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Machine learning approaches for the histopathological diagnosis of prostatic hyperplasia

Machine learning and diagnosis of prostatic hyperplasia

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Abstract
Aim: The aim of the present study is to evaluate the effectiveness of computer vision-based system for the histopathological assessment of prostatic tissue and its diagnostic accuracy for the detection of hyperplasia of the glandular component of prostate.
Materials and Methods: A total of 59 digital images have been acquired from the hematoxylin and eosin-stained sections of the prostatic tissue. In these 59 images, 169 regions were marked as sites of hyperplasia of the prostatic glandular component.
The entire dataset has been divided into three classes, which included the training set containing 41 images (70% of the total images), that had 109 marked regions as prostatic hyperplasia, validation set contained 6 images (10% of total images), that had 19 marked regions as prostatic hyperplasia and Testing set contained 12 images (20% of total images), that had 41 marked regions as the hyperplasia of the glandular component of the prostatic tissue.
Results: A total of fifty-nine digital images containing one hundred and sixty-nine marked regions of glandular hyperplasia of prostatic tissue are used in which 70% were employed for training, 10 % for validation, and 20% for testing. The computer vision-based system has diagnosed correctly with 96.3% f1-score.
Discussion: The application of artificial intelligence with the help of computer is emerging an important technique that will improve the diagnostic accuracy and will reduce the chance of human errors. The development of pattern recognition algorithms may be of great help in the histopathological diagnosis in the near future.
Conclusion: The present study revealed that computer vision-based system may be an effective adjunct tool for the histopathological assessment of benign prostatic hyperplasia.
Keywords
Prostatic Hyperplasia; Artificial Intelligence; Computer Vision

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Introduction

Benign prostatic hyperplasia (nodular hyperplasia) is the most prevalent lesion among elderly men. With the advancing age, the prevalence of benign prostatic hyperplasia (nodular hyperplasia) rises in men. About fifty percent of the male population between the ages of 50 and 60 years revealed benign prostatic hyperplasia [1]. This lesion is characterized by more number of epithelial cells and stromal components in the prostate that are predominantly in the transitional zone which is the principal site for benign prostatic hyperplasia [2]. The increase in the number of cells has been attributed to decreased cell death. The increase in the number of cells increases the size of organ and this enlarged organ can compress and obstruct the urethra leading to urinary obstruction and urinary retention. The enlargement of prostate in case of benign prostatic hyperplasia (nodular hyperplasia) causes weak urinary stream, hesitancy, urgency, frequency, dysuria, and nocturia [3]. The risk of the development of lower urinary tract symptoms increases with the increase in the size of prostate [4].

The management of benign prostatic hyperplasia includes treatment with medicine (pharmacotherapy) and surgery (transurethral resection of the prostate or photoselective vaporization of the prostate using greenlight laser) if the urinary symptoms persist. The advancing age of the patients with benign prostatic hyperplasia is associated with a higher rate of surgeries [5]. With the increased life expectancy and rising prevalence of obesity, the number of prostatic surgeries has increased. After the surgery, the excised prostatic tissue is submitted to pathology laboratory for the histopathological examination in which multiple sections of the tissue are examined under a light microscope after the processing of the submitted tissue. The thorough microscopic examination of multiple sections of prostatic tissue is a very important but quite difficult and time-consuming task. The application of computer vision-based approach for the histological assessment of microscopic slides of the prostatic tissue may be evaluated for its usefulness in this regard.

The aim of the present study is to assess the usefulness and diagnostic accuracy of computer vision-based system for the histopathological examination of prostatic hyperplasia.

Material and Methods

Fifty-nine images from the hematoxylin and eosin-stained glass slides of the sections from prostatic tissue have been acquired. These images were used to mark the regions where hyperplastic prostatic glandular component was present. Though the histopathological examination of section from the prostatic tissue is a binary classification problem (hyperplasia of glandular component or normal prostatic gland), but in our case, not only we detect the hyperplastic prostatic glandular component but also the system returns the region of interest (ROI), clearly showing the boundary around the area where the system thinks contains the hyperplastic prostatic glandular component.

To develop the proposed method, we used the Mask-RCNN with Resnet 50. Our implementation of the Mask-RCNN model used the existing implementation by Matter-port Inc Abdulla.

