KAERI

딥러닝을 이용한 최적설계 및 시뮬레이션 소개

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(ygyu@kaeri.re.kr)

2018.03.19

Korea Atomic Energy Research Institute

Image-to-Image Translation with Conditional Adversarial Networks

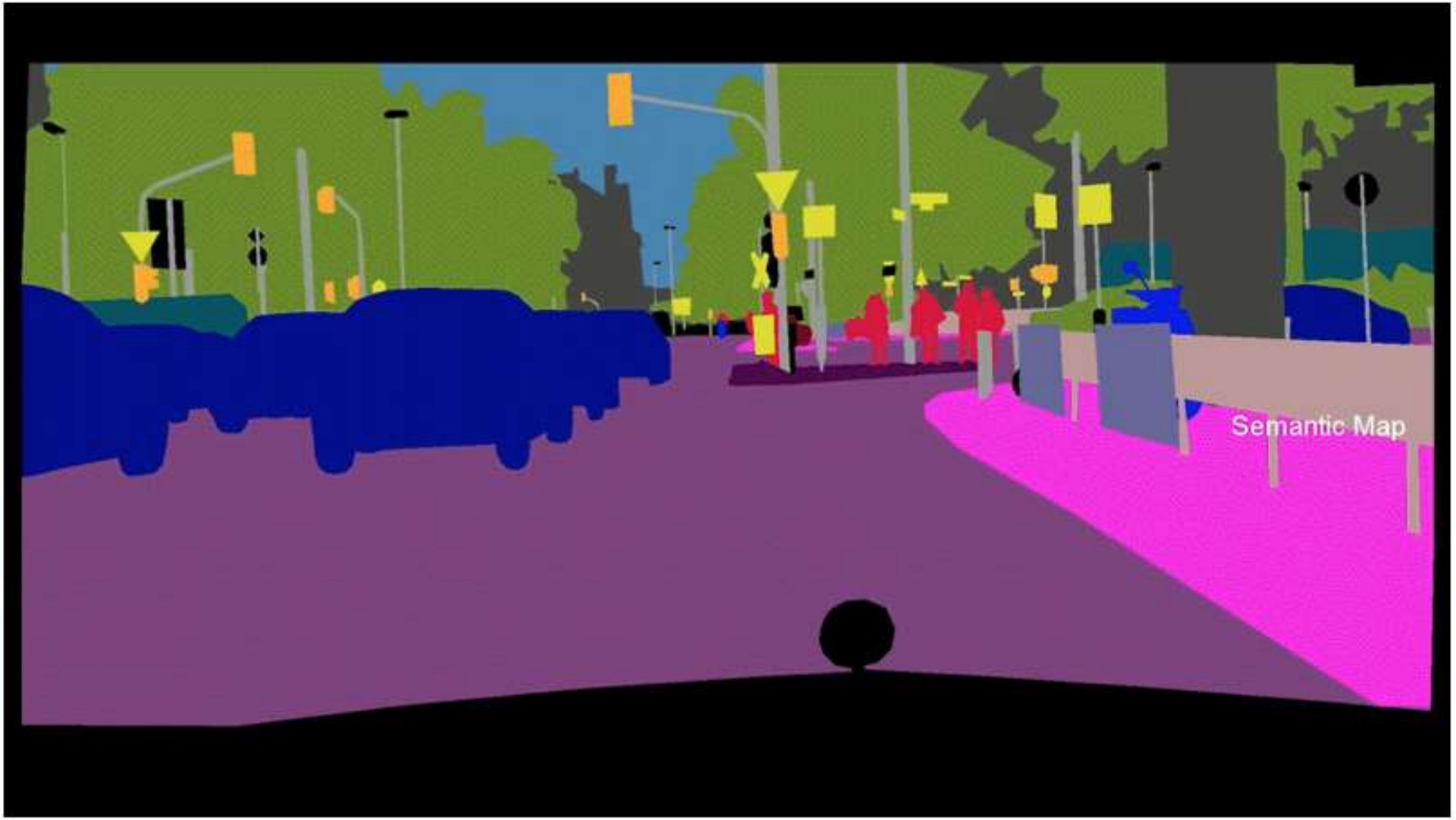

Image-to-Image Translation with Conditional Adversarial Networks

