Machine Learning for Wireless Communications

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Dec. 19, 2018

Physical Layer Challenges and Machine Learning

- **Signal Detection**
  - Chanel state information and Channel models
  - Complex channels – difficult to characterize
  - Unknown effects
    - underwater acoustic channels - molecular communications
  - Needs for more adaptive framework
  - ML-Based Detection
    - learn the design directly from the measurement data

Physical Layer Challenges and Machine Learning

- **Memory**
  - **Processing Blocks**
  - **Block structures vs. global optimality**
  - **Channel encoding, modulation, and signal detection**
  - **Locally optimized – no guaranty on global optimum**
  - **Optimal communications is changing with time**
  - **ML-based methods optimized over a large training sets**

Physical Layer Challenges and Machine Learning

- **Complexity of the Signal Processing Algorithms**
  - Equalizations, Decoding, Detection
  - Hardware imperfection and non-ideal factors in Mathematically designed algorithms
  - Complexity of Robust signal processing algorithms in Power limited devices
  - ML-based methods can be optimized for specific hardwares

ML Applications in Communications

- Signal Detection
  - Joint Channel Estimation and Signal Detection:
- Auto encoders and Decoders
  - Joint Source-Channel Coding
- Network security
- Resource Management in Wireless Network
- Data-driven optimization of wireless networks
- User localizations

ML Applications in Communications

- Cognitive Radio
- Internet of Things
- Ultra-Reliable and Low-Latency Communications
- Underwater sensor networks
- Satellite communications

Challenges

- Not enough theory and empirical design methods
- Evaluating ML-Based methods
  - Understanding of the fundamental performance limits
  - In contrast to what is common in communications
- Algorithm choices, data and model management strategies in wireless communications