Trendy i wyzwania w optymalizacji strukturalnej – podsumowanie
The 16th World Congress on Structural and Multidisciplinary Optimization (WCSMO-16)

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Plan spotkania

- Przedstawienie ogólnych informacji o Kongresie
- Omówienie panelu SOTA oraz sesji „ The Dawn of Topology Optimization”
- Przegląd sesji
    - Novel approaches of topology optimization
    - Data-driven, machine-learning and surrogate modeling based optimization
    - Novel approaches of shape optimization
    - Optimization and manufacturing
    - Optimization of metamaterials
    - Multidisciplinary optimization
    - Multi-physics optimization
    - Optimization of materials
- Omówienie referatu wygłoszonego na Kongresie przez **Helen Fairclough**, School of Mechanical, Aerospace and Civil Engineering, University of Sheffield, UK: *Simultaneous topology and geometry optimization of grid-shells under self-weight loading* Helen Fairclough, Karol Bolbotowski, Linwei He, Andrew Liew, Matthew Gilbert - omówi **Karol Bołbotowski**, Wydział Matematyki, Informatyki i Mechaniki, Uniwersytet Warszawski

Kongres WCSMO (The World Congress on Structural and Multidisciplinary Optimization) organizowany jest od roku 1995 przez ISSMO The International Society of Structural Optimization).

ISSMO zostało założone w Berchtesgaden w Niemczech w październiku 1991 roku. Założycielem Towarzystwa był profesor Rozvany. Pierwsze oficjalne spotkanie Towarzystwa – „5th Symposium on Multidisciplinary Analysis and Optimization” odbyło się w Panama City na Florydzie w dniach 7–9 września 1994 roku, gromadząc 370 uczestników.

Obecnie do ISSMO należy **2086** członków.

WCSMO	Location	Chairs
1st 1995	Goslar, Germany	G Rozvany, N Olhoff
2nd 1997	Zakopane, Poland	W Gutkowski, Z Mroz
3rd 1999	Buffalo, NY, US	C Bloebaum
4th 2001	Dalian, China	GD Cheng, YX Gu
5th 2003	Lido di Jesolo-Venice, Italy	C Cinquini
6th 2005	Rio de Janeiro, Brazil	J Herskovits
7th 2007	Seoul, Korea	BM Kwak
8th 2009	Lisbon, Portugal	Helder C. Rodrigues
9th 2011	Shizuoka, Japan	M Arakawa, H Yamakawa
10th 2013	Orlando, Florida, USA	Rafi Haftka, NH Kim
11th 2015	Sydney, Australia	Qing Li, Grant Steven
12th 2017	Braunschweig, Germany	T Vietor, A Schumacher, S Fiebig
13th 2019	Beijing, China	Xu Guo, Hai Huang
14th 2021	Boulder CO, USA	Kurt Maute
15th 2023	Cork, Ireland	Denis Kelliher

- Zgłoszono 641 streszczeń
- Przyjęto 622 streszczenia
- 530 prezentacji
- 636 rejestracji z 30 krajów i regionów:

Japonia	149
Chiny	146
Korea Południowa	90
USA	50
Niemcy	32
Dania	24
Francja	19
Wielka Brytania	17
Belgia	15
Australia	14

Holandia	11
Brazylia	10
Indie	10
Izrael	8
Włochy	8
Hiszpania	7
Szwecja	6
Kanada	3
Hong Kong	3
Norwegia	2

Polska	2
Singapur	2
Anguilla	1
Węgry	1
Indonezja	1
Portugalia	1
Arabia Saudyjska	1
Republika Południowej Afryki	1
Wietnam	1
Tajwan	1

Główne trendy tematyczne

- Innowacyjne podejścia do optymalizacji kształtu i topologii
- Optymalizację kształtu i topologii w strukturach wielomateriałowych
- Optymalizację kształtu i topologii dla zagadnień cieplnych i przepływowych
- Optymalizację kształtu i topologii w kontekście akustyki oraz drgań
- Optymalizację kształtu i topologii dla zastosowań w optyce i elektromagnetyzmie
- Optymalizację kształtu i topologii w inżynierii materiałowej
- Optymalizację kształtu i topologii dla technologii przyrostowych (addytywnych)
- Optymalizację odporną i opartą na niezawodności
- Optymalizację opartą na danych i uczeniu maszynowym
- Optymalizację z wykorzystaniem modeli zastępczych i metod aproksymacyjnych
- Algorytmy optymalizacji oparte na gradientach oraz analizę wrażliwości
- Metaheurystyki i algorytmy ewolucyjne
- Zastosowania w inżynierii lotniczej i kosmicznej
- Zastosowania w inżynierii lądowej i architektonicznej
- Zastosowania w inżynierii mechanicznej
- Zastosowania w inżynierii biomedycznej
- Zaawansowane zastosowania optymalizacji kształtu i topologii
- Zagadnienia odwrotne i identyfikację parametrów
- Edukację w zakresie metod optymalizacji
- Ogólne zagadnienia z zakresu optymalizacji
- i inne

Temat sesji	Liczba sesji	Liczba referatów
Novel approaches of topology optimization	26	133
Data-driven, machine-learning and surrogate modeling based optimization	17	88
Novel approaches of shape optimization	9	45
Multidisciplinary optimization	8	42
Optimization and manufacturing	6	33
Multi-physics optimization	5	26
Multi-objective optimization	4	28
Novel approaches of layout and topology optimization	4	22
Optimization of materials	4	22
Multiscale optimization	4	19
Optimization of metamaterials	4	18
Robust and reliability-based optimization	3	17
Novel approaches of sizing optimization	3	16
Optimization of dynamic problems	3	15
General optimization topics	2	10

Program konferencji

9:00 · 9:30 · 10:00 · 10:30 · 11:00 · 11:30 · 12:00 · 12:30 · 13:00 · 13:30 · 14:00 · 14:30 · 15:00 · 15:30 · 16:00 · 16:30 · 17:00 · 17:30 · 18:00 · 18:30

May 18, Sunday	15:00 - 17:00 Registration							
May 19, Monday	8:30 - 10:30 Registration	10:30 - 12:10 SOTA Panel	Lunch (Sponsor Seminar)	13:40 - 15:40 Session 1	Coffee Break	16:00 - 18:00 Session 2	18:30 - 20:00 Reception	
May 20, Tuesday	9:00 - 10:40 Session 3	Coffee Break	11:00 - 13:00 Session 4	Lunch (Broadening participation event)	Coffee Break	15:30 - 17:30 Session 5		
May 21, Wednesday	9:30 - 11:30 Session 6	Lunch (Sponsor Seminar)	13:00 - 19:00 Excursion					
May 22, Thursday	9:00 - 10:40 Session 7	Coffee Break	11:00 - 13:00 Session 8	Lunch	14:30 - 16:10 General Assembly	Coffee Break	16:30 - 18:30 Talk Show "The Dawn of Topology Optimization"	19:00 - 21:00 Banquet
May 23, Friday	9:00 - 10:40 Session 9	Coffee Break	11:00 - 13:00 Session 10	Lunch (to go*)				

Onsite Registration desk opens:
- May 18 : 15:00 - 17:00 @ 5F
- May 19 - 22 : 8:30 - 17:00 @ 3F
- May 23 : 8:30 - 11:00 @ 3F

