ECE Open House

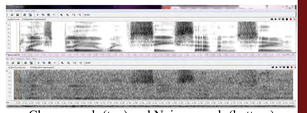
Optimization for Signal Processing and Communication

Statistical plus Dictionary Learning Approach for Speech Enhancement

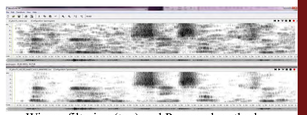
- **Speech Model:**
  - Y = S + W
  - Estimate the clean speech signal (S) from a given noisy speech (Y)
- **Proposed Approach**
  - Combine both statistical approach and dictionary learning approach
  - Statistical approach (classical): Use the statistical difference between speech and noise to do enhancement, such as Wiener, MAP, etc.
  - Dictionary learning approach (modern): Use the spectrogram structure difference between speech and noise to do enhancement
    - $|S| \approx D \times G$, but $|W| \neq D \times G$, G is a sparse matrix

Statistical plus Dictionary Learning Approach for Speech Enhancement

- **Simulation Results (-6dB)**
  - Objective Measure (PESQ):
    - Wiener filtering: 20% improvement
    - Proposed method: 43% improvement
  - Subjective Listening:
    - Reduce the background musical-like noise
    - Maintain speech intelligibility



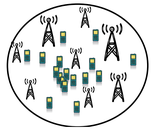
Clean speech (top) and Noisy speech (bottom)



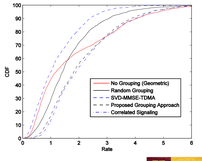
Wiener filtering (top) and Proposed method (bottom)

User Grouping in Modern Cellular Networks

- Fair utility function of the users
- Congestion in the network
- Schedule/Group the users in different time slots
- Optimization problem with no binary/discrete variables



- Numerical experiments:
  - Proportional fairness utility
  - 3GPP (TR 36.814) evaluation methodology
  - Throughput: 75% improvement
  - Cell edge users: 195% improvement

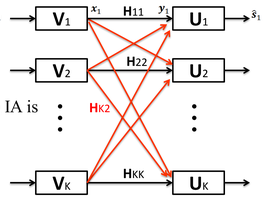


Interference Alignment and Limitations

- Introduced to maximize the total DoF (Maddahali, Jafar, Tse,…)
- DoF of a user $= \delta$
- Maximum total DoF = K/2
  - Achievability through interference alignment

$$\delta = \lim_{SNR \to \infty} \frac{Rate}{\log(SNR)}$$

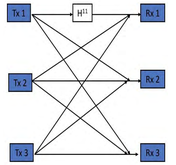
$$\begin{cases} U_k^H H_{kj} V_j = 0, \forall j \neq k \\ rank\left(U_k^H H_{kk} V_k\right) = \delta_k, \forall k \end{cases}$$



- **Fundamental Results on IA**
  - Maximizing total DoF using IA is NP-hard
  - MIMO-IA
    - $\delta(K+1) \leq 2M$ w.p.1
    - Achievable iff $\delta | M$

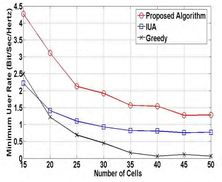
Optimal Joint BS Assignment and Power Allocation in a Celluar Network

- **Motivation**
  - Power allocation is easy to solve
  - How about joint BS assignment and power allocation?
- **Model**
  - K BSs and K users, single antenna
- **Problem**
  - Jointly optimize BS assignment and power allocation, to maximize min rate, under constraints SINR>=1
- **Main Result**
  - The problem is polynomial time solvable.



Optimal Joint BS Assignment and Power Allocation in a Celluar Network

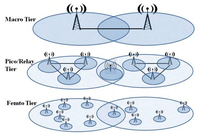
- **Distributed Algorithm**
  - First stage: find a BS assignment by solving a max weighted matching problem
  - Second stage: find power by solving a power allocation problem
  - It is distributed, and globally optimal if optimal min-rate > 1



- **Simulation results**
  - The proposed algorithm achieves 50%-80% higher min-rate than other widely used algorithms

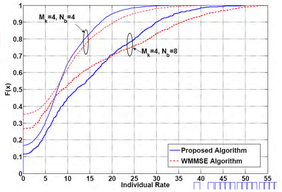
Joint Linear Precoder Optimization and Base Station Assignment for MIMO Network

- **Motivation**
  - Traditional wireless network is migrating to the Heterogenous Network (HetNet)
  - In HetNet, Base Stations (BS) are densely deployed
- **Problem**
  - Jointly optimize the transceivers and user-BS assignment
- **Model**
  - Q BSs and N users in the network
  - The users and BSs are all equipped with multiple antennas
  - All users and BSs interfere with each other



Joint Linear Precoder Optimization and Base Station Assignment for MIMO Network

- **Approach**
  - We use a game theoretical approach
  - The users and BSs are players of the game; they optimize some properly designed utility functions
  - The resulting algorithm is distributed and efficient



- **Simulation results**
  - The proposed algorithm achieves greater throughput as well as higher fairness level , compared with algorithms that only consider transceiver design