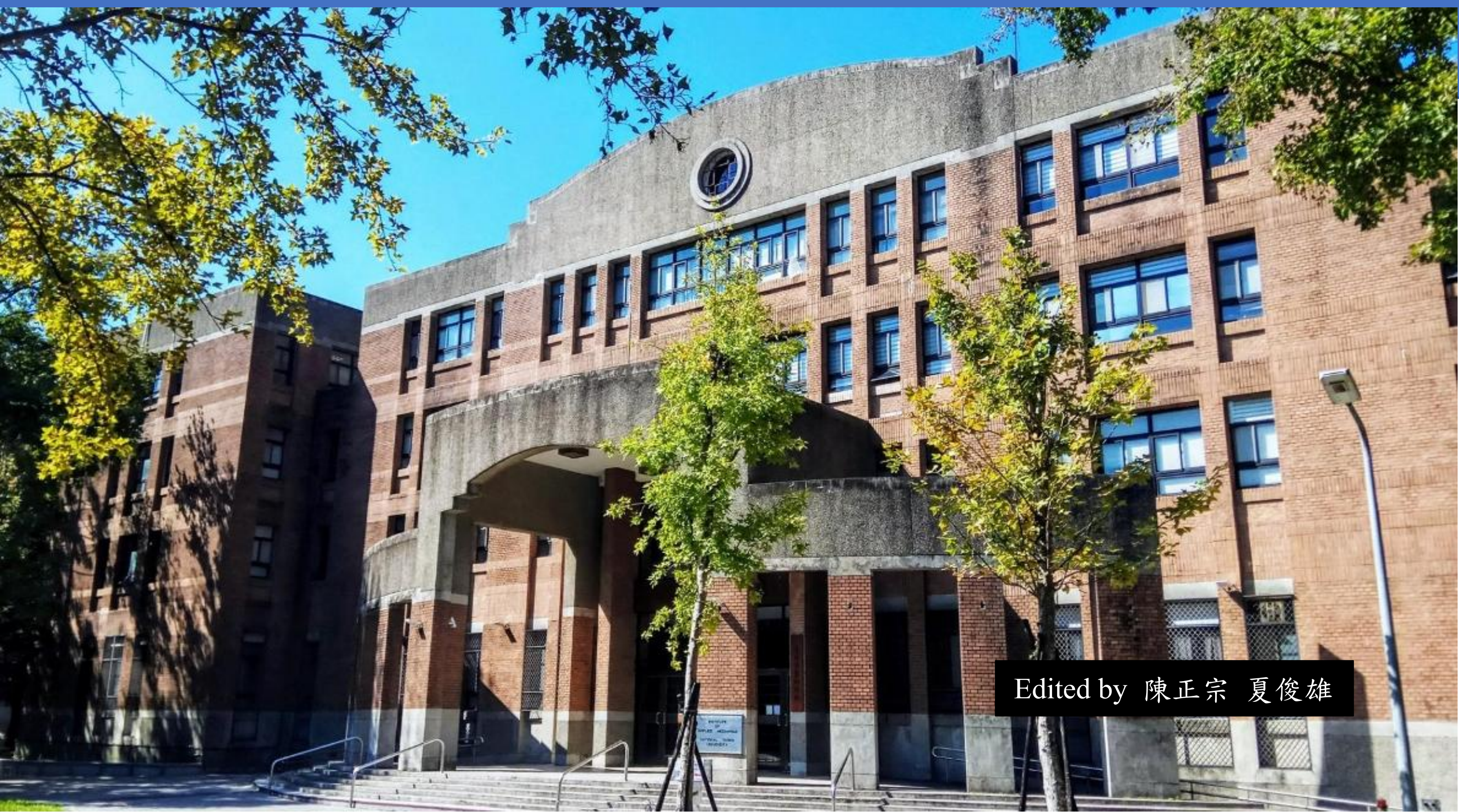
第四屆台灣計算力學學會年會與學術研討會暨第十七屆臺灣邊界元素法會議

THE 4TH ANNUAL MEETING AND CONFERENCE OF ASSOCIATION OF COMPUTATIONAL MECHANICS TAIWAN (ACMT) 2026
& THE 17TH WORKSHOP ON BOUNDARY ELEMENT METHODS IN TAIWAN

2026/October/16-17



Edited by 陳正宗 夏俊雄

目錄

台灣邊界元 大家來結緣

邊界積分方程或邊界元素法自 1969 年代 Rizzo 解決二維平面彈力問題，迄今已超過半世紀。1986 年，鮑亦興院士邀請 Rizzo, Shippy 與 Mukherjee 來台開講習班。1989 年楊德良老師邀請 Liggett 教授來台訪問。1998 年國科會由本人組織了一個邊界元研討會在新竹國家高速電腦中心舉行邀請了程宏達教授主講。一直到 2010 年 NTOU/MSV 結合了數學同好創辦了台灣邊界元年會，由工程與數學不同領域學者，交叉每年舉辦研討會，在沒有學會的支持與資助下所走到 17 屆是相當不易的事。這過程中數學推動中心李志豪主任對第一屆會議經費支持與海大河工系友會贊助下得以篳路藍縷。這十餘年過程中得到 NCTS 及國震中心的支持與逢甲(1)、中興(1)、成大(3)、中山(1)、義守(1)、宜蘭大學(1)、陽明交大(1)和海大(3)均主辦過，更曾擴大到兩岸與台日研討會。中間因 COVID 19 有兩次配合力學會議線上進行。有大家共襄盛舉才能走到今天，到達這裡。期待同好們與年青朋友們能持續傳承，讓學術研究的種子，可以發芽茁壯。
今年獲得 ACMT 陳俊杉理事長與理監事同意，由台大應力所(周佳靚教授)
與數學系(夏俊雄教授)主辦，ACMT 4 與 TwBEM 17 得以一同舉辦，預祝會議成功，大家多交流，能收穫滿滿！

陳正宗 夏俊雄 June, 2026

TwBEM 2026 (2026/10/16-17)