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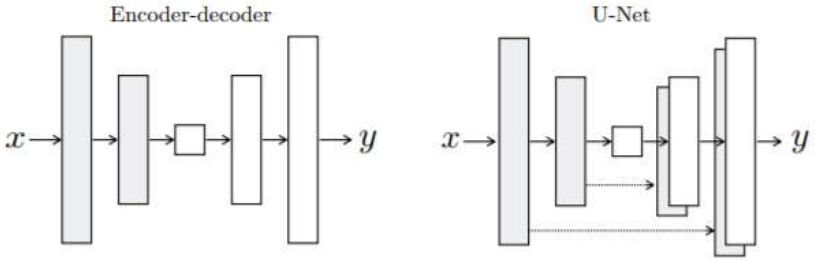
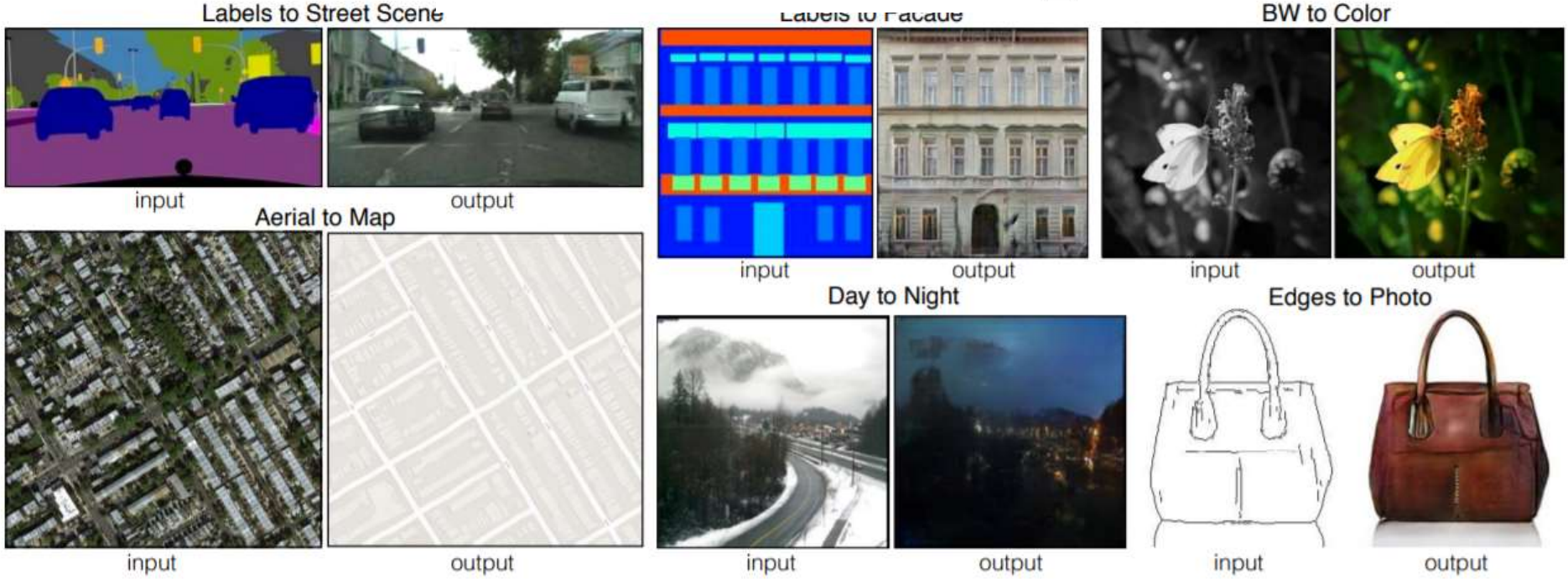
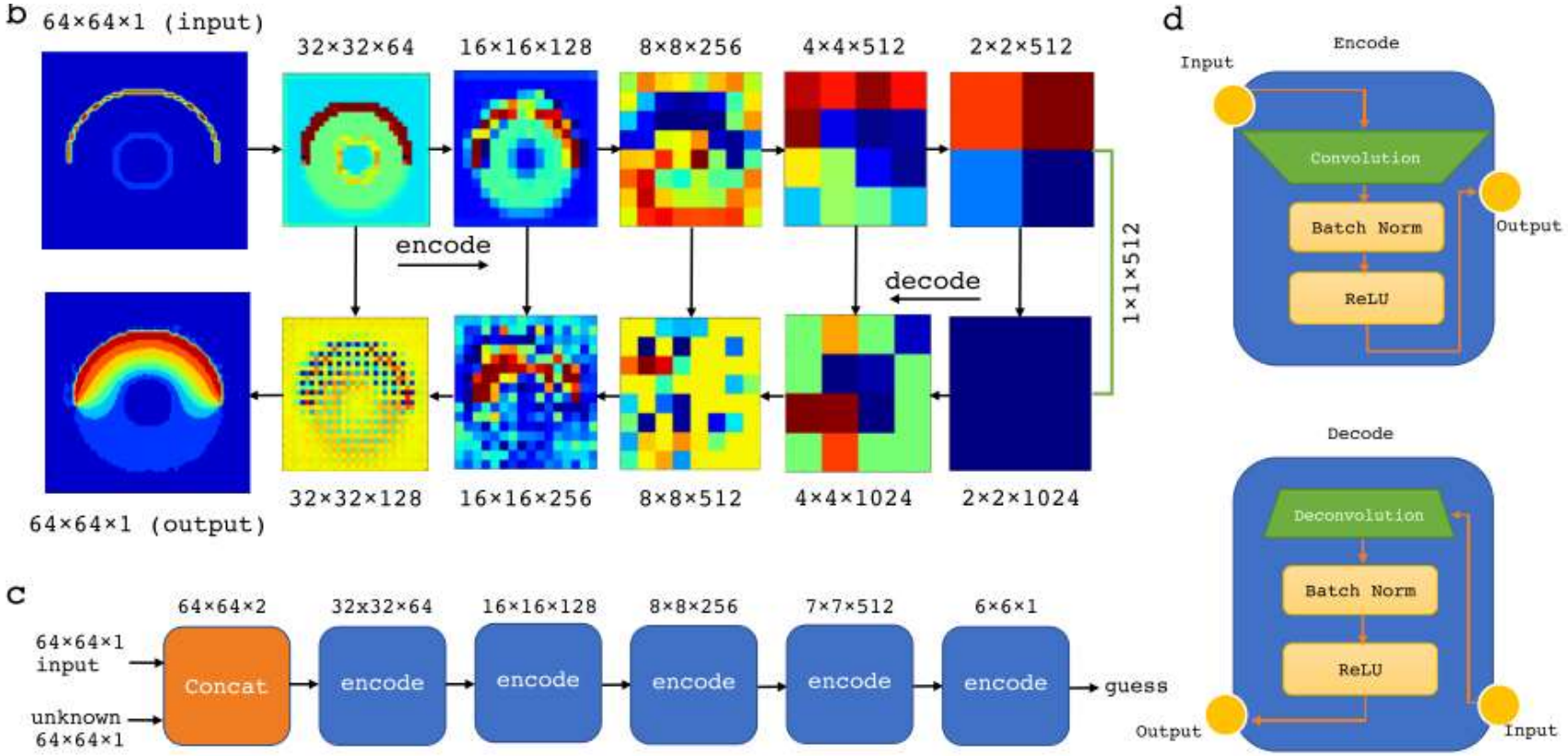
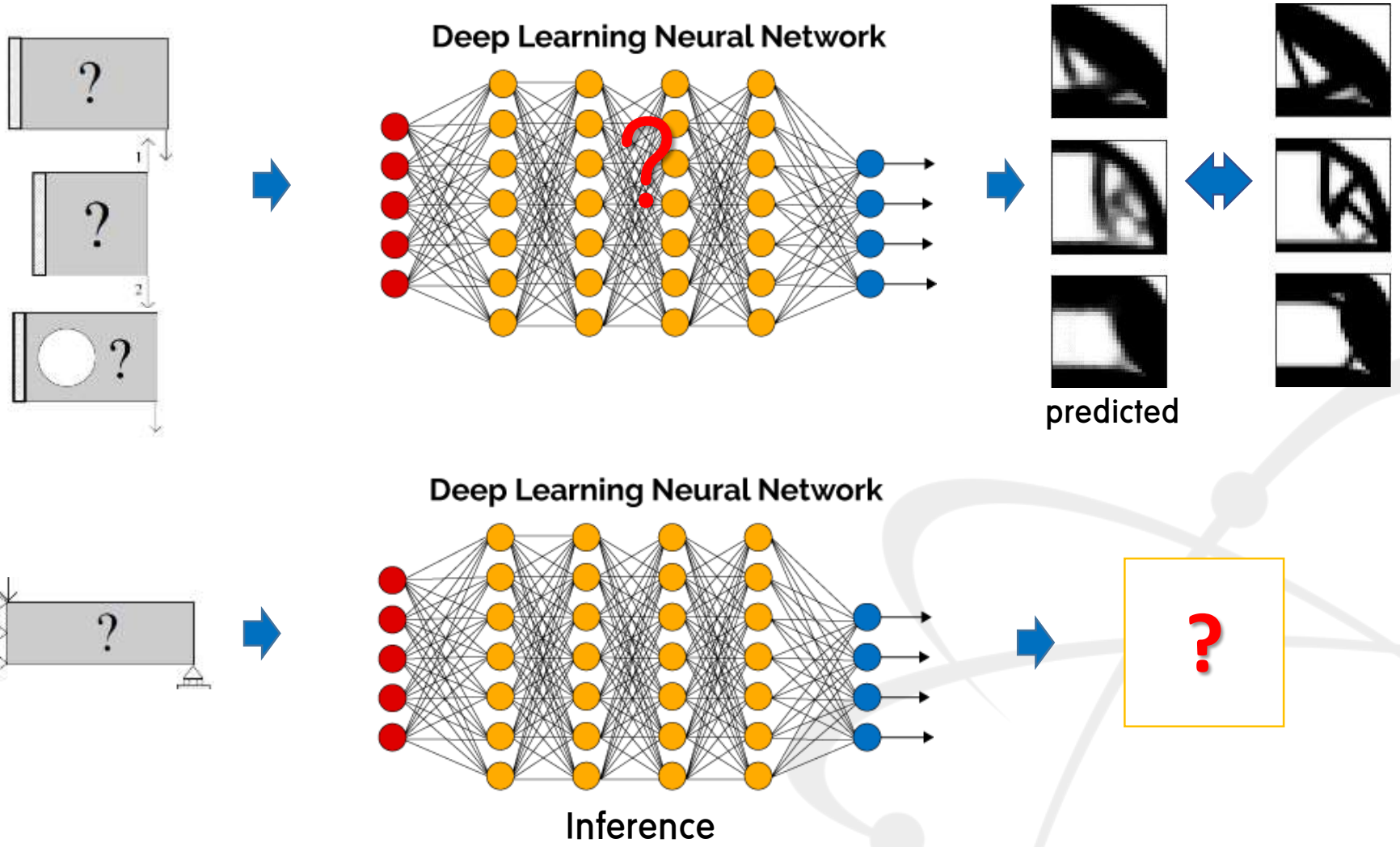




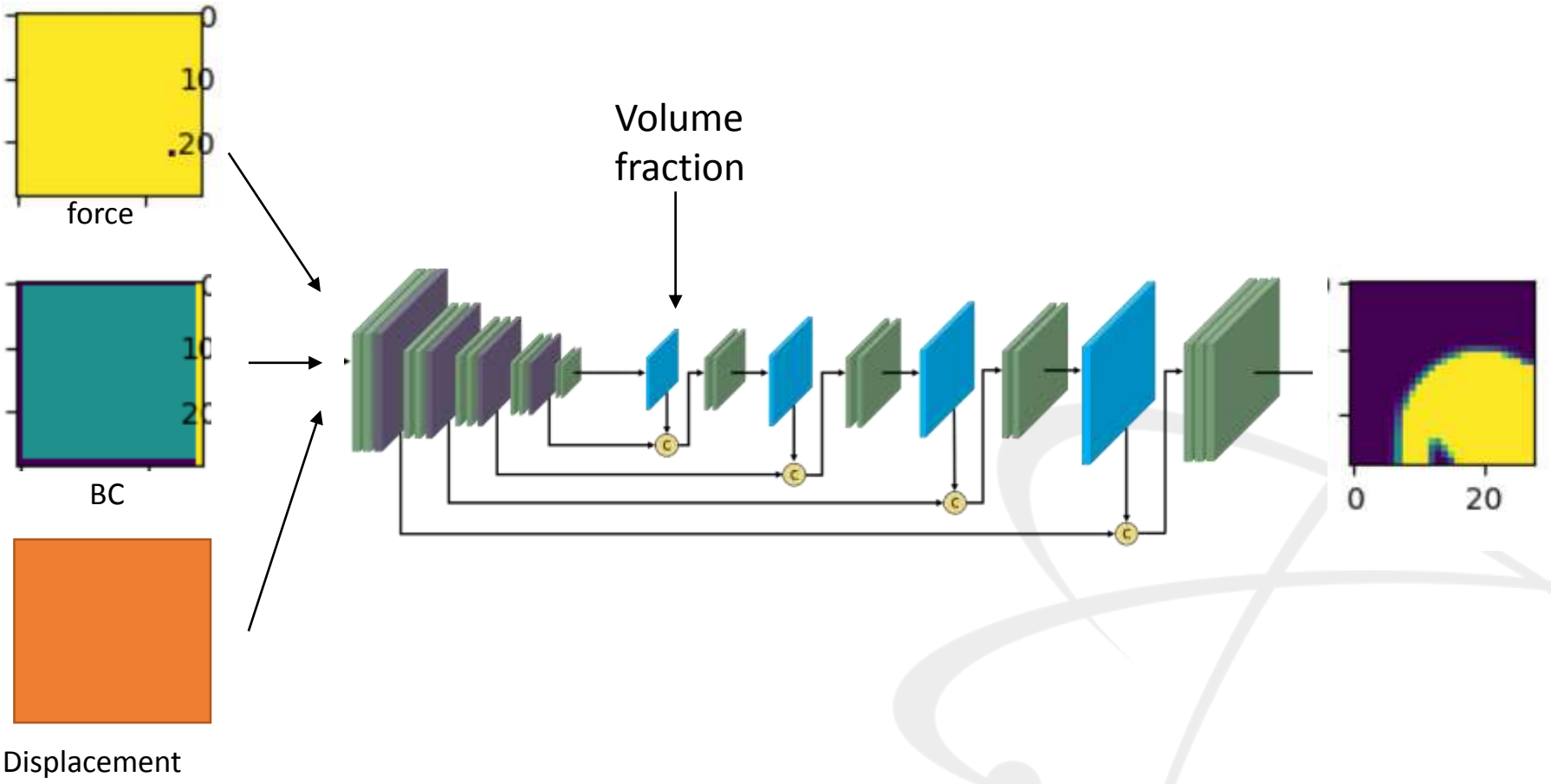
Deep Learning the Physics of Transport Phenomena



