Dokument elektroniczny

PODPIS ZAUFANY
MACIEJ
TRUSIAK
14.04.2026 10:20:09 GMT +0200
Dokument podpisany elektronicznie podpisem zaufanym

Politechnika Warszawska
Wydział Mechatroniki

Strasbourg, 13.04.2026

Maciej Trusiak, PhD, DSc
Head of Quantitative Computational Imaging Lab
Institute of Micromechanics and Photonics
Faculty of Mechatronics
Warsaw University of Technology

Review of the PhD dissertation submitted by MSc Eng. Maria Miażdżyk

The dissertation under review titled "Estimation of corneal light scattering parameters which are independent of external factors and anterior eye geometry" - supervised by prof. D. Robert Iskander from Wroclaw University of Science and Technology and prof. Alejandra Consejo Vaduero from Universidad Zaragoza - is a monographic work devoted to quantitative assessment of corneal transparency and to the estimation of optical properties of corneal tissue using Scheimpflug imaging and optical coherence tomography (OCT). The main scientific claims of the dissertation are documented, in particular, in the following published papers: *Assessing and compensating for the confounding factors in Scheimpflug-based corneal densitometry* (Biomedical Optics Express, 2022), *OCT based corneal densitometry: the confounding effect of epithelial speckle* (Biomedical Optics Express, 2023), and *Estimating the optical properties of corneal tissue from the OCT speckle* (Biomedical Optics Express, 2026). In all three papers, Maria Miażdżyk is the first author.

1. Scientific topic and relevance of the dissertation

The topic of the dissertation is well chosen and scientifically relevant. Quantitative characterization of corneal transparency is an important problem in biomedical optics and ophthalmic imaging because it lies at the intersection of tissue optics, image-derived biomarkers, and clinically interpretable diagnostics. The central scientific issue addressed in the dissertation is whether image-based densitometric descriptors genuinely reflect intrinsic stromal optical properties or whether they are materially affected by confounding factors related to ocular geometry, epithelial contribution, and image statistics. This is a legitimate and nontrivial problem, with both methodological and translational significance of the results. The scientific value of the thesis lies in the fact that it does not treat densitometry as a purely technical output of an imaging device. Instead, the dissertation approaches corneal densitometry as an inverse problem in which the biological meaning of a measured parameter depends on the physics of light scattering, the layered architecture of the tissue, and the statistical properties of the imaging process itself. This perspective is scientifically mature and appropriate for doctoral-level work in biomedical engineering.

Plac Politechniki 1,
00-661 Warszawa
tel.: 22 628 59 85,
fax 22 234 72 04
e-mail:
maciej.trusiak@pw.edu.pl

Politechnika Warszawska
Wydział Mechatroniki

2. General assessment of the scientific content

The dissertation is thematically coherent and conceptually well organized. The line of argument progresses from identification of confounding variables in Scheimpflug-based densitometry, through quantitative assessment of epithelial effects in OCT-derived stromal densitometry, to a Monte Carlo model-based framework for estimating physically meaningful optical parameters from OCT speckle. This progression is logically sound. It demonstrates that the candidate did not merely produce several related observations, but developed a consistent research program aimed at improving the interpretability of image-based corneal assessment.

Chapter 1 – Introduction – constitutes a very nice overview of the research area considered within the dissertation.

The first of the reported studies – described in Chapter 2 - shows that Scheimpflug-based corneal densitometry is affected by age and eye-biometry-related variables, which complicates interpretation of raw densitometric data. Importantly, the work does not end with a descriptive observation - it proposes compensation procedures designed to suppress these unwanted dependencies. This is a methodologically relevant result because it shifts the analysis from simple correlation reporting to correction and normalization of the measured signal. The work therefore contributes to improving the robustness of quantitative densitometry rather than merely documenting its instability.

The second reported study - Chapters 3 and 4 - addresses OCT-based corneal densitometry and demonstrates that epithelial integrity has a statistically significant effect on speckle-derived stromal parameters. The paper is based on OCT images from 11 freshly enucleated porcine eyes acquired before and after epithelial debridement and shows that the presence of the epithelium materially alters stromal estimates, especially in the anterior part of the cornea. This result is scientifically important because it clarifies that OCT-derived densitometric descriptors cannot be interpreted in absolute terms without accounting for the superficial epithelial layer. In other words, the study identifies a concrete source of bias that must be controlled if OCT densitometry is to be used as a meaningful tissue biomarker.