10/16 (五)		
時間	講者	演講題目
09:00 ~ 09:30	報到	
09:30 ~ 09:50	開幕式	
10:00 ~ 11:00	專題演講 一	
11:00 ~ 11:20	茶敘交流	
11:20 ~ 12:10	專題演講 二	
12:10 ~ 13:20	午餐	
13:20 ~ 14:10	專題演講 三	
14:20 ~ 14:50	陳桂鴻 (宜大)	An overview of the Boundary-Source Method of Fundamental Solutions
14:50 ~ 15:20	樂美亨 (台師大)	Boundary-Based Numerical Optimization for Conformal Surface Parameterization
15:20 ~ 15:50	許嘉文 (成大)	Boundary Element Method for Smart Laminated Composite Plates
15:50 ~ 16:10	茶點時間	
16:10 ~ 16:40	陳人豪 (清大)	A Deep Learning Surrogate for Accelerating Convex Hull Approximation in Quantum State Separability Detection
16:40 ~ 17:10	林俊宏 (中原)	Interface-Aware Multiphysics Metamaterials for Seismic Resilience, Thermal Control, and Low-Carbon Infrastructure
17:10 ~ 17:40	呂秉澤 (中正)	A Multilevel Stochastic-Gradient Neural Solver for Boundary Integral Equations
18:00 ~ 21:00	晚宴	

10/17 (六)		
時間	講者	演講題目
09:00 ~ 09:30	報到	
09:30 ~ 10:10	學生短講比賽	
10:10 ~ 10:40	學生海報	
10:50 ~ 11:20	半大會演講 (I) (II)	
11:20 ~ 11:50	半大會演講 (III) (IV)	
12:00~ 13:00	午餐	
13:00~ 13:30	朱家杰 (清大)	Multicontinuum homogenization of piezoelectric materials with multiscale porous microstructure
13:30 ~ 14:00	蘇昱臻 (中央)	Generalized Interpolation Material Point for Simulating Droplet Impact on Flexible Sheets with Experimental Validation
14:00 ~ 14:30	吳金典 (陽交大)	A Skew Freeform Design for Two-Dimensional Illuminance
14:30 ~ 14:50	茶點時間	
14:50 ~ 15:20	徐文信 (屏科大)	平面 P 波入射下雙峽谷地形場址效應之複合法與 COMSOL 數值比對研究
15:20 ~ 15:50	舒宇宸 (成大)	Neural Initialization and Local Search for Accelerating Digital and GPU Annealers in QUBO Problems
15:50 ~ 16:20	Behera (海大)	Capillary-Gravity Wave Interaction with an Offshore Oscillating Water Column Device over a Porous Seabed
16:20 ~ 16:50	閉幕式	

History & Background of Taiwan BEM workshop (1986-2026)
(TwBEM 12, on line meeting)

Year	Host	Organizer	Ceremony	Keynote
1986	NTU IAM	Prof. Y H Pao	Establishment of NTU IAM	Prof. F J Rizzo
1989	NTU	Prof. D L Young	NSC	Prof. J A Liggett
1998	NSC	Prof. J T Chen	NCHC	Prof. A H D Cheng
2010	NTOU/MSV	Prof. J T Chen	NTOU-HRE 50th anniversary	Prof. Z C Li
2011	NCTS(South)	Prof. K M Lee	NCKU 80th Anniversary	NCKU
2012	Feng Chia University	Prof. Y C Shiah	Prof. Hong's 60th birthday	Prof. H-K Hong
2013	National Chung Hsing University	Prof. K J Shou	Congratulations for Academician	Dean S L Crouch Academician, NAE
2014	National SYS University	Prof. T T Lu	Prof. Young's 70th birthday	Prof. D L Young
2015	NCREE (Cross strait)	Dr. R Z Wang	NCREE	Cross strait ceremony
2016	NCTS (Japan-Taiwan)	Prof. J H Lee	NCTS	Prof. H-K Hong Prof. W-W Lin
2017	NIU	Prof. I L Chern Prof. K H Chen	Ilan Univ.	Prof. H-K Hong Prof. W-C Wang
2018	ISU	Prof. H T Huang Prof. I L Chen	Iso Univ.	Prof. D L Young
2019	NCKU	Prof. L W Liu	Cheng Kung Univ.	Prof. J T Chen
2020	NTOU	Prof. Y T Lee Prof. C M Fan	NTOU-HRE 60th anniversary	Prof. C B Hwu
2021	On-line	Prof. J W Lee	CTAM	Prof. C S Chen
2022	CTAM	Prof. J T Chen	CTAM	Prof. J W Lee
2023	NTOU	Prof. Y T Lee	NTOU 70th Anniversary	Prof. E N Pan Prof. T W Lin
2024	NCKU	Prof. Y C Sue	ACMT 2	Prof. C H Yu
2025	NYCU	Prof. M C Shiue	ACMT 3	Prof. T K Lin
2026	NTU	Prof. C H Hsia	ACMT 4	Prof. C C Chou

一路走來 17 年贊助單位
(since 2010)

The 4th Annual Meeting and Conference of the Association of Computational Mechanics Taiwan &
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October 16–17, 2026

An overview of the Boundary-Source Method of Fundamental Solutions

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Abstract

In this presentation, we provide an overview of the background and major developments of a family of techniques collectively known as the **Boundary-Source Method of Fundamental Solutions (BSMFS)**. The underlying concept originated from the pioneering work of Young and co-workers, published in 2005 under the title *"Novel Meshless Method for Solving Potential Problems in Arbitrary Domains"* [1]. Within the BSMFS framework, the solution is represented by a distribution of kernel functions associated with singular or double-layer potentials. Various techniques have subsequently been proposed to allow source points to be placed directly on the physical boundary, thereby removing the need for a fictitious boundary. Particular emphasis is placed on the derivation and treatment of the singular diagonal terms that appear in the influence matrix when the source and collocation points coincide on the boundary. The mathematical foundations, theoretical formulations, and computational implementations of these approaches are systematically reviewed. The goal of this presentation is to provide the audience with a comprehensive understanding of these methodologies and their practical implementation.

