2022 WIRELESS ACCESS NETWORK

Antenna selection with DRL

DRL # Complexity # Wireless

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Antenna selection

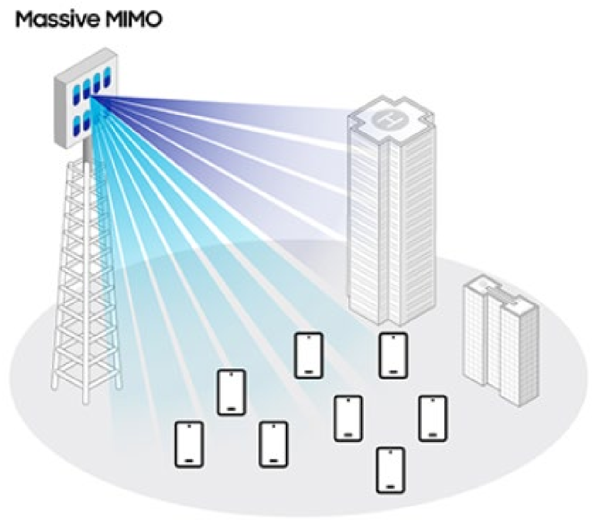
Massive MIMO

Has been recognized as potential candidate technology for 5G networks that use multiple base-station antennas to serves a large of single antenna users.

In fact, Massive MIMO can significantly improve performance such as spectral efficiency and maximum transmission rate compared to conventional systems.

However, the energy consumption in Massive MIMO systems has also increased significantly since the total power consumption is proportional to the number of antennas.

Therefore, some paper has been studied to improve in this problems.



- Massive MIMO technology is a promising for 5G and next-generation wireless communication.
- However, there are several constraints, and research is required to improve them.

Antenna selection

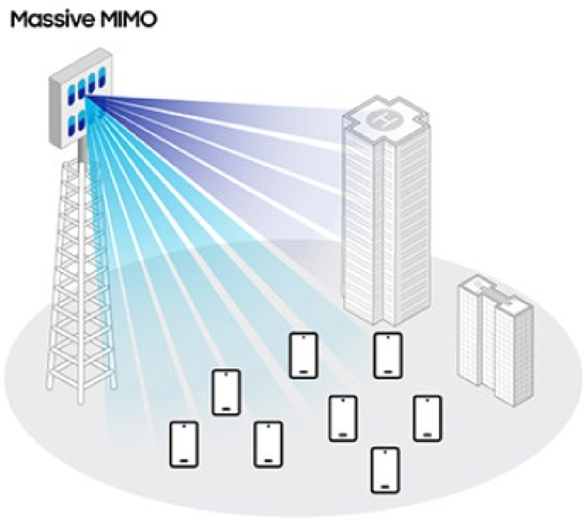
Existing literature

Several researchers have investigated and proposed the antenna selection problem of Massive MIMO systems.

They mainly focused on sum-rate maximization, minimization of power consumption and maximum energy efficiency by considering outage capacity.

Also, the above-proposed antenna selection methods normally used brute-force, exhaustive, and greedy algorithms.

However, the complexity of this algorithm increases exponentially according to a number of antennas.



- Several papers have proposed to improve sum-rate maximization.
- The algorithms can provide optimal performance, but increase complexity simultaneously.

Antenna selection with DRL

Considered scenario

We considered a MIMO system, it consists of M of transmit antenna and K is receive antennas. ($M \gg K \gg 1$)

In this scenario, we considered Rayleigh fading signal model as follows as below.

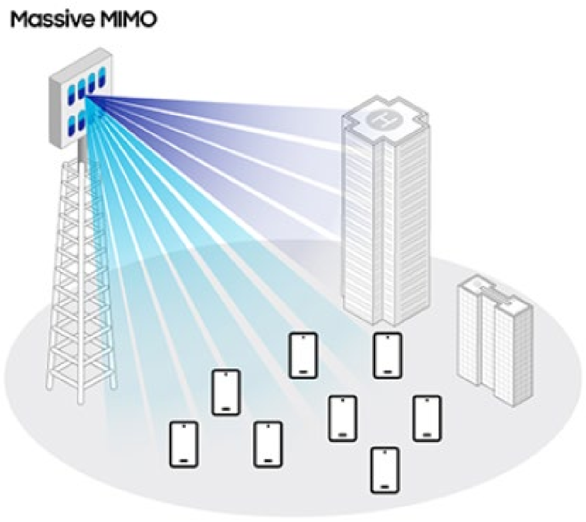
$$r = \sqrt{\frac{S}{M}} H_x + n$$

Then, we can calculate channel capacity by using Shannon theory.