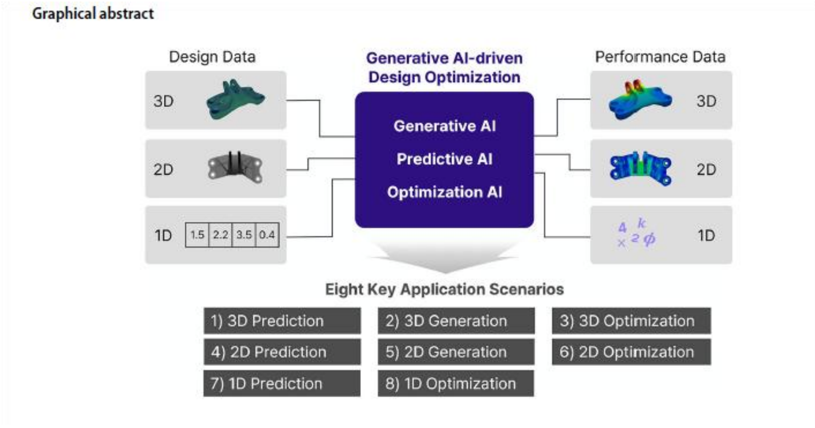
Room A only | Room B only | Room A - K | Outside of the Convention venue

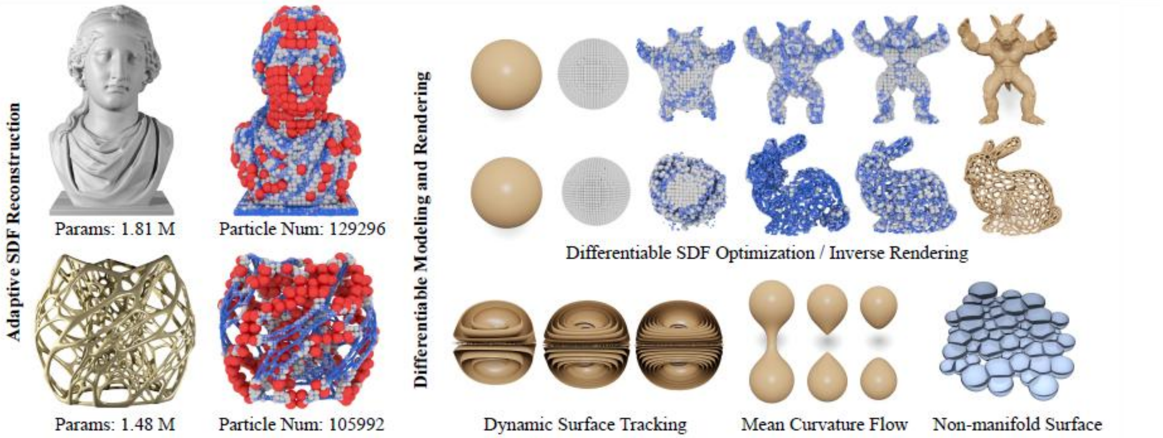
Tematyka WCSMO 16

- Novel approaches of shape and topology optimization
- Multi-material shape and topology optimization
- Data-driven and machine-learning based optimization
- Robust and reliability-based optimization
- Surrogate modeling and approximation based optimization
- Gradient-based optimization algorithm and sensitivity analysis
- General optimization topic
- Shape and topology optimization for
  - thermal and fluid problems, sound and vibration problems, optics and electromagnetics, materials engineering, additive manufacturing
  - aerospace, civil and architectural, mechanical, biomedical engineering
- Metaheuristics and evolutionary algorithms
- Advanced applications of shape and topology optimizaion
- Inverse problems and parameter identifications
- Education in optimization

SOTA Panel

- Namwoo Kang (KAIST) *AI design optimization*

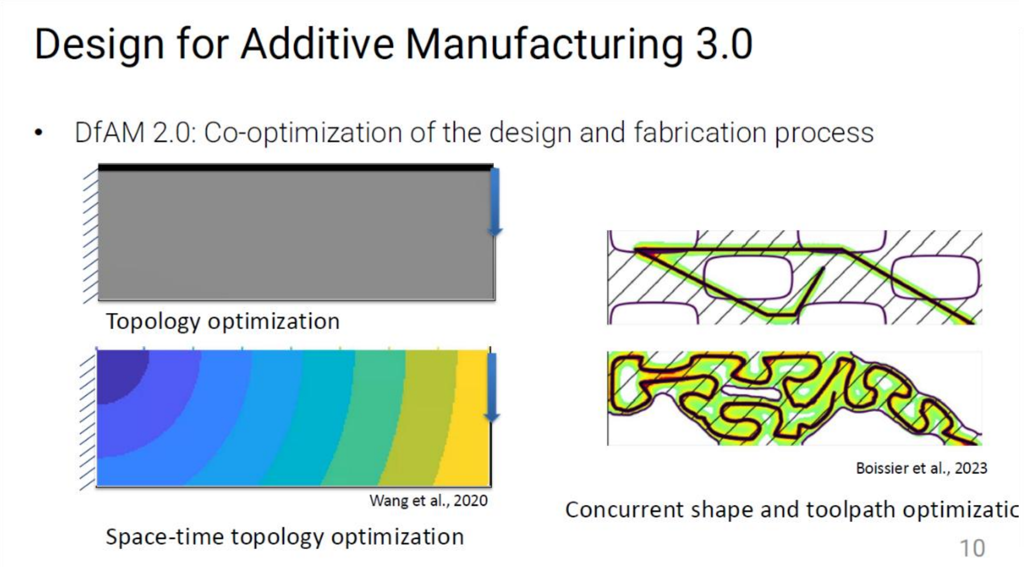


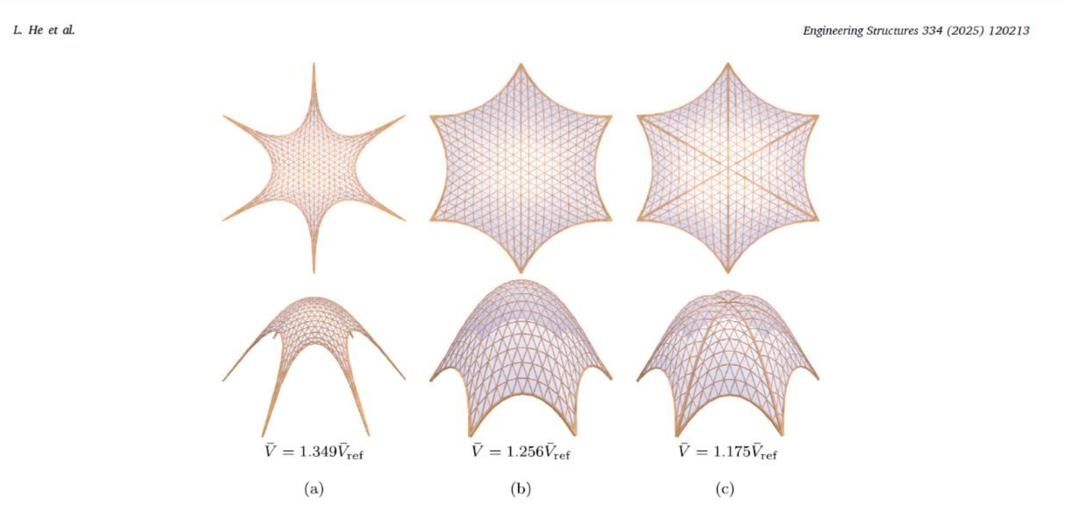


- Tsuyoshi Nomura (Toyota Central R&D Labs) *Design applications: success stories and emerging trends*
  - *soft robots*
  - *prototyping a CFRP-aluminum automotive frame via multi-component anisotropic topology optimization*

SOTA Panel

- Jun Wu (TU Delft) *Recent advances in design for manufacturing*





- Helen Fairclough (University of Sheffield) *Advances in mixed integer algorithms and opportunities for design optimization* (omówienie: K. Bołbotowski)
  - *Second order cone programming*
  - *3D arches*