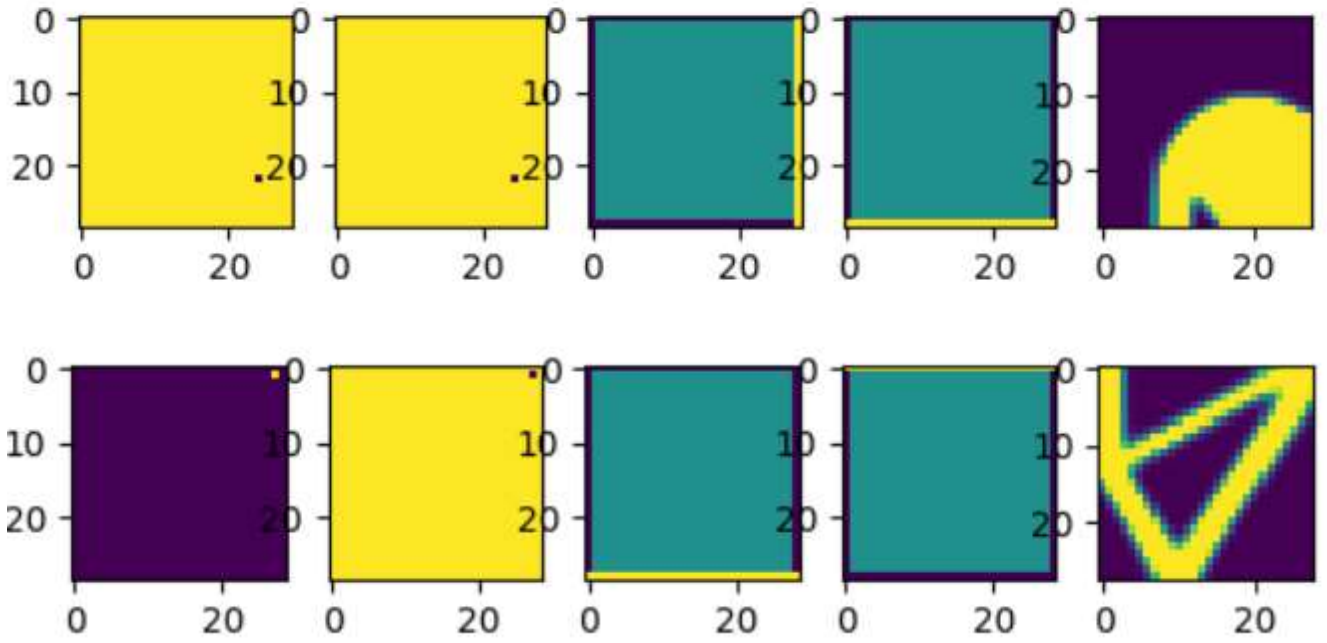
Deep Learning for Topology Optimization Design



Deep Learning for Topology Optimization Design

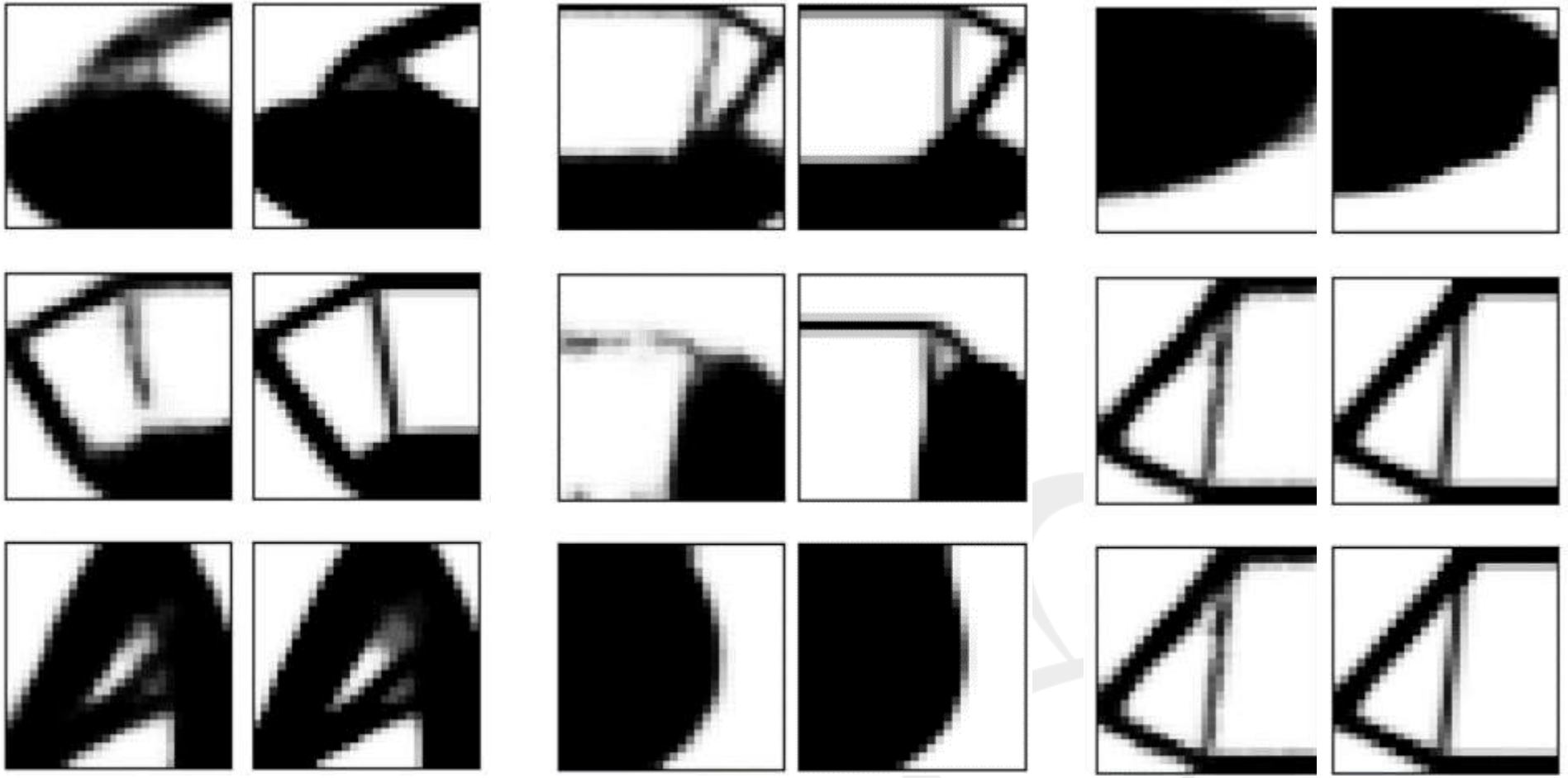


Deep Learning for Topology Optimization Design



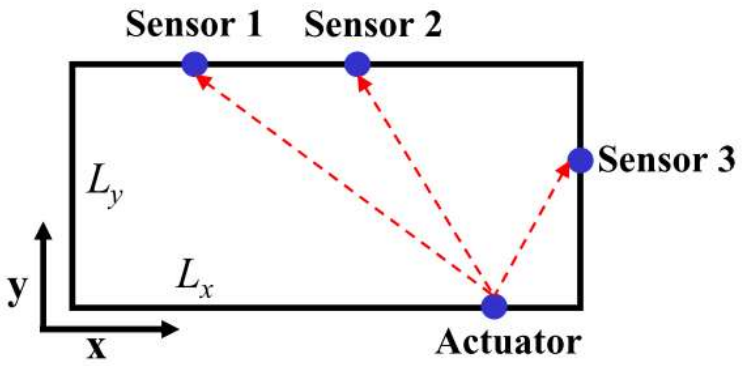
입력 및 출력 데이터의 시각화

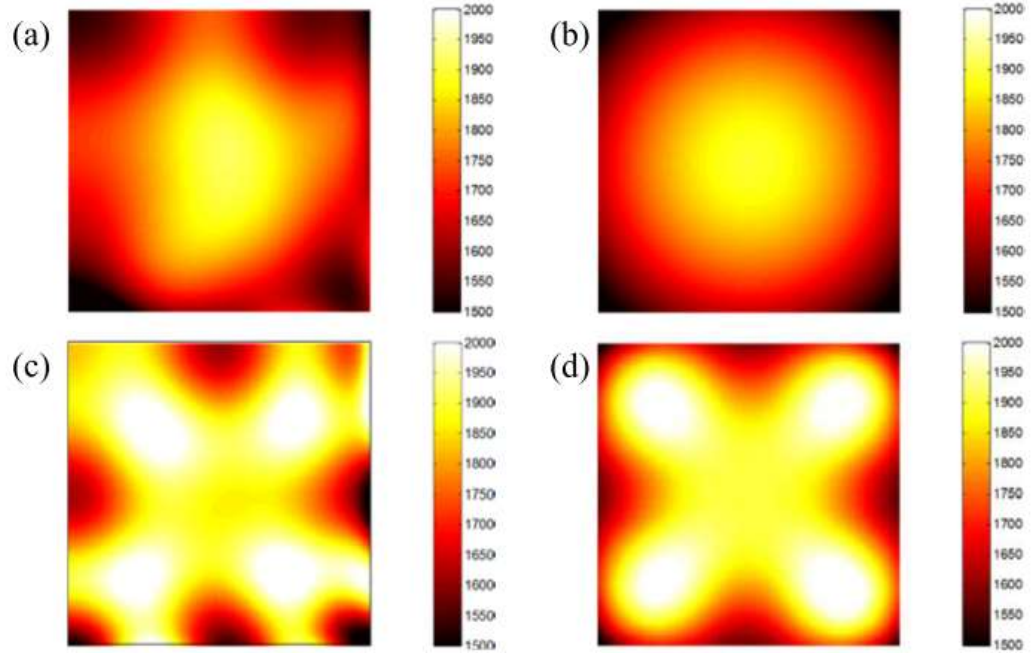
Deep Learning for Topology Optimization Design



