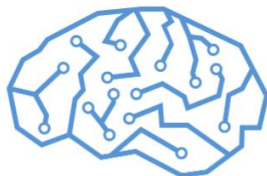# Learning Flexible Body Collision Dynamics With Hierarchical Contact Mesh Transformer

ICLR 2024 Poster

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Seok-Woo Lee[3], Joon-Young Yang[3], Sooyoung Yoon[3], Noseong Park[4]

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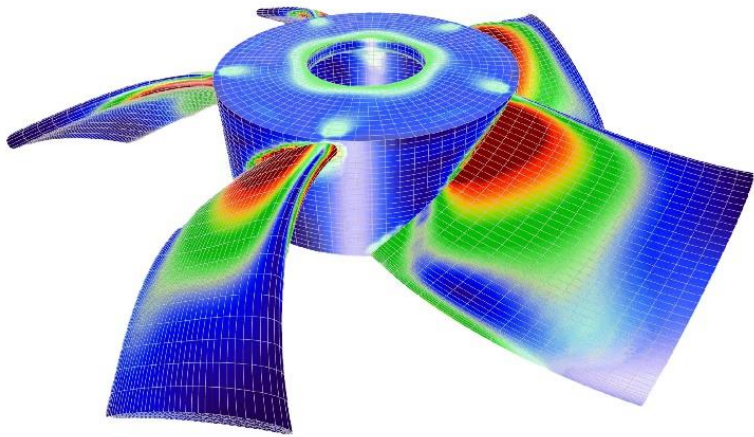
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Big Data Analytics & Learning Laboratory
Korea Advanced Institute of Science & Technology
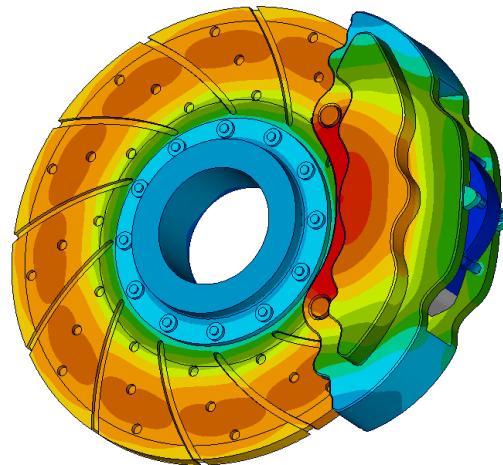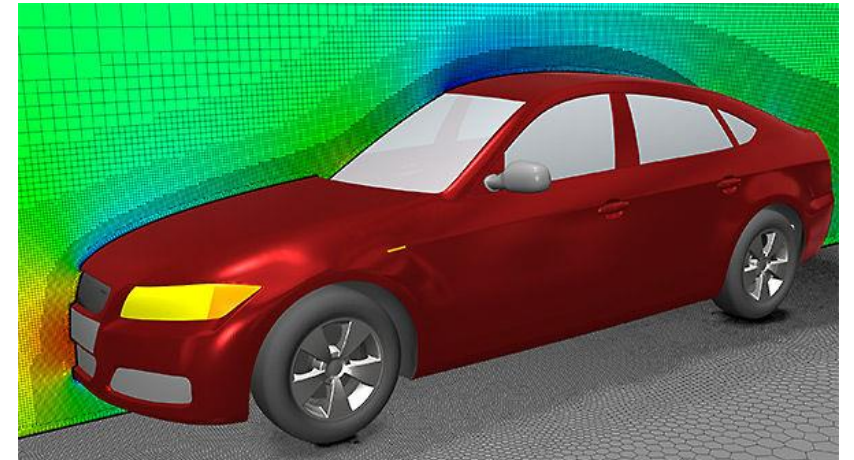

