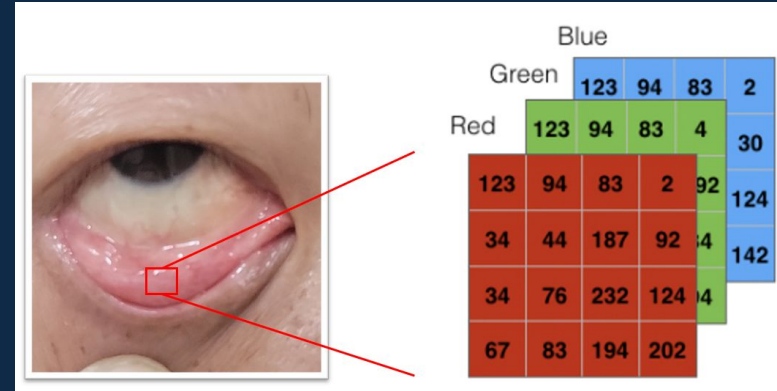


# Principles of Pathology

In anemia diagnosis, the color characteristics of the eyelid, particularly the degree of pallor, are key indicators. In healthy individuals, the eyelid appears reddish, reflecting sufficient levels of hemoglobin in the blood. However, when anemia occurs, hemoglobin levels drop, and the color of the eyelid tends to become pale, as the blood's oxygen-carrying capacity decreases, affecting oxygen supply to tissues.

Technically, changes in eyelid color can be captured using image processing methods. Specifically, the image processing system can decompose the eyelid image into red, green, and blue channels, and compare the value of the red channel against other color channels. Studies have shown that anemic patients often exhibit lower red channel values, with RGB channel values being similar, causing the eyelid to appear pale or pinkish. This phenomenon serves as a potential indicator for quantifying hemoglobin levels, providing a non-invasive approach for evaluating anemia.



# Application Principles

## Data Preprocessing



To address the issue of glare in the images, we implemented two methods. First, we used the HSV color space to filter out glare points with excessively high brightness or low saturation. The second method involved converting the image to grayscale and using threshold operations to detect and correct over-bright areas.

During the image segmentation stage, the UNet model was employed to automatically segment the eyelid region, allowing for precise extraction of anemia-related features. The UNet architecture consists of an encoder and a decoder: the encoder progressively captures critical features within the image to locate the eyelid, while the decoder restores these features to accurately mark the eyelid area.

## Deep Learning Classification



In deep learning classification, a deep learning model is employed to classify anemia images, using a hemoglobin (Hb) concentration threshold of 12 g/dL to determine anemia presence. The model leverages multi-level feature extraction to automatically identify anemia-related features, such as color variations in the eyelid area. To improve the model's generalization, data augmentation techniques are applied during training to diversify the dataset, enhancing the model's performance on new data and strengthening the stability and accuracy of the classification results. The model achieved an accuracy of 85% to 90% on the test set, demonstrating its reliability in anemia detection.

## Regression Analysis



Regression analysis is used to quantify the severity of a patient's anemia by examining trends in hemoglobin levels. This analysis selects features closely related to eyelid color—such as hue, saturation, brightness, the R channel, the difference between R and GB channels, and grayscale—to estimate hemoglobin levels. Linear and polynomial regression models are employed to precisely predict hemoglobin fluctuations, while mean squared error (MSE) and the coefficient of determination ( $R^2$ ) are used to assess model performance, ensuring both predictive accuracy and interpretability.

Our team, having received approval from the Institutional Review Board (IRB), has initiated human trials at Shuang Ho Hospital and the Hemodialysis Center of New Civil Hospital. To date, we have successfully enrolled over 350 participants, and recruitment is actively ongoing.

[illegible]

# Technology support

Our team has been supported by the National Science and Technology Council (NSTC) under Project Nos. 113-2221-E-027-039, 112-2221-E-027-099, and 111-2221-E-027-042, underscoring the study's academic significance and practical potential.

<b>uspto</b> UNITED STATES PATENT AND TRADEMARK OFFICE		Page 1 of 2 P.O. Box 1480 Alexandria, VA 22212-1480 www.uspto.gov	
ELECTRONIC ACKNOWLEDGEMENT RECEIPT			
APPLICATION NO. 18/206,320		OFFICE ACTION DATE 04/16/2024 09:04:37 AM Z ET	
TITLE OF INVENTION EYE IMAGE CAPTURING AND PROCESSING DEVICE		APPLICANT'S CHECK # 68597330	
Application Information			
APPLICATION TYPE Utility - Nonprovisional Application		PATENT #	
CONFIRMATION # 8287		FILED BY SU YU	
PATENT CENTER # 6160615		FLNO DATE 12/06/2023	
CUSTOMER # 65558		FIRST NAME CHENG-CHUN CHANG	
CORRESPONDENCE ADDRESS -		INVENTOR JUSTIN KING	
DOCUMENTS		TOTAL DOCUMENTS: 2	
DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
post1.pdf	1	Power of Attorney	2621 KB
post2.pdf	1	Power of Attorney	4643 KB
Digest			
DOCUMENT	MESSAGE DIGEST(SHA-512)		
post1.pdf	D4548FD67367C688081BC44D4690E8C8FED44C9ED18097639326FF7409CF6792FE198A49B2EE5B21DFFA30C0C0D42C3C699597C917C91B38CDDC32AE4A		

To further secure the legitimacy and commercial applicability of our findings, we have filed multiple patents for the relevant technologies, ensuring legal protection of the intellectual property.

