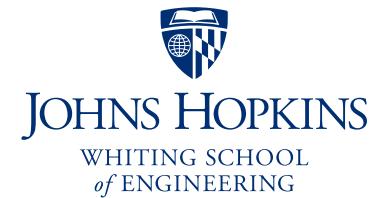


# Johns Hopkins Engineering

## Applied Machine Learning for Mechanical Engineers

Multi-Paradigm Machine Learning Models, Part 1, C

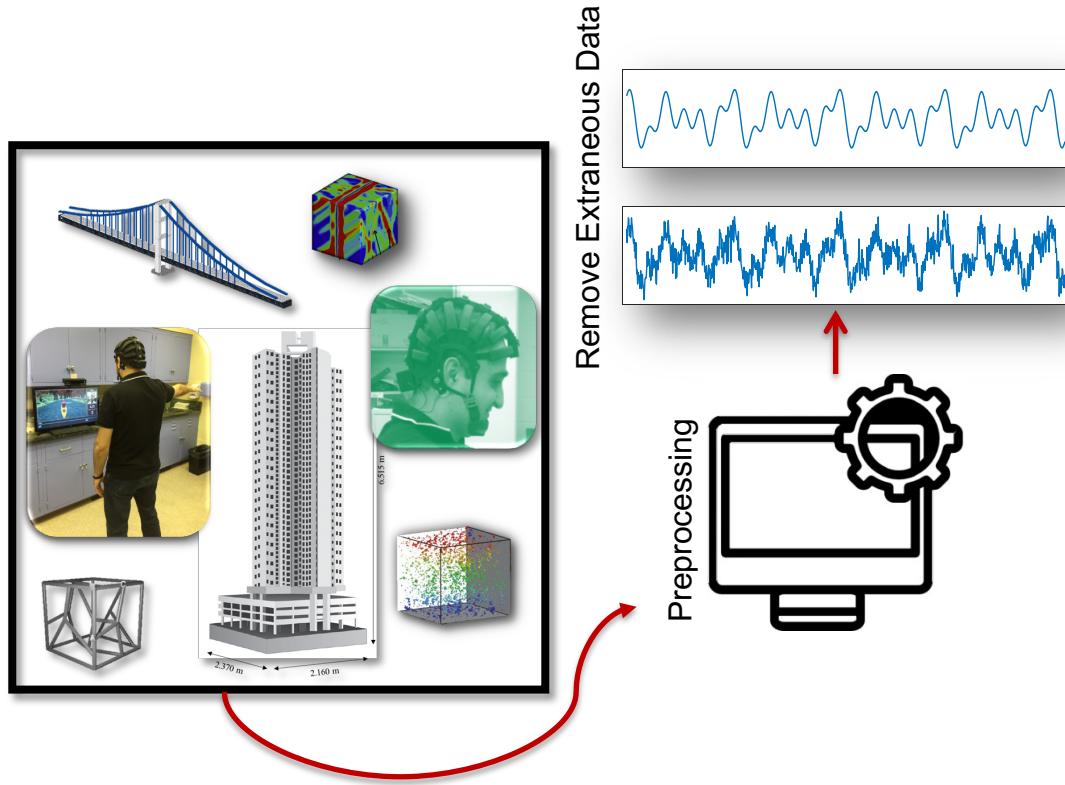


# Multi-Paradigm Smart Systems

- By the end of this lecture you will be able to:
  - Describe data decontamination and processing
  - Describe enriched domain representation
  - Describe feature extraction
  - Describe measurement development
  - Describe smart systems
  - Describe adaptive models

# Multi-Paradigm Smart Systems

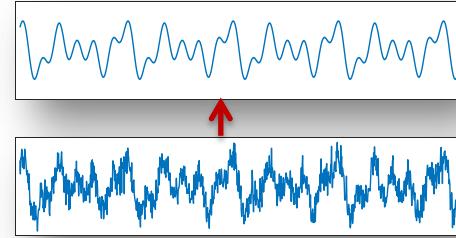
- Data decontamination and processing
  - Bring the data into an appropriate configuration
    - Missing Data
    - Irrelevant Data



# Multi-Paradigm Smart Systems

- Data decontamination and processing
  - Combinatory pattern recognition
  - Signal processing
    - Discrete Wavelet Transform
    - Synchrosqueezed Wavelet Transforms

