Oral presentation | CS Code-sharing session：【CS.2】Code-sharing Session of 3.2 & 4.4

Tue. Sep 17, 2024 9:00 AM - 11:45 AM JST | Tue. Sep 17, 2024 12:00 AM - 2:45 AM UTC A37 (TOKI MESSE 3F)

[17a-A37-1~8] CS.2 Code-sharing Session of 3.2 & 4.4

Hiroyuki Suzuki(Gunma Univ.), Shuji Taue(Kochi Univ. of Tech.)

English Presentation
9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC
[17a-A37-1]
[JSAP-Optica Joint Symposia Invited Talk] Deep Neural Network 3D Reconstruction Using One-Shot Color Mapping of Reflectance Direction Fields

〇Hiroshi Ohno[1] (1.Toshiba RDC)

English Presentation
9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC
[17a-A37-2]
Corneal quality assessment for corneal transplantation using hyperspectral imaging

〇(D)Maria Merin Antony[1], Murukeshan Vadakke Matham[1] (1.Nanyang Techn. Univ.)

English Presentation
9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC
[17a-A37-3]
Enhancing the Accuracy of Identification in Complex Environmental Backgrounds using YOLO V7 and U2NET: Orchid Repotting

〇(M2)HUNG WEI HSU[1], Chih-Chung Wang[1], Jia-Han Li[1] (1.National Taiwan University)

English Presentation
10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC
[17a-A37-4]
[JSAP-Optica Joint Symposia Invited Talk] Compact super multi-view and foveated holographic near eye display for augmented reality and virtual reality applications

〇Jae-Hyeung Park[1], Myeong-Ho Choi[2,1], Woongseob Han[2,1], Minseong Kim[2,1] (1.Seoul National Univ., 2.Inha Univ.)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC
[17a-A37-5]
Femtosecond-laser-generated micro cloud volumetric display with RGB laser illumination

〇(M2)Keisuke Numazawa[1], Kota Kumagai[1], Yoshio Hayasaki[1] (1.Utsunomiya Univ. CORE)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC
[17a-A37-6]
Evaluation of double-pulse-excited aerial voxels and their application to volumetric image drawing

〇Kota Kumagai[1], Togo Endo[1], Yoshio Hayasaki[1] (1.Utsunomiya Univ.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC
[17a-A37-7]
Volumetric beam shaping using a computer-generated hologram

〇(D)Nami Kuroo[1], Yoshio Hayasaki[1] (1.Utsunomiya Univ.)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[17a-A37-8]

Preparation of Volume Holographic Optical Element for Multiple Line Focus Beam Diffraction

〇(M2)Yuki Tamai[1], Daisuke Barada[2] (1.Opt,Eng,Utsunomiya Univ., 2.CORE Utsunomiya Univ.)

Deep Neural Network 3D Reconstruction Using One-Shot Color Mapping of Reflectance Direction Fields

Toshiba RDC, °Hiroshi Ohno

E-mail: hiroshi1.ohno@toshiba.co.jp

In many manufacturing processes, real-time inspection of microscale three-dimensional (3D) surfaces is crucial. Therefore, a method integrating deep neural networks (DNNs) has been proposed for obtaining a microscale 3D surface from a single image, or two images, captured by an imaging system referred to as the one-shot BRDF (Bidirectional Reflectance Distribution Function) system, equipped with a multicolor filter [1-4]. This system can acquire reflectance direction fields using one-shot color mapping that assigns light directions to specific colors. Assuming a smooth and continuous surface, the 3D shape can be reconstructed from either a single image or two images captured by the one-shot BRDF system. This process utilizes DNNs that function as a gradient descent method to solve nonlinear partial differential equations, without the need for training data. This DNN-incorporated method is referred to as OneShot3DNet. The effectiveness of this method has been validated numerically and experimentally.

