

Rely on Domain Knowledge or Handoff to Machine Learning Models?

 **My answer:** not to choose one over the other, but to synergizing the two

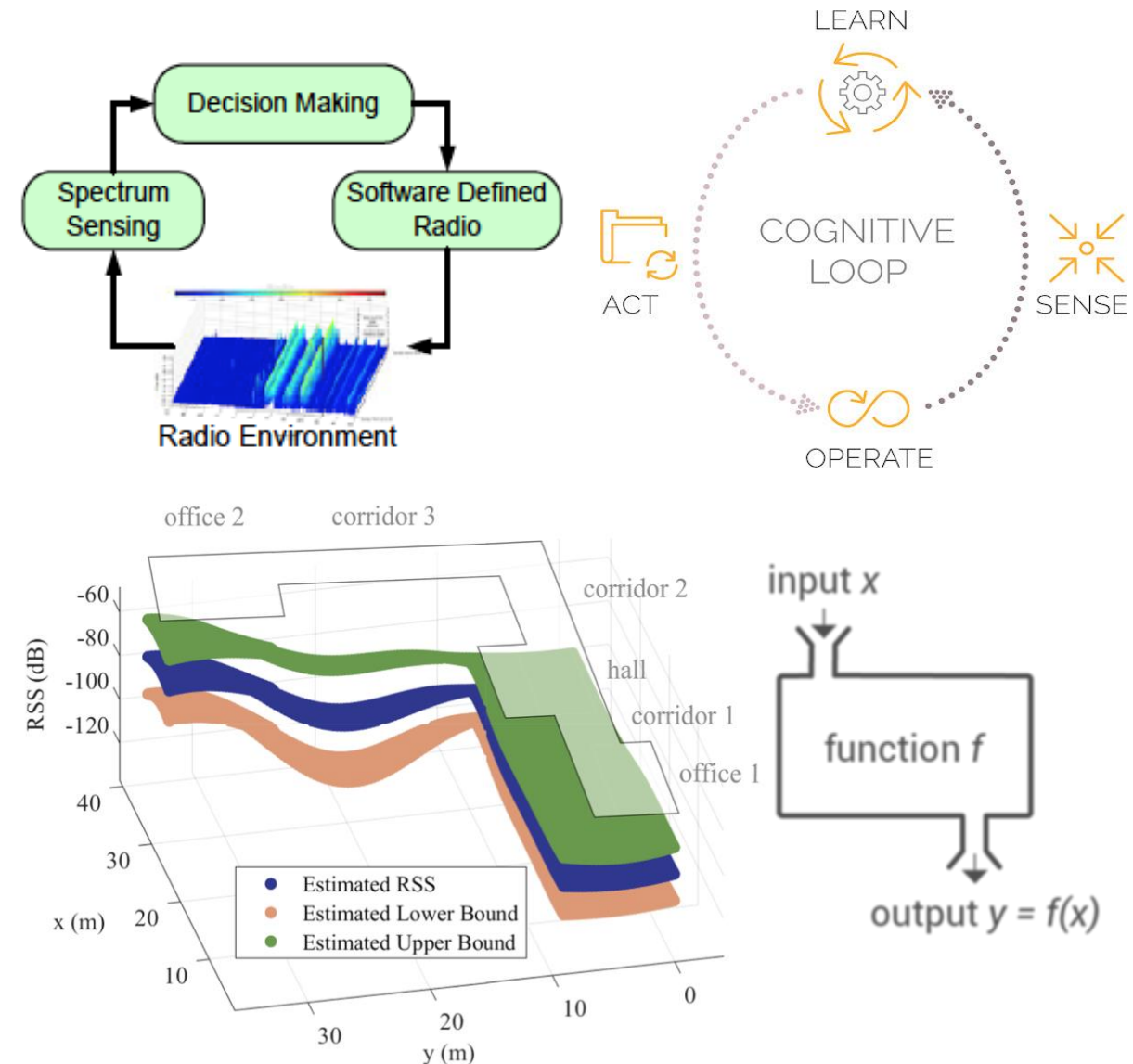
- Traditional models, though limited, have brought us to where we are today
- Potentials of ML has already been demonstrated and widely recognized

Success stories

- Cognitive radio vs. reinforcement learning
- Also: congestion control, distributed power control
- Deep learning-empowered fingerprinting
- Construction of radio maps/confidence maps

 If a problem is well defined and sufficient data is available, ML can effectively find a mapping: $y = f(x)$

- Domain knowledge is essential to define the problem in the first place
- Machine learning is then simply a class of computational algorithms—evolving over time with different models to meet different needs

