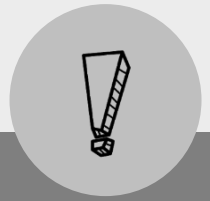
연구실 소개 자료

백 승 훈



Main Page

Biography

Real-Time
Dynamic Simulation

Advanced
Physics Simulation

Structural
Health Monitoring

Mechanical System Design

백 승 훈 / Seunghun Baek

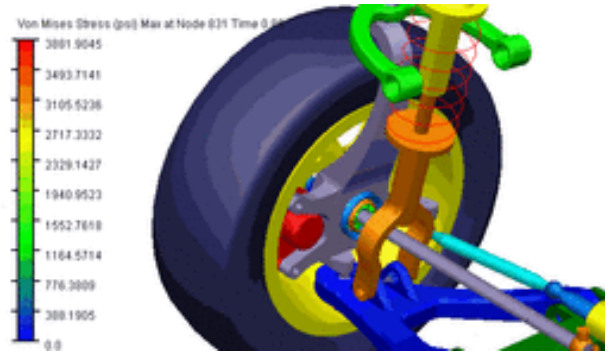
- **Education**
  - 2016, Ph.D., Mechanical Engineering, University of Michigan
  - 2011, MS, Mechanical Engineering, University of Michigan
  - 2009, BS, Mechanical Engineering, Yonsei University

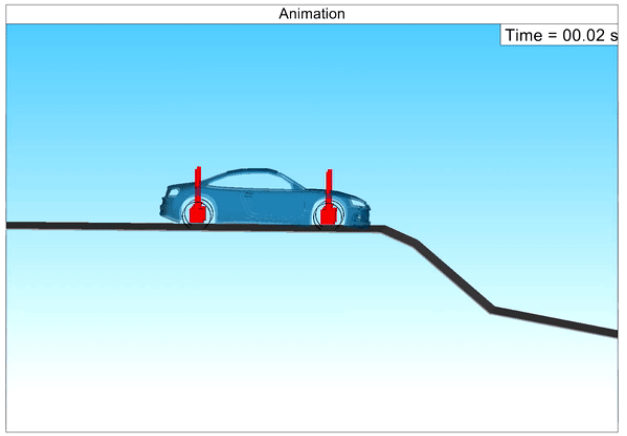
- **Experiences**
  - 2016~2020, Research Engineer, Ford Motor Company, USA
  - 2015, Intern, Sandia National Lab., USA

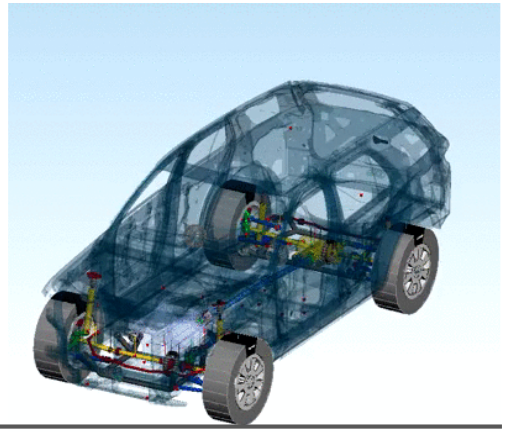
- **Contact Info**
  - baeksh@pusan.ac.kr
  - 기계관 613호 / 051)510-2314

#1 High-fidelity Real-time Dynamic Simulation

- Multibody Dynamics를 이용한 동역학 해석
- Real-time simulation을 위한 High-fidelity 동역학 해석 모델 개발
- High-fidelity를 만족하기 위한 효과적인 Degree-of-freedom reduction 방법 개발