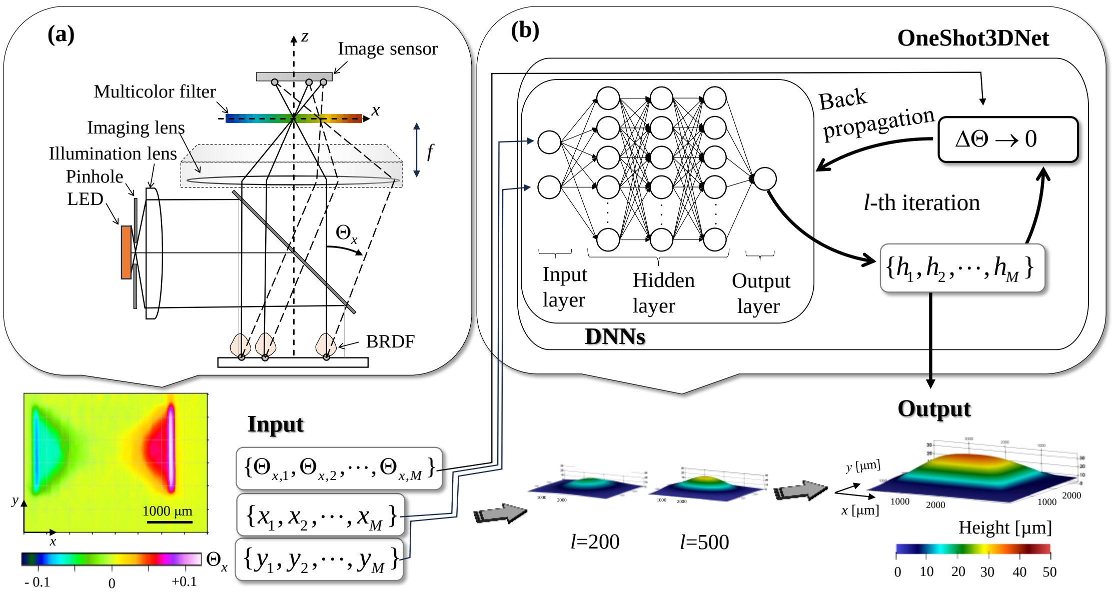

Fig. 1. (a) Schematic cross-sectional view of the one-shot BRDF imaging system. (b) Deep neural network-incorporated method (OneShot3DNet) for reconstructing 3D surfaces.

References

1. H. Ohno, OSA Continuum **4**(3), 840-848 (2021).
2. H. Ohno and T. Kamikawa, Optical Review **28**, 655-661 (2021).
3. H. Ohno and T. Usui, Optics Letters **46**(17), 4116-4119 (2021).
4. H. Ohno, Journal of the Optical Society of America A **41**(7), 1240-1249 (2024).

Corneal quality assessment for corneal transplantation using hyperspectral imaging

Maria Merin Antony, Murukeshan Vadakke Matham*
Centre for Optical and Laser Engineering, School of Mechanical and Aerospace Engineering,
Nanyang Technological University, Singapore
*E-mail: mmurukeshan@ntu.edu.sg

1. Introduction

Cornea is the most widely transplanted human tissue. To ensure good surgical results and effective visual recovery, thorough screening of donors and donor tissues is necessary throughout the process [1]. This screening minimizes the risk of transmitting infectious diseases and environmental contaminants to the recipient, while also guaranteeing the transplant's high optical and functional quality. Therefore, the quality assessment of the cornea at various stages - from donor selection to the transplantation procedure is crucial to ensure its longevity and effectiveness. Currently, these assessments are performed using equipment with the need of skilled personnel, where assessment can be subjective and lack specificity [2]. This research in this context, proposes a methodology using hyperspectral imaging (HSI) for the quality assessment of corneal flaps prior to transplantation to address these issues. HSI, which is a non-invasive imaging technique, captures both spectral and spatial information of the sample under investigation offering automation possibilities and chemical specificity [3].

2. Materials and methods

The corneal flap or button is carefully removed from the porcine eye and was imaged using a hyperspectral imager (Pika XC2, Resonon) with spectral resolution of 1.3 nm as shown in the Fig. 1. Corneal button is then inspected for stains or pigments in transmission mode.

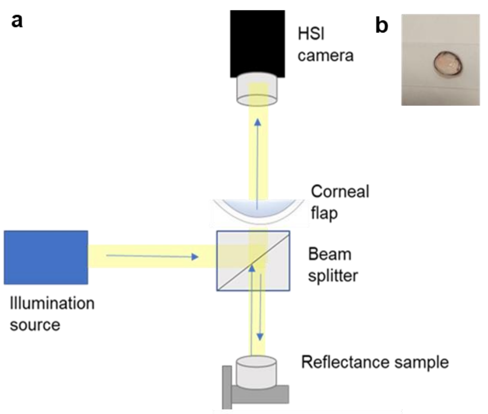

Fig. 1. a. Experimental setup in transmission mode, b. corneal button or flap placed in a glass slide.

The corneal flap is mounted on a stage and scanned at a speed of 100 μm/s across the beam to capture the whole surface of the cornea.