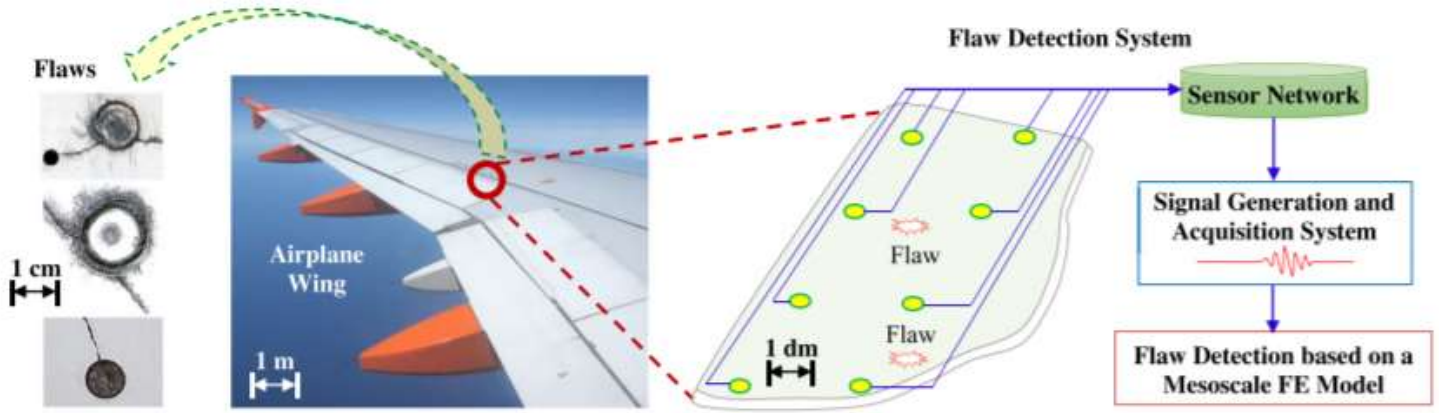
predicted Optimized predicted Optimized predicted Optimized

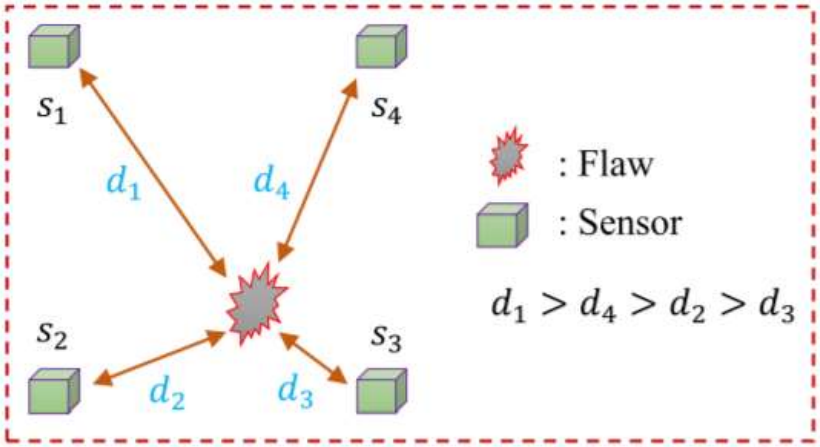
Inverse estimation of the temperature field within a gas-filled duct section by use of acoustic data

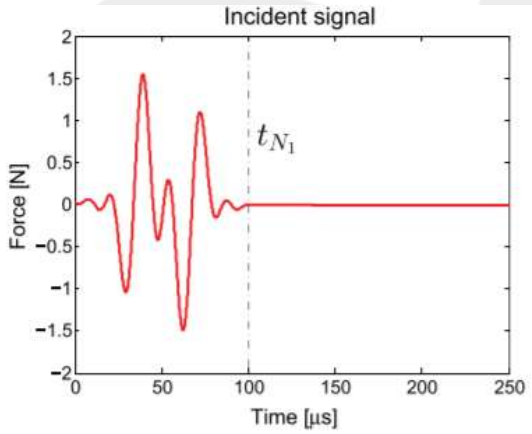




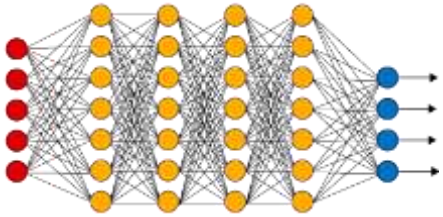
비파괴 검사


Flaws
1 cm
Airplane Wing
1 m
Flaw Detection System
Sensor Network
Signal Generation and Acquisition System
Flaw Detection based on a Mesoscale FE Model
Flaw
Flaw
1 dm

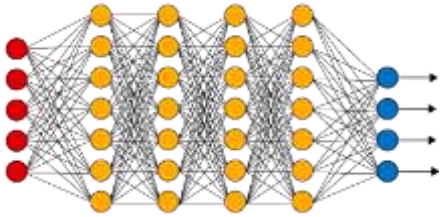

s_1
s_2
s_3
s_4
d_1
d_2
d_3
d_4
: Flaw
: Sensor
$d_1 > d_4 > d_2 > d_3$

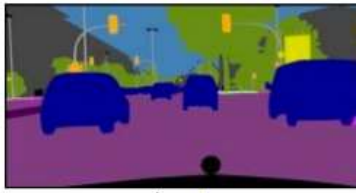

Incident signal
Force [N]
Time [μs]
t_{N_1}

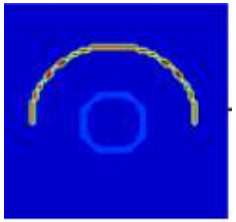
딥러닝이란?