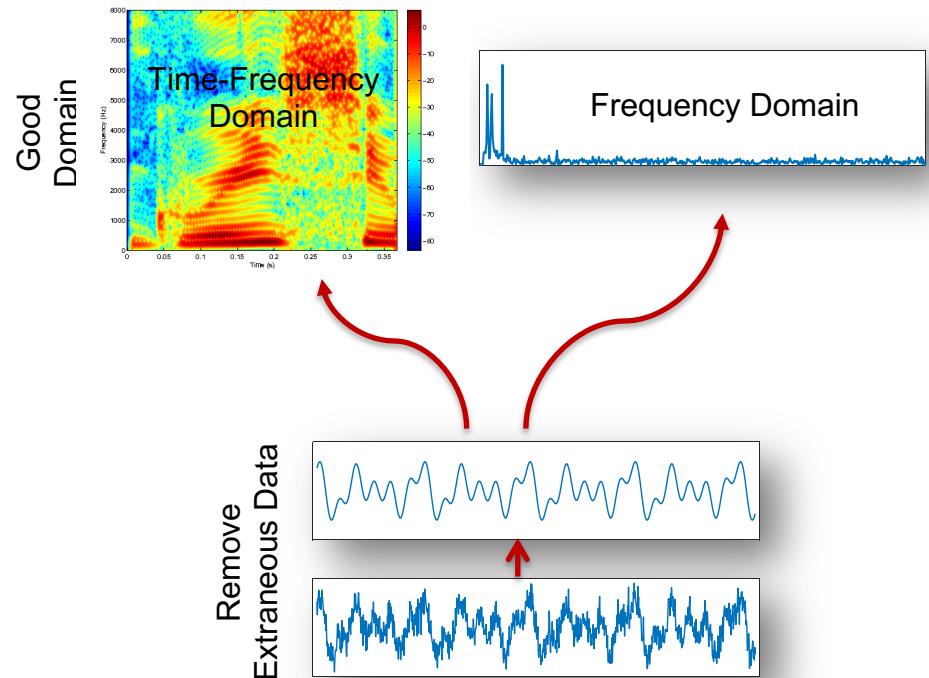
Remove  
Extraneous Data



# Multi-Paradigm Smart Systems

- Enriched domain representation

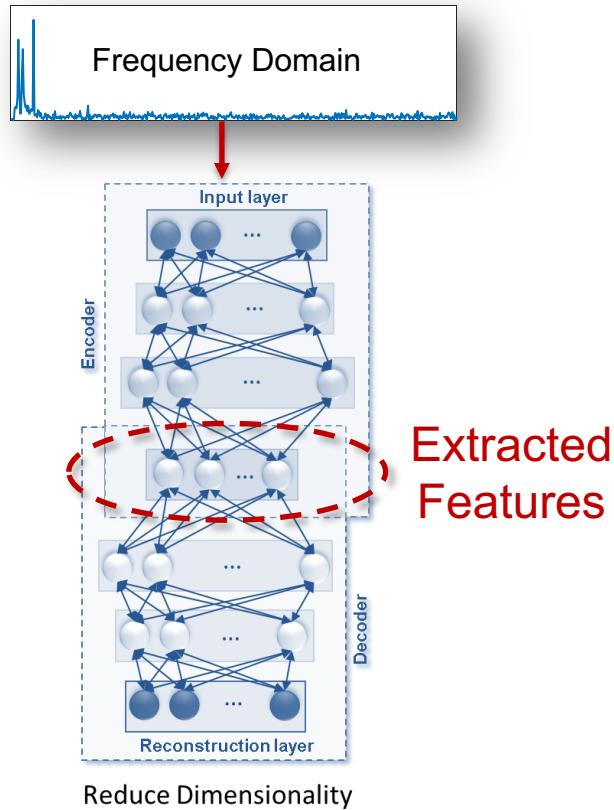
- Transform the data into a domain with enriched information
  - Frequency Domain
  - Time-Frequency Domain
  - Multi-Channel Domain