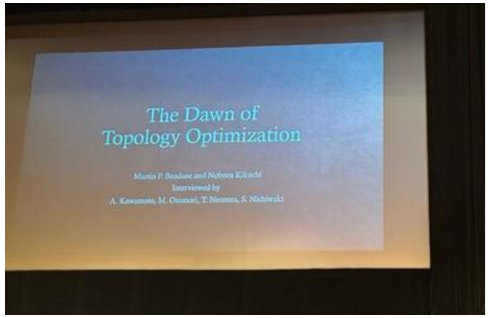
Sesja: The Dawn of Topology Optimization

- *Speakers:*
  - *Martin Philip Bendsøe and Noboru Kikuchi*
- *Moderators:*
  - *Atsushi Kawamoto, Tsuyoshi Nomura, Masaki Otomori, and Shinji Nishiwaki*
- *wywiad/rozmowa z pionierami*
- *początek: plaża w Portugalii (Sintra)*
- *T. Lewiński*
- *dla młodych i starszych badaczy*
- *Tożsamość środowiska*

ISSMO dla młodych badaczy - ISSMO Broadening Participation and Networking Event oraz Talk Show The Dawn of Topology Optimization

Ważnym punktem Kongresu był końcowy talk show z udziałem dwóch pionierów dziedziny, profesorów Noboru Kikuchi i Martina Bendsøe. Ich przesłanie skierowane do młodych naukowców było głębokie i inspirujące:

- Myśl o możliwościach, a nie o przeszkodach.
- Znajdź dobrego, wspierającego promotora.
- Szukaj obszarów, w których ludzie są otwarci.
- Myśl o jeden poziom wyżej – kontekst ma znaczenie.
- Wróć do teorii i matematyki.



https://www.linkedin.com/posts/ole-sigmund-a6604226_just-returned-from-an-inspiring-week-at-wcsmo-activity-7332690865242505216-KuqZ

Celem spotkania jest stworzenie przestrzeni dla uczestników WCSMO, w której będą mogli nawiązywać kontakty i zdobywać wiedzę na temat kwestii związanych z poszerzeniem udziału młodych naukowców, grup niedostatecznie reprezentowanych (np. regionów o niskiej reprezentacji) oraz naukowców z innych dziedzin w działaniach ISSMO. Dyskusja koncentruje się na wyzwaniach i sposobach poszerzenia udziału w społeczności ISSMO. Weterani społeczności pełnią rolę mentorów podczas wydarzenia

Sesja: Novel approaches of Topology Optimization

- **133 presentations / 26 sessions**

➢Main Topics:

Multimaterial optimization (22 presentations), A2-2, E1-2, D2-5, D3-5, E4-3, E4-4, A5-1, A6-2,…….

- Energy absorbing structures, quantum annealing , crshworthiness, univariate mapping, interfacial stress constraints

Optimization including stress (21 presentations) E1-1, E1-2, A2-4, A3-5, E3-4,….

- Stress-constrained multiscale multi-material topology optimization, principal stress orientation use, stress buckling constraints

Sesja: Novel approaches of Topology Optimization

- **133 presentations / 26 sessions**

➢Main Topics:

Level set (21 presentations), A3-3, E3-3, …………………………..

- Energy absorbing structures, quantum annealing , crshworthiness, univariate mapping, interfacial stress constraints

Lattice structures (23 presentations) E4-2, A5-2, A6-4, A10-5, …..

- Failure resistance, dehomogenization of graded lattices, homogenization of non-periodic lattices, elasto-plasticity….

Inverse/dehomogenization (7 presentations) E1-1, E1-2, A2-4, A3-5, E3-4,…

- Dynamic materials, energy absorbers, …..

Isogeometric methods (7 presentations) A1-3, D1-3, A2-3, F4-5, F6,6,…

- Complex structures, shells, lattice structures

Sesja: Novel approaches of Topology Optimization

- **133 presentations / 26 sessions**

➢ Main Topics:

Numerical methods (10 presentations), A3-3, E3-3, D2-1…..

- Human-computer interaction (AR /VR application)
- Quantum annealing
- PolyPlas

Applications (23 presentations) F5-4,

- Thermal problems (11 presentations) ---→ Heat sinks (...many) and pipes
- Landing gear (2 presentations)
- Battery cells
- Lightweight structures / multi component structures

Sesja: Novel approaches of Topology Optimization

Multi-scale problems

- **O. Sigmund, W. Li, X. Schelly**, Solving inverse design problems without topology optimization, (SMO 2024, Nature Comm. 2024)
  - 808-line Matlab educational code for combined multi-scale topology optimisation and phasor-based dehomogenisation titled deHomTop808
  - the multi-scale formulation utilises homogenisation of optimal microstructures to facilitate efficient coarse-scale optimisation.
  - dehomogenisation allows for a high-resolution single-scale reconstruction of the optimised multi-scale structure, achieving minor losses in structural performance, at a fraction of the computational cost, compared to its large-scale topology optimisation counterpart

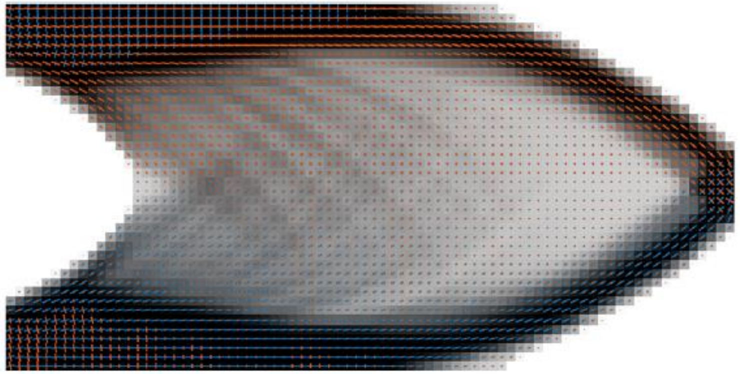


Fig. 12 Multi-scale structure of the Michell cantilever obtained with deHomTop808

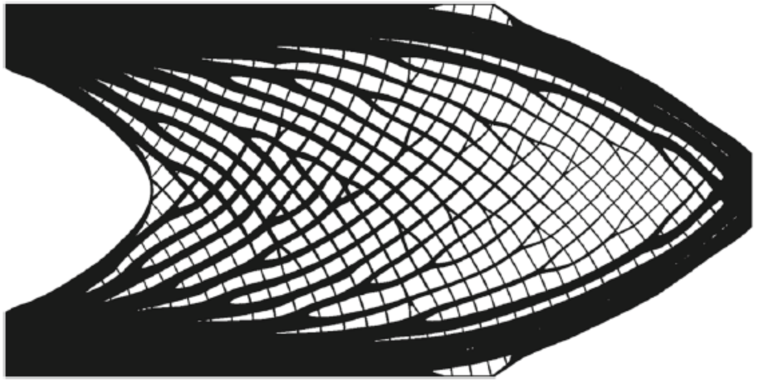


Fig. 13 Dehomogenisation structure of the Michell cantilever obtained with deHomTop808

Sesja: Novel approaches of Topology Optimization

- **Zhaoyou Sun, Yangjun Luo (Shenzen),** A multiscale concurrent topology optimization method based on the material field series expansion model (CMAME, 2023-2024)
  - simultaneously optimization of multiple microstructures and their macroscopic distribution
  - the poor connectivity between microstructures within this method seriously hampers the fabrication and application of the optimized multiscale structures.
  - work presents two novel microstructural connectivity methods using the spital correlation definition in the material field series expansion (MFSE) model.

