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Organization

- Likelihood-Based Automatic Modulation Classification in OFDM With Index Modulation
- Joint Power Control and Beamforming for Uplink Non-Orthogonal Multiple Access in 5G Millimeter-Wave Communications
- Subchannel Allocation and Hybrid Precoding in Millimeter-Wave OFDMA Systems

Likelihood-Based Automatic Modulation Classification(AMC) in OFDM With Index Modulation (J.Zheng and Y.Lv)

- Contributions- ALRT-based classifier, HLRT-based classifier, low-complexity HLRT-LLR, HLRT-Energy classifier and a blind AMC
- N_c Subcarriers in one OFDM symbols are divided into G blocks with N subcarriers,i.e.,N_c=NG
- $I_g^t = \{ i_{g,1}^t, \dots, i_{g,K}^t \}$ denote the set of indices of K active subcarriers
- $S_g^t = \{ s_{g,1}^t, \dots, s_{g,K}^t \}$ corresponds to the set of symbols transmitted over the active subcarriers

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- $x_g^t = x_g^t(I_g^t, S_g^t) = \sum_{k=1}^{K} s_{g,k}^t e_{i_{g,k}^t}$ denote the frequency domain(FD) signal in gth block
- $\mathbf{y}_g^t = N\sqrt{\frac{G}{K}}\mathbf{X}_g^t\mathbf{h}_g + \mathbf{w}_g^t, g = 1, 2, \ldots, G$,received FD signal ,where $h_{g,j}^t, w_{g,j}^t \sim CN(0, \sigma_f^2), j = 1, 2, \ldots, N$
- ALRT-bsed AMC: hypothesis $\mathcal{H}_m = (K, M)$ is accepted if it achieves largest posterior probability

$$p(K, M|y, \theta) = \frac{p(y|K,M,\theta)p(K,M)}{p(y|\theta)}$$

$$\tilde{\mathcal{H}} = \underset{\mathcal{H}=(K,M)\epsilon KxM}{argmax} \quad ln\ p(y|M, K, \theta)$$

- **Theorem 1**: In ALRT-based AMC, the classifier accepts modulation parameter hypothesis according to

$$\hat{\mathcal{H}} = \underset{\mathcal{H}=(K,M)\epsilon KxM}{argmax} \Gamma_{ALRT}(K, M)$$

$$\text{where } \Gamma_{ALRT}(K, M) = -TGln(C(N, K)M^K) +$$

$$\sum_{t=1}^{T} \sum_{g=1}^{G} ln \sum_{I_g^t} (exp(-\frac{\sum_{\alpha\epsilon \bar{I}_g^t} |y_{g,\alpha}^t|^2}{\sigma_f^2})x$$

$$\prod_{\alpha\epsilon I_g^t} \sum_{x_{g,\alpha}^t \epsilon \mathcal{X}_M} exp(-\frac{|y_{g,\alpha}^t - N\sqrt{G/K} x_{g,\alpha}^t h_{g,\alpha}|^2}{\sigma_f^2}))$$

- Complexity of processing the hypothesis is O(TGC(N,K)(N-K+KM)) in ALRT-based AMC
- HLRT-based AMC: To reduce the complexity,first I_g^t is estimated and then S_g^t is averaged out from x_g^t

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- Corollary 1: HLRT-based AMC, the classifier accepts the modulation parameter as

$$\hat{\mathcal{H}} = \underset{\mathcal{H}=(K,M)\epsilon KxM}{argmax} \Gamma_{HLRT}(K,M)$$

$$\text{where } \Gamma_{HLRT}(K,M) = -TGln(M^K) +$$

$$\sum_{t=1}^{T} \sum_{g=1}^{G} ((-\frac{\sum_{\alpha\epsilon\bar{\hat{I}}_g^t} |y_{g,\alpha}^t|^2}{\sigma_f^2}) +$$

$$\sum_{\alpha\epsilon\hat{I}_g^t} ln \sum_{x_{g,\alpha}^t \epsilon \mathcal{X}_M} exp(-\frac{|y_{g,\alpha}^t - N\sqrt{G/K} x_{g,\alpha}^t h_{g,\alpha}|^2}{\sigma_f^2}))$$