3. Results and discussion

RGB photograph of the porcine cornea button used as sample for imaging is shown in Fig. 2a with regions for hyperspectral data extraction marked as 1, 2, 3, and 4. The spectra extracted are shown in Fig. 2b.

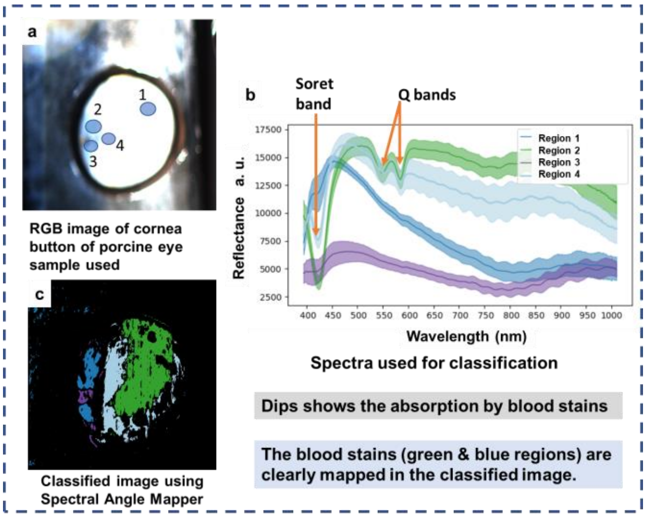

Fig. 2. a. RGB photograph of the cornea button, b. spectra acquired from four different regions, c. SAM based classification.

The dips observed in the reflectance spectra at approximately 420 nm, 550 nm and 580 nm are associated with the Soret band (around 420 nm) and Q bands (550 nm, 580 nm) of oxyhemoglobin, a major component of blood [4]. These spectral features are therefore strongly suggestive of the presence of oxyhemoglobin, confirming that the stains are blood-related which need to be cleaned thoroughly prior to transplantation procedure to avoid any post-operative implications. The spectral angle mapper (SAM) was used for image classification as shown in Fig. 2c where the stains were clearly mapped (green and light blue regions) based on the spectra library created from four different regions. By mapping such specific wavelengths to the known absorption peaks of substances, the various stains and pigments can be accurately identified and confirmed.

4. Conclusions

The proposed spectral image analysis provides a robust and non-invasive method for detecting blood, enhancing the precision and reliability of the corneal quality.

Acknowledgements

The authors also acknowledge financial support received through COLE-EDB funding at COLE, NTU.

References

[1] Vito Romano, et al. Survery of Opthalmology, 69, (2024), 3.
[2] Aschauer, J., Klimek, M.et al. Sci Rep 14, 2124 (2024)
[3] M. M. Antony, C. S. S. Sandeep, M. V. Matham, Optics and Lasers in Engineering, 178, (2024), 108238.
[4] Gienger, J., Smuda, K., Müller, R. et al. Sci Rep 9, (2019) 4623.

Enhancing the Accuracy of Identification in Complex Environmental Backgrounds using YOLO V7 and U2NET: Orchid Repotting

Hung-Wei Hsu, Chih-Chung Wang, and Jia-Han Li*
Department of Engineering Science and Ocean Engineering, National Taiwan University, Taipei 106319, Taiwan
E-mail: r105250001@ntu.edu.tw, d09525016@ntu.edu.tw, * : jiahan@ntu.edu.tw

1. Introduction

In the horticultural industry, determining the appropriate timing for repotting is crucial for plant health and growth. Traditional Automated Optical Inspection (AOI) techniques fall short in addressing the high variability inherent in horticulture due to environmental, genetic, and growth-related factors. These traditional methods are inadequate for dealing with the dynamic and complex nature of plant cultivation. Therefore, advanced deep learning models are needed to predict optimal repotting times and ensure precise target object detection amidst complex backgrounds. This study employs YOLOv7[1] for prediction and U2NET[2] for image segmentation, replacing the masking function of YOLOv7. The effectiveness of three YOLOv7-trained models is compared to evaluate their performance in recognizing Oncidium orchids under challenging, cluttered background conditions.

2. Methodology

Varatharasan[3] et al. addressed cluttered backgrounds in object detection by creating synthetic data with heterogeneous backgrounds to enhance learning efficiency. Extending their methodology, we captured images of Oncidium for back-ground removal. After processing, the data were categorized into three classes: background removal, no background re-moval, and a combination of both.