High-fidelity	O	X	O
Real-time	X	O	O

#1 High-fidelity Real-time Dynamic Simulation

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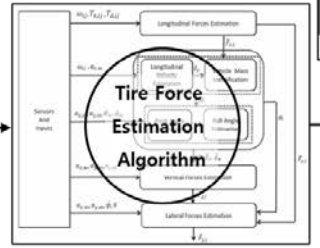
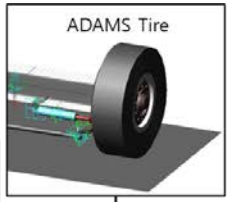
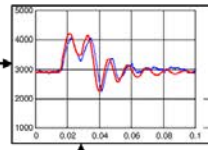
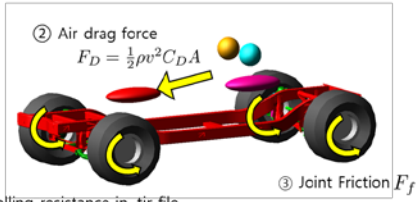
$\omega_{ij},\ a_{x,ij},\ a_{y,ij},$
$\dot{\theta}_{ij},\ \dot{\phi}_{ij}, \cdots$







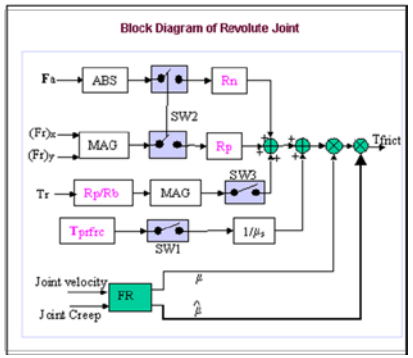


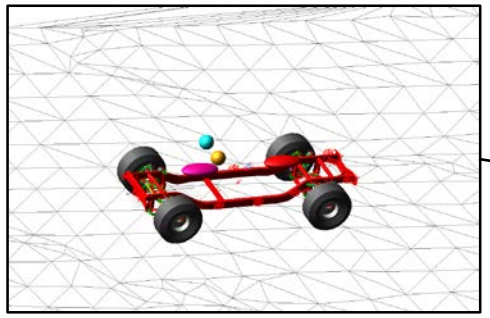
① Tire rolling resistance in .tir file
Road friction in .rdf file

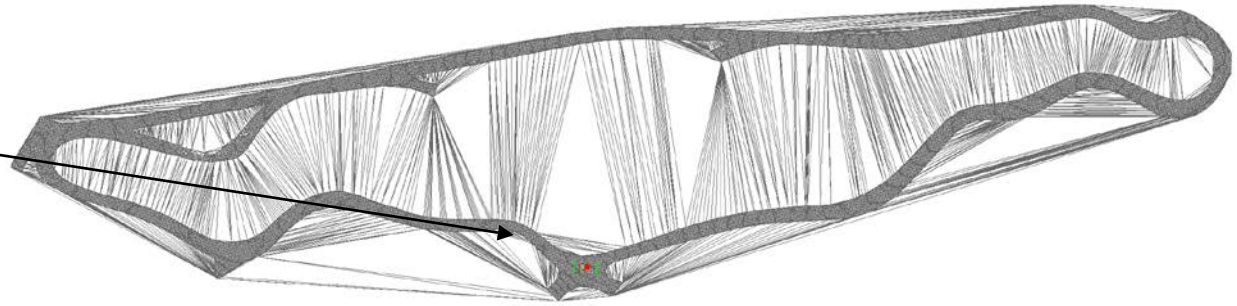
ADAMS model parameter

Parameters	
Tire rolling resistance coefficient	0.1
Road friction coefficient	0.9
Air resistance coefficient (C_D)	0.2
Joint dynamic friction coefficient (μ_s)	0.05
Joint static friction coefficient	0.2