The third reported study - Chapters 5 and 6 - proposes a statistical matching procedure between measured OCT scans and a set of reference OCT B-scans simulated using the Monte Carlo method, with the aim of estimating the corneal scattering coefficient and anisotropy factor. The method was tested on OCT data from 11 porcine eyeballs after epithelial removal and relied on a reference map built from 165 simulated OCT images. The significance of this contribution lies in the fact that it moves beyond phenomenological image description and toward estimation of tissue optical properties in physically interpretable terms. This is the point at which the dissertation most clearly

Plac Politechniki 1,
00-661 Warszawa
tel.: 22 628 59 85,
fax 22 234 72 04
e-mail:
maciej.trusiak@pw.edu.pl

demonstrates a transition from descriptive image analysis to model-based quantitative optical inference.

3. Methodological assessment

From a methodological standpoint, the dissertation is sound and demonstrates good command of the relevant tools. The candidate combines optical image analysis, region-of-interest segmentation, statistical characterization of speckle, comparative quantitative analysis, and Monte Carlo-based simulation of light transport, etc. This creative merger is appropriate to the research problem and competently applied. The work is clearly situated within the methodological framework of quantitative biomedical optics rather than routine clinical image interpretation. The work is highly quantitative, which is a significant advantage.

A further merit of the work is that the candidate repeatedly and quantitatively addresses the issue of interpretability. Many image-based biomedical studies stop at identifying statistical associations - in contrast, the present dissertation repeatedly asks whether the measured quantities correspond to the optical properties they are intended to represent. This concern with validity, rather than with numerical discrimination alone, should be regarded as a substantive strength of the dissertation. Additionally, Author proposes correction schemes which is worth highlighting.

4. Originality and scientific contribution

The dissertation contains an original contribution to the field of biomedical optics and biomedical engineering. Its originality does not lie in introducing a new imaging modality, but in identifying and quantifying nontrivial confounding effects in corneal densitometry and in proposing a methodologically stronger route toward estimating intrinsic optical tissue parameters from OCT data. This is a genuine scientific contribution because it improves the evidence-based status of the measured quantities: it helps distinguish what is attributable to stromal optical structure from what is attributable to imaging conditions or overlying tissue layers.

I also assess positively the candidate's scientific progress as it emerges from the reported work. The studies are not limited to routine data processing. They show problem formulation, physical interpretation, methodological critique, design of corrective strategies, and development of a model-based estimation framework. In substantive terms, this is sufficient to conclude that the candidate demonstrates the ability to conduct biomedical research at the doctoral level.

Plac Politechniki 1,
00-661 Warszawa
tel.: 22 628 59 85,
fax 22 234 72 04
e-mail:
maciej.trusiak@pw.edu.pl

Politechnika Warszawska
Wydział Mechatroniki

5. Critical remarks

An important part of the evidence base is derived from *ex vivo* porcine material, especially in the second and third reported studies. This is methodologically understandable and acceptable at the stage of controlled optical validation - however, it limits direct translation of the findings to *in vivo* human diagnostics. The dissertation would be stronger if the proposed framework had already been tested more extensively under clinically realistic conditions.

The third study, while in my opinion methodologically the most ambitious, remains a proof-of-concept rather than a clinically mature solution. The optical property estimation framework is promising, yet rather early-stage and at present it should be interpreted as improvement in methodological demonstration, not yet as a validated diagnostic tool. The number of approximations made within the model is also significant, in current status the simplified numerical model stays fairly far from observable heterogenic in vivo experimental reality. This reservation does not diminish the doctoral merit of the work, but it is relevant to the scale of claims that may reasonably be made on its behalf. Please discuss the main limitations of extrapolating these findings to *in vivo* human corneas, particularly in the presence of tear film, physiological hydration, and motion. Please discuss which assumptions built into the simulation model are most likely to limit the physical accuracy of the recovered optical properties, and which of these assumptions should be relaxed first in future work. In the proposed inverse framework, scattering coefficient and anisotropy factor are estimated by matching experimental OCT data to simulated reference images. Please comment on the uniqueness and robustness of this estimation problem, especially in view of the possibility that different parameter combinations may produce similar image statistics.

Presented conclusions rely on intensity-based analysis from commercial imaging systems. To what extent can the Author be sure that the statistical properties under analysis reflect tissue optics rather than device-level preprocessing, reconstruction, or automatic acquisition settings? How close the analyzed signal is to the detector-level raw data? Moreover, why it was not considered to compare Scheimpflug and OCT densitometry methods, preferably on human subjects?

Author proposed compensation procedures intended to reduce the effect of confounding variables. Please discuss the extent to which these procedures may also suppress clinically meaningful variation, and how this risk could be evaluated experimentally.