Keywords: Boundary-source method of fundamental solutions; Singular-layer potentials; double-layer Potentials, Singular diagonal terms; Singularity; Hypersingularity.

Reference

1. Young, D., K. Chen, and C. Lee, *Novel meshless method for solving the potential problems with arbitrary domain.* Journal of Computational Physics, 2005. **209**(1): p. 290-321.

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Boundary-Based Numerical Optimization for Conformal Surface Parameterization

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Abstract

Surface parameterization is a fundamental tool for geometric modeling, mesh processing, and scientific computation on surfaces. In this talk, I will present a boundary-based numerical optimization approach for computing conformal parameterizations of simply connected open surface meshes onto the unit disk. The method formulates the problem as a conformal energy minimization problem, in which the boundary correspondence is optimized while the interior mapping is determined by a discrete Laplace–Beltrami equation. A line-search gradient descent method with a quadratic approximation is developed to efficiently minimize the resulting energy functional, together with theoretical convergence guarantees. Numerical examples will be presented to demonstrate the accuracy, efficiency, and robustness of the proposed method for surface mesh parameterization. I will also briefly discuss extensions of this energy minimization viewpoint to area-preserving surface parameterizations, highlighting how different distortion measures lead to related numerical optimization frameworks.

Keywords: conformal parameterization; surface mesh; boundary optimization; conformal energy minimization; numerical optimization.

Acknowledgment The author gratefully acknowledges support from the National Science and Technology Council, Taiwan.

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Boundary Element Method for Smart Laminated Composite Plates

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Abstract
Smart materials may exhibit coupled interactions among mechanical, electric, and magnetic fields, and thus enable energy conversion among different physical forms. This study develops a boundary element formulation for the coupled analysis of smart laminated plates composed of magneto-electro-elastic (MEE) materials. Laminates containing any combination of elastic, piezoelectric, and piezomagnetic layers are included as special cases of the general MEE formulation. The proposed BEM allows arbitrary material orientations and stacking sequences and is applicable to smart laminated plates involving general bending-extension coupling together with fully coupled MEE effects.

Within the framework of classical lamination theory, the governing equations for smart laminated plates are organized into the same mathematical form as those of the corresponding elastic problem. The two formulations differ only in the dimensions of the associated matrices and the physical interpretation of their components. The mathematical analogy allows the general solutions for smart laminated plates to be derived from the Stroh-like formalism [1] through an appropriate expansion of the relevant matrices [2]. Explicit Green's functions are consequently obtained for infinite plates containing elliptical holes or straight cracks, as well as elliptical inclusions. These solutions correspond to concentrated generalized loads, including forces, moments, electric and magnetic charges.

The derived Green's functions are subsequently employed as fundamental solutions for the conventional and special BEMs [3]. In the special BEMs for smart laminated plates containing holes, cracks or inclusions, the relevant traction-free or perfect bonding conditions are exactly satisfied by the corresponding fundamental solutions. Thus, no discretization along the hole, crack, or inclusion boundaries is required. To extend the BEMs to problems involving multiple holes, cracks or inclusions, the subregion technique [4] is incorporated into the proposed boundary element formulations. These BEMs are applicable to a wide range of smart laminated composite plate problems involving various material configurations, geometries, inhomogeneities, loading conditions, and boundary conditions.

Because no built-in finite element formulation is available in ANSYS for fully coupled MEE laminated plates, an electro-elastic special case involving only in-plane fields is considered for validation. As shown in Figure 1, a symmetric $[P/45]_s$ laminated plate containing a piezoelectric inclusion is subjected to uniform in-plane electric displacement D_0 on the two opposite edges. In the stacking sequence, P denotes the piezoelectric material $BaTiO_3$, which is also used for the inclusion. The boundary element results are compared with the finite element results obtained using the quadratic quadrilateral plane element PLANE223 in ANSYS.

Table 1 presents the normal electric displacement D_n along the elliptical interface. The superscripts (1) and (2) denote quantities evaluated on the matrix and inclusion sides, respectively. Due to the perfect bonding conditions, this quantity should be continuous, $D_n^{(1)} = D_n^{(2)}$, on the interface boundary. From Table 1 the interface continuity condition is precisely satisfied by the special BEM, whereas it can only be approximately satisfied by the finite element results. Nevertheless, close agreement is observed between the special BEM and ANSYS results.

Under the present computational settings, the computation requires approximately 7 seconds using the special BEM implemented in MATLAB R2023b, compared with 30 seconds using ANSYS 2019R1. The special BEM also eliminates the need to discretize the inclusion boundary while enforcing the associated interface conditions exactly. Therefore, the special BEM provides a simpler discretization, exact satisfaction of the interface conditions, and a lower computational cost than the conventional finite element method. Additional examples involving unsymmetric smart laminated plates subjected to mechanical, electric, and magnetic loading will be presented at the conference to further demonstrate the general applicability of the proposed formulations. These fully coupled MEE laminated-plate problems cannot be analyzed by directly using the built-in finite elements available in ANSYS.

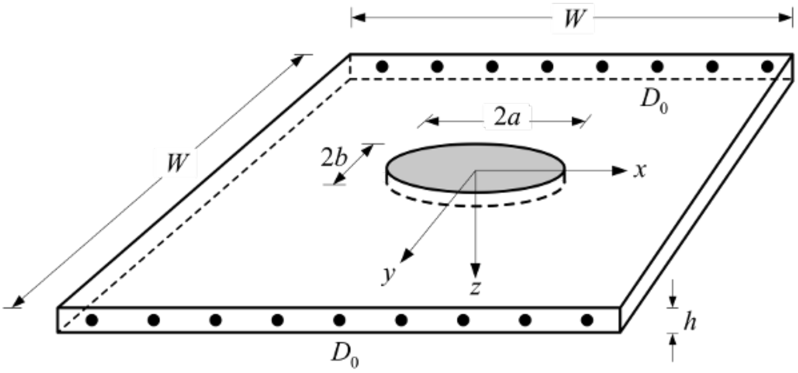

Figure 1 A smart laminated plate with an inclusion subjected to uniform electric displacement.