LG Display

Introduction

- FEA (Finite element analysis) refers to a computer simulation process used in engineering analysis and solves analysis problems using a numerical technique called FEM (Finite element method)
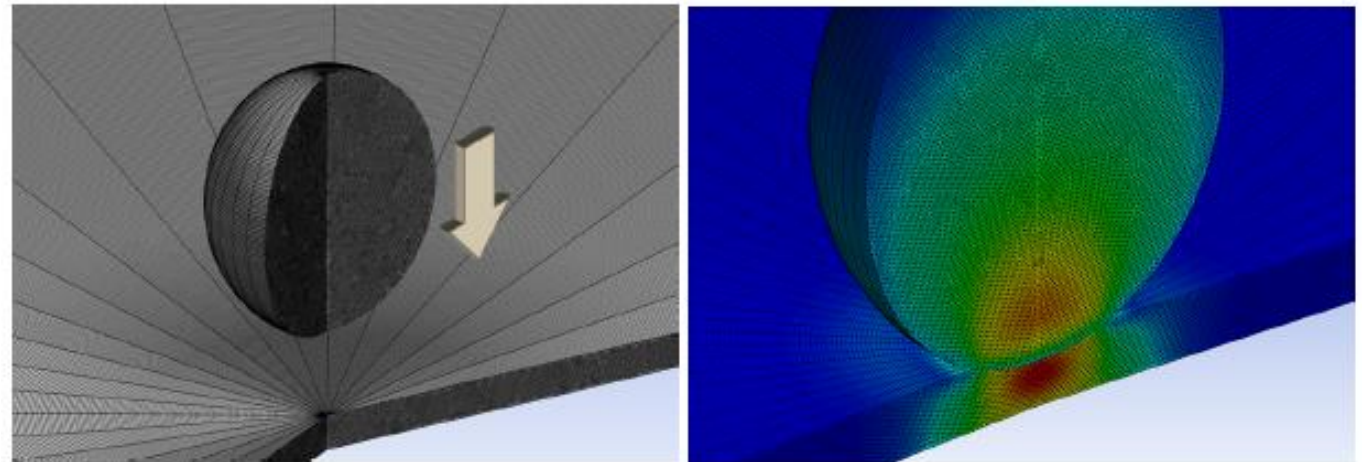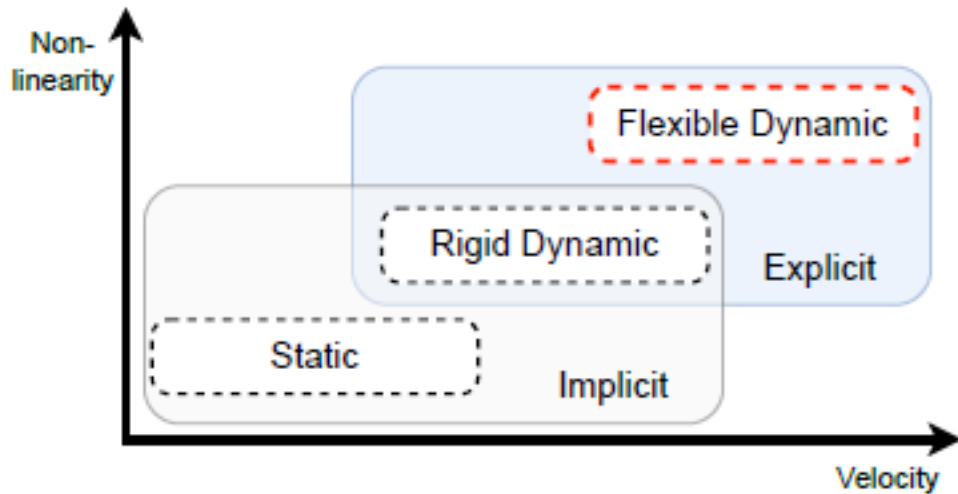

Dynamics

Thermal

Flow

Introduction

- Flexible dynamics, in which objects collide with each other at very **high speeds**, exhibits **highly nonlinear** characteristics.