# Multi-Paradigm Smart Systems

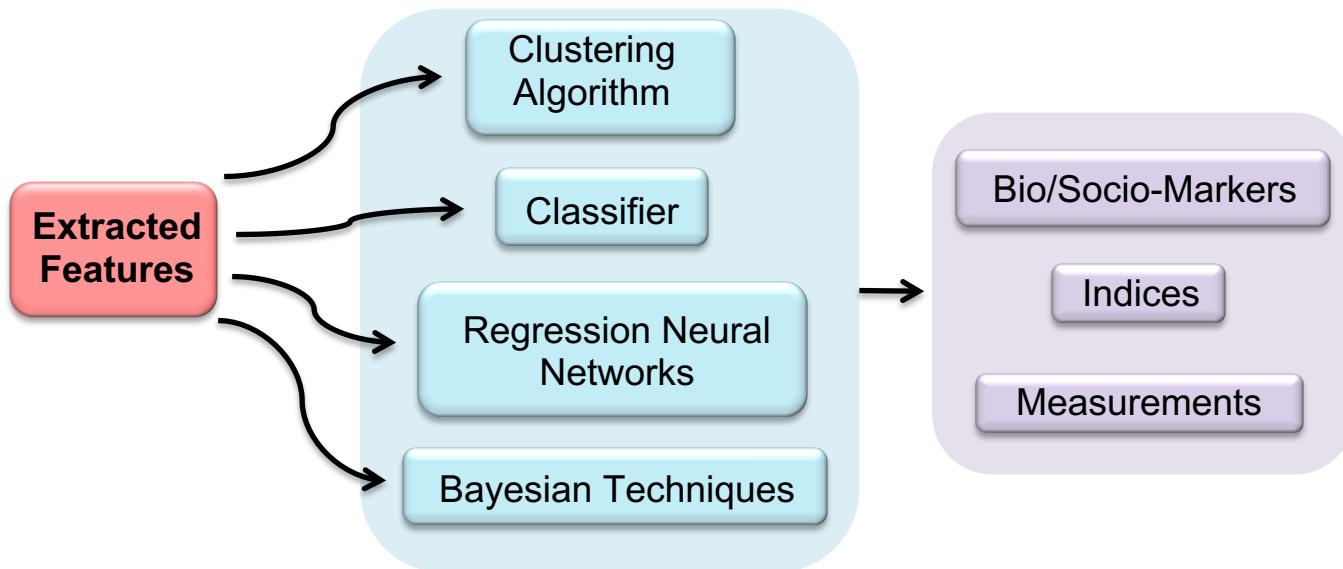
## ■ Feature Extraction

- Extract features from the good domain
  - Extracted features address some properties of the data