Joint friction

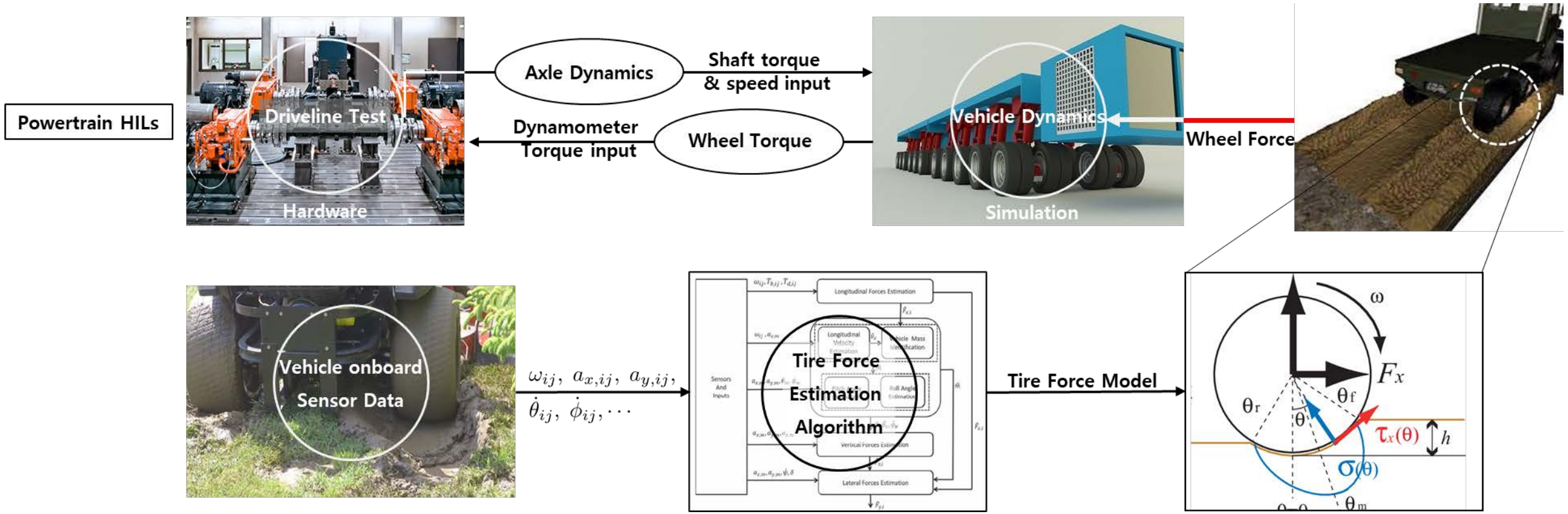






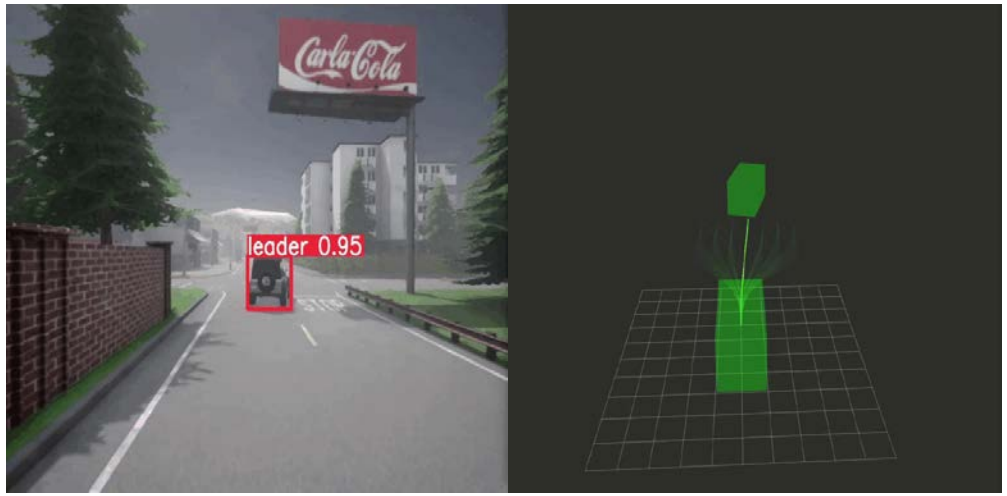
#2 Hardware-in-the-Loop Simulation

- Hardware ↔ Simulation 연동해석



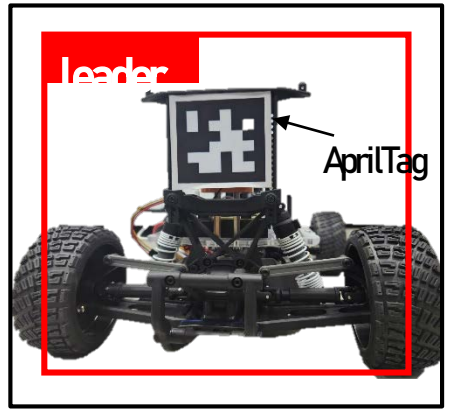
#3 Off-road Autonomous Driving