Sesja: Novel approaches of Topology Optimization

➢ **Numerical approaches**

Dries Toebat, Haoju Lin, Florian Feppon, Local constraints in Topology Optimization with the Null Space Optimizer (SMO 2024)

- to enforce local constraints by leveraging the Null Space Optimizer, a gradient flow algorithm
- the Null Space algorithm is a numerical method for solving generic nonlinear constrained optimization problems

$$\dot{x}(t) = -\alpha_J \xi_J(x(t)) - \alpha_C \xi_C(x(t)).$$

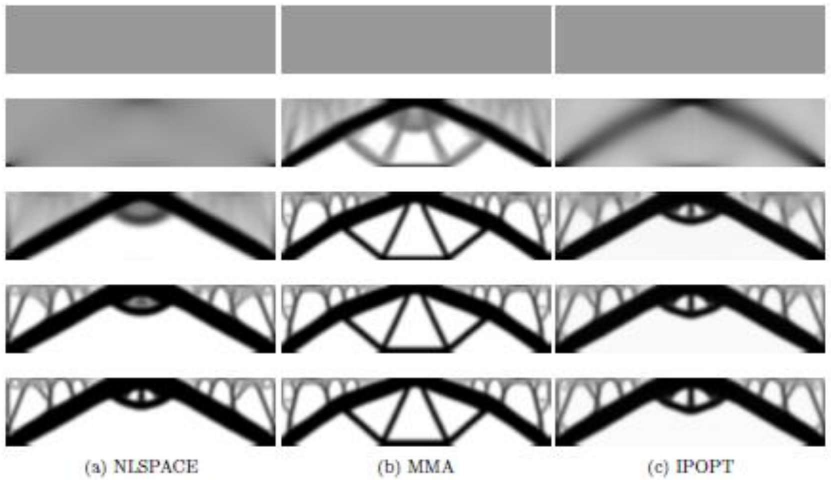


Fig. 11: Intermediate designs with the Null Space Optimizer obtained at iterations 0, 10, 40, 80, and 150 for the bridge test case of Section 4.

Sesja: Novel approaches of Topology Optimization

- **Numerical approaches**

- **Alejandro M. Aragón, Hendrik J. Algra (TU Delft),** ARCADE (Augmented Reality Computational Analysis and Design Environment): An interactive playground for real-time immersed topology optimization
  - ✓ the concept of immersive topology optimization (ITO) as a novel design paradigm that leverages AR environments for TO.

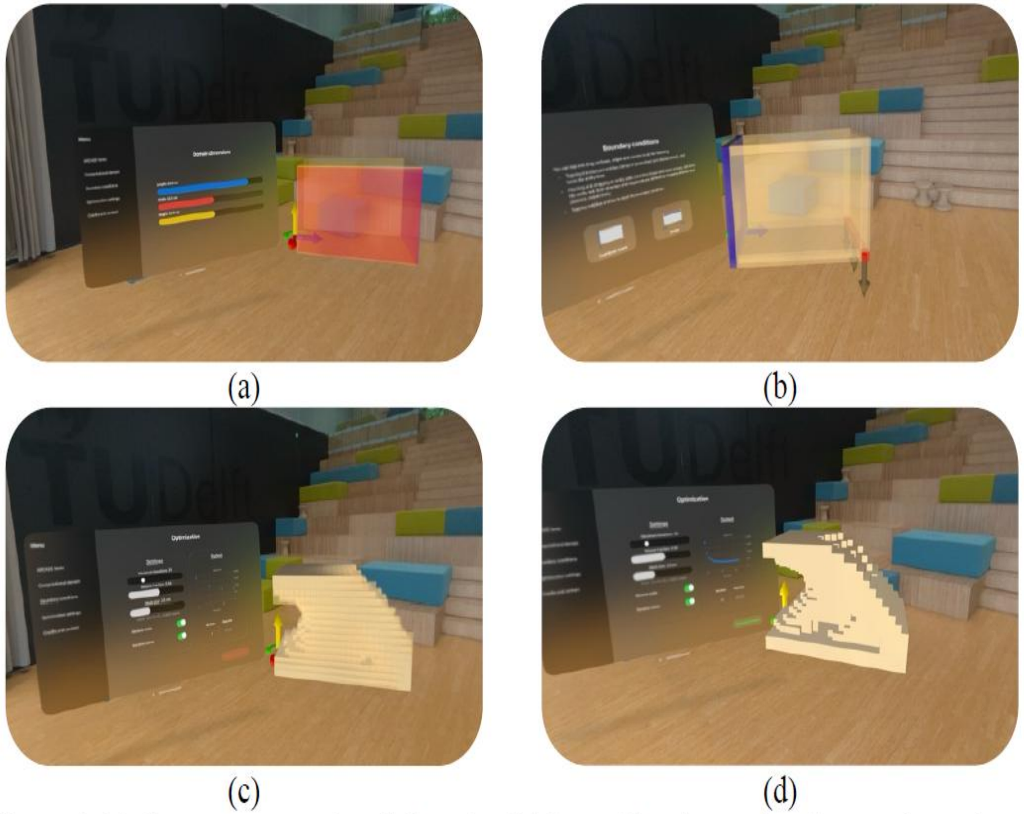


Figure 1 (a) Create computational domain; (b) Prescribe clamped regions and tractions; (c) Adjust optimization settings and start optimization; and (d) Visualize final design.

Sesja: Novel approaches of Topology Optimization

➢ **Numerical approaches**

- **Emily Alcazar, Jonathan B. Russ, Glaucio H. Paulino (Princeton),** PolyPlas: A novel topology optimization software for elastoplasticity with unstructured polygonal finite elements (SMO 2025)
  - ✓ Small strain plasticity model
  - ✓ Newton Raphson procedure with backtracking line search
  - ✓ path-dependent sensitivity analysis is conducted using the adjoint method

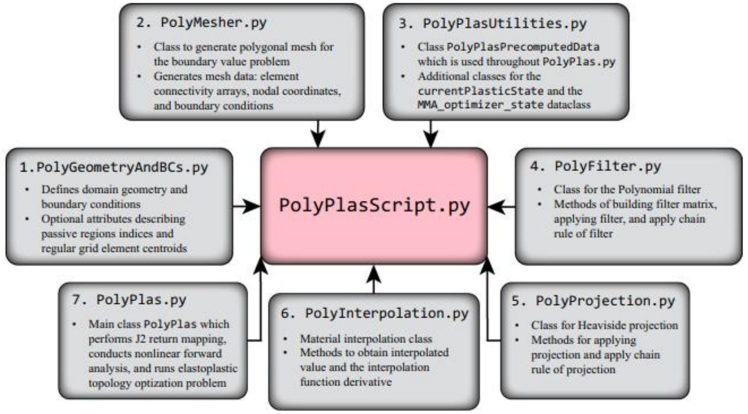
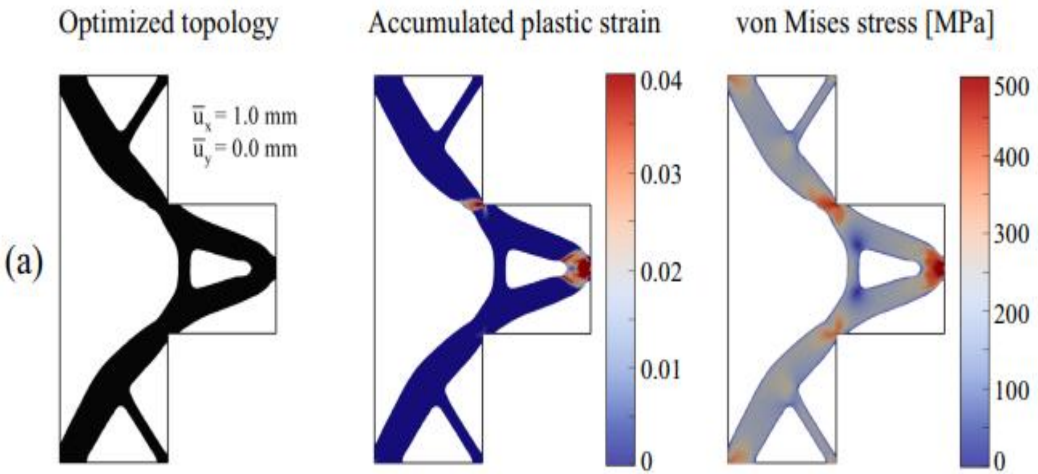