In the data processing phase, images were classified using background removal, no background removal, and a hybrid approach to improve recognition precision. U2NET was uti-lized for background removal, significantly reducing pro-cessing time. Subsequently, we trained the YOLO V7 model on these images to develop a custom recognition model. These three models—background removal, no background removal, and hybrid—were compared to analyze their recognition accuracy.

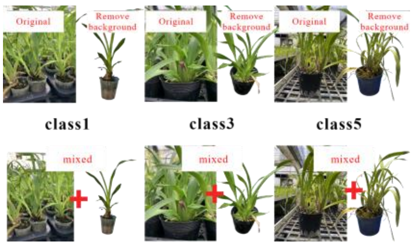

Fig. 1 class 1 represents 1-inch potted plants, class 3 represents 3-inch potted plants, and class 5 represents 5-inch potted plants.

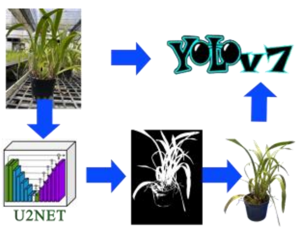

Fig. 2 YOLO V7 deep learning model architecture.

3. Results and Discussion

In practical field recognition, the hybrid model demonstrated the best performance among the three models. Although the training data with background removal yielded the best prediction values during pre-training, the actual field environment, characterized by complex backgrounds, revealed that the background removal model had lower recognition rates in such conditions. From Figure 3, it can be observed that the hybrid model has the best recognition rate among the three models for identifying potted plants that are ready for repotting.

Fig. 3 Predicted results of the three models

3. Conclusions

In the data processing phase, replacing the YOLO V7 mask function with the U2NET model considerably acceler-ates data processing speed. For image handling, photos were processed under three different conditions: with background removal, without background removal, and using a mixed approach. The mixed training meth-od, which combines features from both background removal and non-removal, effectively addresses the challenges posed by complex backgrounds. This method emphasizes training on contour shapes extracted from backgrounds, thereby enhancing training effectiveness in environments with intricate textures. Utilizing advanced models like U2NET and YOLO V7 has substantially improved the precision of identifying and classifying different growth stages of orchids, which is vital for automating horticulture and customizing applica-tions in orchid cultivation.

Acknowledgements

We are grateful to National Taiwan University Molecular Farm and Industrial Technology Research Institute, grant number ITRI-112HZE1100D.

References

[1] WANG, Chien-Yao; BOCHKOVSKIY, Alexey; LIAO, Hong-Yuan Mark. YOLOv7: Trainable bag-of-freebies sets new state-of-the-art for real-time object detectors. In: Proceedings of the IEEE/CVF conference on computer vision and pattern recognition. 2023. p. 7464-7475.
[2] QIN, Xuebin, et al. U2-Net: Going deeper with nested U-structure for salient object detection. Pattern recognition, 2020, 106: 107404.
[3] V. Varatharasan, H. -S. Shin, A. Tsourdos and N. Colosimo, "Improving Learning Effectiveness For Object Detection and Classification in Cluttered Backgrounds," 2019 Workshop on Research, Education and Development of Unmanned Aerial Systems (RED UAS), Cranfield, UK, 2019, pp. 78-85, doi: 10.1109/REDUAS47371.2019.8999695.

Compact super multi-view and foveated holographic near eye display for augmented reality and virtual reality applications

Jae-Hyeung Park[1], Myeong-Ho Choi[1,2], Woongseob Han[1,2], Minseong Kim[1,2]

[1] Seoul National University, [2] Inha University
E-mail: jaehyeung@snu.ac.kr

1. Introduction

Near eye displays (NEDs) are glasses-type wearable displays that play a pivotal role in augmented reality (AR) and virtual reality (VR) applications. Various optical techniques have been developed to realize compact form factor, light weight, wide field of view, large eyebox, and high angular resolution. However, natural three-dimensional (3D) image presentation without the vergence-accommodation conflict (VAC) remains a challenging issue. The VAC adversely affects the visual comfort of users, leading to eye fatigue, particularly during prolonged use. To address the VAC, NEDs should present optical 3D images to each individual eye of the users. Super multi-view (SMV) and holographic display techniques can generate optical 3D images and their application to the NEDs has been an active research topic recently.

In this presentation, we introduce our recent work on SMV and holographic NEDs for AR and VR applications. We show that the light source array can be adopted in both AR and VR configurations to achieve the SMV NED with a slim form factor. The realization of the foveated holographic VR NED is also discussed, demonstrating its compact implementation using a geometric phase lens.