專題研究計畫執行同意書	
主同意書人即本研究計畫主持人：張正春。國家科學及技術委員會審議通過之專題研究計畫案卷宗，在行政院國家科學技術發展基金項下接受補助。此項專題研究計畫：《國家科學及技術委員會第 74 次行政會議通過、通知文號：1130942695(113_08_28)》。	
計畫名稱：全感式 PVE 感測、化學習法人在公共無意識量測環境中研究計畫(11)	
計畫編號：NSTC 113 - 2221 - E - 027 - 039 - MY2	
補助經費：新台幣(大寫) 零 佰 陸 拾 萬 柒 仟 元 整	
茲經國家科學及技術委員會開庭決定執行本計畫，並同意進行下列規定：	
一、本計畫執行期間自民國 113 年 03 月 01 日起至 115 年 02 月 28 日止，補助項目由國家科學及技術委員會審查通過之專題研究計畫經費核定清單所列為限。	
二、本計畫之補助經費，由國家科學及技術委員會核定，由計畫主持人，執行期間滿三個月內，依國家科學及技術委員會補助專題研究計畫作業辦法規定，辦理經費核結，如有超額，應全數繳還，如已實施比例基金制度之學校、國立組織機構作業基金之機構及中央研究院，得不繳還。	
三、本計畫(含分年計畫及變更計畫)執行期間三個月內，依國家科學及技術委員會補助專題研究計畫經費核定清單及有關規定擬定可列帳之研究成果報告，送國家科學及技術委員會辦理核結。如無可列帳成果(如無如：電腦影片、學術研討會、論文之發表、執行機構辦理研討會報告、資料彙編核結、空白引卷、通統統計彙編(CODEBOOK)、電腦資料數據檔、資料關切定義核表(SAS、SPSS 或其他統計程式)及及調查資料彙編利用設備書各一份送中央研究院人文社會科學研究中心「國際學術會議中心」。	
四、本計畫有無之執行期間、經費分配、主持、協理、變更、追加、減損及延期等，應依國家科學及技術委員會補助專題研究計畫作業辦法規定辦理。國家科學及技術委員會補助專題研究計畫經費核定清單及其中相關法令規定辦理。	
五、本計畫之補助經費及另覓經費來源，依行政院審議國家科學及技術委員會所有案件，全部歸屬執行機構所有(特別與學術研究計畫之研究或成果歸屬)，並受列字時、技術轉移、著作權及權益分配等相關事宜，由執行機構依科學技術法之基本法，政府科學技術研究發展成果歸屬及運用辦法規定辦理。依國家科學及技術委員會補助專題研究計畫辦法及其中相關法令規定辦理。	
六、計畫主持人應請分配國家科學及技術委員會經費，提供規則規定參考資料：如屬列管計畫，應依管理辦法相關規定，提供審查參考資料。	
七、計畫執行中如涉及人體試驗或涉及人體倫理，計畫主持人應依有關法令規定辦理。應先受試驗者或受試驗者書面同意書，受試驗者如為限制行為能力人，受監護宣告人，或受輔助宣告之人，則應取得其本人、法定代理人、監護人或輔助人之書面同意書，並依執行機構規定，如得進行人體實驗或涉及倫理，實驗過程應經本人及法定受試驗者個人確認同意書後，如涉及人體實驗或涉及倫理之計畫，應由計畫主持人自行認定之。如涉及人體實驗或涉及倫理之計畫，應遵守有關法令並依規定經醫療委員會或人體試驗倫理委員會審查通過同意後執行。如屬動物實驗，亦同意遵守有關法令暨動物之態度進行。如違反相關規定，應即轉報中央研究院、教育部或相關主管機關處理，應遵守有關法令暨動物之態度進行。如違反相關規定，應即轉報中央研究院、教育部或相關主管機關處理。	
八、計畫主持人對於計畫內容及研究成果應予以嚴格管理財產權者，應即轉報中央研究院、教育部或相關主管機關處理。如屬動物實驗，亦同意遵守有關法令暨動物之態度進行。如違反相關規定，應即轉報中央研究院、教育部或相關主管機關處理。	
九、計畫主持人應依國家科學及技術委員會辦法，依權利或送其法律責任，並應遵守相關規定。	
十、計畫主持人如未依規定辦理經費核結及報研究或成果報告，國家科學及技術委員會不再給與補助研究計畫之補助。	
十一、計畫之主持人及參與人員研究計畫之權限、執行或成果呈現階段，如有違反學術倫理之情形，國家科學及技術委員會將依國家科學及技術委員會補助專題研究計畫經費核定清單規定處理。	
十二、計畫主持人心中所有情事將轉送上述執行機構辦理。如屬動物實驗，亦同意遵守有關法令暨動物之態度進行。如違反相關規定，應即轉報中央研究院、教育部或相關主管機關處理。	
十三、本同意書一式三份，分由國家科學及技術委員會、執行機構及計畫主持人收執，以資留存。	
此 致 國家科學及技術委員會	
計畫主持人：張正春 (簽名及蓋章)	