- Impact plate simulation, which is performed in the display industry to evaluate the rigidity of display panels, is a flexible dynamics area with very high non-linearity.
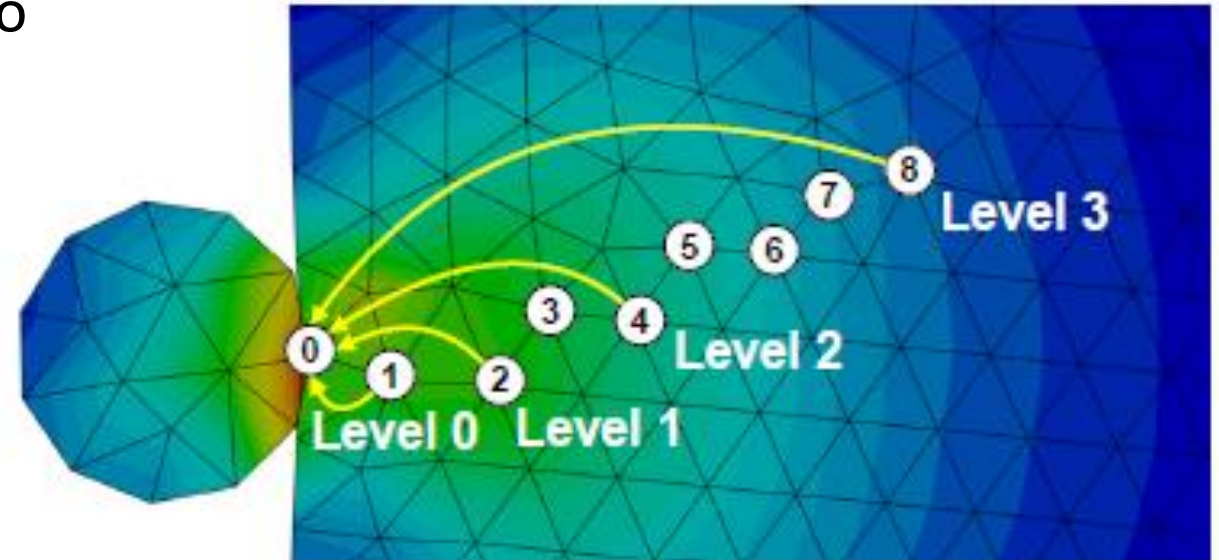

(a) Before the ball drops   (b) After a collision

Hierarchical Contact Mesh Transformer

- We propose a **Hierarchical Contact Mesh Transformer** (HCMT), which, to the best of our knowledge, incorporates collisions into **flexible body dynamics** for the first time.

- We efficiently use two Transformers with different roles for flexible and **contact dynamics**.

Hierarchical Contact Mesh Transformer
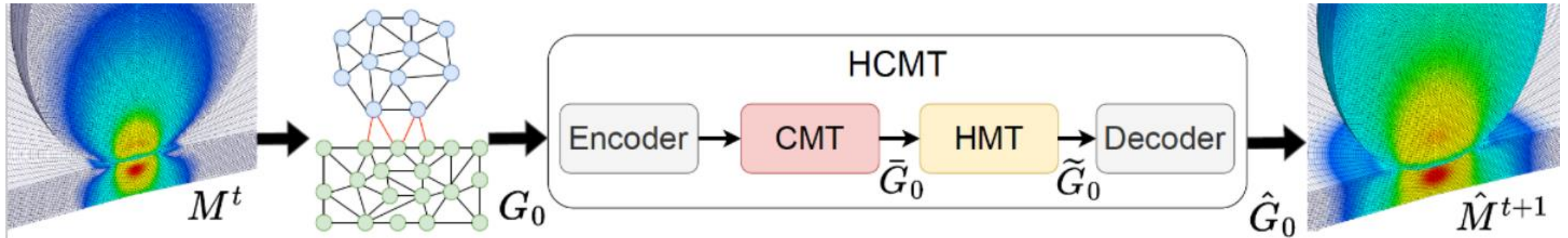
- CMT propagates contact messages through the contact edges between two colliding objects (e.g., a ball and a plate)