- Complexity of processing the hypothesis is O(TG(N-K+KM+N(M+1))) in HLRT-based AMC

Joint Power Control and Beamforming for Uplink Non-Orthogonal Multiple Access in 5G Millimeter-Wave Communications (L.Zhu , J.Zhang , Z.Xiao)

- Contributions- (Suboptimal solution) Decomposes the original problem into two sub-problems: one is a power control and beam gain allocation problem, and the other is a beamforming problem
- Uplink Scenario is used where BS is equipped with a N-element antenna array
- $y = h_1^H w \sqrt{p_1} s_1 + h_2^H w \sqrt{p_2} s_2 + n^H w$,2-user NOMA model where w denotes a beamforming vector with $|[w]_k| = \frac{1}{\sqrt{N}}$ for $k = 1, 2, \ldots, N$ and $h_1 \geq h_2$

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- $h_i = \lambda_i a(N, \Omega_i)$,channel between user i and BS is an mm-wave channel, a(.) is a steering vector
- **Decoding**- Case 1: s_1 is decoded first

  $$R_1^{(1)} = \log_2(1 + \frac{|h_1^H w|^2 p_1}{|h_2^H w|^2 p_2 + \sigma^2}), R_2^{(1)} = \log_2(1 + \frac{|h_2^H w|^2 p_2}{\sigma^2})$$

  Case 2: s_2 is decoded first

  $$R_1^{(2)} = \log_2(1 + \frac{|h_1^H w|^2 p_1}{\sigma^2}),\ R_2^{(2)} = \log_2(1 + \frac{|h_2^H w|^2 p_2}{|h_1^H w|^2 p_1 + \sigma^2})$$
- $R_1 + R_2 = log_2(1 + \frac{|h_1^H w|^2 p_1 + |h_2^H w|^2 p_2}{\sigma^2})$, sum rate of different decoding orders are identical

- **Problem**:

$$\underset{p_1,p_2,w}{Maximize}\ R_1 + R_2$$

$$\text{Subject to } R_1 \geq r_1, R_2 \geq r_2$$

$$0 \leq p_1, p_2 \leq P$$

$$|[w]_k| = \frac{1}{\sqrt{(N)}}$$

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- **Solution**: Problem is non-convex, proposed solution is sub-optimal(decomposes the original problem into two sub-problems)
- Solution of Power Control and Beam gain allocation Sub-Problem:
  Lemma 1: With the ideal beamforming, the beam gains satisfy
  $$\frac{c_1}{|\lambda_1|^2} + \frac{c_2}{|\lambda_2|^2} = N$$
  where $c_1 = |h_1^H w|^2$ and $c_2 = |h_2^H w|^2$

  Lemma 2: With the ideal beamforming, the optimal transmission power is
  $$p_1^* = P, p_2^* = P$$

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- From Lemma 1 and Lemma 2, the optimal values of $|h_2^H w|^2$ and $|h_1^H w|^2$ are
$$c_2^* = \frac{(2^{r_2}-1)\sigma^2}{P},\ c_1^* = |\lambda_1|^2(N - \frac{c_2^*}{|\lambda_2|^2})$$
Decoding s_1 first is optimal
- Solution of the Beamforming Sub-Problem:

$$\underset{w}{Maximize}\ |h_1^H w|^2$$
$$\text{Subject to } |h_2^H w|^2 \geq c_2^*$$
$$|[w]_k| = \frac{1}{\sqrt{(N)}}, k = 1, 2, \ldots, N$$