2. Slim SMV NED

SMV displays present 3D images by projecting their slightly different multiple perspectives to the corresponding viewpoints inside the pupil of each individual eye of the user. When the eye is focused at the intended 3D image distance, the projected perspective images are precisely overlapped in the retina plane, forming a clear and sharp image. When the eye is focused at different distance, the perspective images are spatially separated in the retina, giving defocused or blurred imagery. This effect drives the proper accommodation response of the user, solving the VAC problem.

The implementation of the SMV technique to the AR and VR NEDs often results in bulky system form factor and reduced image resolution, diluting its own advantages. In our work, we use an LED array and a ferroelectric liquid crystal display on silicon (FLCoS) with a waveguide configuration [1]. The light from a LED is delivered by the waveguide to the eye side, modulated by the FLCoS, and then focused on a single viewpoint spot in the eye pupil plane by an out-coupler holographic optical element (HOE) on the waveguide. The time-multiplexed synchronized operation of the LED array and the FLCoS enables the projection of the multiple perspective images to the slighted separated viewpoints within the eye pupil, presenting 3D images. The use of the time-multiplexing scheme enables the 3D image presentation with its full resolution of the FLCoS regardless of the number of the viewpoints. The novel optical configuration with the LED array, FLCoS, and waveguide enables slim and compact system implementation without compromising the form factor.

3. Compact foveated holographic NED

Holographic displays present 3D images by reproducing the wavefront of the object. Coherent laser illumination is modulated by a spatial light modulator (SLM), forming 3D images with complete depth cue. The holographic NEDs have several advantages including the VAC-free natural 3D image presentation, wide depth range, and the aberration pre-compensation capability. These features make the holographic NED highly promising.

In our work, we add a foveated display feature to the holographic NED. The foveated display is a technique realizing a wide field of view with a smaller number of pixels utilizing the non-uniform visual resolution of the eye across the field of view. We develop a novel optical configuration comprising a geometric phase lens and two SLMs for the foveated holographic NED [2]. The polarization dependent optical power of the geometric phase lens gives different magnifications to the holographic images from two SLMs, realizing the foveated image presentation. The holographic virtual image formation at an arbitrary distance by the individual SLM allows all the physical system components to be tightly packed, enabling highly compact system implementation.

4. Conclusions

We have developed a waveguide-type SMV NED and a foveated holographic NED. Both of these designs address the VAC while maintaining slim and compact form factor. In the presentation, the principle and the experimental results will be discussed.

Acknowledgements

This research was supported by National Research Foundation of Korea (2022R1A2C2013455).

References

[1] W. Han et al., Proc. SPIE **12913** (2024) article 13.
[2] M.-H. Choi et al., Proc. SPIE **12913** (2024) article 14.

３色レーザー照明を有するフェムト秒レーザー励起マイクロクラウド体積ディスプレイ

Femtosecond-laser-generated micro cloud volumetric display with RGB laser illumination

宇都宮大オプティクス °(M2)沼澤 啓亮，熊谷 幸汰，早崎 芳夫
Utsunomiya Univ. CORE °Keisuke Numazawa, Kota Kumagai, Yoshio Hayasaki
E-mail: hayasaki@cc.utsunomiya-u.ac.jp

体積的ディスプレイは, ボクセルを実空間上に３次元的に生成し, 体積的映像を表示する装置である．これは，広い視野とヒトの奥行き知覚を満足する体積像の表示を特徴とする. 表示方法としては, ボクセルが発光する自発光型と, ボクセルが照明光を散乱する光散乱型に分類される．光散乱型は，照明光によりボクセルの色を調節できるため, 体積像のカラー化が容易である．

本研究は, 霧箱にフェムト秒レーザーを集光照射することで生成される雲をボクセルとした体積的ディスプレイを提案する. フェムト秒レーザーを霧箱内に集光すると, その高いピーク強度が多光子励起を引き起こし, 空気がイオン化される．マイクロクラウドは，イオン化された空気を凝結核として形成される微小な液滴の集合体で，集光点近傍でのみ生成される．照明光によって可視化されたこれらの液滴は，光散乱型ボクセルとして機能する. レーザー光が走査されると, 飛行機雲のようにその場に一定時間残存するため, 人間の目にとってのリアルタイム体積映像を描画できる.

Figure 1 は，実験光学系を示す．実験光学系は，主に，フェムト秒レーザー，ガルバノスキャナ，Fθレンズ，RGB レーザー，霧箱で構成された. 霧箱内の側面上部にはスポンジテープが接着された. スポンジには無水エタノールが浸された. 霧箱の底はドライアイスで冷やされ, エタノールの過飽和状態を生成された.