Table 1 Electric displacement along the interface boundary of the inclusion.

φ	Special BEM $D_n^{(1)}/D_0$	Special BEM $D_n^{(2)}/D_0$	ANSYS $D_n^{(1)}/D_0$	ANSYS $D_n^{(2)}/D_0$
0°	-0.026	-0.026	-0.025	-0.026
45°	-1.065	-1.065	-1.061	-1.065
90°	-1.178	-1.178	-1.176	-1.178
135°	-1.042	-1.042	-1.039	-1.042
180°	0.026	0.026	0.026	0.026

Keywords: Boundary element method; Smart material; Laminated composite plate;
Fully coupled analysis; Hole/crack/inclusion problem.

Acknowledgment
The first author gratefully acknowledges financial support from the National Science and Technology Council, Taiwan, under Grant No. NSTC 115-2222-E-006-005-MY2, for attending the conference.

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A Deep Learning Surrogate for Accelerating Convex Hull Approximation in Quantum State Separability Detection

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Abstract

Determining the separability of quantum states is a fundamental yet computationally challenging problem in quantum information theory, especially when mixed states and higher-dimensional systems are involved. The Convex Hull Approximation (CHA) method provides an interpretable geometric approach by constructing a finite inner approximation of the separable-state set from sampled pure separable states. However, improving the approximation quality requires increasing the number of sampled extreme points, which in turn leads to substantial computational cost because a linear programming problem must be solved for each test sample. This study proposes a deep learning surrogate for accelerating CHA-based quantum state separability detection. Instead of directly formulating the task as binary classification, the proposed framework learns the CHA scaling coefficient as a continuous regression target and uses the predicted value to induce the final separability decision. The input to the model consists of a real-vector representation of the density matrix based on the generalized Gell-Mann basis, supplemented by auxiliary physical features that provide additional information on spectral structure, mixedness, and separability-related properties. The regression model is implemented using a staircase residual neural-network architecture, and training is guided by a composite weighted mean-squared-error loss that gives higher importance to samples near the CHA decision boundary while suppressing the influence of CHA-induced labels that are inconsistent with the reference labels. A deep ensemble strategy is further adopted to improve prediction stability. Numerical experiments are conducted on two-qubit and two-qutrit bipartite systems. In the two-qubit case, the Positive Partial Transpose (PPT) criterion provides the reference labels, while in the two-qutrit case the evaluation focuses on PPT samples and uses a CHA result computed using a large number of sampled extreme points as the proxy reference. The results show that the proposed surrogate improves classification consistency under low-to-moderate convex-hull sampling settings and remains close to the proxy CHA reference under large sampling settings. Efficiency comparisons further demonstrate that the proposed method replaces sample-wise linear programming with fast post-training neural-network inference, substantially reducing the computational time required for repeated CHA-based evaluations while maintaining consistency with the CHA-based decision framework.

Keywords: Quantum entanglement; Separability detection; Convex hull approximation; Deep learning; Residual neural network

Interface-Aware Multiphysics Metamaterials for Seismic Resilience, Thermal Control, and Low-Carbon Infrastructure

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Abstract

Taiwan lies along active plate boundaries and is frequently exposed to earthquakes, making seismic resilience a continuing priority for buildings and infrastructure. At the same time, global commitments to net-zero emissions by 2050 and increasingly extreme climate conditions are driving demand for efficient, adaptable thermal-energy systems. Addressing these pressures separately can lead to competing use of underground space, materials, and investment. This work therefore combines seismic metamaterials, ground-source heat pumps, and thermal metamaterials in a coupled framework that explicitly accounts for imperfect mechanical and thermal interfaces. The objective is to transform subsurface infrastructure from a single-purpose protective system into a multifunctional platform for hazard mitigation, heat-flow control, and low-carbon energy exchange.

The framework progresses from component physics to system integration. Periodic and locally resonant subsurface arrays are designed to attenuate or redirect elastic waves [1–3], while transformation thermodynamics and tailored conductivity provide thermal cloaking, concentration, insulation, and heat-flux rotation [4,5]. Mechanical and thermal jump laws replace ideal continuity, making interface stiffness and contact conductance explicit design variables [6]. These descriptions are then coupled to co-design barriers, piles, resonators, and periodic foundations with closed-loop geothermal exchange [7,8]. Dispersion, scattering, effective-medium, and thermo-mechanical analyses are combined with multi-objective optimization to balance seismic, structural, and thermal requirements.

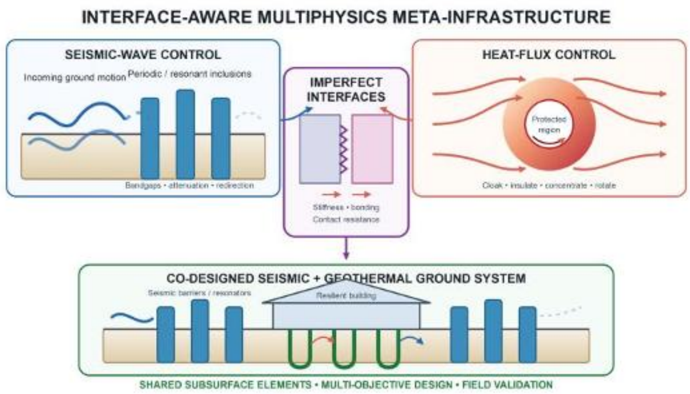

Figure 1. *Interface-aware framework integrating seismic-wave control, heat-flux control, imperfect mechanical/thermal interfaces, and dual-function seismic–geothermal ground systems.*

The unified analysis links behavior at interfaces directly to performance at the infrastructure scale. Geometry and material contrast set the available wave and heat-control mechanisms, whereas interface quality determines how reliably those mechanisms are realized. Imperfect interfaces may shift attenuation bands, detune resonances, cause heat leakage through a cloak, and localize stress or heat flux; when modeled explicitly, the same compliance or resistance can become a tuning mechanism. At system scale, shared subsurface components can concurrently attenuate waves, carry structural loads, and exchange heat, while exposing clear trade-offs among attenuation bandwidth, thermal capacity, pumping energy, construction tolerance, and long-term durability.