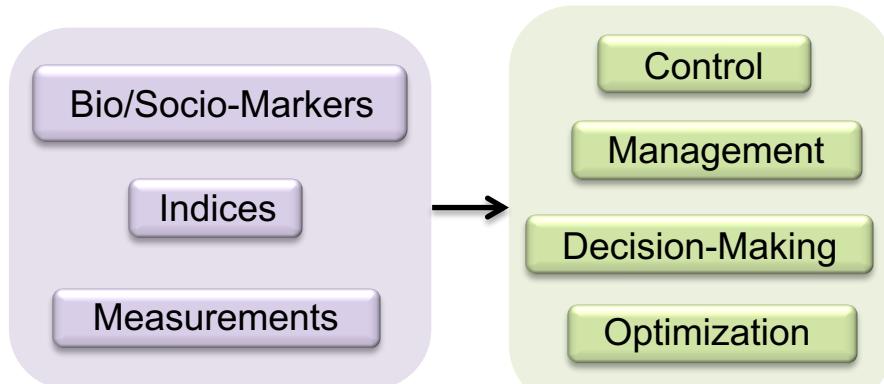
# Multi-Paradigm Smart Systems

## ■ Measurement Development



# Multi-Paradigm Smart Systems

- Smart Systems

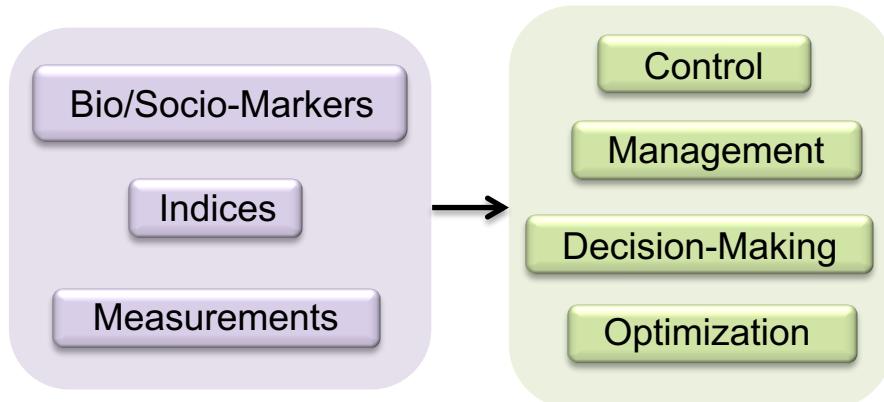


*"Hi, I'm calling to book a women's haircut for a client."*

**Google AI Assistant  
(Duplex)**

# Multi-Paradigm Smart Systems

## ■ Smart Systems



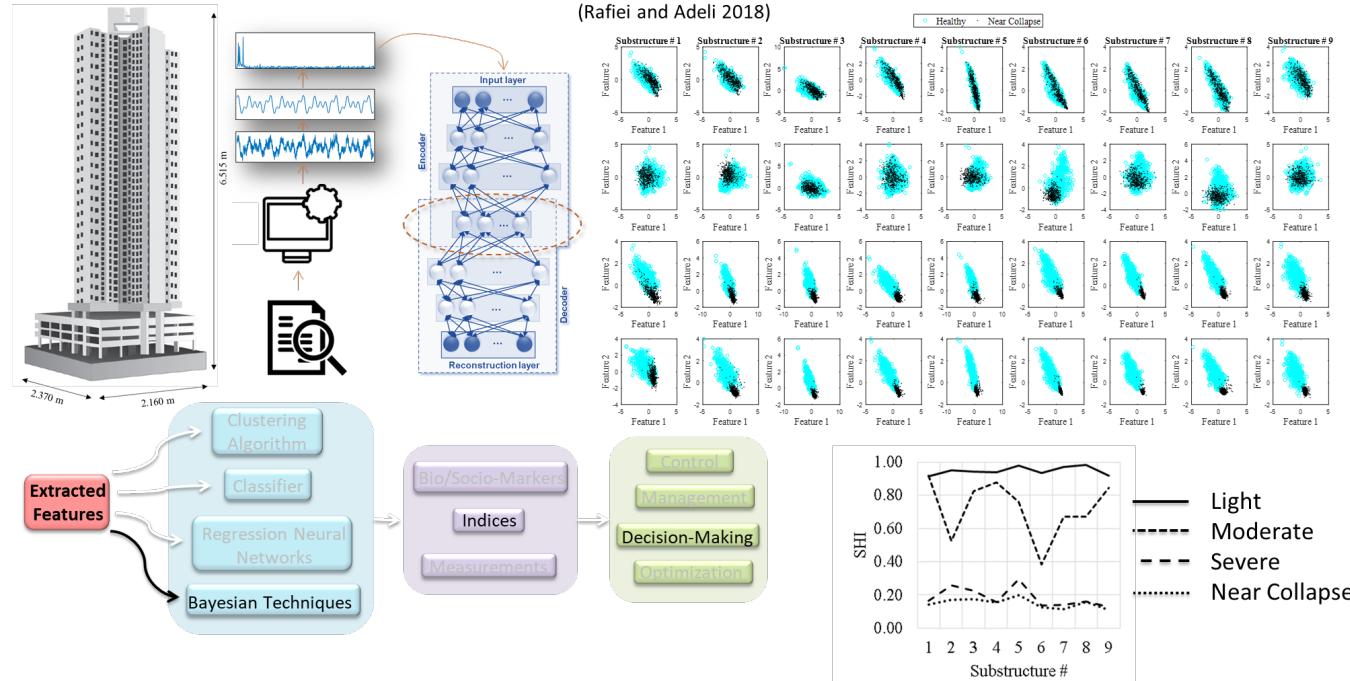
Google Fan?  
As of 11/2020

Federated Learning (Global Model)  
Gboard  
Live Transcribe  
Live Caption  
Live Relay  
Project Euphoria