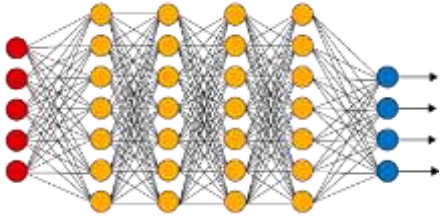


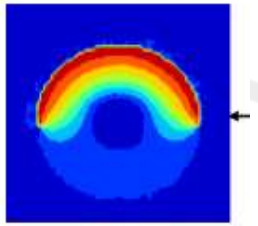
사람

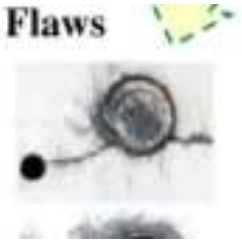


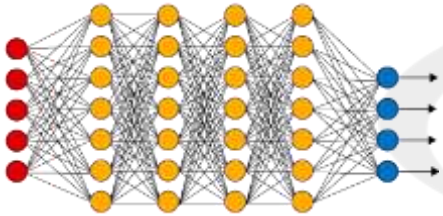


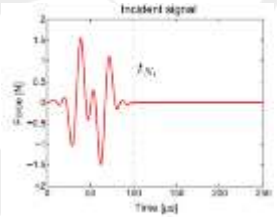




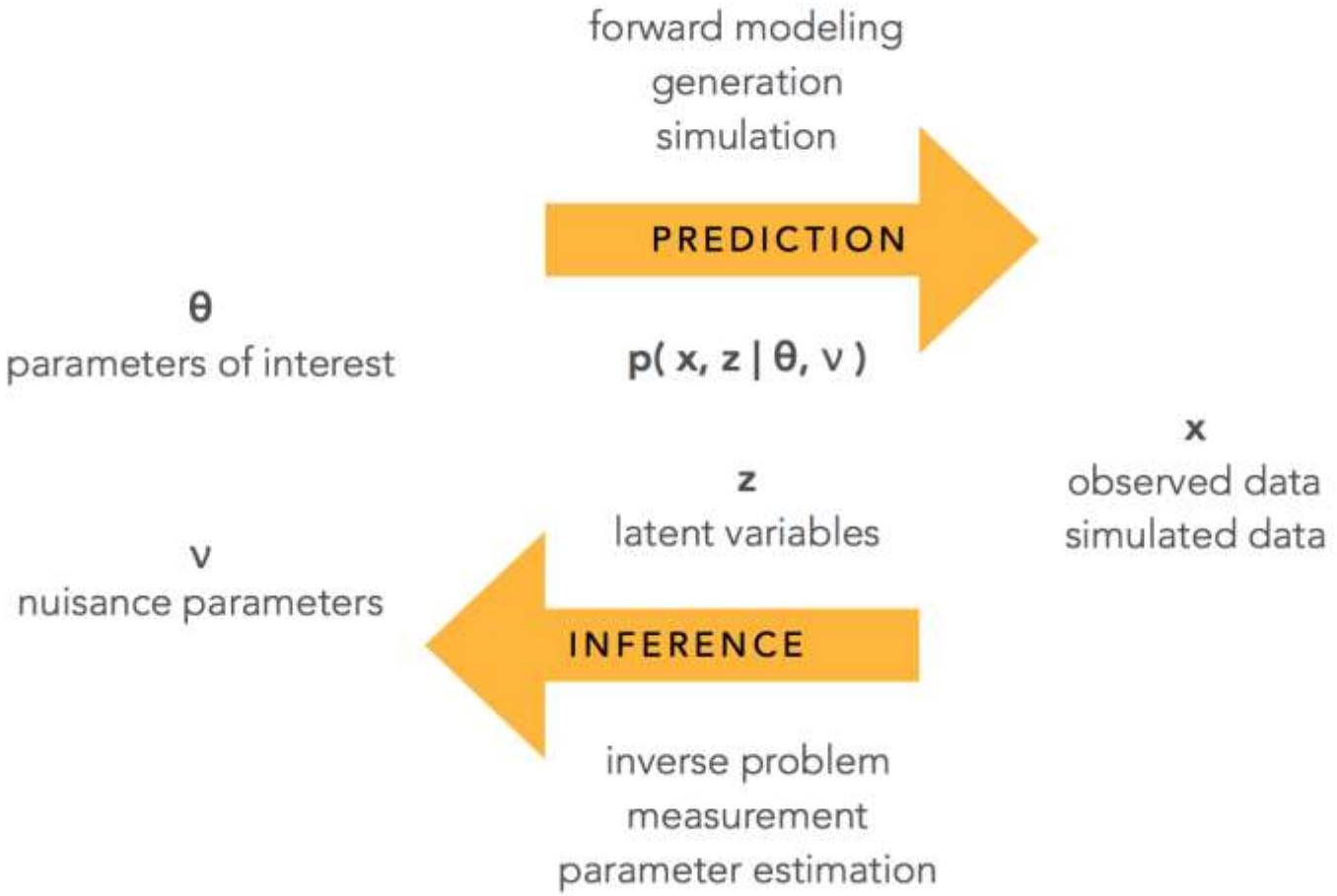






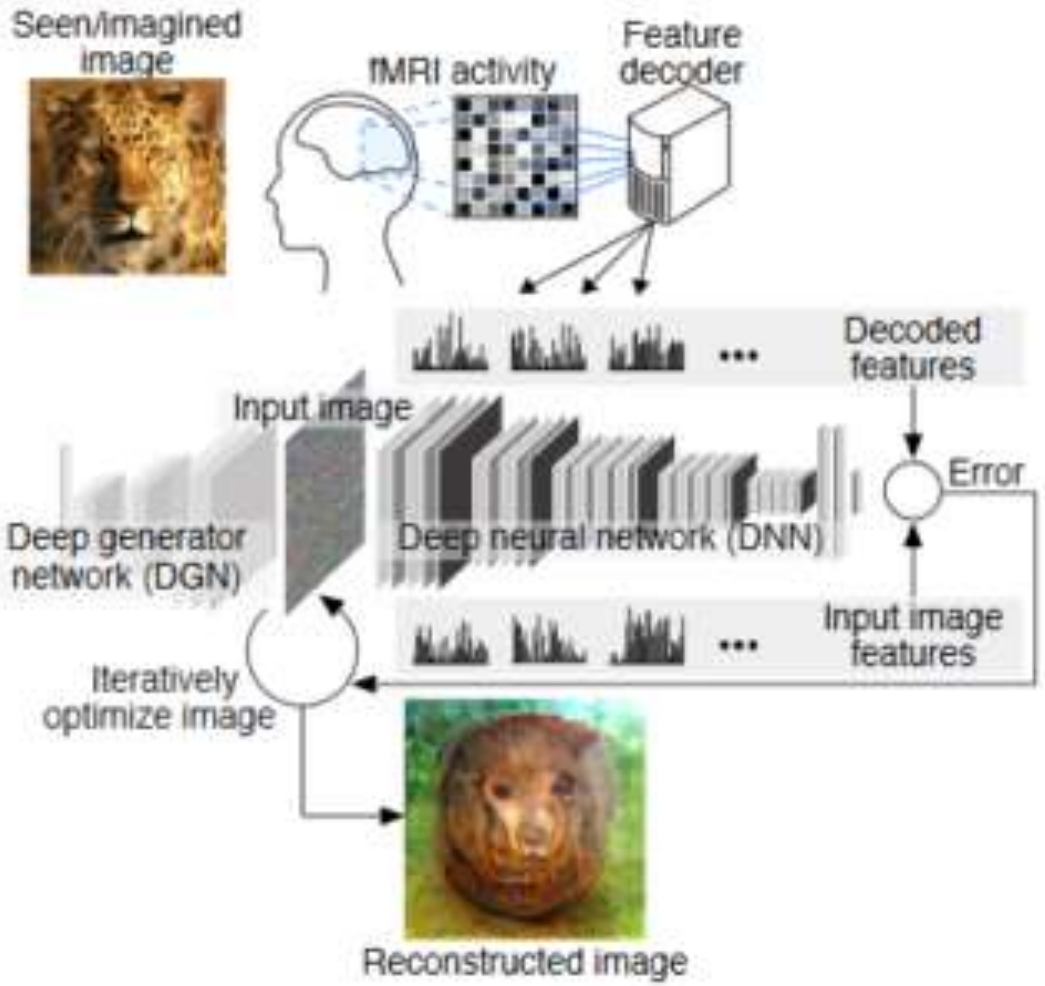


딥러닝을 이용한 물리현상 분석



http://helper.ipam.ucla.edu/publications/dlt2018/dlt2018_14649.pdf

fMRI to Image

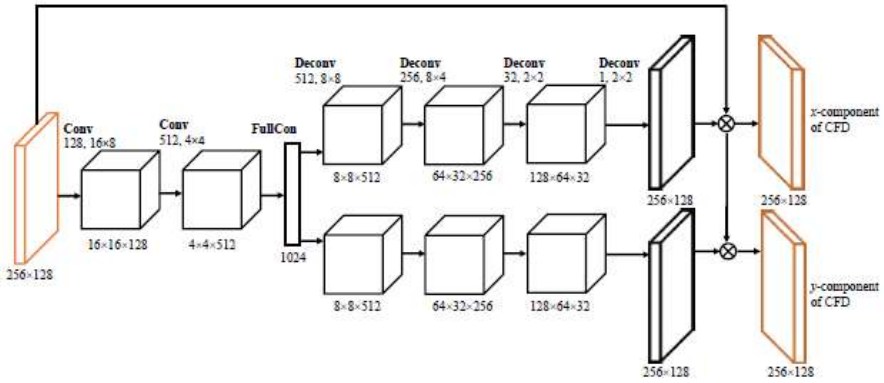


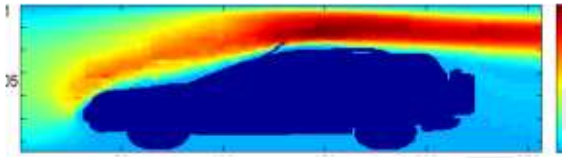
뇌의 동작 원리를 꼭 알아야 할까요?

https://www.biorxiv.org/content/biorxiv/early/2017/12/30/240317.full.pdf

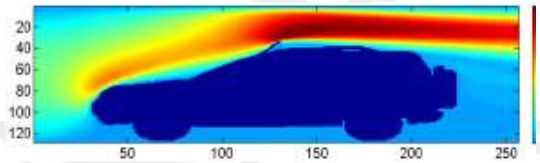
Convolutional Neural Networks for Steady Flow Approximation

$$y = f'(x)$$





CNN Prediction

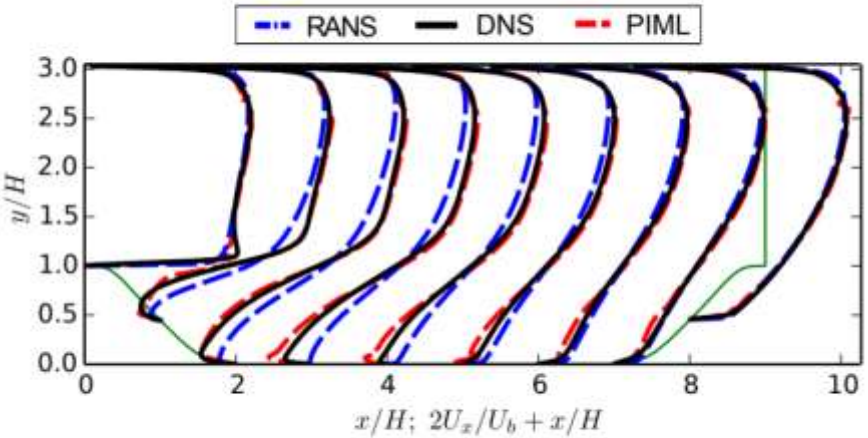


LBM

A comprehensive physics-informed machine learning framework for predictive turbulence modeling