- Leader-Follower project
- Vision-based vehicle locomotion planning



Obstacle avoidance

Wall following

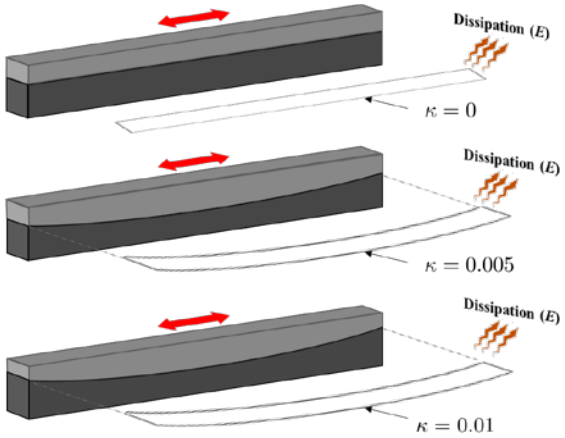


Object detection(leader)

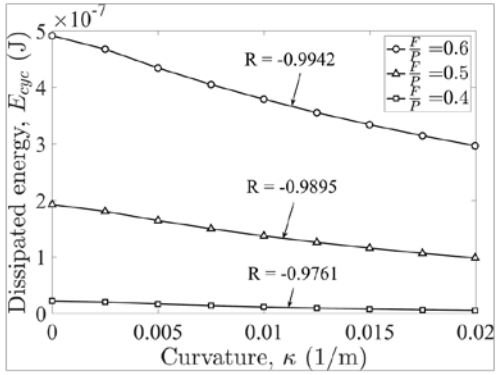
#1 Vibration analysis with Contact Force