$$C(\overline{H}_{(J)}) = \log_2 \det\left(I_N + \frac{S}{M}\overline{H}_{(J)}\overline{H}_{(J)}^H\right)$$

Find An optimal antenna subset index J^* that maximize the channel capacity.

$$J^* = \underset{J \in N_c}{\operatorname{argmax}}\, C(\overline{H}_{(J)})$$



- Consider a MIMO system, and Rayleigh fading signal model.
- Find the optimal antenna subset by calculating maximize the channel capacity.

Antenna selection with DRL

Markov Decision Process (MDP)

Prior to reinforcement learning application, the following states, actions, and rewards are defined.

$$a = (N_1, \cdots, N_c), \quad a \in A, \quad N_c = \binom{M}{L}$$

$$s = \left(C([a_t]), C([a_{t+1}]), \cdots\right), \quad s \in S$$

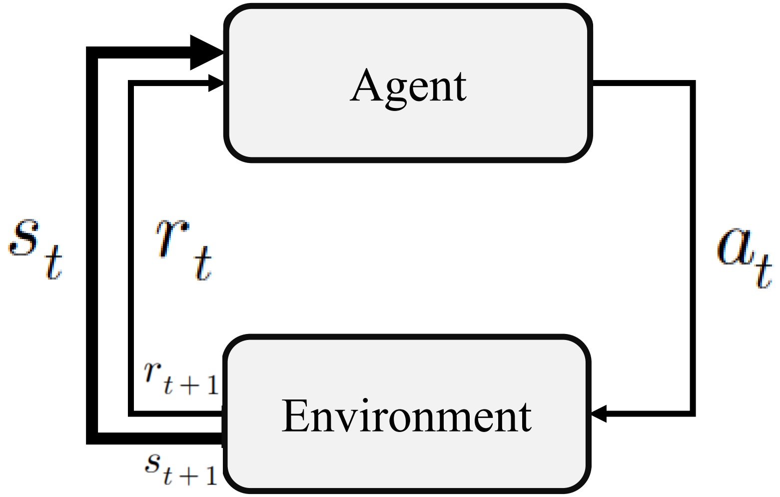
we defined reward according to immediately channel capacity.

$$R = E\left[r[t] + \alpha r[t+1] + \alpha^2 r[t+2] + \cdots \mid S = s, A = a\right]$$

Then, we'll can apply and solve the optimal antenna selection occur complexity problem by using reinforcement learning.

$$\underset{a}{\text{maximize}} \sum_{n=1}^{N} R$$

$$s.t. \quad a \in A$$



- Defined Markov Decision Process for applying deep reinforcement learning
- The state is defined as the channel capacity, action is combination of antenna subset, reward is positive, or zero.