# Multi-Paradigm Smart Systems

## Smart Systems

### Health Assessment of Infrastructures



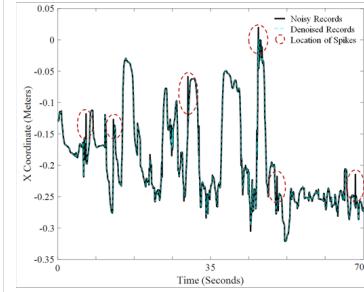
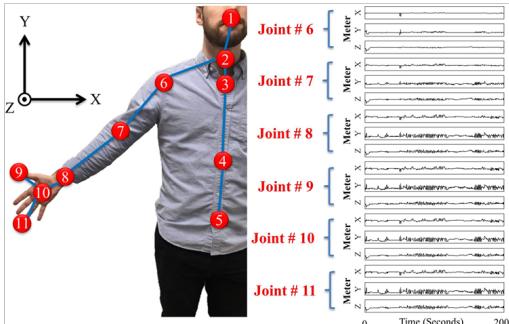
Rafiei, M. H., & Adeli, H. (2018). A novel unsupervised deep learning model for global and local health condition assessment of structures. *Engineering Structures*, 156, 598-607.

# Multi-Paradigm Smart Systems

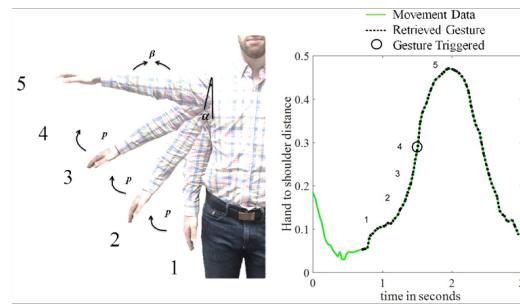
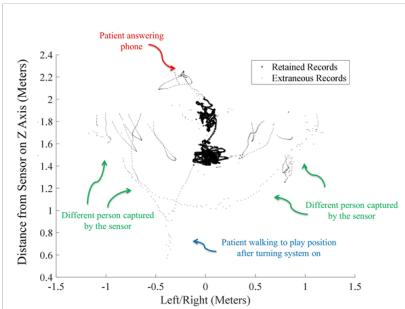
## Smart Systems

### Physical Therapy

(Yang et al. 2018)



Upper body skeleton joints captured by Microsoft Kinect™ optical motion capture system



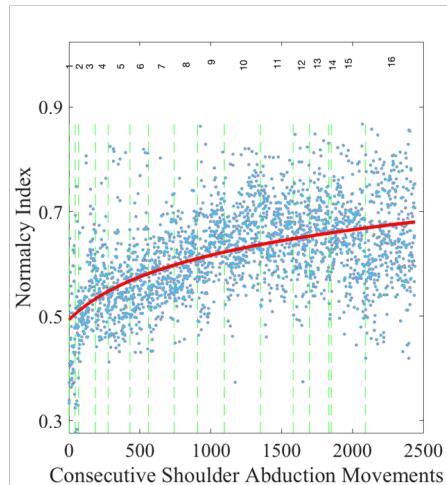
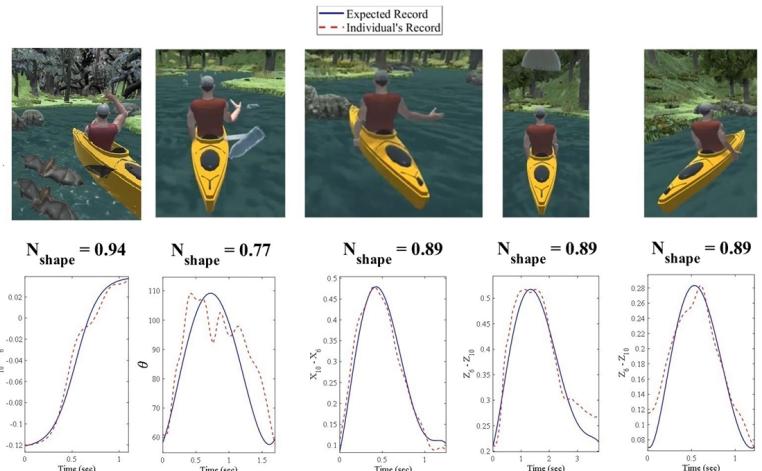
Yang, Z., Rafiei, M. H., Hall, A., Thomas, C., Midtlien, H. A., Hasselbach, A., ... & Gauthier, L. V. (2018). A novel methodology for extracting and evaluating therapeutic movements in game-based motion capture rehabilitation systems. *Journal of medical systems*, 42(12), 255.