- HMT module uses a hierarchical graph with nodes properly pooled into the mesh structure to enable long-range propagation.
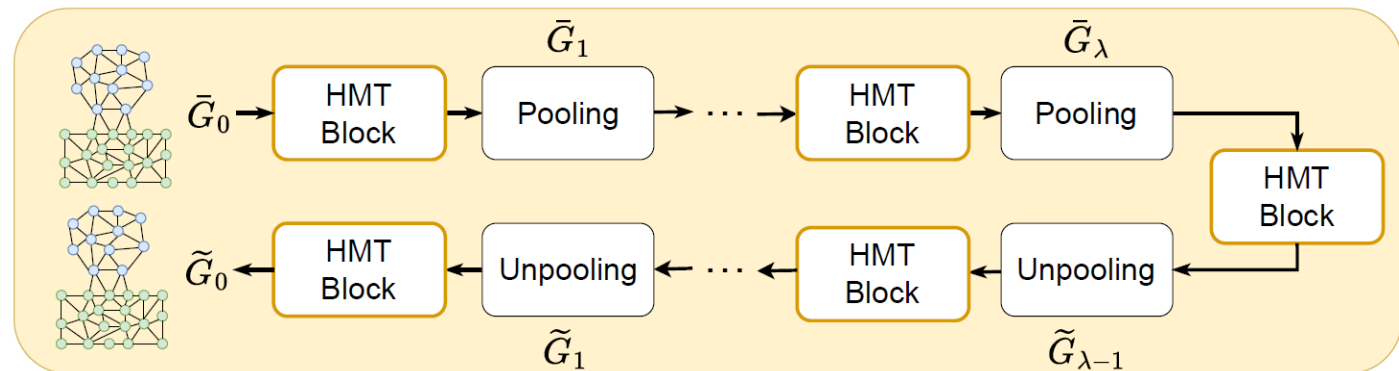
Experimental Results

Table : RMSE (rollout-all, ×10³) for our model and the baselines. Improv. means the percentage improvement over the runner-up and bold denotes the best performance.

Model	Impact Plate		Deforming Plate		Sphere Simple	Deformable Plate
	Position	Stress	Position	Stress	Position	Position
GT	59.18±4.45	39,291±21,529	11.34±0.28	9,168,298±164,941	243.85±141.08	13.74±0.47
MGN	40.73±2.94	35,871±11,893	7.83±0.16	4,644,483±92,520	33.26±6.33	10.78±0.54
HCMT	**20.71±0.57**	**14,742±502**	**7.49±0.07**	**4,535,956±49,937**	**30.41±1.71**	**7.67±0.42**
Improv.	49.2%	58.9%	4.3%	2.3%	8.6%	28.9%

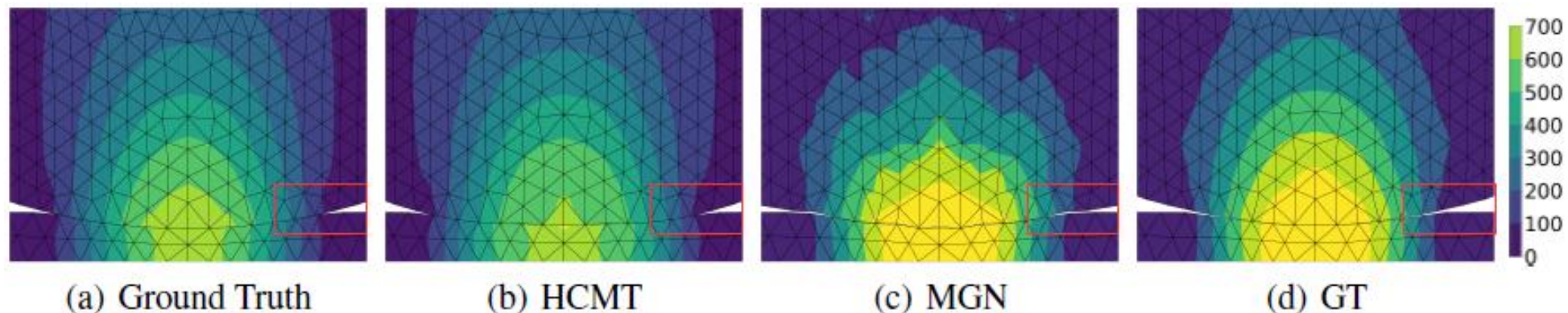(a) Ground Truth   (b) HCMT   (c) MGN   (d) GT