We gathered a dataset of 59 images containing 169 regions with the hyperplastic prostatic glandular component. The data were split into training, validation and test sets. The train dataset had 70% of the total images, where we used 10% of total images for validation and 20% for total images for testing purpose.

Resnet takes an image of size 224x224 by default. As images in the dataset consisted of various sizes, all images were resized to fit the requirement of Resnet. To reduce the risks of overfitting we applied data augmentation on the images by flipping of images both left to right and up to down. All augmentation options were randomly applied with the probity of 33%.

We used the following parameters for our proposed deep learning algorithm

- Learning Rate = 1e-2
- Batch size = 4
- Epochs = 200
- Optimizer = Adam with default values for β_1 and β_2
- Metrics = Dice Similarity Coefficient (DSC)

Results

After training the proposed system, the prediction is done on the test dataset. As the problem was a segmentation problem hence DSC is used as a metric.

DSC= (A∩B) / (A+B), where A is the predicted region and B is ground truth region.

In our case, if the DSC value is greater than or equal to 0.75, then we consider this as a true detection. Using this, we generated confusion metrics. There were 41 regions with prostatic hyperplasia (glandular component) and the computer has identified 40 regions correctly. The results are depicted in Figure 1 and 2. One area has not been picked by the computer vision-based system while two regions were incorrectly identified as the hyperplastic glandular component of the prostate. The analysis of the data revealed that the sensitivity of computer vision-based system is 95.2% with a precision of 97.5%, F1-Score 96.3% and accuracy 93% respectively. The results are shown in Table 1.

Table 1. The diagnostic accuracy of computer vision-based system

Sensitivity	Precision	F1-Score	Accuracy
95.2%	97.5%	96.3%	93%

Discussion

The use of computer programs to perform cognitive functions for the analysis of the data is emerging as a very important tool in the field of artificial intelligence for the solution of human health issues. The development of algorithms for the pattern recognition and advancement in the imaging processing techniques has revolutionized the computer-assisted complex task performance in the field of medicine. The computer with artificial intelligence programs can analyze the raw data for the extraction of important information which may help in yielding the appropriate solution of the problems.

The development of computer software based on machine learning may be able to assist in the performance of complex

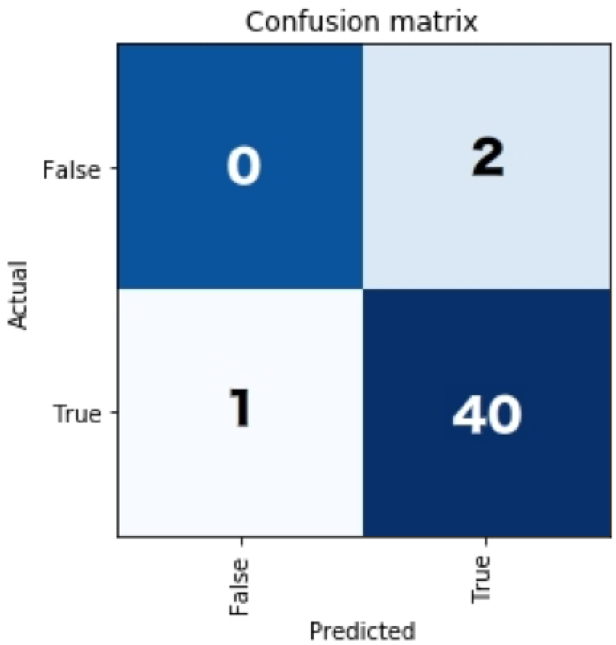

Figure 1. It shows the confusion matrix about the accuracy of computer vision-based system regarding the diagnosis of the hyperplastic glandular component of prostatic tissue

functions to find out the solution of vital medical issues such as diagnosis and treatment of various ailments and may reduce the burden on the medical consultants. These computer- based support systems may also contribute to the reduction of medical errors due to fatigability and may be quite helpful in reducing the cost and improving patient care.

For the appropriate drug therapy of the patients, computerized clinical decision supports systems have been developed which has reduced medication errors [6].

For appropriate treatment, an accurate diagnosis has got vital importance. Laboratory investigations help in reaching to the conclusive diagnosis of the particular ailment. An important laboratory test is the histopathological assessment of the tissue for the diagnosis which requires expertize in the histological assessment of various tissue for different diseases. With the rising trend in the prevalence of surgeries for prostatic lesions, the histopathology department is working under more burden. In this regard, the use of artificial intelligence with the help of machine learning may provide assistance in the accurate diagnosis and mitigate the chance of human errors. The digital image analysis of various pathological lesions by developing pattern recognition algorithms may be of great help in the histopathological diagnosis.