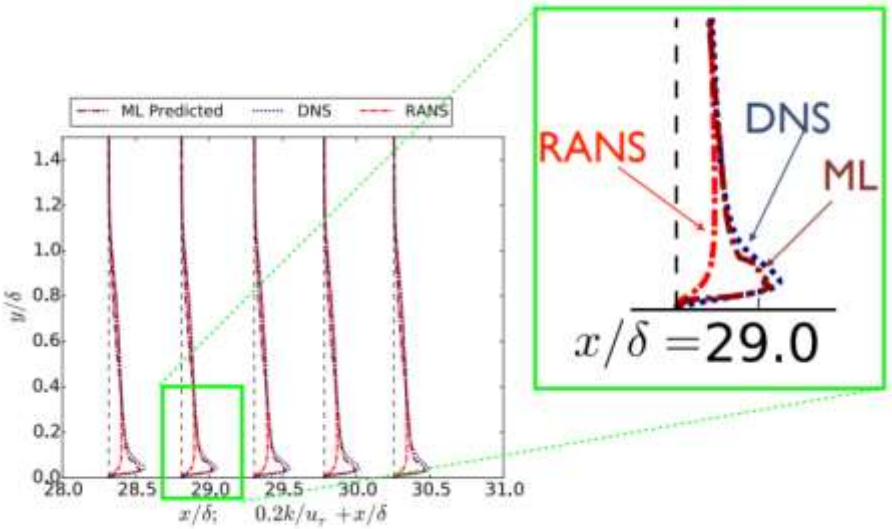
$$y=f(x)+f'(x)$$

Learning Both Reynolds Stress & Eddy Viscosity



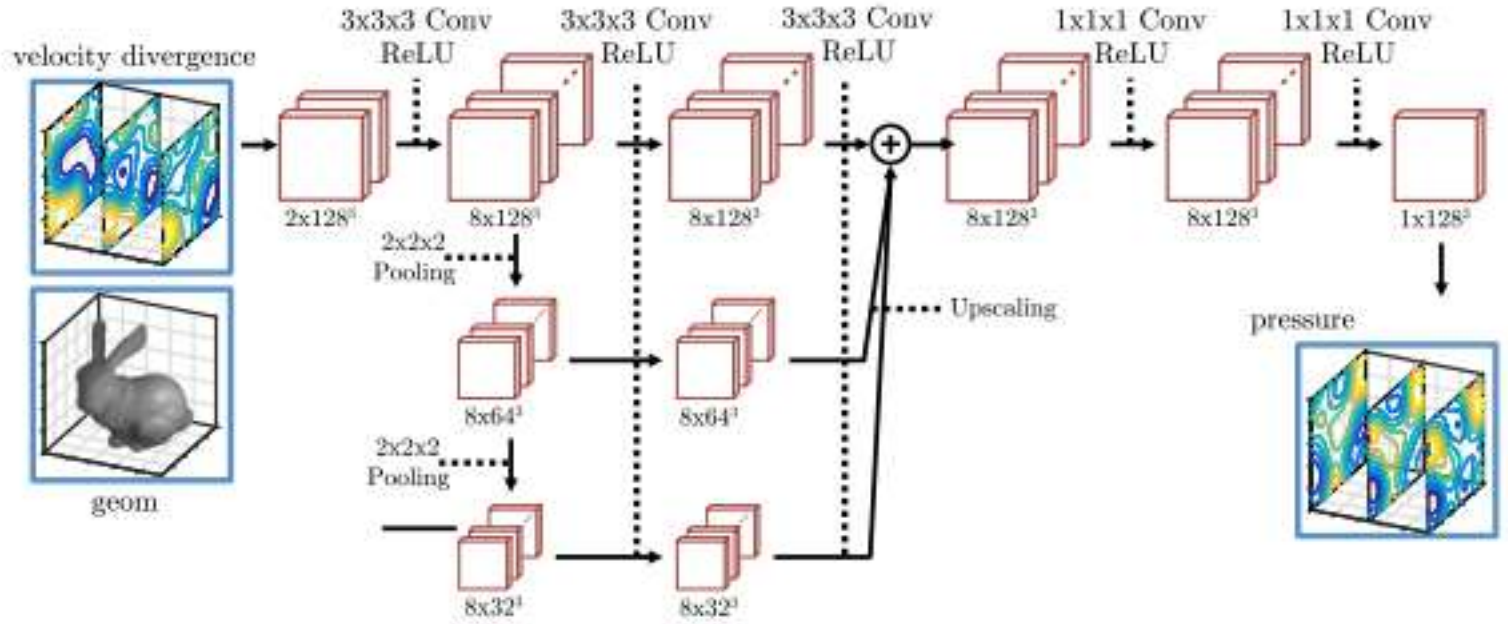
Mean Velocity Prediction

Turbulent Kinetic Energy

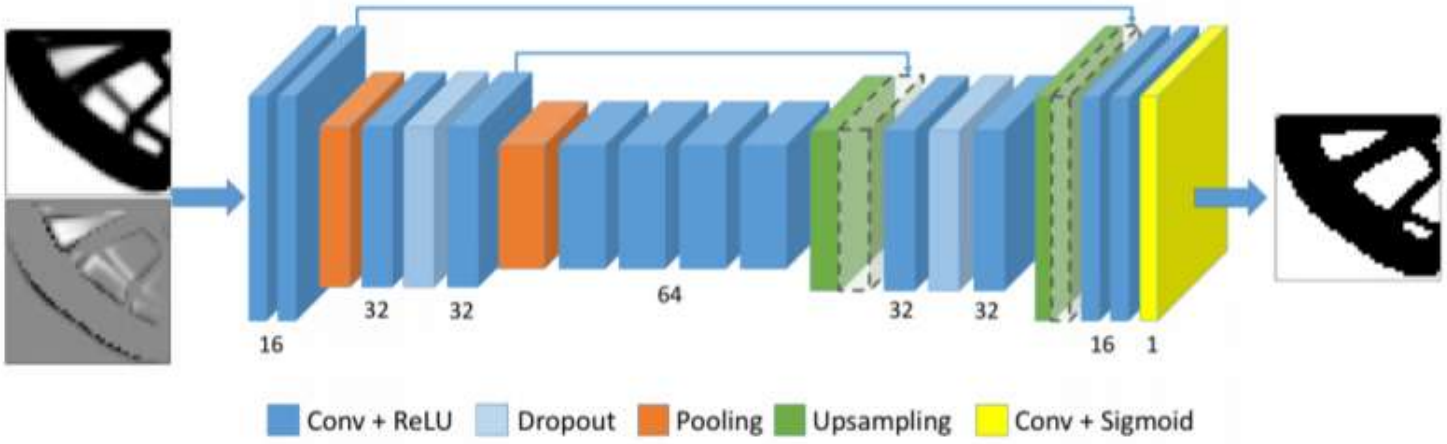


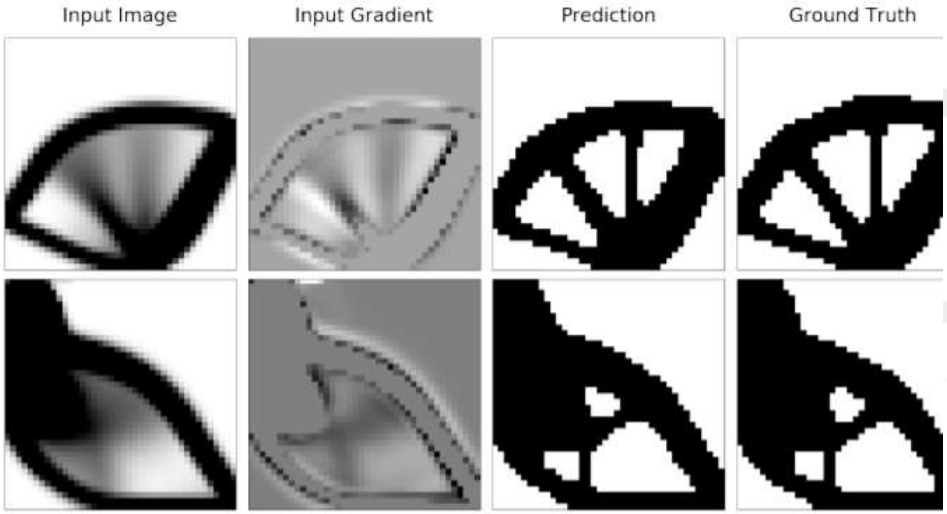
Accelerating Eulerian Fluid Simulation with Convolutional Networks