Figure : 2D cross-sectional contour of the stress field in Impact Plate. In the red bounding box, HCMT is the most similar to the node positions in the ground truth. Brighter colors mean higher stress.
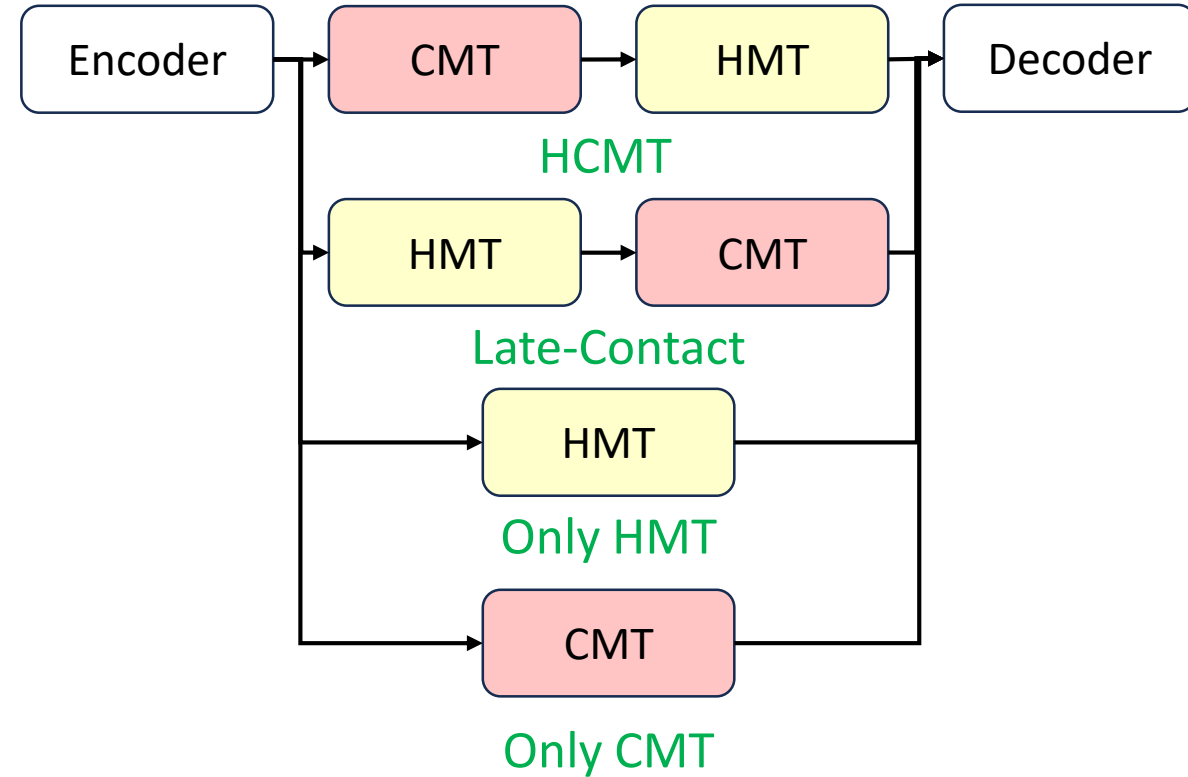
Experimental Results

Table A: Shows training time/step(ms)

Model	Impact Plate	Deforming Plate	Sphere Simple	Deformable Plate
GT	79.3	76.9	130.3	56.7
MGN	51.6	**51.1**	89.3	**38.6**
HCMT	**51.1**	53.5	**59.0**	53.1

Table B: The results of ablation studies

Position RMSE(rollout-all, x10^3)

Model	Impact Plate	Deforming Plate	Sphere Simple	Deformable Plate
HCMT	**20.34**	**7.37**	**28.30**	**7.67**
Late-Contact	42.90	7.74	38.81	7.97
Only HMT	46.27	22.32	144.73	24.69
Only CMT	55.63	7.96	30.15	**7.67**
HCMT+LPE	21.11	7.52	30.16	7.86

Paper: https://arxiv.org/abs/2312.12467

Code : https://github.com/yuyudeep/hcmt