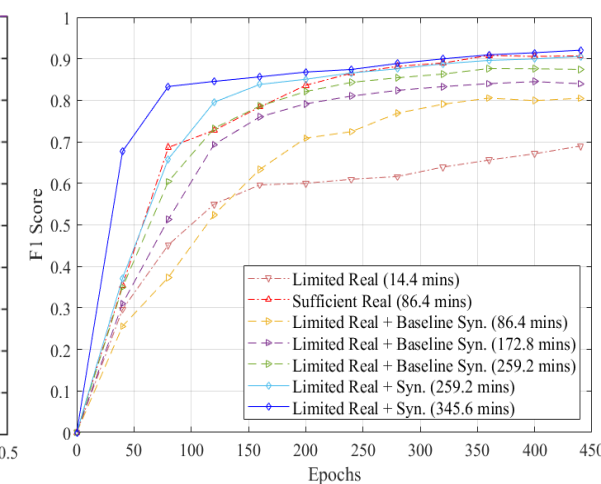
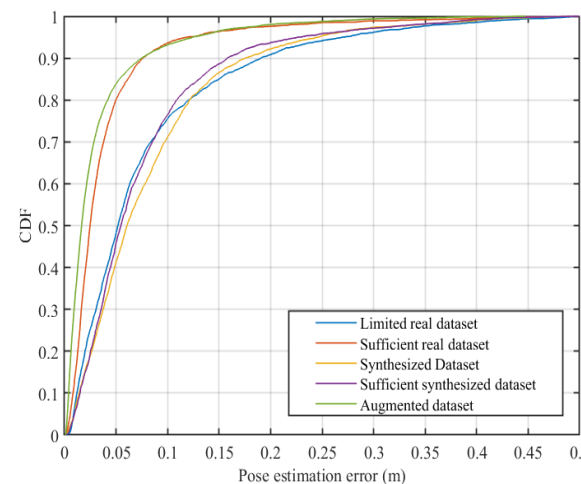
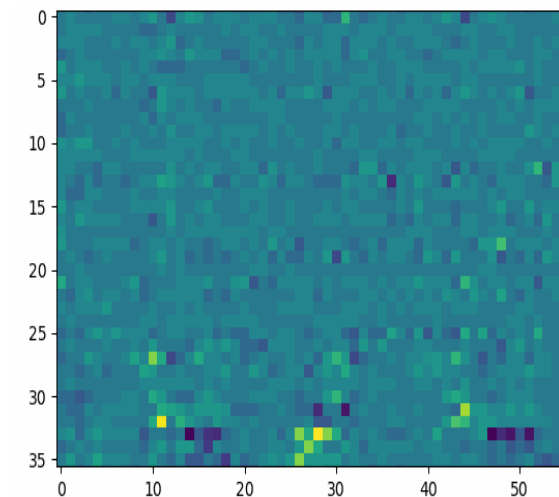
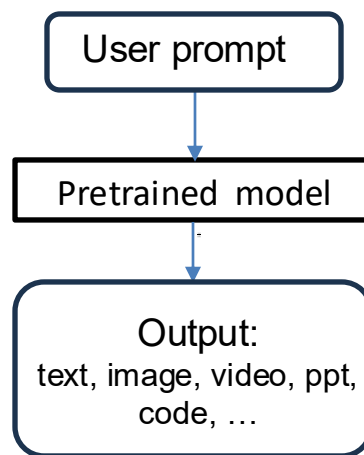


Data Augmentation

- Deep learning is powerful, but fundamentally limited by the availability, quality, and diversity of data
- Unlike CV and NLP, RF data collection is time-consuming and costly, and
 - ➔ Collected data is often noisy and sparse,
 - ➔ ... spans spectral, temporal, and spatial dimensions
 - ➔ Diversity of environment is often limited
 - ➔ Variability in the RF signal representations across different types of devices
 - ➔ Difficult with generalization beyond training data