Fig. 3 Illustration of how files are integrated within `PolyPlasScript.py` in order to run the elastoplastic topology optimization problem



Sesja: Novel approaches of Topology Optimization

➢ **Numerical approaches**

- **Felix Endress, Markus Zimmermann (Munich),** Distributed optimization with informed decomposition: extension to 3d structures with asymmetrical 2-interface elements (SMO 2024)
  - ✓ Informed Decomposition is based on two types of optimization problems:
  - ✓ (1) one for system optimization to produce stiffness requirements on components using pre-trained meta models and
  - ✓ (2) one for the optimization of components with two interfaces to produce detailed geometries that satisfy the stiffness requirements

Fig. 17 Optimized component designs $\boldsymbol{x}_{(i)}$ for (P2) of the monolithic optimization (**A**) and Informed Decomposition (**B**)

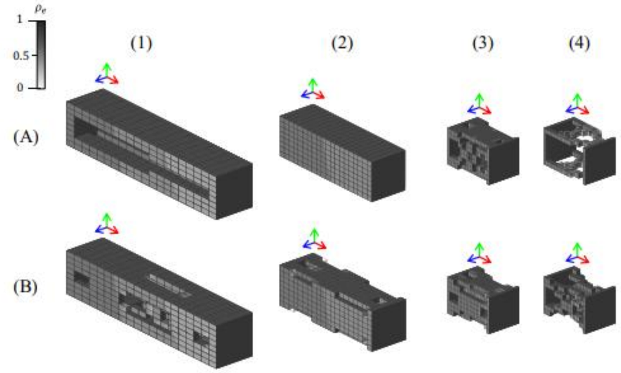


Fig. 18 Resulting low-cost lightweight robot with topology-optimized and post-processed components for n_p = 100 load cases

Sesja: Novel approaches of Topology Optimization

- **Grégoire Allaire, Théodore Cherričre, Thomas Gauthey, Maya Hage Hassan, Xavier Mininger,** Self-adjoint objective functions when optimizing non-linear models (HAL 2024)
  - optimization problems under nonlinear partial differential equation (p.d.e.) constraints
  - the p.d.e. arises from minimizing a convex energy
  - it is proved that the optimization problem is self-adjoint when the objective function is the dual energy,
  - in a large class of objective functions the dual energy is the only one which is self-adjoint,
  - electrical actuators

Sesja: Data-driven, machine-learning and surrogate modeling based optimization

- 87 presentations / 17 sessions

Bayesian optimization

1) A constrained multi-fidelity Bayesian optimization method with application to design optimization Tucker Hartland (Livermore) [B1-1]
   - ✓ constrained multi-fidelity Bayesian optimization method; various sets of objective and constraint models, at differing degrees of model fidelity; inertial confinement fusion design

Multi-objective optimization

1) Multi-objective optimization for minimizing warpage and cycle time in vibration assisted injection molding, Kenta Yamaya (Kanzawa, Japan)[B2-2]
   - ✓ Plastic injection molding; sequential approximate optimization using radial basis function network is adopted to identify the pareto-frontier between the warpage and the cycle time

Sesja: Data-driven, machine-learning and surrogate modeling based optimization

- **Multi-objective optimization**

1) Multi-objective Multimodal Surrogate Optimization of Mixed-variable Motor Design Problem
   Tatsuya Asanuma (Tokyo) [B4-4]
   - ✓ electric motor design; surrogate-based sequential approximation optimization alternating direction method of multipliers;

- **Surrogate models and neural networks**

1) A study on multi-fidelity surrogate for multiple data sources, Mingyu Lee (KAIST) [C1-1]
   - ✓ a methodology that adaptively selects and integrates low-fidelity data based on quality assessment to enhance the accuracy of multi-fidelity surrogates.
   - ✓ The key idea is to consider the quality levels of low-fidelity data sources as the relative significance of the low-fidelity surrogates, which act as basis functions in a multi-fidelity surrogate.

Sesja: Data-driven, machine-learning and surrogate modeling based optimization

- **Stochastic Optimization**

1) A Classification-based Approach for the Stochastic Optimization of Structures Subjected to Random Vibrations Luis E. Ballesteros Martínez [B6-5]

    - ✓ an adaptive classification-based approach that employs a Support Vector Machine (SVM).
    - ✓ Switching the optimization from a regression to a classification scheme enables one to substantially reduce the number of function evaluations since not all failure modes or probabilistic constraints need to be evaluated at a given point in the design space;
    - ✓ stochastic optimization of a cantilever beam

Sesja: Data-driven, machine-learning and surrogate modeling based optimization

➢ **machine learning/artificial intelligence**

1) Inverse Design via AI Agents for Dynamic Materials Jonathan L. Belof + 18 authors [C6-3]
   - ✓ Richtmyer—Meshkov instability of shockwaves suppression; control their effect on material and fluid Interfaces

2) A discrete physics-informed neural networks with finite elements for geometrically nonlinear topology optimization Jichao Yin, Hu Wang, Guangyao Li (Beijing, China) [C4-5]
   - ✓ [C7-2] hyperelasticity problem; Fourier features embedding

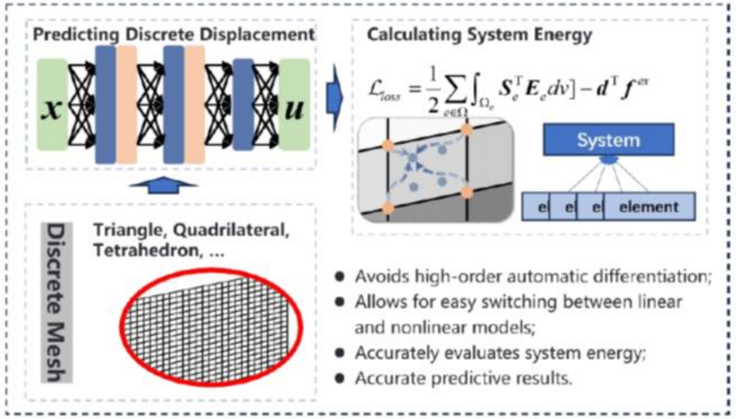


Figure 1 The schematic diagram of the dPINN

Sesja: Data-driven, machine-learning and surrogate modeling based optimization

➢ **machine learning/artificial intelligence**

3) Aerodynamic design optimization by quantum annealing Yuichi Kuya, Ryo Tanaka, (Fukuoka, Japan) [C4-6]

- ✓ Quantum annealing gives the optimum combination of a binary variable $q_i \in \{0,1\}$ or $s_i \in \{+1,-1\}$, solving the following cost functions:

$$E_{\mathrm{QUBO}}(\{q_i\}) = \sum_{i,j} Q_{ij}\, q_i q_j, \quad E_{\mathrm{Ising}}(\{s_i\}) = \sum_i h_i\, s_i + \sum_{i,j} J_{ij}\, s_i s_j,$$

Figure 1: (a) Best shape in sample data (L/D=0.76), (B) Optimum shape obtained by quantum annealing (L/D =0.86)

Sesja: Novel approaches of shape optimization

- **9 sessions/ 50 presentations**
- **Diversified topics and approaches**
- **Mostly application oriented**
  - Lithium-ion battery (F1-2, F4-4)
  - Aerospace problems; vehicle design (F1-4, F1-5, F2-2, F6-3,F7-5, F8-6)
  - Trusses ; arches ; shells (F7-1, F7-4, F8-3, F8-5,
  - Medical structures (F10-2,
  - Gridshell structures (F7-3

Sesja: Novel approaches of shape optimization

➢Curvature minimization/curved surfaces

- Shape optimization for curvature minimization using boundary measure and domain integral of extended-normal's divergence Shuichi Tango (Toyota Systems Corporation) [F1-6]
  - the mean curvature is defined as the divergence of a signed distance
  - function with the zero isosurface on boundary
  - the extended normal is defined as the solution of an elliptic partial differential equation (PDE) for a vector-valued function with Robin boundary conditions on the normal.