# Multi-Paradigm Smart Systems

## ■ Smart Systems

### Physical Therapy

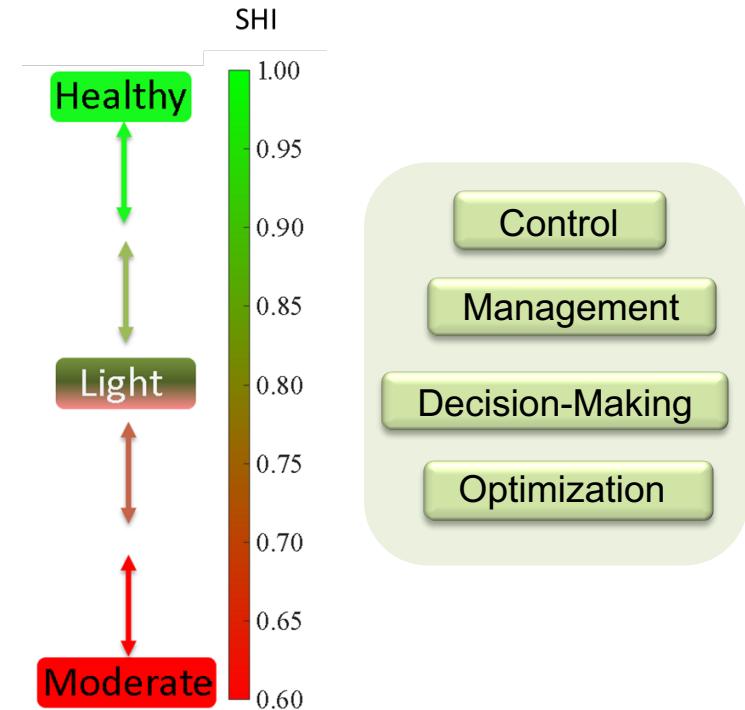
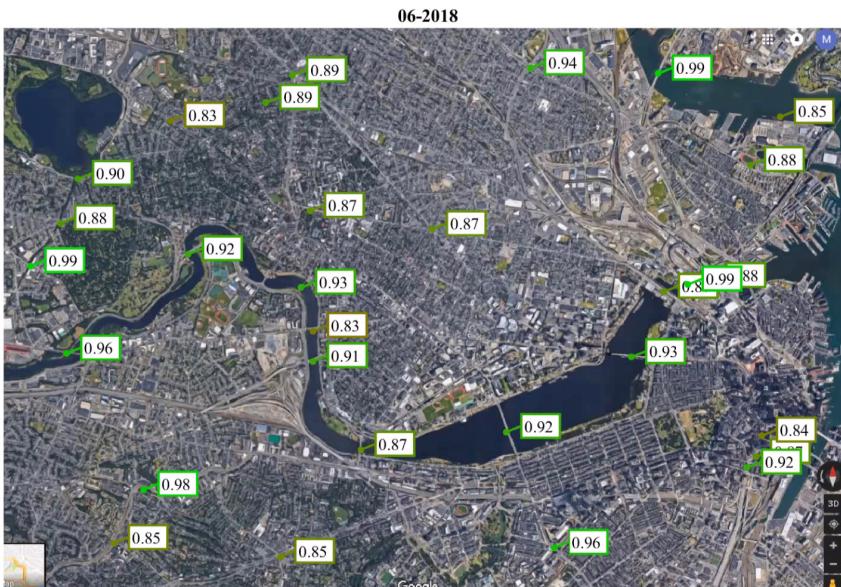
(Yang et al. 2018)



Yang, Z., Rafiei, M. H., Hall, A., Thomas, C., Midtlien, H. A., Hasselbach, A., ... & Gauthier, L. V. (2018). A novel methodology for extracting and evaluating therapeutic movements in game-based motion capture rehabilitation systems. *Journal of medical systems*, 42(12), 255.