- 마찰 저항에 의한 구조물의 거동 변화 관찰
- 마찰 댐핑이 구조에 미치는 영향 관찰

Curved surface contact model

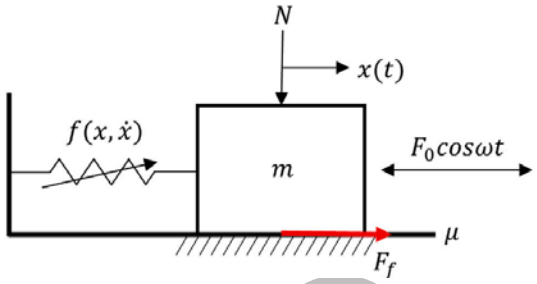


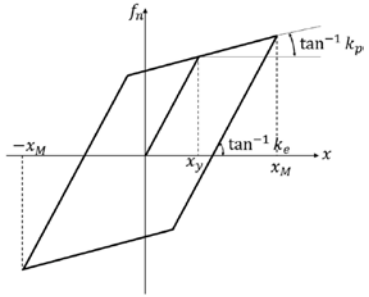
Frictional energy dissipation

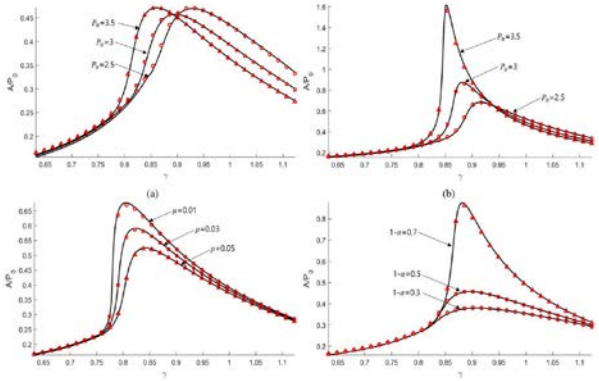


#2 Dynamic behavior analysis of systems with Friction and Hysteretic effects

- 마찰력과 탄성 가소성을 모두 포함한 재료의 동적 거동 해석
- 마찰과 탄성 가소성을 포함하는 구조물의 analytic solution 도출

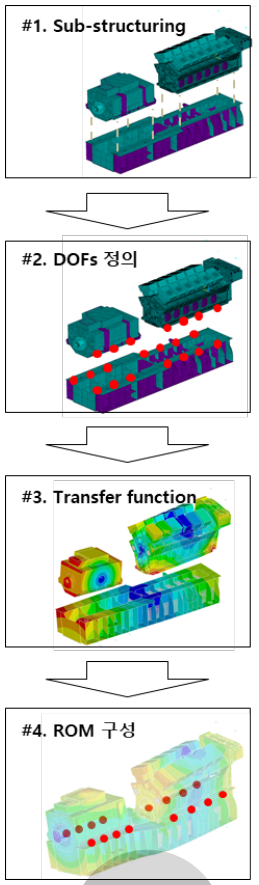






#1 Reduced Order Modeling

- Finite Element Method (FEM)을 이용한 구조체 해석
- Dynamic substructuring을 통한 해석시간 감소



1. Part별 ROM matrix 추출
2. ROM matrix coupling
3. Full system의 E.O.M
4. Harmonic analysis

Modal domain
Physical domain

$$\hat{M}_{rom} = \begin{bmatrix} I_{ii} & \hat{M}_{ib} \\ \hat{M}_{bi} & \hat{M}_{bb} \end{bmatrix} \vdots \xrightarrow{\text{Coupling}} M_{ROM}$$

$$\hat{C}_{rom} = \begin{bmatrix} \hat{C}_{ii} & \hat{C}_{ib} \\ \hat{C}_{bi} & \hat{C}_{bb} \end{bmatrix} \vdots \rightarrow C_{ROM}$$

$$\hat{K}_{rom} = \begin{bmatrix} \Lambda_{ii} & 0_{ib} \\ 0_{bi} & \hat{K}_{bb} \end{bmatrix} \vdots \rightarrow K_{ROM}$$

E.O.M

$$M_{ROM}\ddot{q} + C_{ROM}\dot{q} + K_{ROM}\,q = \mathrm{T}^{\mathrm{T}}\mathrm{F} = \mathrm{T}^{\mathrm{T}}\begin{bmatrix} \mathrm{F_i} \\ \mathrm{F_b} \end{bmatrix} = \mathrm{T}^{\mathrm{T}}\begin{bmatrix} \mathrm{F_i} \\ 0 \end{bmatrix}$$

ω_i : excitation frequency

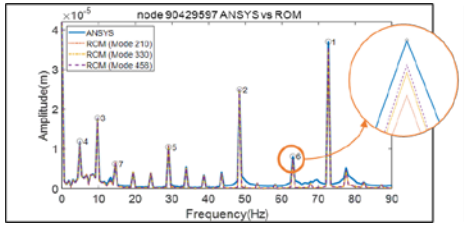
$$[(-\omega_i{}^2\mathrm{M_{ROM}} + \mathrm{K_{ROM}}) + \mathrm{i}\omega_i C_{ROM}]q = \begin{bmatrix} \mathrm{T}^{\mathrm{T}}\mathrm{F_i} \\ 0 \end{bmatrix}$$

