1. What is this work about?

* The problem of secrecy rate maximization in a multi-input multi-output multi-eavesdropper (MIMOME) wiretap channel is considered
* An algorithm to achieve an exact solution is developed
* Approach: Maximize achievable secrecy rate by performing joint-beamforming-and-artificial-noise optimization
* Method: Develop a minorization-maximization algorithm to solve the difficult to optimize problem
* The locally optimal solution allows us to benchmark existing methods

2. System Model

* Alice, Bob and Eve are multi-antenna devices with $N_A$, $N_B$, and $N_E$ antennas respectively
* Alice generates data ($s$) and artificial noise ($z$)
* Bob is full-duplex - generates artificial noise ($w$) while receiving data
* Bob is equipped with self-interference cancellation ($\rho$)

$$
X = s + z
$$

$$
y_{Bob} = Hx + \sqrt{\rho} Fw + n_{Bob}
$$

$$
y_{Eve} = Gx + Jw + n_{Eve}
$$

$$
s \sim \mathcal{CN}(0, Q), z \sim \mathcal{CN}(0, \Sigma), w \sim \mathcal{CN}(0, W)
$$

3. Secrecy Rate Maximization

We maximize the achievable secrecy rate as follows:

$$
R_s^* = \max_{Q, \Sigma, W} \left\{ C_s(Q, \Sigma, W) - C_t(Q, \Sigma, W) \right\}
$$

subject to:

- $Q \geq 0, \Sigma \geq 0, W \geq 0$
- $\operatorname{Tr}(Q) \leq P_s$, $\operatorname{Tr}(\Sigma) \leq P_r$, $\operatorname{Tr}(W) \leq P_t$

where

$C_s(Q, \Sigma, W)$ \text{ achievable rate at Bob}

$C_t(Q, \Sigma, W)$ \text{ achievable rate at Eve}

4. Minorization-Maximization Algorithm (MM)

* In its original form, the secrecy rate maximization problem cannot be solved as it contains some convex terms.
* We use MM to reformulate it into a sequence of simpler and easy to optimize cost (surrogate) functions.
* These surrogate functions must minimize the original cost function at a given point to ensure tightness.
* We use Lemma 1 to reformulate the secrecy rate maximization problem.

Lemma 1: For $f(X) = -\log \det X$, a function of square matrix $X$, the minorizing function at $X = X_0$ is given by $f(X; X_0) = -\log \det X_0 - \operatorname{Tr}(X_0^{-1} X)$. Here $f(X; X_0)$ is the tangent plane of $f(X)$ which lower bounds it at $X = X_0$ while $X_0^{-1}$ is the gradient of $\log \det X$ evaluated at $X_0$.

**MM estimation of optimal $(Q, \Sigma, W)$**

* $k = 0$, Initialize $Q^{(0)}, \Sigma^{(0)}, W^{(0)}$
* do

$$
R_s^{(k)} = \text{Solve reformulated problem using } Q^{(k)}, \Sigma^{(k)}, W^{(k)}
$$

$k = k + 1$

$$
Q^{(k)} = Q^{(k-1)}, \Sigma^{(k)} = \Sigma^{(k-1)}, W^{(k)} = W^{(k-1)}
$$

until convergence

* $Q^* = Q^{(k)}, \Sigma^* = \Sigma^{(k)}, W^* = W^{(k)}$
* Calculate secrecy rate $R_s^*$ using $(Q^*, \Sigma^*, W^*)$

5. Experiments

**Setup 1:** No noise from Alice - effect of different system parameters

**Setup 2:** Alice and Bob are located one kilometer apart at (-0.5,0) and (0.5,0) respectively and Eve moves along the line $y = 0.5$ from (-2,0.5) to (2,0.5).

6. References


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8. Acknowledgement

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