinal Images using Thresholding," no. February, 2017.

[9] S. Sedai, P. K. Roy, D. Mahapatra, and R. Garnavi, "Segmentation of optic disc and optic cup in retinal fundus images using shape regression," *Proc. Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. EMBS*, vol. 2016–October, pp. 3260–3264, 2016.

[10] Erwin, Saparudin, and W. Saputri, "Hybrid multilevel thresholding and improved harmony search algorithm for segmentation," *Int. J. Electr. Comput. Eng.*, vol. 8, no. 6, pp. 4593–4602, 2018.

[11] G. Lim, Y. Cheng, W. Hsu, and M. L. Lee, "Integrated optic disc and cup segmentation with deep learning," *Proc. - Int. Conf. Tools with Artif. Intell. ICTAI*, vol. 2016–January, pp. 162–169, 2016.

[12] A. Septiarini, A. Harjoko, R. Pulungan, and R. Ekantini, "Optic disc and cup segmentation by automatic thresholding with morphological operation for glaucoma evaluation," *Signal, Image Video Process.*, vol. 11, no. 5, pp. 945–952, 2017.

[13] Saparudin, Erwin, and M. Fachrurrozi, "Tongue Segmentation Using Active Contour Model," in *IAES International Conference on Electrical Engineering, Computer Science and Informatics IOP Publishing*, 2017, pp. 1–6.

[14] R. R. V. E Silva, F. H. D. De Araújo, L. M. R. Dos Santos, R. M. S. Veras, and F. N. S. De Medeiros, "Optic disc detection in retinal images using algorithms committee with weighted voting," *IEEE Lat. Am. Trans.*, vol. 14, no. 5, pp. 2446–2454, 2016.

[15] P. Xu, C. Wan, J. Cheng, D. Niu, and J. Liu, "Optic Disc Detection via Deep Learning in Fundus Images," vol. 3, pp. 134–141, 2017.

[16] N. Muangnak, P. Aimmanee, S. Makhanov, and B. Uyyanonvara, "Vessel transform for automatic optic disk detection in retinal images," *IET Image Process.*, vol. 9, no. 9, pp. 743–750, 2015.

[17] W. Zhou, C. Wu, and W. Du, "Automatic optic disc detection in retinal images via group sparse regularization extreme learning machine," *Chinese Control Conf. CCC*, pp. 11053–11058, 2017.

[18] L. Listyalina, H. A. Nugroho, S. Wibirama, and W. K. Oktoeberza, "Automated localisation of optic disc in retinal colour fundus image for assisting in the diagnosis of glaucoma," *Commun. Sci. Technol.*, vol. 2, no. 1, pp. 18–23, 2017.

[19] N. Kulkarni, "Relevance of Computational model for Detection of Optic Disc in Retinal images," no. December 2015, 2016.

[20] V. Patil, M. Phil, V. Kumbhakarna, M. Phil, and S. Kawathekar, "Hough Transform used for Detection of Optic Disc in Retina," vol. 6, no. 6, pp. 7759–7761, 2016.

[21] O. Phyo and A. Khaing, "Automatic detection of optic disk and blood vessels from retinal images using image processing Techniques," pp. 300–307, 2014.

[22] M. Goldbaum, A. Hoover, and M. Goldbaum, "the fuzzy convergence of the blood vessels Locating the Optic Nerve in a Retinal Image Using the Fuzzy Convergence of the Blood Vessels," *EEE Trans. Med. imaging*, vol. 22, no. September 2003, pp. 951–958, 2017.

[23] B. Gui, R. Shuai, P. Chen, B. Gui, R. Shuai, and P. Chen, "ScienceDirect ScienceDirect Optic disc localization algorithm based on improved corner Optic disc localization algorithm based on improved corner detection detection," *Procedia Comput. Sci.*, vol. 131, pp. 311–319, 2018.

[24] H. S. Alghamdi, H. L. Tang, S. A. Waheeb, and T. Peto, "Automatic Optic Disc Abnormality

Detection in Fundus Images: A Deep Learning Approach," pp. 17–24, 2016.

[25] M. N. Reza, "Automatic detection of optic disc in color fundus retinal images using circle operator," *Biomed. Signal Process. Control*, vol. 45, pp. 274–283, 2018.

[26] C. Sinthanayothin, J. F. Boyce, H. L. Cook, and T. H. Williamson, "Automated localisation of the optic disc, fovea, and retinal blood vessels from digital colour fundus images," *Br. J. Ophthalmol.*, vol. 83, no. 8, pp. 902–910, 1999.

[27] T. Walter, J. C. Klein, P. Massin, and A. Erginay, "A contribution of image processing to the diagnosis of diabetic retinopathy - Detection of exudates in color fundus images of the human retina," *IEEE Trans. Med. Imaging*, vol. 21, no. 10, pp. 1236–1243, 2002.

[28] X. Zhu, R. M. Rangayyan, and A. L. Ells, "Detection of the optic nerve head in fundus images of the retina using the hough transform for circles," *J. Digit. Imaging*, vol. 23, no. 3, pp. 332–341, 2010.

Technique automatic for detection and segmentation of optic disc area in retinal image

ORIGINALITY REPORT

89%	12%	89%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Erwin, B Cania, I K Larasati. "Technique automatic for detection and segmentation of optic disc area in retinal image", Journal of Physics: Conference Series, 2020 Publication	89%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		