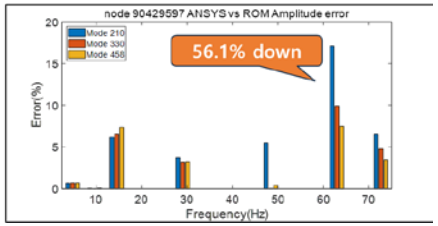
$$q = [(-\omega_i{}^2\mathrm{M_{ROM}} + \mathrm{K_{ROM}}) + \mathrm{i}\omega_i C_{ROM}]^{-1}\begin{bmatrix} \mathrm{T}^{\mathrm{T}}\mathrm{F_i} \\ 0 \end{bmatrix}$$

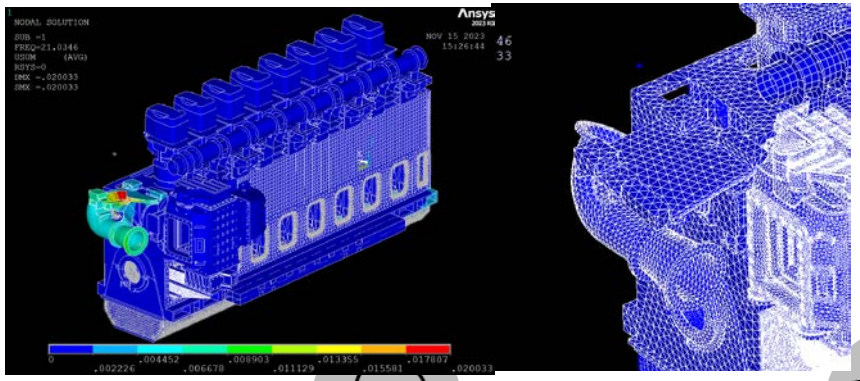
$X = Tq$ Calculate amplitude

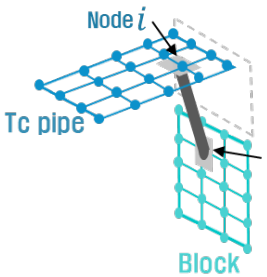
▪ 연구결과

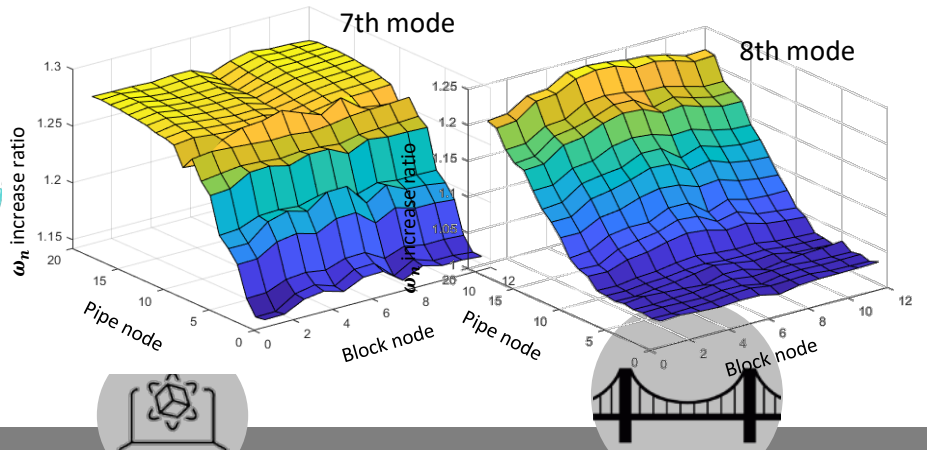
- ➢ 해석 정확도 : 오차 최대 9.45%
- ➢ 해석 시간단축 : 5Days → 20min