Coupling seismic, thermal, geothermal, and interfacial physics provides a coherent route toward resilient and low-carbon infrastructure. The next steps are cross-scale parameter identification, coupled experimental validation, manufacturable detailing, and field demonstration. For earthquake-prone and energy-constrained regions such as Taiwan, interfaces and underground elements should be designed together as functional parts of a multifunctional system rather than treated as separate components or secondary imperfections.

Keywords: seismic metamaterials; thermal metamaterials; thermal invisibility cloak; imperfect interfaces; ground-source heat pumps; energy geo-structures

Acknowledgment: This research was partially supported by grants from the Taiwan National Science and Technology Council (NSTC) under the contract number NSTC 113-2221-E-033 -024 -MY3.

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A Multilevel Stochastic-Gradient Neural Solver for Boundary Integral Equations

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Abstract

We solve second-kind Fredholm boundary integral equations by representing the unknown density with a neural network, exploiting the spectral bias of neural network training as an implicit smoother rather than an obstruction. We propose a multilevel training scheme that progressively refines the quadrature grid, warm-starting each level from the previous one. The resulting GPU-trained solver substantially outperforms GMRES run in plain MATLAB on a conventional 64-core CPU workstation.
Keywords: second-kind Fredholm integral equations; multilevel training; neural network solvers; stochastic optimization; neural tangent kernel

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Multicontinuum homogenization of piezoelectric materials with multiscale porous microstructure

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Abstract

This talk presents a multicontinuum modeling framework for multiscale piezoelectric materials with complex porous microstructures. Unlike standard homogenization methods, which may fail to capture interactions across multiple pore scales, the proposed approach represents pores of different sizes as interacting continua. Multicontinuum expansions of the mechanical displacement and electric potential are developed, together with coupled constrained cell problems that characterize the effective behavior. These cell solutions lead to a generalized piezoelectricity model for an arbitrary number of continua. Numerical examples with two continua demonstrate the validity of the proposed framework.

Keywords: Piezocomposites; Multicontinuum; Homogenization; Porous materials; Perforated media

Acknowledgment (Dr. Chu was partially supported by the National Science and Technology Council, Taiwan with grant number NSTC-114-2115-M-007-011- .)

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Generalized Interpolation Material Point for Simulating Droplet Impact on Flexible Sheets with Experimental Validation

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Abstract

The development of numerical approaches for fluid-structure interaction (FSI) has been recognized as a crucial research topic over the past several decades. Due to the distinct differences in the governing equations of fluids and solids, coupled with the large-deformation characteristics of fluids, integrating the two domains poses significant challenges. The numerical method employed in this research is the Material Point Method (MPM) [1,2]. MPM integrates the advantages of both Eulerian grid-based methods and Lagrangian particle-based methods, effectively overcoming the limitations of mesh distortion in large-deformation problems. Furthermore, the procedure for updating the stress tensor via the strain rate tensor in MPM is inherently consistent with fluid dynamics formulations. Consequently, the MPM and its advanced variant, the Generalized Interpolation Material Point (GIMP) method, have been validated as effective simulation approaches through a series of bulk FSI problems.

However, when the scale of the FSI problem decreases to the millimeter level—such as a water droplet impacting a deformable sheet—research employing MPM remains highly scarce. This scarcity is primarily because surface tension, viscosity, and the incompressibility of the droplet become increasingly dominant at this scale—factors typically neglected in bulk water—and accounting for them substantially increases both computational costs and programming complexity. To address this challenge, this study utilizes GIMP to simulate a water droplet impacting a deformable sheet by adopting assumptions commonly used for bulk water: neglecting surface tension and viscosity while assuming the water is weakly compressible. By varying the dimensions of the sheet and incorporating a series of experimental results, this work qualitatively and quantitatively validates the feasibility of applying GIMP to this problem through the analysis of geometric deformation, height, and diameter variations following the droplet impact. The corresponding experimental and numerical settings for the droplet-sheet models are shown in Figures 1 and 2, respectively.

By comparing the configurations and normalized diameters of the droplet between the experimental and numerical results, the GIMP has been validated as a useful approach, as illustrated in Figure 3. Therefore, this study aims to provide future researchers with a straightforward and efficient computational approach for simulating droplet impacts.

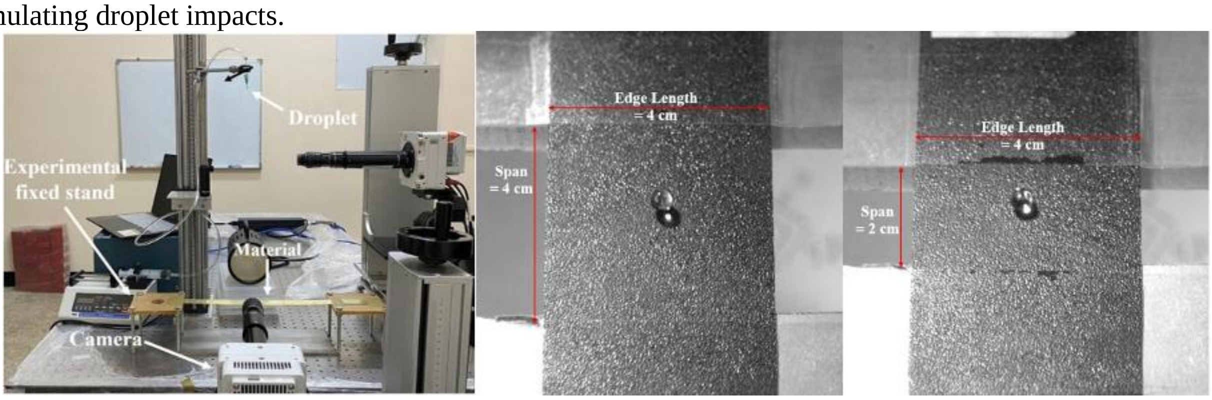

Figure 1. Experimental setups of the droplet-sheet model.