# Multi-Paradigm Smart Systems

## ■ Adaptive Smart Systems



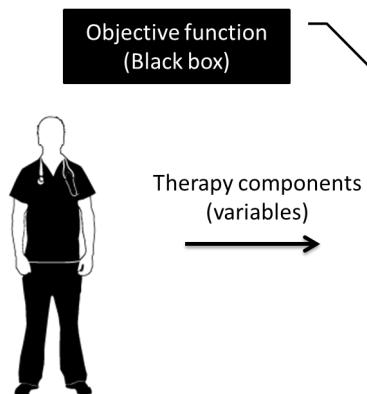
# Multi-Paradigm Smart Systems

## ■ Adaptive Smart Systems

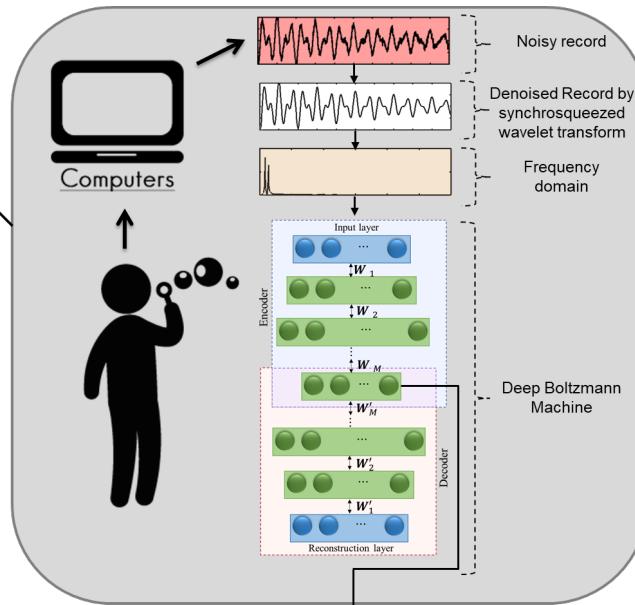
MULTI-PARADIGM ALGORITHMS FOR BIG DATA

### Dose-Response Model

- Example: dose-response systems

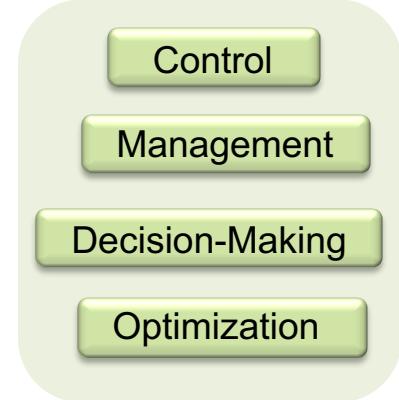


Goal: Find the optimum variables such the probability of getting higher index is maximized



$$P = \left( \frac{1}{J} \right) \sum_{j=1}^J \exp \left( \frac{\|\bar{H}_j - H\|^2}{2\sigma^2} \right)$$

Normality index  
using the last layer  
of encoder



# Multi-Paradigm Smart Systems

- Adaptive Smart Systems



Driverless cars



Smart phones  
voice recognition  
(e.g. Siri)

Control

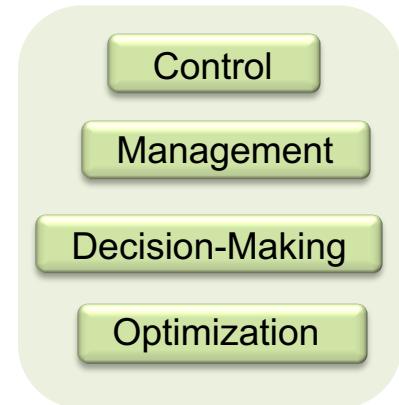
Management

Decision-Making

Optimization

# Multi-Paradigm Smart Systems

- adaptive Smart Systems
  - Thermostat
  - Medical devices
  - Cars
  - Planes
  - Jets
  - Fuel cells
  - Materials design
  - Energy and cost management
  - Health assessments of mechanical devices



# Multi-Paradigm Smart Systems

- In this lecture, you learned about:
  - Data decontamination and processing
  - Enriched domain representation
  - Feature extraction
  - Measurement development
  - Smart systems
  - Adaptive models
- In the next module, we will develop some multi-paradigm machine learning models in Python



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