The first 6G Intelligent Wireless Communication System Competition

（Date 2022.12.26-2023.3.10）

Sponsor：IMT-2030(6G) Promotion Group

Organizer：China Academy of Information and Communications Technology (CAICT)

HUAWEI TECHNOLOGIES CO., LTD.

Guangdong OPPO Mobile Communications Corp., Ltd

Zhejiang University

1、 Competition Background

The deep integration of communication and AI technologies has become one of the most important directions in the development of wireless communication systems. For 6G, the breadth and depth of communication and AI integration will be further expanded to meet "unlimited" possibilities. This competition is proposed at the key development stage of 6G research, aiming at promoting the visions, advanced technologies and concepts of 6G to all walks of life, and attracting talents around the world to study the impact of AI on future wireless communication systems, to find solutions to key problems in a systematic and multi-faceted manner. Hopefully, through this competition, we can facilitate technological breakthroughs in intelligent 6G and build industrial first-mover advantages.

With upholding public welfare, adhering to the principles of fairness, justice and openness, the main objective of the competition is to attract the global wireless communication technology research enthusiasts, researchers from enterprises and institutions, students and teachers from universities and research institutions to participate in the competition, and to find outstanding talents to help 6G research.

2、Competition Tasks

Competition Task 1：Intelligent Beam Prediction and Model Transfer

The wireless Massive-MIMO technology significantly increases the capacity of communication systems. In high carrier frequency scenarios, the intelligent beamforming with higher accuracy and lower overhead is the key to achieve even higher capacity increasing in future 6G communication systems. Proper MIMO beam selection is based on accurate beam measurement. However, as the number of beams increases, the overhead of scanning and measuring all beams is huge and unacceptable in real systems. A more practical solution would be to first perform sparse beam scanning measurements, then predict the remaining beams based on the measured results, and finally select the best beam. How to achieve beam prediction with a higher accuracy based on a limited measurement overhead by AI technology is a very important research topic in future 6G communications.

This task is related to the intelligent beam prediction, focusing on the key performance indicators such as prediction accuracy and generalization ability, and guiding the research direction of key technologies for 6G intelligent air interface.

Competition Task 2：Intelligent Distributed Radio Map Construction

Radio map is a key tool for wireless communication systems to satisfy requirements of potential 6G scenarios such as smart cities and smart factories. Radio maps have a wide scope of applications in base station siting, user scheduling, transmission policy optimization, etc. However, constructing precise radio maps often requires processing huge amount of data, so AI-based methods are more suitable than traditional methods.

This task expects to find the intrinsic connection between user location and radio signal strength with the learning ability of neural network, then complete the construction of radio maps. Furthermore, a distributed learning architecture will be considered to utilize the data from user devices distributed in different geographical locations, jointly completing the map construction. In such scenario, how to improve the training efficiency and model accuracy of the distributed learning system while at the cost of a low communication overhead through effectively coordinating the data and model interactions between devices is one of the most important research problems for 6G-oriented intelligent wireless communication systems.

This task will address the radio map construction problem, explore the key technologies of 6G intelligent networks through distributed learning methods, and guide the research direction.

Competition Task 3:

Recently, as an important topic of pre-research of 6G, AI-based wireless communication system attracted lots of attentions of academia and industry. However, in addition to obtaining the high-performance advantages brought by data-driven methods, AI-based solutions also face generalization problems in different scenarios with the high cost of data acquisition and model training, which bring the challenges for the landing of the technologies. Therefore, to solve these problems, the 6G AI competition will take "Design of wireless AI system for requirements of online updating with limited dataset" as the topic to explore possible solutions.

3、 Competition Schedule

Date	Schedule
November 15, 2022	Competition announcement. Organizers announce the competition at Global 6G Development Conference.
December 26, 2022	Competition launching. Participants register on the official website.
January 3, 2023 to March 10, 2023	Competition conducting. Participants can download the sample code and dataset for tasks, finish the tasks then upload the results to the platform.
March 31, 2023	Results review. Award list announcement
April, 2023	Presentation of results and awarding of prizes.

※Please keep an eye on the competition platform and the communication group for the specific schedule of the competition.

4、 Competition Rules

- **Participants:** The competition is open to all people in the world, regardless of age and nationality. All universities, research institutes, enterprises and institutions, individuals, etc. can register on the official website.