$$y=g(f'(x))$$



Neural networks for topology optimization



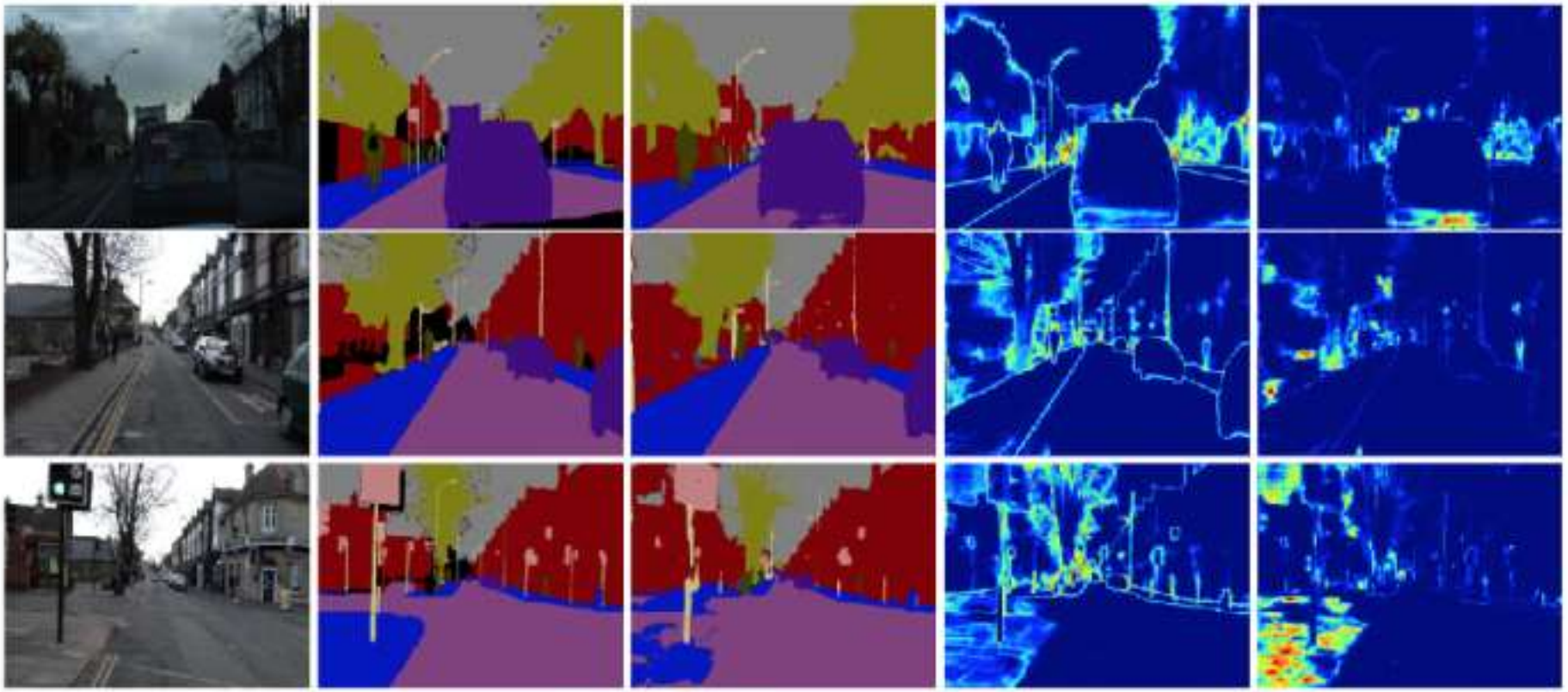


https://arxiv.org/abs/1709.09578

문제점....

얼마나 예측한 값을
믿을 수 있는가?

Aleatoric & Epistemic Uncertainty



(a) Input Image (b) Ground Truth (c) Semantic Segmentation (d) Aleatoric Uncertainty (e) Epistemic Uncertainty

https://arxiv.org/abs/1703.04977

Hybrid Approach?

PDE

$y=g(x)$

Machine Learning

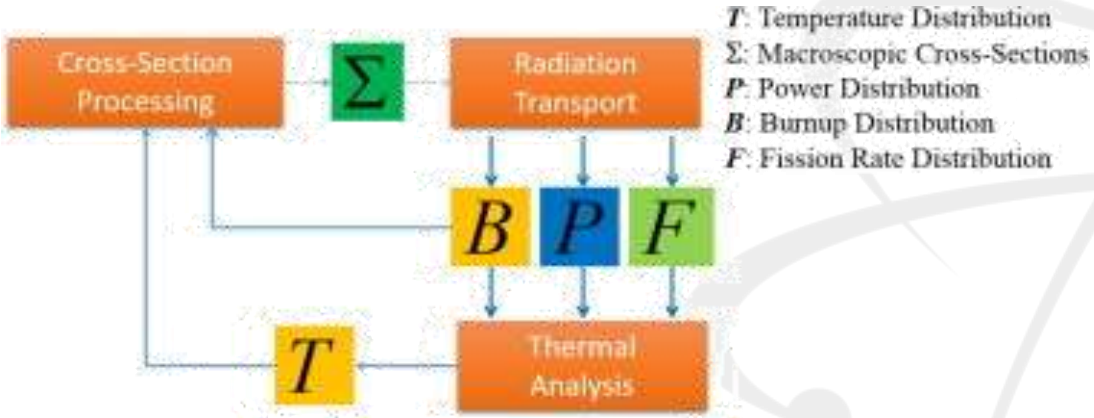
$y=g'(x)$

Dimensionality reducibility for multi-physics reduced order modeling

The final goal of this study is to construct a surrogate model for the coupled Rattlesnake-BISON models

The computational cost needed for the construction of surrogate models for a multi-physics model can be significantly reduced if one employs dimensionality reduction to identify the effective DOF.

Another important conclusion of this study is that while fine mesh simulation is highly needed to accurately describe the multi-physics nature of system behavior, it comes at a great cost.



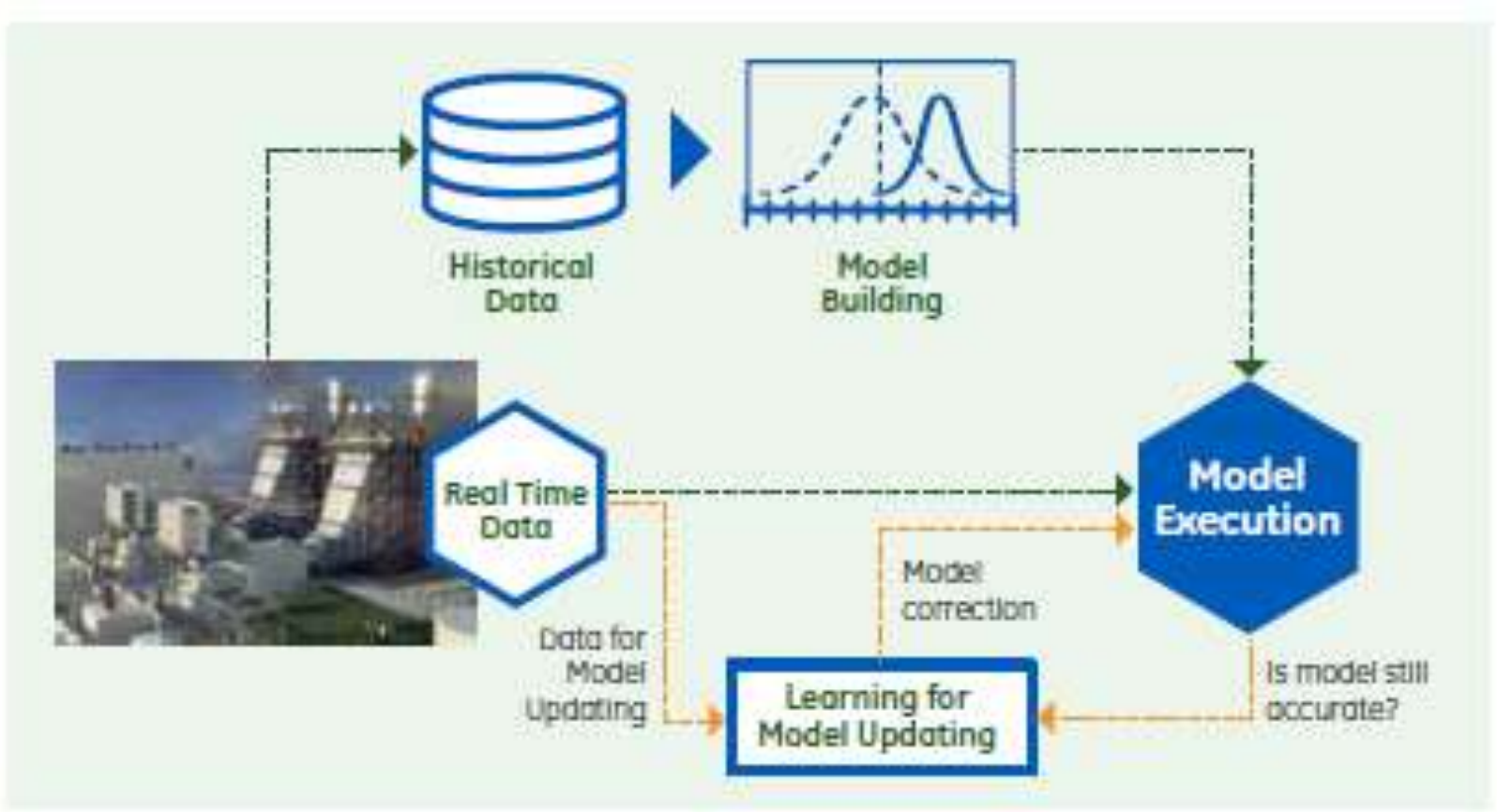
Combustion modeling using principal component analysis

- Direct numerical simulation of combustion systems is impossible
  - Resolution requirement
  - Number of equations to be solved
    - Ex) 53 species and 325 reactions
    - 57 strongly coupled PDE