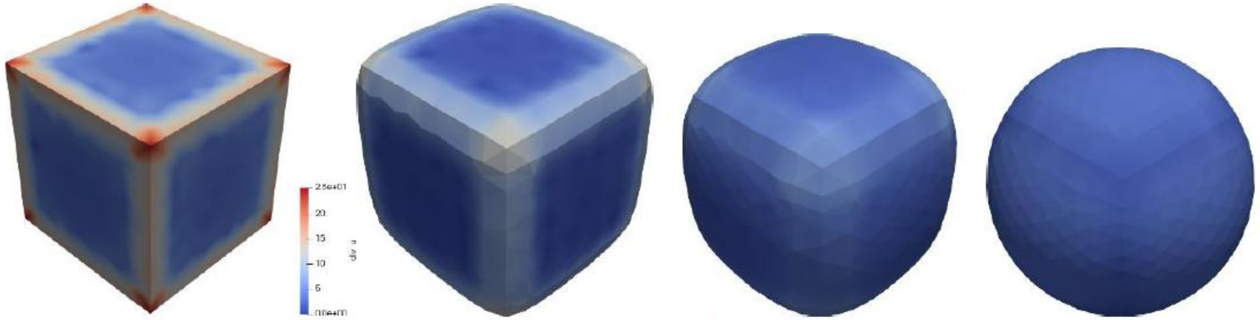


Figure 1 An example of a cube with moderate curvature obtained by the proposed method. (color: div ***u***, ***u*** represents the extended-normal).

Sesja: Novel approaches of shape optimization

- **Curvature minimization/curved surfaces**
  - Isogeometric shape design sensitivity analysis for curved surfaces with arc-lengths parameters considering tangential design perturbations Keun-Hyeong Ko (Seoul) [F5-3]
    - Extension of shape design sensitivity analysis and tangential divergence to three dimensional curved surfaces
    - cylindrical shells and twisted plates of different geometries
  - Length scale control for level set-based topology optimization through spread skeletons N. Hermann (Delft TU)
    - a framework to impose a minimum length scale for level set-based topology optimization through spread topological skeletons
    - The structural analysis is based on an immersed boundary technique to predict the structure responses, considering small strain linear elasticity. In this case, the eXtended Finite Element Method is used

Sesja: Novel approaches of shape optimization

➢ **Level sets**

- Parameterized shape optimization with level sets and mesh morphing Daniel A. Tortorelli (Lawrence Livermore, USA) [F7-2] (SMO 2024)
  - a parameterized shape optimization that relies on an implicit geometric component representation, i.e. level set, and a mesh morphing scheme
  - Two- and three-dimensional shape optimization problems are solved

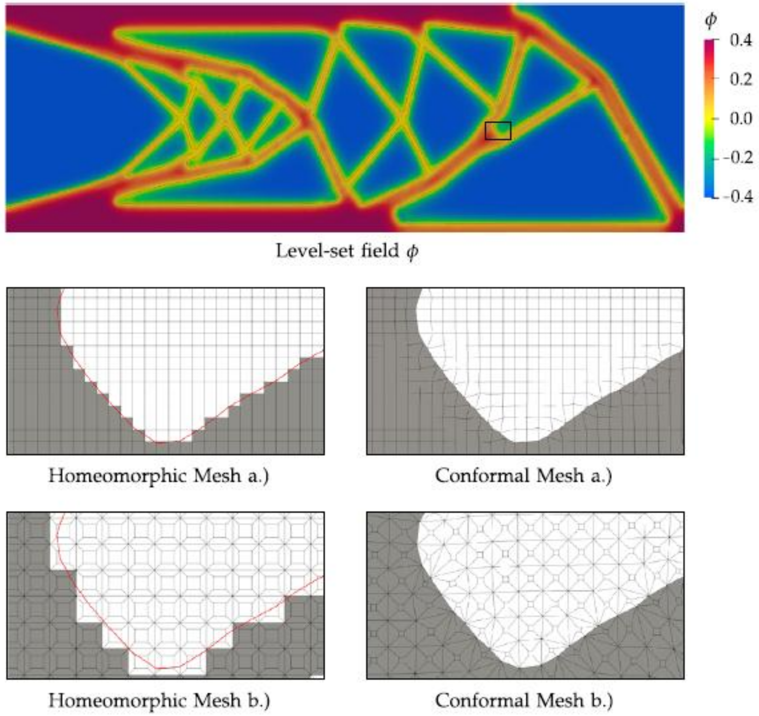
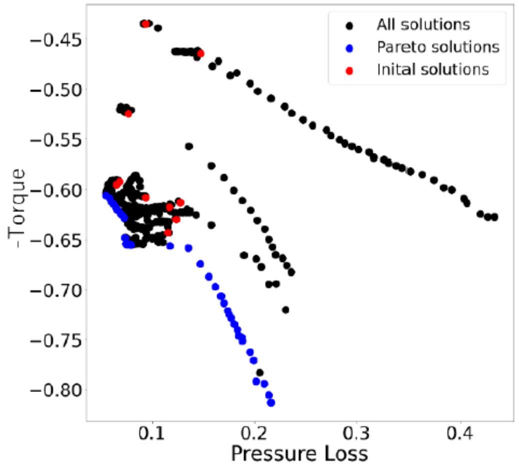


Fig. 14 Level-set field of optimized design and magnifications of the different homeomorphic and conforming meshes

Sesja: Novel approaches of shape optimization

➢Machine learning/bioinspired approaches

- Multiscale Shape Optimization of Porous Composites Based on Biological Microstructures Takea Sakai (Toyota) [F2-5]
  - a multiscale shape optimization method which uses biological microstructures as the initial shapes, inspired by the diverse and complex shapes found in nature
  - The optimization problem aims to determine the optimal microstructure shape while minimizing the compliance of the macrostructure, maintaining a constant total volume
- Multi-objective design optimization using deep reinforcement learning coupled with hypervolume-based rewards Kazuo Yonekura (Tokyo) [F6-5]
  - the reinforcement learning agent tries to enlarge the hypervolume of the Pareto solutions
  - turbine optimization problem



Sesja: Novel approaches of shape optimization

- **Machine learning/bioinspired approaches**
  - Integrating Human Creativity into Structural Optimization: A Human-In-The-Loop Approach Jonathan Melchiorre (Torino) [F10-3]
    - This research introduces a Human-In-The-Loop structural optimization approach, leveraging machine learning to integrate human creativity into optimization processes
    - Traditional structural optimization relies on rigid mathematical formalization, making it challenging to integrate design intuition. To bridge this gap, a multi-objective constrained structural optimization is proposed, with designer preferences treated as a key objective.
    - The system progressively learns the designer preferences using a Vision Transformer Neural Network for feature extraction together with a Gaussian Mixture Model (GMM) for soft clustering
    - method was validated through a case study involving a formfound gridshell structure, where multiple designers participated in the optimization process.

Thank you!!!