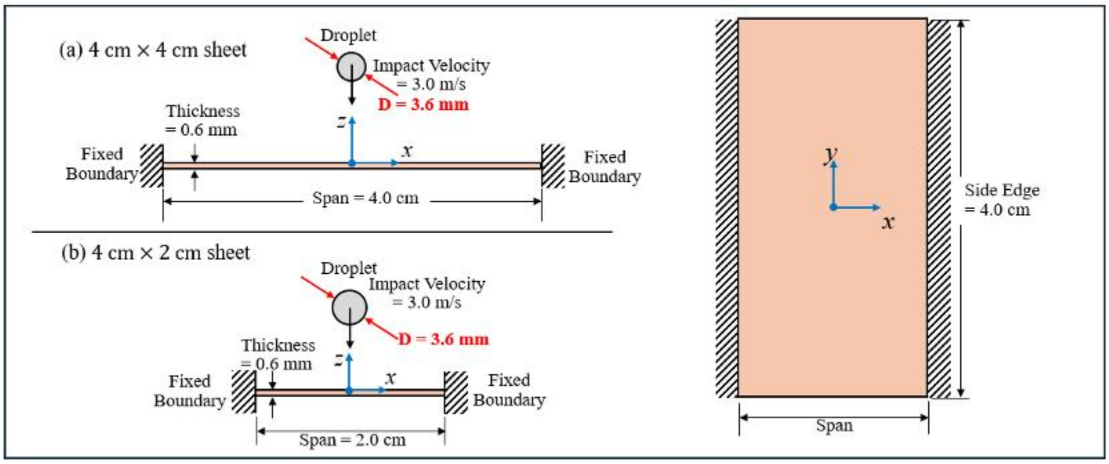

Figure 2. Computational setups of the droplet-sheet model.

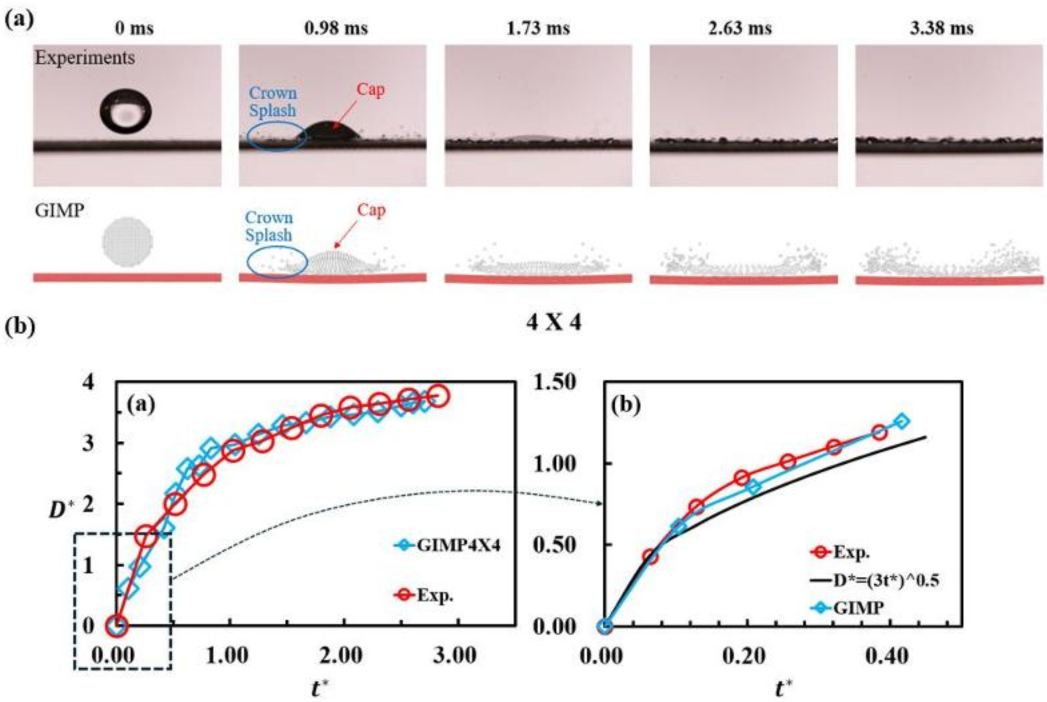

Figure 3. Comparative results obtained by the experiments and GIMP: (a) snapshots of the droplet configurations, (b) normalized diameters.

Keywords: Droplet Impact; Solid-fluid Interaction; Generalized Interpolation Material Point Method

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A Skew Freeform Design for Two-Dimensional Illuminance

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Abstract

The freeform optics is to transfer radiant flux from a given source into a target plane with a prescribed energy distribution by reflective or refractive surfaces. The differential forms of two-dimensional (2D) design and three-dimensional (3D) design are second-order ordinary differential equation (ODE) and Monge-Ampère equation, respectively, under the point light source assumption [1,2]. A simple approach based on grid mapping is to consider that the four end points of each source grid cell are mapped to the four end points of the associated target grid cell and the cells in each corresponding grid pair share equal energy flux [3]. Some other advanced approaches are the optimal transport ray-mapping method and the supporting quadratics method [4,5], where the desired freeform surface is obtained by unifying quadratics and optimizing the energy transportation.