➤ A promising approach is to leverage AIGC for synthesizing RF data, with

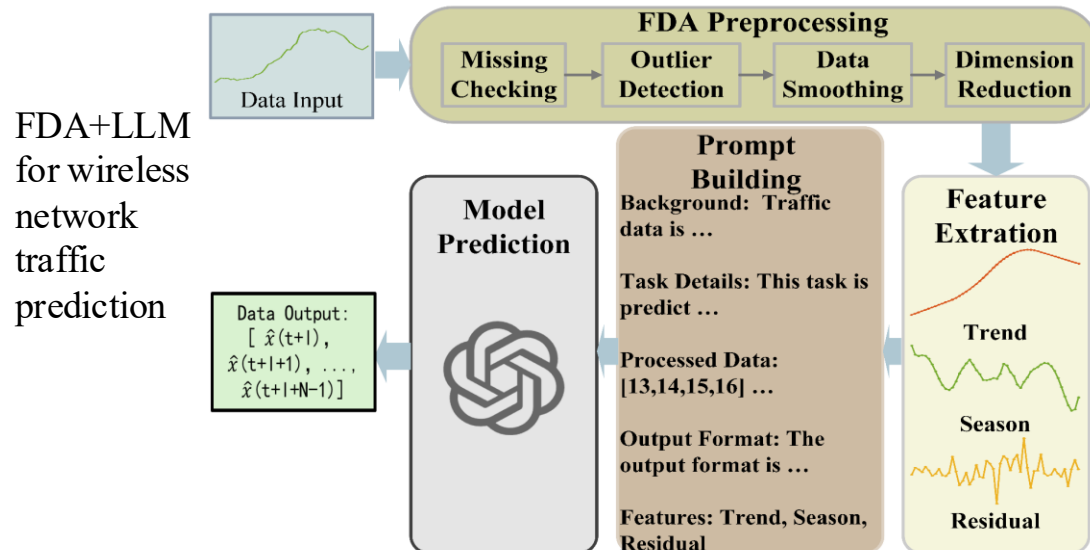
- ➔ Conditional GAN models
- ➔ Diffusion and stable diffusion models
- ➔ Domain knowledge remains crucial for model design and for assessing the quality of the synthesized datasets



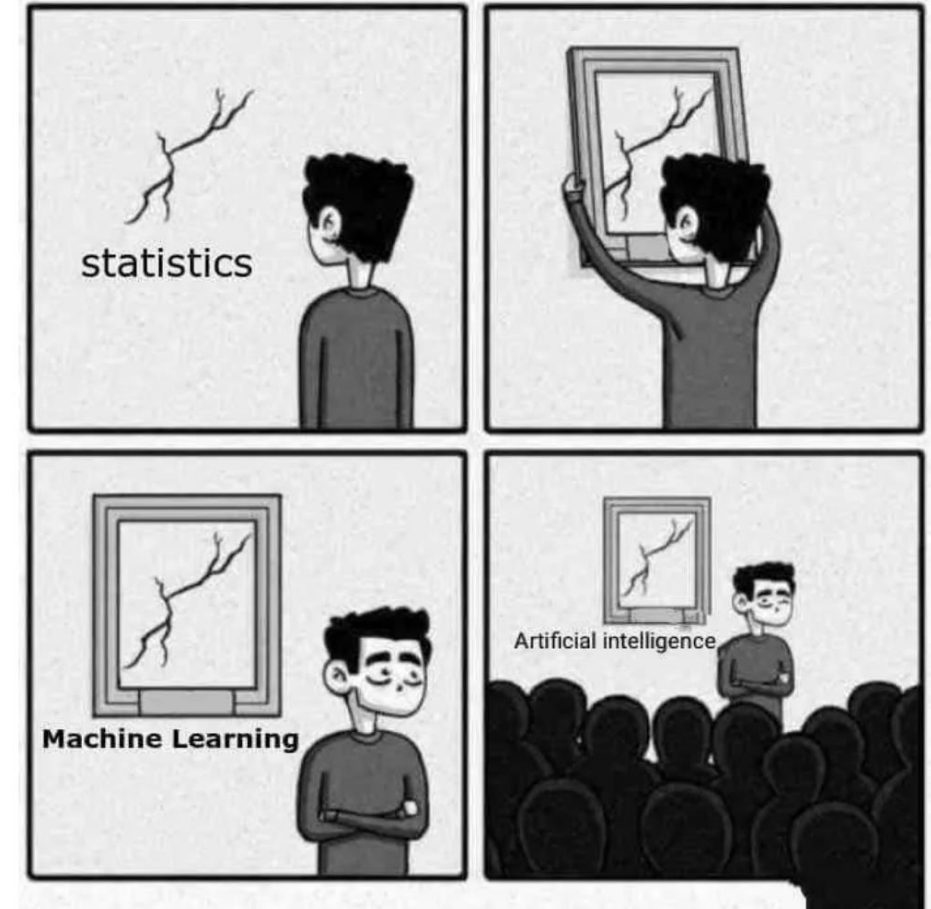
Leverage Advances in Other Fields

Example: Functional Data Analysis (FDA)

-  Wireless data belong to the class of functional data, which can be represented by curves or functions
 - ➔ The process that generates wireless data naturally follows a stochastic function
 - ➔ Many spectrum-related problems can be more effectively addressed when the data are treated as functions
 - ➔ Unlike black-box approaches, FDA can provide interpretable results, such as performance guarantees



Machine Learning is not just glorified Statistics



original comic by [sandserif](#)