Sesje, część II

Multidisciplinary optimization

Optimization and manufacturing

Multi-physics optimization

Multi-objective optimization

Optimization of materials

Multiscale optimization

Optimization of metamaterials

Robust and reliability-based optimization

Multidisciplinary optimization – 42 referaty
Multi-physics optimization – 26 referaty

1. Optymalizacja topologiczna - dominujący trend całej konferencji.
2. Optymalizacja topologii w robotyce miękkiej (soft robotics) i systemach dynamicznych - rozszerzenie klasycznych metod na systemy aktywnie kontrolowane i deformowalne w czasie.
3. Integracja metod sztucznej inteligencji i uczenia maszynowego z optymalizacją:
   - Deep learning-based topology optimization,
   - Generative design z wykorzystaniem Large Language Models (LLM- duże modele językowe) ,
   - Agentowe systemy zarządzania optymalizacją oparte na LLM.
4. Nowe metody numeryczne i algorytmiczne - wiele referatów dotyczyło rozwoju narzędzi obliczeniowych.
5. Integracja optymalizacji topologicznej w strukturach MDO (**Multi-disciplinary design optimization MDO**) i projektowaniu systemowym - praktyczna implementacja w przemyśle i przejście od badań akademickich do wdrożeń.
   - Embedded TO into MDO – integracja TO w globalnym procesie optymalizacji systemu,
   - Co-design optimization – współprojektowanie rodziny robotów lub złożonych produktów z komponentami współdzielonymi,
   - Democratizing MDO – tworzenie narzędzi przyjaznych dla inżynierów przemysłowych.
6. Optymalizacja inspirowana nowymi technologiami wytwarzania i materiałami - połączenie projektowania generatywnego i topologii z ograniczeniami technologicznymi wytwarzania.
7. Silny nacisk na zastosowanie TO w kontekście additive manufacturing i zaawansowanych materiałów
   - ścieżki włókien kompozytowych,
   - kontrola mikrostruktur w drukowaniu metali,
   - projektowanie struktur porowatych

Multidisciplinary optimization

Wybrane referaty:

[Coupled topology and parametric optimization for electrical machine design with body-fitted meshes](#)
*Thomas Gauthey (Safran, Centralesupélec, Université Paris-saclay, Cnrs, Group of Electrical Engineering Paris , Cmap Ecole Polytechnique)
Grégoire Allaire (Cmap, Ecole Polytechnique, 91128 Palaiseau)
Felipe Bordeu (Safran Tech, Magny-les-hameaux)
Maya Hage Hassan (Centralesupélec, Université Paris-saclay, Cnrs, Group of Electrical Engineering Paris)
Xavier Mininger (Centralesupélec, Université Paris-saclay, Cnrs, Group of Electrical Engineering Paris)
Rémy Ul (Safran Additive Manufacturing Campus, 33187, Le Haillan)

[Topology optimization by a machine learning-based homogenization method: application to hyperelastic periodic lattice structures](#)
*Breno Ribeiro Nogueira (Cmap, École Polytechnique, Institut Polytechnique de Paris, Palaiseau, France.)
Grégoire Allaire (Cmap, École Polytechnique, Institut Polytechnique de Paris, Palaiseau, France.

[Fluid-Structure Interaction Topology Optimization Through a Modularized and Interoperable Architecture](#)
*Andreas Neofytou (University of California, San Diego)
H Alicia Kim (University of California, San Diego)

[Discussion on Topology Optimization Software and its Reusability and Interoperability](#)
*H Alicia Kim (UC San Diego)
Zasady FAIR w projektowaniu konstrukcji:
1. Findable (odnalezienie)
2. Accessible (dostępność)
3. Interoperable (współdziałanie)
4. Reusable (ponowne wykorzystanie)

https://www.sciencedirect.com/science/article/pii/S0898122118304255

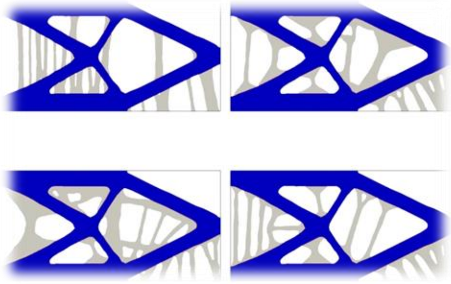
Optimization and manufacturing – 33 referaty

1. Dominujący temat: wytwarzanie addytywne (szczególnie metodą druku 3D) oraz projektowanie z uwzględnieniem ograniczeń produkcyjnych.
2. Addytywne wytwarzanie i kontrola parametrów druku –optymalizacja trajektorii druku, strategie łączenia projektowania topologii i orientacji włókien - anizotropia.
3. Wielomateriałowość i metamateriały w kontekście metod wytwarzania.
4. Zrównoważony rozwój – uwzględnienie wpływu środowiskowego.
5. Integracja topologii z innymi parametrami i funkcjami konstrukcji – projektowanie kompleksowych struktur – materiał + geometria + proces wytwarzania – manufacturing-aware topology optimization

Wybrane referaty:

Design and testing of print-path aware topology optimized material architectures
*Hajin Kim-Tackowiak (MIT)
Josephine Carstensen (MIT)

Topology optimization of continuous fiber structures for 3d printing with depostion constraints
*Joaquín Castro (University of Liege)
Eduardo FernÁndez (University of Liege)
José Rothkegel (University of Liege)
Pierre Duysinx (University of Liege)



https://link.springer.com/article/10.1007/s00158-022-03284-z

Optimization of materials – 22 referaty
Optimization of metamaterials - 18 referatów

1. Optymalizacja topologii – dominująca metoda w projektowaniu materiałów i metamateriałów.
2. Integracja metod sztucznej inteligencji i uczenia maszynowego z optymalizacją.
3. Automatyzacja projektowania metamateriałów - optymalizacja właściwości: mechanicznych, optycznych, akustycznych, magnetycznych.
4. Integracja z produkcją i technologiami addytywnymi.

Optimization of materials
Optimization of metamaterials

Wybrane referaty:

Towards certification-ready and sustainable wind turbine blade designs: sandwich failure optimization and blade design implications
*Sebastian Hermansen (Aalborg University)
Gregor Borstnar (Gurit Wind Systems A/S)
Erik Lund (Aalborg University)

Disordered Network Metamaterials with Optimally Tailored Mechanics
*Lucien Tsai (Princeton University)
Glaucio Paulino (Princeton University)

Topology optimization of 3D composites exhibiting the Hall effect and other nonreciprocal effects
*Christian Kern (Technical University of Denmark)
Rasmus Ellebæk Christiansen (Technical University of Denmark)
Ole Sigmund (Technical University of Denmark)

Optimizing Brittle Fracture Toughness of Two-Dimensional Cellular Microstructures
*Sukhminder Singh (Technical University of Denmark)
Ole Sigmund (Technical University of Denmark

Extreme nonlinearity by layered materials through inverse design
*Xiaojia Shelly Zhang (University of Illinois at Urbana Champaign)
Zhi Zhao (University of Illinois Urbana-champaign)
Rahul Kundu (University of Illinois Urbana-champaign)
Ole Sigmund (Technical University of Denmark

Multi-physics optimization – 26 referatów

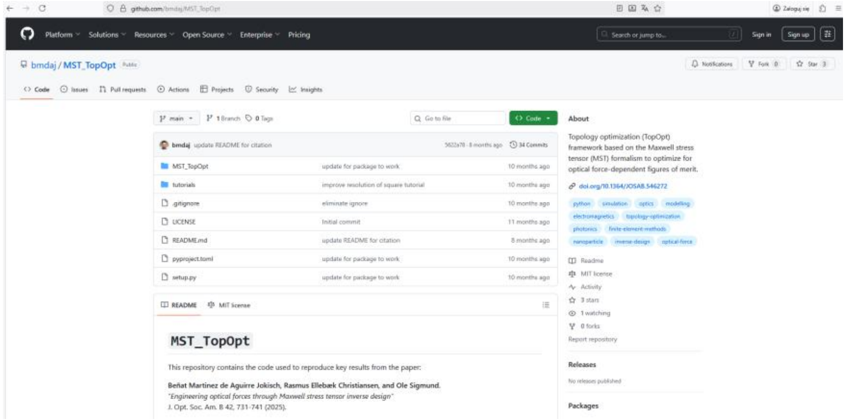
1. Dominująca metoda: optymalizacji topologiczna w zastosowaniach mechanicznych, elektromechanicznych, optycznych, wymiany ciepła i przepływu
2. Zastosowanie przemysłowe i integracja z automatyzacją (systemy chłodzenia, optyka satelitarna, elektormagnesy, silniki i inne)

