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Tear film break-up detection basis of YOLO neural network

Tai-Yuan Su and Tsung-Yen Tsai

***Abstract*—Tear film unstable is one of the major features of dry eye syndrome. One diagnostic method is fluorescein tear film break-up time test, this test is limited by its subjective and necessity to use manually reading the fluorescent image to identify the break-up area and thus variable result. The previously study use a deep convolution neural network to perform an automatic method to detect the fluorescent tear film break-up detection. However, the method is complex and required a lots of computer power. In this study we use a real time data segmentation method " You only look once (YOLO)" to screen the tear film break up pattern in real time mater. We demonstrate that YOLO is effective method and comparatively fast for recognition and localization in fluorescent tear film break up test. Experimental verification proves their high detection ability, location precision and real time processing speed using modern graphics processing unit.**

***Keywords*—Tear film break up time test, Computer aided diagnosis, Dry eye screening**

I. Introduction

Dry eye has a high prevalence in the general population. It reduced the quality of life of the patients [1] and has become one of the most common ocular conditions among patients seeking eye care [2].

Currently, the fluorescein tear-film break-up time (FTBUT) tests are the most widely used objective tear stability tests for evaluating dry-eye[3]. To perform this test, fluorescein is instilled into the tear film, and the tear film is observed with the cobalt light source. The patient is instructed to blink several times naturally. The FTBUT is measured as the time elapsed between the last blink and the first appearance of a dark spot on the ocular surface, which identifies the break-up of the tear film. A FTBUT shorter than 5 s indicates low tear-film stability [4]. FTBUT test is the most common tear film stability test, however, this test is affected by low repeatability mainly due to a subjective appreciation of the dark spots and the variability of the tear film. The automation of this test would reduce its subjective character.

Dr. Tai-Yuan Su
Assistant Professor, Yuan-Ze University
Taiwan

Tsung-Yen Tsai
Yuan-Ze University
Taiwan

Recently, deep learning has pervaded every aspect of medical image analysis [5], and the potential of convolutional neural network (CNN) for medical image applications has been confirmed [6]. Previous studies have shown a deep CNN model detects tear film break up areas with a reasonable accuracy [7]. However, the test still required the real time performances.

You Only Look Once (YOLO)[8] is an fast and advanced approach object detection. In this study, we use the YOLO architecture for FTBUT measurement to achieve a real time and automatic fluorescein tear film break time measurement. The results demonstrate that our design could provide an objective standard which performs screening of dry eye efficiently.

II. Methods

A. *Fluorescent tear film break-up measurement*

Total of 30 participants were went through the same procedure. The bulbar conjunctiva was injected with 2 micro liters of 2 % fluorescein by using a micropipette. The participants were asked to blink several times, and then record the video [9]. A slit-lamp biomicroscope was adapted a digital camera which records 24 films per second, the resolution of the video image was 1024 × 960 pixels. A typical fluorescent tear film image as shown in Fig. 1.

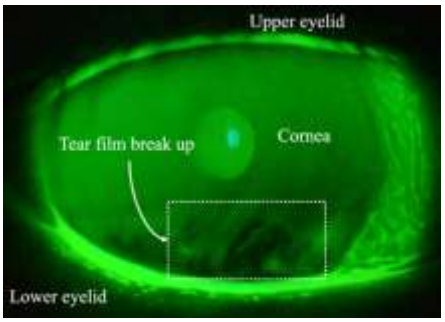

Figure 1. The fluorescent tear film image, the box indicates a fluorescent tear film break up area.

B. *You Only Look Once (YOLO)*

YOLO applies a single deep convolutional neural network to an entire image which further divides the image into grids. Prediction of bounding boxes and respective confidence score are calculated for each grid. These bounding boxes are analyzed by the predicted confidence score. The Architecture of YOLO has 24 convolutional layers and 2 fully connected layers. The input image size

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was 448 × 448 pixels while the output image size was 7 × 7 × 30 tensor [8].

C. *Prepare for training the YOLO net model*

Right eye of 25 participants were used for training the YOLO model. Each participant has recorded an FTBUT measurement video. To train the YOLO net model, we first prepare the training image. The fluorescent tear film image was selected by a region of interest segmentation manually as shown in Fig. 2. YOLO networks have been trained for only a single object class i.e. "break-up area". The training was divided into two subsets, that is, training set, and test set, the number of samples in each set was shown in Table 1.

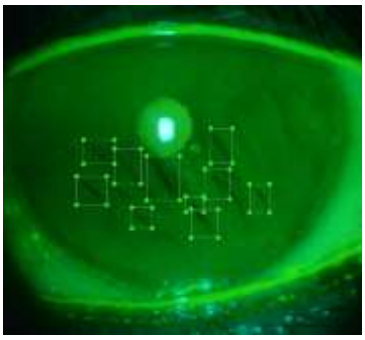

Figure 2. The tear film break-up pattern is selected manually with a square region.

TABLE I. SUMMARY AMONG TRAINING AND TESTING DATASETS FOR FEATURES.