- Above problem is non-convex,after relaxing contraints we get,

$$\underset{w}{Maximize}\ a_1^H w$$

$$\text{Subject to } |a_2^H w| \geq g$$

$$|[w]_k| \leq \frac{1}{\sqrt{(N)}}, k = 1, 2, \ldots, N$$

where $g = \sqrt{\frac{c_2^*}{|\lambda_2|^2}}$, $a_i \equiv a(N, \Omega_i)$

- Still it is not convex, split it into a serial of convex optimization problems ,i.e., assume different phases for $a_2^H w$

$$\underset{w}{Maximize}\ a_1^H w$$

$$\text{Subject to } Re(a_2^H w e^{2\pi j \frac{m}{M}}) \geq g$$

$$|[w]_k| \leq \frac{1}{\sqrt{(N)}}, k = 1, 2, \ldots, N$$

where $m = 1, 2, \ldots, M$ and M is the number of candidate phases

Subchannel Allocation and Hybrid Precoding in Millimeter-Wave OFDMA Systems (V.Ha, D.Nguyen, J.Frigon)

- Contributions- Maximizes the sum rate under a constraint on the number of data streams
- **System model**- downlink mm-wave MU-OFDMA HB(Hybrid beamforming) system with a BS with N_T antennas and N_{RF} RF chains serves K remote single-antenna UE over S subcarriers
- SINR at user k over subcarrier s ,

$$SINR_{k,s} = \frac{a_{k,s}|h_{k,s}^H A w_{k,s}|^2}{\sum_{j \neq k} a_{j,s}|h_{k,s}^H A w_{j,s}|^2 + \sigma^2}$$

where

$a_{k,s} = 1$ if user k is assigned subcarrier s

0 ,else .

$w_{k,s}$,digital precoding vector applied to data symbols $x_{k,s}$

A denotes analog precoding matrix to map RF signals to RF chains

Continue..

- Problem-

$$\max_{a_{k,s}, w_{k,s}, A} \sum_{k,s} log(1 + SINR_{k,s}) \tag{1}$$

s.t

$$A \epsilon A_R \tag{2}$$

$$\sum_{k,s} |a_{k,s}|^2 w_{k,s}^H A^H A w_{k,s} \leq P_T \tag{3}$$

$$\sum_{k,s} a_{k,s} \leq \bar{D} \tag{4}$$

where $\bar{D}$ denotes highest number of concurrent data streams which system can support in one transmission slot

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- Solution- let

$$\tilde{w}_{k,s} = a_{k,s} w_{k,s}$$
$$\tilde{p}_{k,s} = \tilde{w}_{k,s}^H \tilde{w}_{k,s} = |a_{k,s}|^2 w_{k,s}^H w_{k,s}$$

- Inequality (4) can be transformed as

$$||\tilde{p}||_0 \leq \bar{D} \tag{5}$$

- Problem-

$$\max_{\tilde{w}_{k,s}, A} \sum_{k,s} log(1 + SINR_{k,s})$$
$$\text{s.t. } (2),(3),(5)$$

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- Sparse HP Design:

  Stage one- max-sum-rate Optimization:

$$\max_{u_{k,s}} \sum_{k,s} log(1 + \frac{|h_{k,s}^H u_{k,s}|^2}{\sum_{j\neq s} |h_{k,s}^H u_{j,s}|^2 + \sigma^2})$$

$$\text{s.t. } \sum_{k,s} u_{k,s}^H u_{k,s} \leq P_T$$

  where $u_{k,s} = A\tilde{w}_{k,s}$
  Stage two- Sparse HP Design: Let $u_{k,s}^{opt}$ be the outcome of above problem

$$\min_{\tilde{w}_{k,s}, A} \sum_{k,s} ||u_{k,s}^{opt} - A\tilde{w}_{k,s}||_2^2$$

$$s.t. (2), (3), (5)$$

- Results show that the joint SA and HP design achieves better sum-rate while requiring the lowest computational complexity