Figure 2 は，フェムト秒レーザーと同軸に入射された RGB レーザーによって照明されたマイクロクラウドを示す. ボクセルの生成位置と照明光の波長切り替えの同期を行うことで, フルカラー映像を描画できる．今後は，照明光の波長に対する光散乱特性の評価を行う予定である.

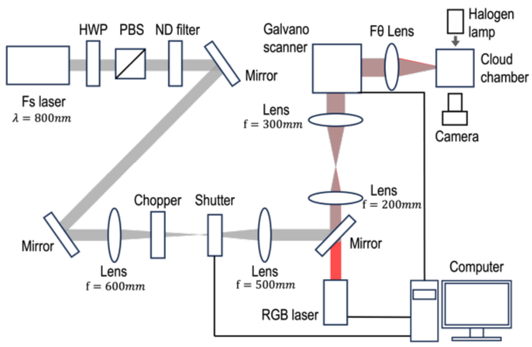

Fig. 1 Experimental setup.

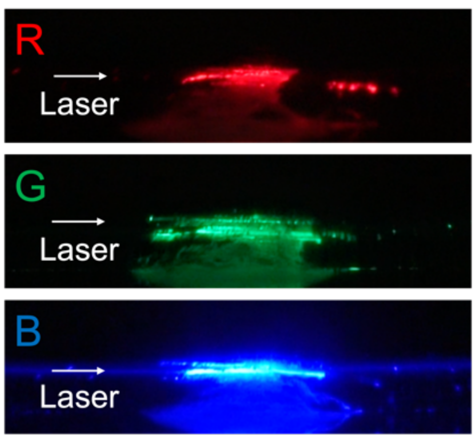

Fig. 2 Micro clouds illuminated with RGB lasers.

ダブルパルス励起空中ボクセルの評価と体積映像描画への適用

Evaluation of double-pulse-excited aerial voxels and their application to volumetric image drawing

宇都宮大オプティクス，熊谷 幸汰，遠藤 統伍，早崎 芳夫
Utsunomiya Univ. , °Kota Kumagai, Togo Endo, Yoshio Hayasaki
E-mail: kumagai@a.utsunomiya-u.ac.jp

ボリュメトリックディスプレイは，対象の形状を描くようにボクセルを生成することで体積映像を表示する技術である．とくに，空気中への体積映像表示は，ユーザーと映像空間がシームレスに繋がっているため，AI を実世界に具現化できるインタフェース技術として期待される．これまでに空気中へ体積映像表示する方法は，ボクセルとなる粒子をレーザー[1]や超音波[2]を用いて補足する方式と，フェムト秒レーザー励起プラズマの自発光を用いて生成する方式[3]が提案された．補足方式は，照明光を与えることで可視化される光散乱型ボクセルであり，照明光の色変化のみでカラー化できる優位性がある．生成方式は，ボクセルを補足し続ける必要がないため，実世界の物体との接触があっても消滅しない堅牢性の高い映像を表示できる．しかし，レーザー励起により生成されたボクセルは，励起対象となる空気に依存して青白色であり，そのカラー化に課題があった．一方で近年，我々は，波長 515 nm を有するフェムト秒レーザーにより励起された空中ボクセルの評価を通して，光散乱型ボクセルとしての有用性を示した[4]．本研究では，空中カラーボリュメトリックディスプレイの実現に向けて，ボクセルの光強度増強を目的としたダブルパルス励起空中ボクセルを評価し，体積映像描画への適用について検討する．

Figure 1 は，実験光学系を示す．第二次高調波発生器により 1030 nm から 515 nm に変換されたフェムト秒レーザーは，偏光ビームスプリッターによりふたつのパルスに分けられた．このダブルパルスは，一方が光学ディレイにより時間遅延が与えられた後，焦点距離 50 mm のレンズにより空気中に集光照射されることでボクセルを形成した．形成されたボクセルは，空間光強度分布とスペクトルをそれぞれカメラと分光器により取得された．Figure 2 は，シングルおよびダブルパルス励起により空気中に生成されたボクセルである．ダブルパルス励起は，エネルギー330 μJ/pulse, 時間差 1.8 ns で照射され，シングルパルス励起に比べ著しいボクセルの光強度増加を示した．

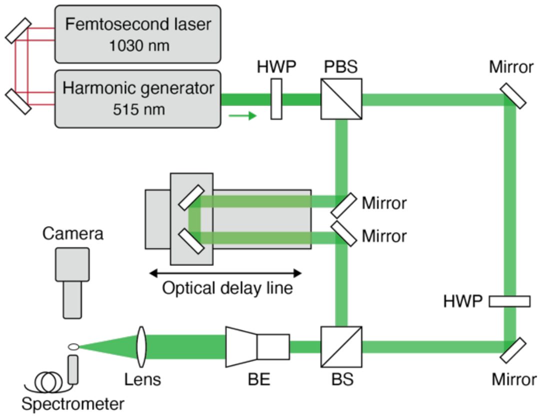

Fig.1 Optical setup.