In this work, we propose a 3D freeform surface design method. The freeform surface is constructed by using the 2D skew freeform model and quadric surfaces fitting without optimization process. First, the global light source domain and illuminant target domain, denoted by Ω_p and Ω_c respectively, are partitioned into numerous subdomains Ω_p^i and Ω_c^i, $i = 1 \cdots n$, satisfying local energy conservation. Next, a 2D skew freeform is constructed by solving a series of nonlinear ODEs resulting from 2D non-coplanar freeform design where the source and target illuminant distribution are computed to represent the energy distribution in each of the corresponding subdomain pairs [6]. Finally, a 3D freeform design is constructed by fitting quadric surfaces on a 3D skeletal frame consisting of the 2D skew freeform curves [7].

Keywords: Freeform; Monge-Ampère equation; quadric surface

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平面 P 波入射下雙峽谷地形場址效應之複合法與 COMSOL 數值比對研究

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摘要

針對不規則地形承受二維反平面 SH 波和平面 P 波、及 SV 波擾動的研究，自 1973 年由 Trifunac 提出級數解[1]進行分析後，多種數值方法的研究，如波函數展開法[2]、邊界元素法和複合法[3]。所研究的地形種類從單一峽谷、沉積谷地、山丘，到複雜地形，如雙峽谷或沉積谷地[2, 4]。

複合法係處理半無限域上含不規則形狀地形引致的散射問題，如圖 1(a)所示的半圓形雙峽谷(半徑為 a)，被 $\mathbf{x}_t^2$ 所形成的半圓弧包圍，內部區域 Ω^0 則可以有限元素網格進行切割，半圓弧區域上則佈點搭配 Lamb 級數，可得出矩陣方程式如下：

$$\begin{bmatrix} \mathbf{K}^{aa} - \omega^2 \mathbf{M}^{aa} & -\mathbf{K}^{ac} \\ -\mathbf{K}^{ca} & \mathbf{K}^{cc} \end{bmatrix} \begin{Bmatrix} \mathbf{a} \\ \mathbf{c} \end{Bmatrix} = \begin{Bmatrix} \mathbf{P}^a \\ -\mathbf{P}^c \end{Bmatrix} \tag{1}$$

其中 $\left[\mathbf{K}^{aa}\right]$ 和 $\left[\mathbf{M}^{aa}\right]$ 表區域 Ω^0 的勁度矩陣及質量矩陣；$\left\{\mathbf{P}^a\right\}$ 及 $\left\{\mathbf{P}^c\right\}$ 則為沿 $\mathbf{x}_t^2$ 邊上所形成的力量向量；$\left[\mathbf{K}^{ac}\right]$ 和 $\left[\mathbf{K}^{ca}\right]$ 為有限區域和邊界上耦合產生的矩陣；$\left[\mathbf{K}^{cc}\right]$ 則為 Lamb 級數所形成的矩陣。透過(1)式可知，針對二維反平面或平面問題，區域 Ω^0 的勁度矩陣和質量矩陣不變，因此僅需調整為反平面問題或平面問題的 Lamb 級數如下：

$$u_y^s = \sum_{m=0}^{\infty} \left(u_y^s\right)_m C_m \tag{2a}$$

$$u_j^s = \sum_{m=0}^{\infty} \left(u_j^s\right)_m^v C_m^v + \sum_{m=0}^{\infty} \left(u_j^s\right)_m^h C_m^h \quad , \quad j = x, z \tag{2b}$$

其中 $\{\mathbf{c}\}$ 為 Lamb 級數中的待定係數，而向量 $\{\mathbf{a}\}$ 則區域 Ω^0 中的位移 u_y^0 或 u_x^0 和 u_z^0 。

透過圖 1(b)的 TFI 映射函數(transfinite interpolation mapping function)[5]，可得到圖 2(a)之半圓形雙峽谷的網格切割，進行反平面 SH 波入射後的計算結果，可與陳正宗教授[2]進行比對後得到一致的結果。

現引入平面垂直 P 波入射的雙峽谷問題，透過調整 Lamb 級數後的計算結果，與 COMSOL 軟體計算結果進行比對。圖 3(a)為 COMSOL 軟體進行網格切割後的結果，透過無因次化的方式，以半圓形雙峽谷的半徑 a 為特徵長度進行，可得到一致的結果，如圖 3(b)所示。結果顯示在高頻入射下，雙峽谷之交互散射將導致中央平坦平台區產生顯著的動態共振與能量聚焦的放大效應。此外，平面問題所呈現的結果，對於模態轉換的現象可提供更多的參考價值。