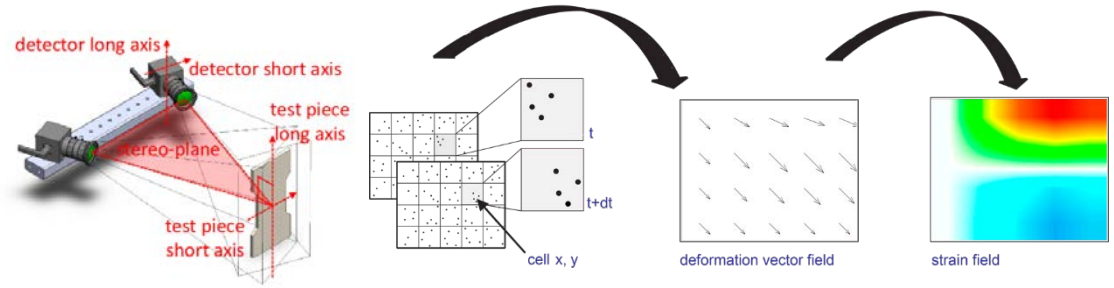


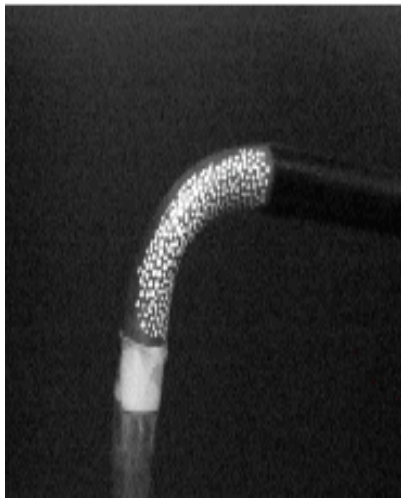


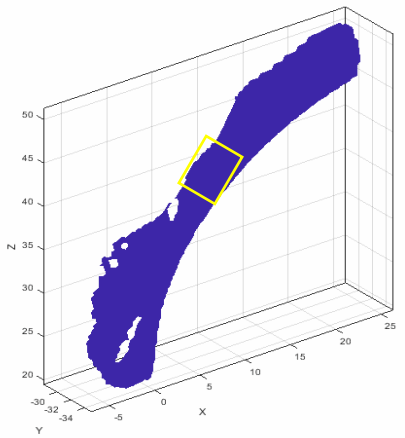


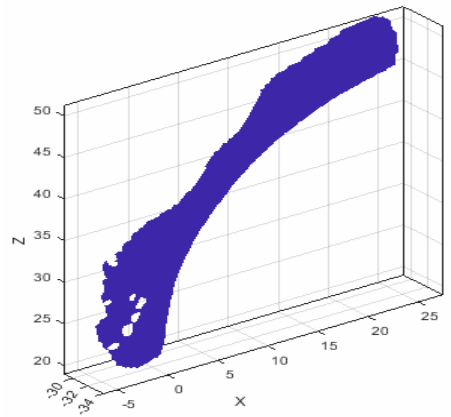
#2 Visual information based-structural analysis

- Digital Image Correlation 기반 응력측정









Instrinsic Parameters

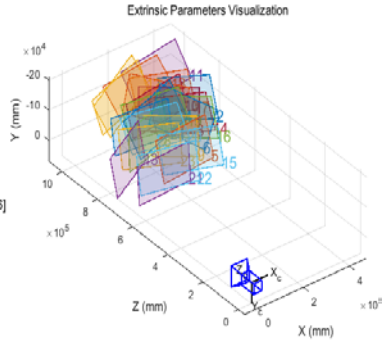
Focal length [fx,fy]
[1044.6 ± 2.3 , 1041.9 ± 2.1]