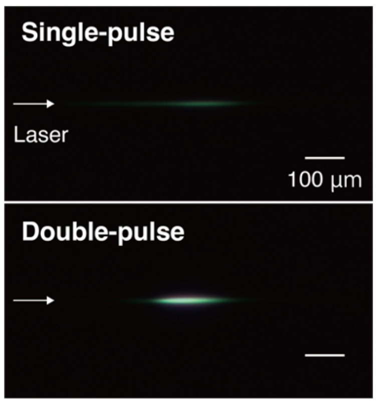

Fig.2 Single and double-pulse-excited voxels.

参考文献

[1] D. E. Smalley et al., Nature **553**, 486 (2018).
[2] R. Hirayama et al., Nature **573**, 320 (2019).
[3] Y. Ochiai et al., ACM Trans. Graph. **35**, 1 (2016).
[4] 熊谷ら，第 70 回応用物理学会春季学術講演会, 15p-A202-6 (2023).

計算機ホログラムを用いた体積的ビーム成形

Volumetric beam shaping using a computer-generated hologram

○(DC)黒尾 奈未，早崎 芳夫

Center for Optical Research and Education (CORE), Utsunomiya University

°(DC) Nami Kuroo, Yoshio Hayasaki

E-mail: kuroo_n@opt.utsunomiya-u.ac.jp

レーザー加工は，品質とスループットの要求を満たしながら，対象や加工形状の高度化・複雑化が要求される．そのため，ガウスビームの強度や直径とビームの照射方法だけでは，十分に最適化されない場面も増え，多様な成形ビームを用いたレーザー加工が，実施されるようになってきた．さらに，特殊集光形状や複数ビーム生成等の 2 次元的ビーム成形に加えて，光軸方向のビーム形状も同時に成形する 3 次元的ビーム成形(発表者らは体積的ビーム成形と呼ぶ)が求められるようになった．

体積的ビーム成形は，液晶空間光変調素子(LCSLM: liquid-crystal spatial light modulator)上に表示された計算機ホログラム(CGH: computer-generated hologram)を用いて補償光学的に実行され，その光強度分布制御方法[1]が確立され始めた．しかし，これまで示されてきたビーム成形は，3 次元的に配列された集光ビームや，線上ビームなど基本的な形状で，多様な成形例は多くない．

本研究では， 3 次元方向に拡張された荷重フーリエ反復法（weighted Gerchberg - Saxon (WGS) method) [2, 3]を用いて CGH が最適化される．Fig. 1 は WGS 法のフローチャートである．

Fig. 2 は軸方向長尺ビーム成形用に最適化した CGH を用いて再生したビーム強度分布である．Fig. 2(a)は形が崩れ，成形不良となった例である．Fig. 2(b)は緩やかに最適化が進むように重みを調節し，軸方向に強度がフラットな長尺ビームが成形された．本発表では，WGS 法を用いて様々な形状の体積的ビーム成形を試み，体積的ビーム成形用最適化アルゴリズムの可能性を探った結果を報告する．

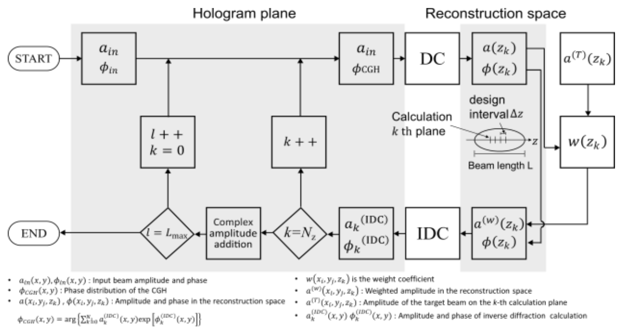

Fig. 1. Algorithm of the WGS method.

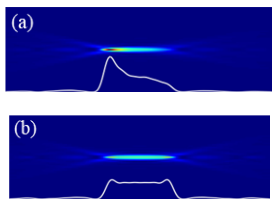

Fig. 2 Reconstructed images of the axially shaped beams: (a) failure case and (b) success case.