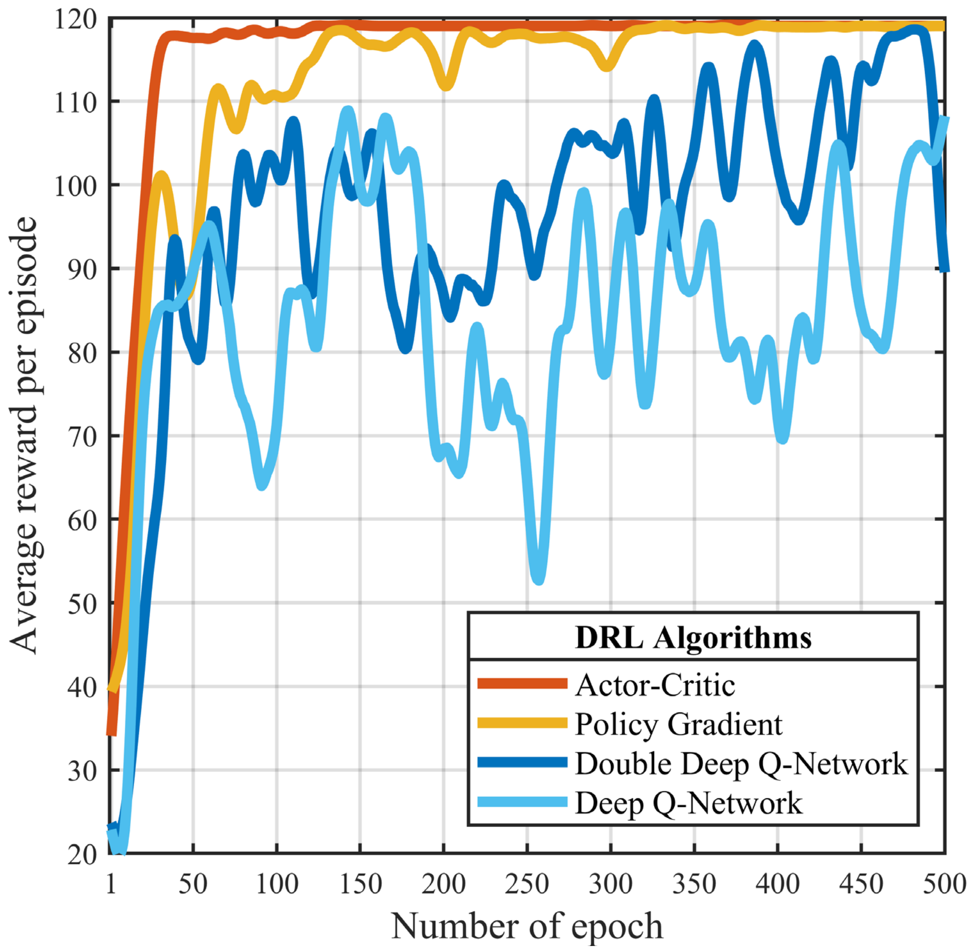
Comparison of complexity between existing AS methods.

Proposed DRL-based antenna selection method [training efficiency]

Before comparing the performance of proposed antenna selection,
we analyze the training performance of each reinforcement learning algorithms.

The A2C, and policy gradient methods show stable training performance
Compared to Q value-based DQN, and DDQN methods.

In particular, Q value-based learning algorithms has a problem of the fluctuation.



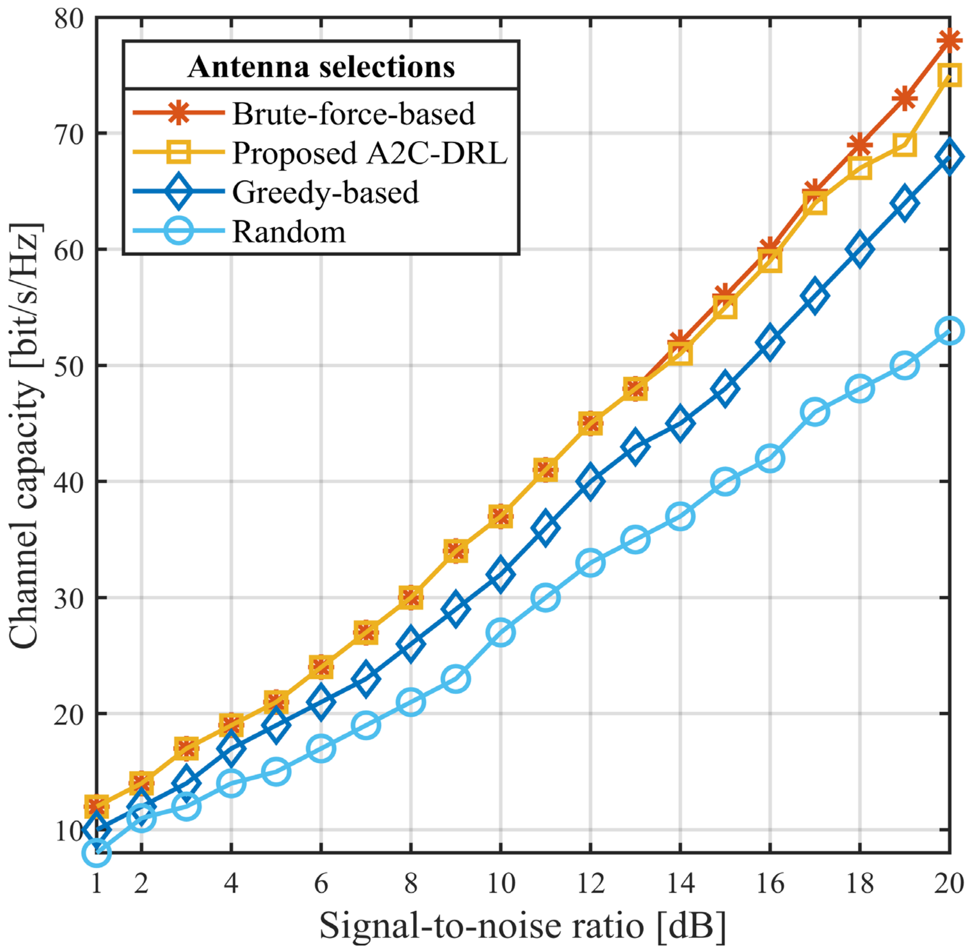
Comparison of complexity between existing AS methods.