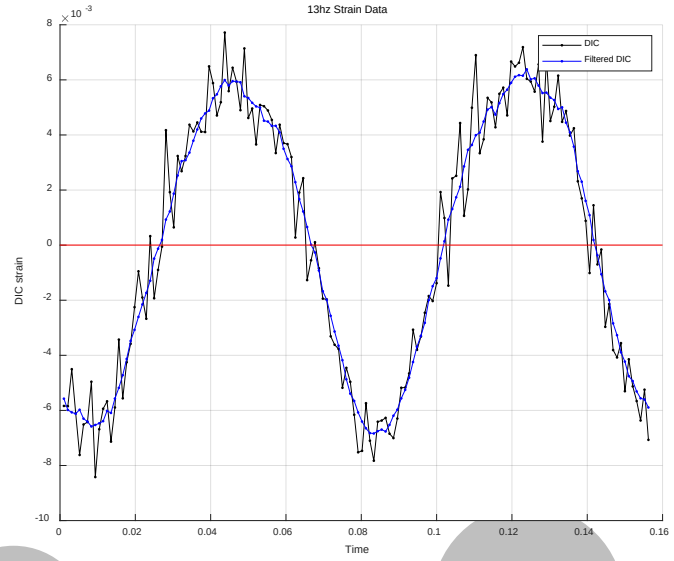
Principal Point
[647.45 ± 2.9 , 497.5 ± 1.8]

RadialDistortion [k1,k2,k3]
[-0.002213 ± 0.00771 , 0.006092 ± 0.02317 , -0.006286 ± 0.03656]

Tangential Distortion [p1,p2]
[0.0001086 ± 0.0006254 , -0.0007178 ± 0.001163]

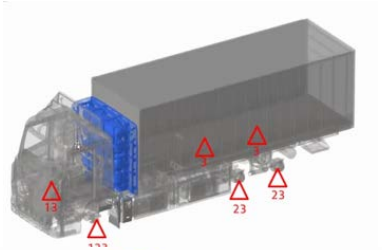
Skew [s]
-0.06938 ± 0.4244 (-6.658e-05° ± 0.0004073°)

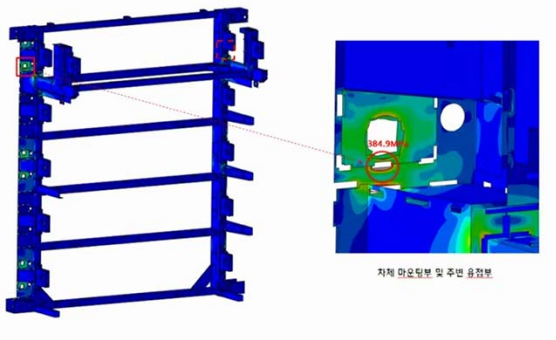




#3 CAD → FEM 자동변환

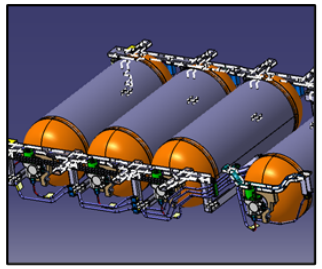
- AI 기반 해석모델 생성/해석



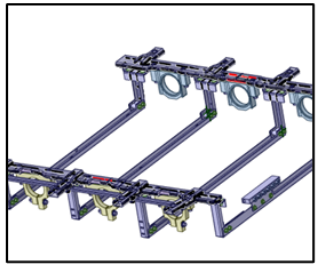


CATIA → ANSYS SpaceClaim → Ansys Mechanical

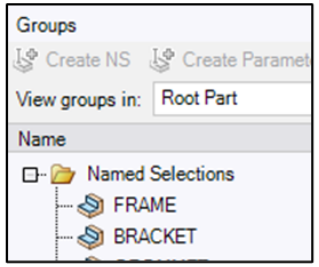
CAD → Post-process for CAD → Grouping → Pre-process for FEA → FE Analysis



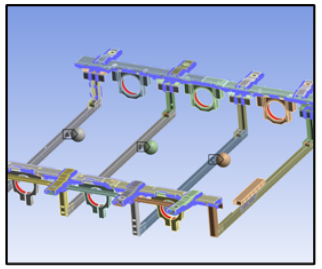
1 Sub-structuring

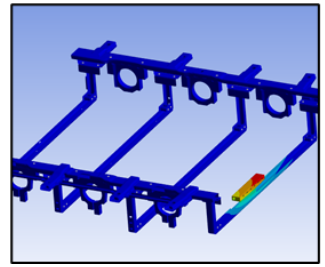


2 Mid- surface



3 Weld





4 Make group