Many studies have been carried out for the characterization of prostatic lesion based on radiological images with the help of computer software and revealed quite impressive results [7-9]. But the biopsy and histopathological evaluation of the biopsy are gold standard for the diagnosis of prostatic lesions particularly the neoplasms [10]. In the present study, the computer vision-based system identified the areas with glandular hyperplasia of prostatic tissue correctly in 96% of the cases which have been confirmed by the two pathologists. These findings are a bit higher than the reported figures of 85% to 92.5% for the various lesions of the prostatic tissue by Bhattacharjee S et al [11]. Similar findings have been observed in other studies [12,13].

With the rising trend in the surgeries for the prostatic lesions, it becomes imperative to find out the computer- assisted systems for the sharing and reducing of the burden and stress of histopathologists. These computer vision- based programs can also reduce the chance of human errors and may prove to be more cost-effective. The present study has certain limitations but in the light of the present study, further research in this field is suggested with more extensive data of the various lesions.

Conclusion: The present study revealed that computer vision-based software may be an effective adjunct tool for the histopathological assessment of benign prostatic hyperplasia.

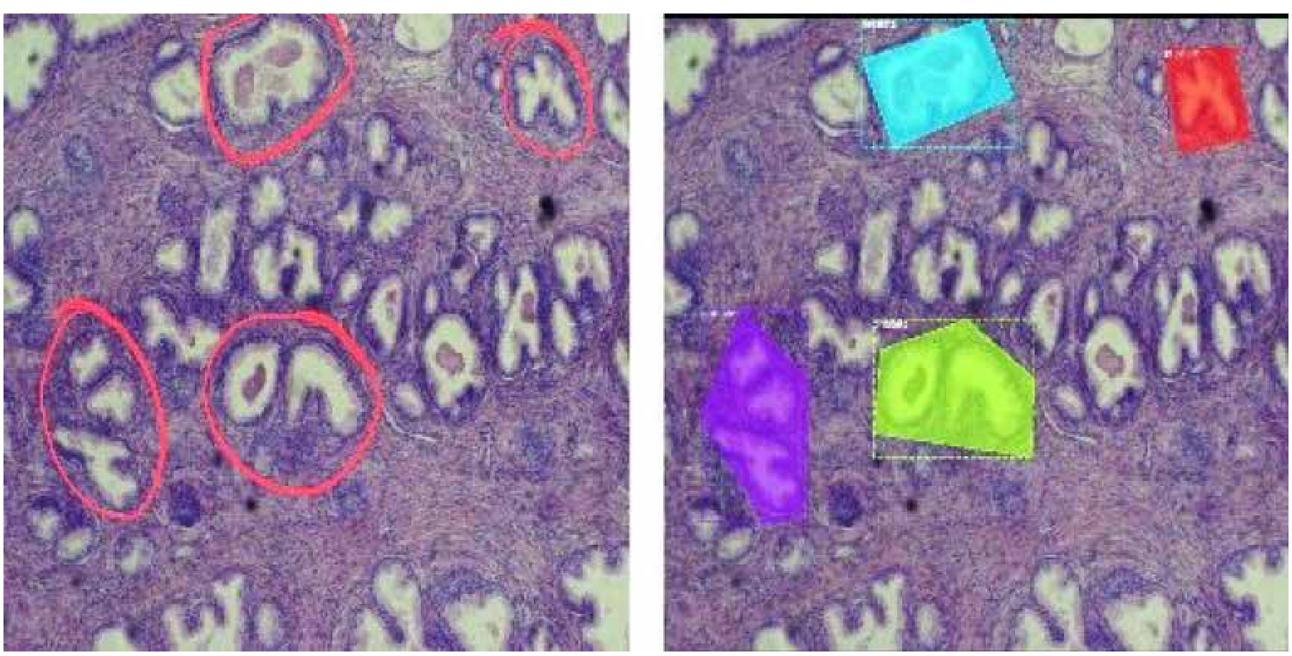

Figure 2. It reveals the diagnosis of glandular hyperplastic component of prostatic tissue by the specialist (A) and computer vision-based system (B).

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Scientific Responsibility Statement
The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest
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