	Training	*Testing*	*Total*
Break-up image	225	25	250
Non Break image	225	25	250

D. *Testing the proposed YOLO-BUT method*

A series of fluorescent tear film images from a participant were displayed at 1 s intervals, as shown in Fig. 4. The green color indicates a stable tear film area while the dark color indicates a break-up area. Three break-up areas were detected by the YOLO net model at 3th seconds after the blinking (i.e. YOLO-BUT = 3 seconds). In this study, 5 participants were used for testing the YOLO-BUT. One YOLO-BUT measurements were recorded for each participant and then compared to the expert measurement results.

III. Result and discussions

A. *Evaluation with the Yolo net model*

A confusion matrix contains information about actual and predicted classifications generated by a classification system. The accuracy for Tear film image and Break-up, image were respectively 91 and 92 %. The analysis of the data obtained shows that the YOLO classifier was able to detect the break-up image in 92% of the testing set images.

B. *Correlation FTBUT vs. YOLO-BUT*

We used the YOLO-BUT to calculate the tear film break up time for 5 participants as shown in Fig.3. The high correlation value (R = 0.91) between the manually defined and our method defined results show the proposed system provides acceptable measurement result.

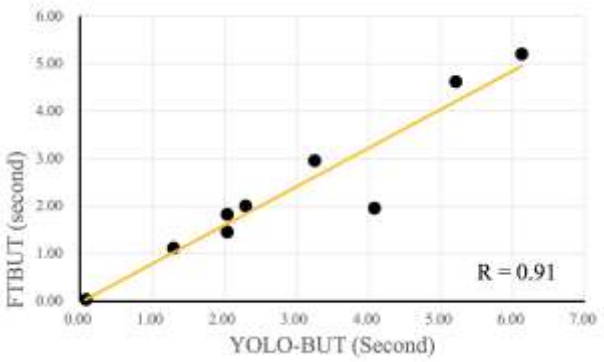

Figure 3. The scatter plot of fluorescent tear film break-up time (FTBUT) and the YOLO break-up time (YOLO-BUT). R = correlation coefficient.

C. *The real time measurement*

The experiments were implemented on the graphics processing unit (GPU). The YOLO package written in Python language based on NVIDIA CUDA 9.0 and cuDNNv2 7.1. Our experiments are conducted on a NVIDIA GTX 1050Ti 4GB and a 4-core Intel(R) Core i3-8100 3.60

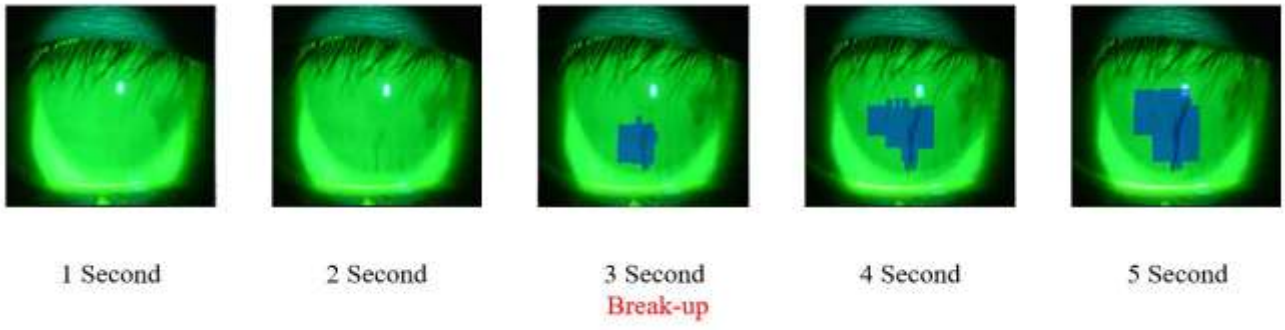

Figure 4. The YOLO Tear film break-up time (YOLO-BUT) measurement. The proposed model indicates the tear film break-up area at 3th second after the blinking.

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GHz computer. The mean computed speed of 5 YOLO-BUT measurements was 32 film per second.

Tear film break-up time assessment is an easily accessible and indirect measure of the function of the lacrimal gland and the patency of the meibomian gland system. The evaluation of FTBUT provides valuable diagnostic information to the clinical with respect to the overall tear film stability in the dry eye evaluation. The current study reports the application of YOLO method disclosed great potential of this new technology to fast analyze tear film dynamics and quantify automatically.

IV. Conclusion

The current study reports the application of YOLO to evaluate the FTBUT for dry eye screening. The YOLO model was trained to detect the tear film break-up area first, and then used to evaluate the tear film break up time automatically in real time. The YOLO-BUT have a strong correlation to the clinical FTBUT measurement results. The proposed method could become an established method for evaluating dry eye disease automatically and real time diagnosis in the future.

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Tai-Yuan Su received the M.S. degree in automation and control from National Taiwan University of Science and Technology, Taiwan, in 2009, and the Ph.D. degree in biomedical engineering from National Yang-Ming University, Taiwan, in 2014. He is currently an Assistant Professor of the Department of Electrical Engineering, Yuan-Ze University. His research interests include computer vision and computer-aided diagnosis system.

Tsung-Yen Tsai completed the university studies in Department of Physics from National Chung Cheng University, Taiwan, in 2017. He is now studying for M.S. degree in the Department of Electrical Engineering, Yuan-Ze University, Taiwan. His research include computer vision, video signal processing, and computer-aided diagnosis system.