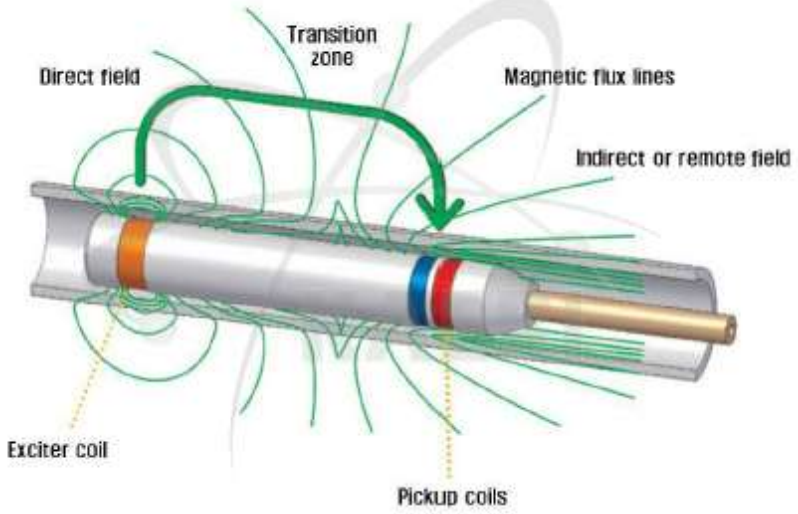
- PCA offers the potential to automate the selection of an optimal basis for representing the manifolds

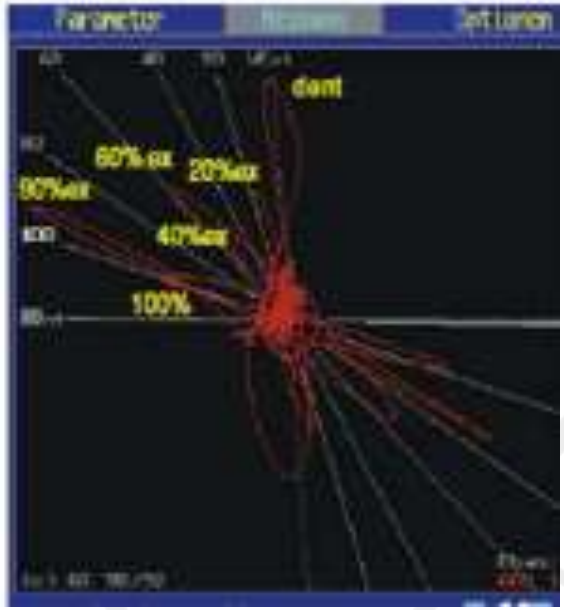
$$\mathbf{X} \approx \boldsymbol{\eta}\mathbf{A}^{\mathsf{T}} \qquad \rho\frac{\mathrm{D}(\boldsymbol{\Phi})}{\mathrm{D}t} = -\nabla\cdot(\mathbf{j}_{\boldsymbol{\Phi}}) + (s_{\boldsymbol{\Phi}}) \qquad \rho\frac{\mathrm{D}}{\mathrm{D}t}(\eta) = -\nabla\cdot(\mathbf{j}_{\eta}) + (s_{\eta}),$$

Digital Twin



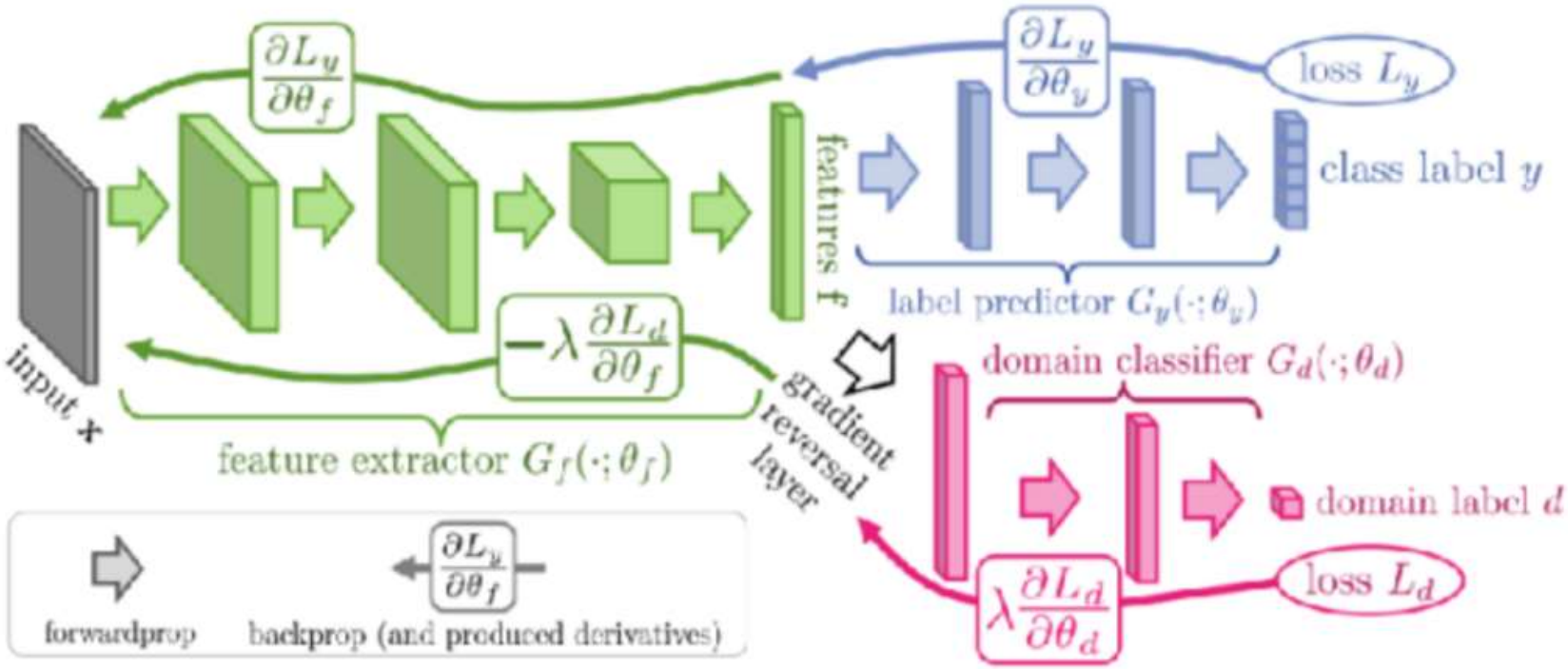
Simulation vs. Real Data





- (필요한) 데이터는 부족
- 시뮬레이터가 필요.
- 시뮬레이터 와 실제 데이터 사이의 차이는?

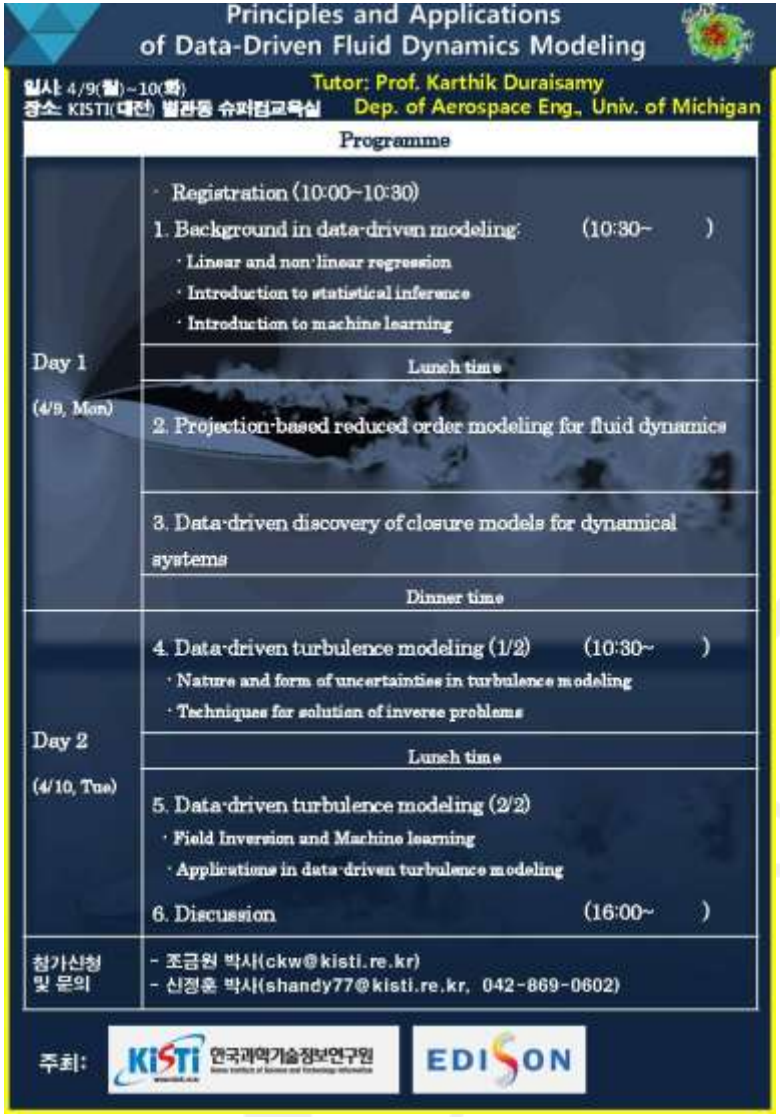
Domain Adaptation



https://arxiv.org/abs/1505.07818

연구 그룹

- Duraisamy, Univ. of Michigan
  4.9~4.10 Workshop in KISTI
- Verginia Tech
- Nam Dinh



Facebook group: Physics-informed Machine Learning

덕업일치를 꿈꾸며....

출처:네이버 웹툰 '호랭총각'

THANK YOU

Korea Atomic Energy
Research Institute