Presented results indicate that epithelial speckle has a significant effect on stromal OCT densitometry. Please explain in greater detail what physical mechanism can be regarded as dominant in this effect and how it should influence interpretation of stromal measurements.

Plac Politechniki 1,
00-661 Warszawa
tel.: 22 628 59 85,
fax 22 234 72 04
e-mail:
maciej.trusiak@pw.edu.pl

Politechnika Warszawska
Wydział Mechatroniki

In my opinion it is not fully justified to separate Chapters 5 and 6. Moreover, in the printed version of the dissertation I received, a big part of Chapter 6 was misplaced towards the end of the book.

6. Conclusion

Having evaluated the dissertation of MSc Eng. Maria Miażdżyk, I state that it constitutes a scientifically sound and coherent monographic study in the area of quantitative corneal imaging and ocular tissue optics. The work addresses a relevant problem, is methodologically competent, and contains an original contribution in the form of a critical analysis of confounding effects in corneal densitometry and a model-based approach to estimating optical properties from OCT speckle. In my opinion, the dissertation meets the statutory requirements for a doctoral dissertation under the Act of 20 July 2018 – Law on Higher Education and Science. I therefore support the admission of MSc Eng. Maria Miażdżyk to the public defense of her doctoral dissertation.

Plac Politechniki 1,
00-661 Warszawa
tel.: 22 628 59 85,
fax 22 234 72 04
e-mail:
maciej.trusiak@pw.edu.pl

weryfikacja recenzji Trusiak / Miazdzyk
RDN.004/4110-50/2026

Ministerstwo Finansów

Krajowa Administracja Skarbowa

SISC SYSTEM INFORMACYJNY SKARBOWO-CELNY

Raport weryfikacji

Wynik	**WAŻNY/PRAWIDŁOWY**
Wynik przetwarzania	**Zakończono**
Szczegóły weryfikacji:	**Podpis elektroniczny nie został złożony za pomocą kwalifikowanego urządzenia do składania podpisu (QSCD)**
Skrót pliku z podpisem	**f711b14783cf43717879c20a4ad5dd02a39b723b**
Nazwa pliku z podpisem	**Recenzja_MariaMiazdzyk_MT podpis elektroniczny.pdf**
Identyfikator weryfikacji	**CF3E6A3FFD72A3A2ADA45074A8D09D1F954E20D9**

Lista podpisów

Status weryfikacji podpisu	**WAŻNY/PRAWIDŁOWY**
Data i czas wykonania podpisu	**2026-04-14 10:20:09 GMT+02:00**
Data i czas weryfikacji podpisu	**2026-04-14 12:24:11 GMT+02:00**
Format podpisu	**PAdES**
Poziom podpisu	**BES (Podpis w postaci podstawowej)**
Certyfikat podpisującego	**kwalifikowany**

Osoba podpisująca (profil zaufany ePUAP)

Imię i nazwisko	**: MACIEJ TRUSIAK**

Ścieżka certyfikacji

Certyfikat podpisującego

Walidacja certyfikatu	**WAŻNY/PRAWIDŁOWY**
Status certyfikatu	**WAŻNY**
Wystawiony dla	**CN=Minister do spraw informatyzacji - pieczęć podpisu zaufanego, O=Ministerstwo Cyfryzacji, C=PL**
Wystawiony przez	**CN=Centrum Kwalifikowane EuroCert, O=EuroCert Sp. z o.o., C=PL,**
Ważny od	**2024-02-13 10:27:09 GMT+01:00**
Ważny do	**2027-02-12 10:27:09 GMT+01:00**
Data wystawienia CRL/OCSP	**2026-04-14 08:00:02 GMT+02:00**
Numer seryjny	**efd46f5b31b845d08071c5eed94d4eb9d37d**

Certyfikat wystawcy

Walidacja certyfikatu	**WAŻNY/PRAWIDŁOWY**
Status certyfikatu	**WAŻNY**
Wystawiony dla	**CN=Centrum Kwalifikowane EuroCert, O=EuroCert Sp. z o.o., C=PL,**
Wystawiony przez	**CN=Narodowe Centrum Certyfikacji, O=Narodowy Bank Polski, C=PL**
Ważny od	**2017-02-14 13:26:19 GMT+01:00**
Ważny do	**2028-02-15 00:59:59 GMT+01:00**
Numer seryjny	**1a5734b0d472d251e1d37cfe3d796ac117102490**

STARSZY SPECJALISTA
mgr inż. Renata Wejtyłak

POLITECHNIKA WROCŁAWSKA
Data Wpływu 14. 04. 2026
RDN.004/4110-51/2026
Katedra Inżynierii Biomedycznej