關鍵詞：雙峽谷；複合法；反平面問題；平面問題；COMSOL

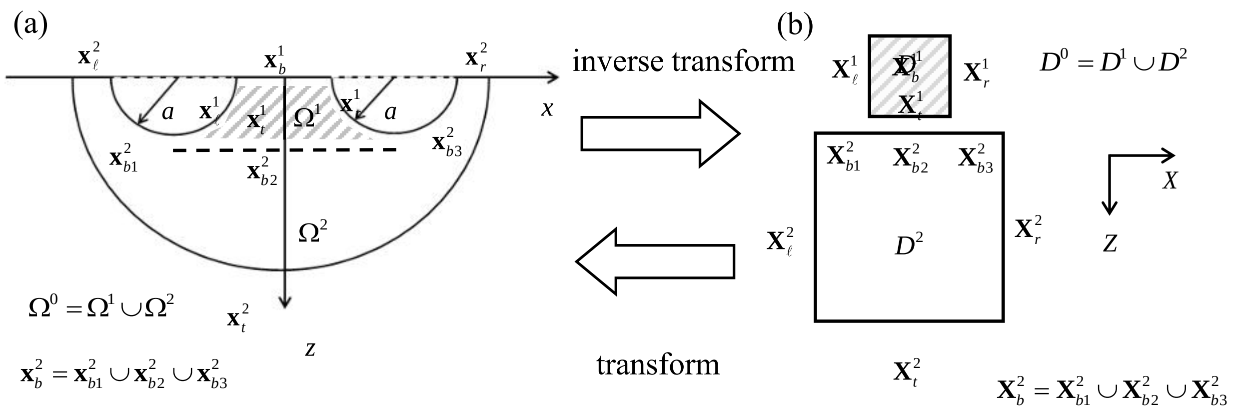

圖1 (a) 半圓形雙峽谷之區域及邊界圖；(b) 運用TFI進行轉換。

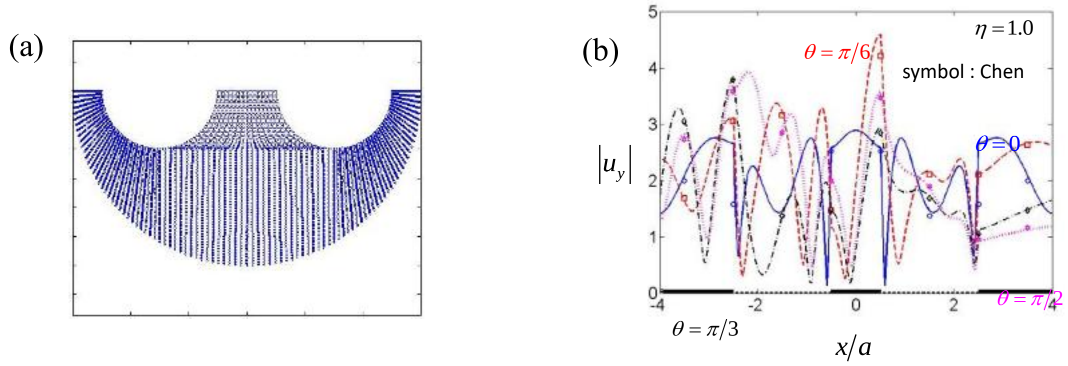

圖2 (a) 透過TFI轉換後得到之區域格點座標；(b) 反平面問題之結果(與Chen的結果比對)

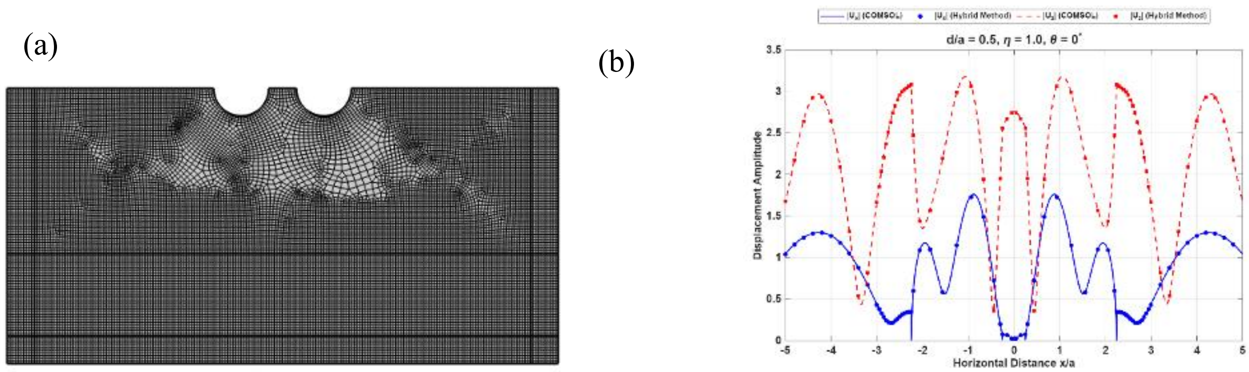

圖3 (a) COMSOL的網格切割；(b) 平面問題P波垂直入射結果(與COMSOL的計算比對)。

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Neural Initialization and Local Search for Accelerating Digital and GPU Annealers in QUBO Problems

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Abstract

Quadratic unconstrained binary optimization (QUBO) is a common framework for modeling large-scale combinatorial optimization problems in scientific computing, scheduling, manufacturing, and resource allocation. This talk presents a neural initialization and local search strategy for accelerating QUBO solvers based on digital and GPU annealers. From each QUBO matrix, bit-wise structural features are extracted and used by a neural network to predict variable-wise probabilities. Candidate binary solutions are generated by thresholding and Bernoulli sampling, refined by local search, and used as initialization for annealing. Experiments on random QUBO matrices and synthetic subset-sum instances show that the proposed approach reduces solving time while maintaining final objective quality.

Keywords: Quadratic unconstrained binary optimization; Annealers; keyword 3 (3–6 keywords)

Acknowledgment

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Capillary-Gravity Wave Interaction with an Offshore Oscillating Water Column Device over a Porous Seabed

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Abstract

Oscillating water column (OWC) devices are promising wave energy converters due to their simple design, reliability, and ability to convert wave-induced air-pressure oscillations into useful energy, but their performance is strongly affected by resonance, chamber geometry, seabed condition, and environmental effects. Most existing studies consider OWC devices under gravity waves over rigid bottoms and in still water, whereas real offshore conditions may involve porous seabeds, surface tension, and ambient currents. A porous seabed can dissipate wave energy and modify the wave field near the chamber, while surface tension and current can shift resonance frequencies and influence efficiency, radiation conductance, and radiation susceptance. Therefore, this study examines the hydrodynamic response of an offshore OWC device over a permeable seabed under capillary-gravity waves and uniform current.

The problem is formulated as a boundary value problem governed by the Laplace equation with boundary conditions at the free surface, porous bottom, chamber walls, and far-field boundaries. Surface tension is included through a modified free-surface condition, uniform current through the dispersion relation and boundary conditions, and the permeable seabed through a porous-bottom condition. The velocity potentials are obtained using the eigenfunction expansion method, while a hybrid boundary element method and finite difference method is used for validation and for treating the higher-order free-surface condition. The hydrodynamic performance is evaluated in terms of energy-conversion efficiency, radiation conductance, and radiation susceptance. Results show that seabed permeability modifies resonance through additional dissipation, surface tension shifts resonance toward higher frequencies and smooths sharp variations, and following and opposing currents shift the resonance in opposite directions.

Keywords: Oscillating water column; Permeable seabed; Surface tension; Uniform current; Capillary-gravity waves.

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