参考文献

[1] H. Zhang, S. Hasegawa, H. Toyoda, and Y. Hayasaki, "Three-dimensional holographic parallel focusing with feedback control for femtosecond laser processing," Opt. Lasers Eng. **51**, 106884 (2022)

[2] R. Di Leonardo, F. Ianni and G. Ruocco, "Computer generation of optimal holograms for optical trap arrays," Opt. Express **15**, 1913–1922 (2007).

[3] Y. Zhao, L. Cao, H. Zhang, D. Kong, and G. Jin, "Accurate calculation of computer-generated holograms using angular spectrum layer-orient method," Opt. Express **23**, 25440–25449 (2015).

複数のライン集光ビームを回折する体積ホログラフィック光学素子の作製

Preparation of Volume Holographic Optical Element for Multiple Line Focus Beam Diffraction

○ 玉井 裕基 [1] ,○ 茨田 大輔 [2] ◦Yuki Tamai[1] ,◦Daisuke Barada[2]
1. 宇都宮大学光工学，2. 宇都宮大学 CORE
1 . Opt, Eng, Utsunomiya Univ. , 2. CORE Utsunomiya Univ.
E-mail: mc236537@s.utsunomiya--u.ac.jp

1. はじめに

近年，VR/AR 技術が注目を集めているが，装着型のデバイスにおいては長時間使用による負担を減らすために軽量化が検討されている．三次元計測技術を併用すると，リアルタイムで空間認知や 3D モデルを生成することが可能となる．本研究では，AR コンバイナと 3D スキャン用の光パターン生成素子を一体化させることによって，三次元計測機能をもつ軽量な AR デバイスを作製することを目的とする．本研究グループでは軽量でかつ広視野・広アイボックスの AR コンバイナの実現のために円筒波体積ホログラフィックコンバイナを提案してきた[1]．これは，この素子が複数のラインビームから広がる白色光をそれぞれ異なる角度で平面波として回折するような効果をもつ．この特性を利用すると，赤外光の複数のライン集光も可能であることが考えられ，これをストラクチャードライト法で使用するパターンとして用いることが可能である．本研究では，この光パターンを生成について検討する．

２．複数のラインビームを生成する体積ホログラフィック光学素子の作製

シリンドリカルレンズは、特定の軸に沿って光を集束させる特性を持つ.この特性によりレンズを通過した光が特定の軸に沿って集束し、直線状の干渉縞が形成される.この直線状の干渉縞に対して反対側から参照光を照射すると、横一本の回折光が観察される.複数のライン集光ビームを生成するための体積ホログラフィック光学素子を作製する光学系を Fig.1 に示す.露光用の媒体に厚さ 0.3mm のフォトポリマーを用い，波長 532nm のレーザー光を分岐して，一方を平面波，一方をシリンドリカルレンズによってライン集光ビームとした後に広がったビームとして，フォトポリマー上で重ね合わせて照射した.その際，直進ステージで高さを変えながら多重露光を行った.作製したホログラフィック光学素子に露光時に使用した平面波と逆側から He-Ne レーザー(632.8nm)の平面波を入射することによって， Fig.2 のような回折光が確認された.今後は赤外光で同様なパターンが生成できるか確認し，それを用いて三次元計測を行なう方法を検討する．

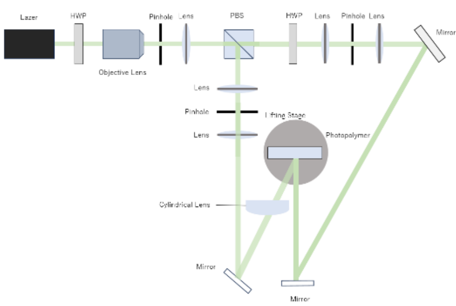

Fig.1 Optical system

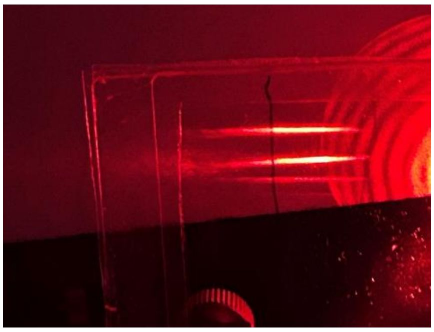

Fig.2 Diffracted light

[1] 木原健太他，OPJ2023 講演予稿集，28pP33 (2023).