Wybrane referaty:

Engineering optical forces through topology optimization
*Beñat Martinez De Aguirre Jokisch (Technical University of Denmark)
Rasmus Ellebæk Christiansen (Technical University of Denmark)
Ole Sigmund (Technical University of Denmark)

Topology Optimization of Vibroacoustic Black Holes through Boundary Interpolations
*Jonathan Mirpourian (Technical University of Denmark (DTU))
Glaucio H. Paulino (Princeton University)
Niels Aage (Technical University of Denmark (DTU)

Narrow-Band Topology Optimization for Large-Scale Thermal-Fluid Applications
*Vladislav Pimanov (University of California San Diego)
John-paul Sabino (The Boeing Company)
Michael Stoia (The Boeing Company)
H. Alicia Kim (University of California San Diego

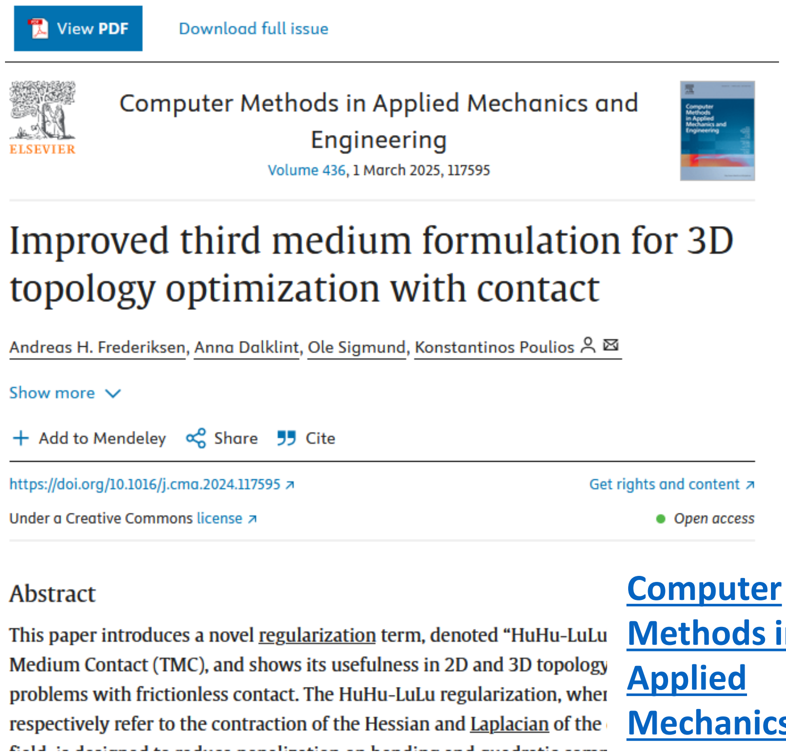


https://github.com/bmdaj/MST_TopOpt
https://arxiv.org/html/2410.20009v1
Artykuł ukazał się w Computer Methods in Applied Mechanics and Engineering

Multi-objective optimization – 28 referatów

Wybrane referaty:

[Internal Contact in Topology Optimization: Introducing “HuHu-LuLu” regularization and an improved Third Medium Contact Topology Optimization framework in 3D]()
*Andreas Henrik Frederiksen (DTU)
Anna Dalklint (DTU)
Ole Sigmund (DTU)
Konstantinos Poulios (DTU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Computer Methods in Applied Mechanics and Engineering
Volume 436, 1 March 2025, 117595

Improved third medium formulation for 3D topology optimization with contact

Andreas H. Frederiksen, Anna Dalklint, Ole Sigmund, Konstantinos Poulios

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Abstract

This paper introduces a novel regularization term, denoted “HuHu-LuLu
Medium Contact (TMC), and shows its usefulness in 2D and 3D topology
problems with frictionless contact. The HuHu-LuLu regularization, wher
respectively refer to the contraction of the Hessian and Laplacian of the

https://www.sciencedirect.com/science/article/pii/S0045782524008491

Computer Methods in Applied Mechanics and Engineering

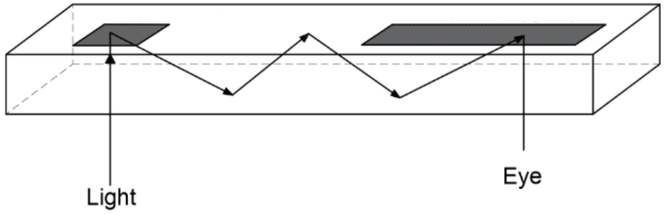
Robust and reliability-based optimization – 17 referatów

Wybrane referaty:

https://www.geometrica.com/en/latestnews/gridshells-free-form

Optimal design of spherical like grid shells with uncertain nodal positions
*Janos Logo (Budapest University of Technology and Economics)
Bálint Tóth (Budapest University of Technology and Economics, Politecnico di Milano)
Matteo Bruggi (Politecnico di Milano)

Topology Optimization with Stochastic Geometric Perturbations for Optical Waveguide Design
*Philip Elbek (Technical University of Denmark)
Niels Aage (Technical University of Denmark)
Rasmus Ellebæk Christiansen (Technical University of Denmark)
Ole Sigmund (Technical University of Denmark)



https://avantierinc.com/resources/application-note/application-of-optical-waveguides-in-ar-glasses/

Dziękuję za uwagę

https://www.issmo.net/committee-documents/wcsmo-16-general-assembly/

Call for proposals to hold WCSMO-17

One of the aims of ISSMO is to bring together researchers and practitioners in the field of structural and multidisciplinary optimization, by means of international meetings having a high scientific standard. Selection criteria include:

- up-to-date conference facilities,
- affordable costs to all members of the society (including registration, hotel, travel expenses, considering also free lunches, banquet, excursions etc.),
- proven congress organizing experience and strength of the local organizing group,
- geographical diversity reflecting the distribution of SMO researchers over the world.

This is meant to imply a reasonably uniform distribution of congresses over three zones, namely Asia-Australia, Europe-Africa and North & South Americas.

The congress should be held within the mid-May – mid-June period and expected to last between 4.5 and 5 days.

Timeline: submission deadline November 15, 2025; decision by the EC January 2026.

Call for proposals to hold WCSMO-17

Preference is given to proposals that ensure the geographical diversity of WCSMO:

WCSMO-1, Goslar, Germany, 1995
WCSMO-2, Zakopane, Poland, 1997
WCSMO-3, Buffalo NY USA, 1999
WCSMO-4, Dalian, China, 2001
WCSMO-5, Lido di Jesolo, Italy, 2003
WCSMO-6, Rio de Janeiro, Brazil, 2005
WCSMO-7, Seoul, Korea, 2007
WCSMO-8, Lisbon, Portugal, 2009
WCSMO-9, Shizuoka, Japan, 2011
WCSMO-10, Orlando FL USA, 2013
WCSMO-11, Sydney, Australia, 2015
WCSMO-12, Braunschweig, Germany, 2017
WCSMO-13, Beijing, China, 2019
WCSMO-14, Boulder CO USA, 2021 (virtual)
WCSMO-15, Cork, Ireland, 2023
WCSMO-16, Kobe, Japan, 2025