Proposed DRL-based antenna selection method [channel capacity]

It can be confirmed that the proposed DRL–AS method
provides almost the same performance as the optimal method (Brute–force).

Greedy algorithm–based antenna selection method shows the sub–optimal
Performance of the channel capacity.

Randomly antenna selection still gives the worst performance.

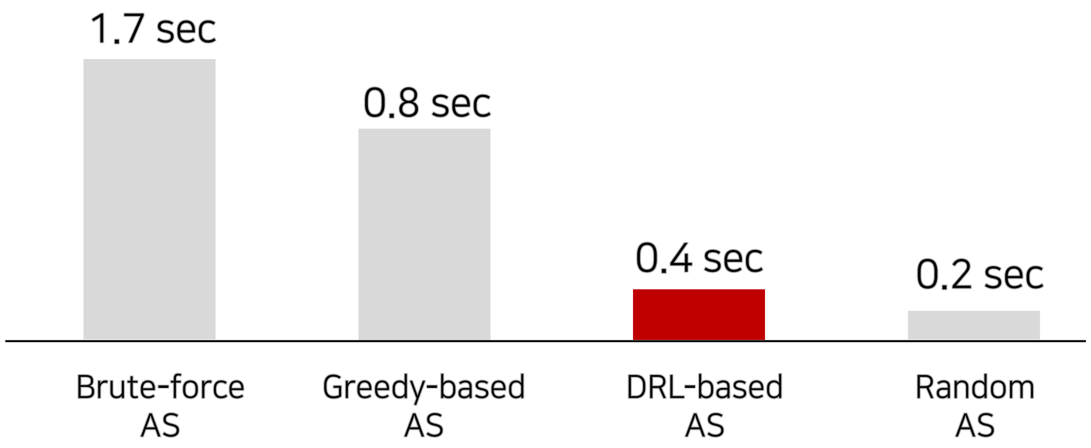


Complexity

Comparison of complexity between existing AS methods.

Proposed DRL-based antenna selection method [complexity]

[Search time of optimal antenna]



[Performance summary]

Compared to Brute-force AS, Proposed DRL-AS can reduce the complexity by **76.47%**

Table of antenna selection complexity

Brute-force	Greedy-based	DRL-AS	Random
1.7 sec	0.8 sec	0.4 sec	0.2 sec

Conclusion

Introduction

- Massive MIMO technology require to efficiently resource allocation such as antenna selection, power allocation.
- Proposed methods normally used exhaustive and greedy algorithms, also increase complexity according to number of resources.

Proposed idea

- Try to reduce the optimal antenna selection algorithm complexity by using reinforcement learning
- Defined the states, actions, and rewards for applying antenna selection in reinforcement learning

conclusion

- The experimental results, we confirmed that the proposed DRL-AS method provides almost the same optimal antenna selection.
- At the same time, compared to optimal antenna selection, and proposed idea can reduce the complexity by 76.47%.

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THANK YOU

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