Employees belonging to the relevant organizers, contractors and their affiliated units can participate but cannot win, and will not occupy the prize quota. (i.e. if the team is in the top rank after the rank list is locked, the team will not be awarded, nor will it occupy the award quota. The team can participate in sharing activities. The winning team will be ranked in sequence except for this team.)

- **Registration requirements**: One participant can either work solo or join only one team per task. The number of participants in each team should not exceed 5. One participant can sign up for multiple competition tasks. All members must provide their basic personal information and pass the real name authentication during registration; team formation must be completed before the deadline, and once the team is formed, no withdrawal or replacement is allowed; the participant's account is for the participant's personal use only, and may not be transferred, rented, lent, sold, disclosed or leaked to a third party in any form. Participants are obliged to ensure the authenticity and validity of the account information, and the participants shall bear the consequences caused by invalid or incorrect information. Participants are responsible for the use of their account and should notify the organizing committee immediately when they encounter security problems (such as account loss, stolen, unauthorized use, etc.).
- **Submission rules**: In order to ensure that all teams have equal opportunities for submission, each team should submit their works at most 3 times per day.
- **Fair competition**: Participants are not allowed to use rule loopholes or technical loopholes and other undesirable ways to improve the ranking of results outside the scope of the specified assessment of technical ability, and it is forbidden to copy others' works, exchange answers, use multiple IDs to submit works, or use identical works by different teams for malicious submission in the competition. The participants are requested to keep the competition in fair order and will be disqualified if above mentioned unproper behaviors are found.
- **Organizational Statement**: The committee reserves the right to adjust and modify the competition rules, the right to determine and dispose of cheating in the competition, and the right to withdraw or refuse to grant awards to teams that affect the organization and fairness.
- **Competition data**: The committee authorizes the participants to use the provided data to conduct model training in the designated competition. And the participants are not allowed to

use the data for any commercial purposes, or share the data with non-participants. If used for scientific research, please indicate that the data comes from the relevant data provider.

- **Intellectual property rights of the works**: The intellectual property rights of the works (including but not limited to algorithms, models, etc.) belong to the participants. The committee may use the works, work-related and team information for promotional materials, relevant publications, designated and authorized media releases, official website browsing and downloading, exhibitions (including touring exhibitions) and other activity projects with the consent of the participants. The organizers of the competition have the priority of cooperation. Works must guarantee originality, not violate any relevant laws of the People's Republic of China, and not infringe any third party intellectual property rights or other rights. During the competition period, data, code and models are strictly prohibited from open source.
- **Special avoidance**: personnel involved in task designing and data processing in the relevant organizers and contractors are prohibited from participating, and entrusting others to participate or guide the participating teams is also prohibited.
- **Notification of communication**: The organizing committee will send all notifications only via the contact information reserved by the teams. Competition information include but are not limited to activity schedules, trainings and sharing, winner notifications, awarding ceremony, etc.
- If the team does not reply within 3 days after the above-mentioned notification, it will be regarded as automatically abandoning the corresponding opportunity, and the organizer has the right to substitute other teams in sequence.

5、Violations and Treatment

In case of the following or other major violations by the participating teams, the teams may be disqualified and their results may be cancelled after the joint deliberations of the committee of the competition, and the list of winning teams will be postponed in turn. Major violations are as follows.

- Serious violation of competition rules.
- Cheating behavior such as using alt. IDs, collusion, plagiarizing others' code.
- Illegal use of external data.
- Other major violations.

6、 Statement of rights and responsibilities

- The committee has the right to determine and dispose of cheating behavior in the competition.
- The committee reserves the right to modify the submission deadline, defense date and award date of the competition. The committee has the right to suspend or terminate the competition under special conditions.
- The committee reserves the right to withdraw or refuse to award prizes to teams that affect the organization of the competition and the fairness of the competition.
- The committee has the right to re-evaluate the results of the competition and update the ranking if for any reason there are data updates, judging code updates, cheating checks, etc.
- The committee reserves the right to adjust and modify the rules of the competition, and the committee has the final right to interpret the competition.

7、 Competition Awards

- The prize is set according to the task, and the total prize money for each task is 500,000 RMB. See the introduction of the task for the specific prize settings.

8、 Competition Committee

（Ranking in no particular order）

President：

Zhiqing Wang Vice President of China Academy of Information and Communications Technology (CAICT), Chair of IMT-2030 (6g) Promotion Group

Wen Tong CTO of Huawei Wireless

Ning Yang Head of OPPO Standard and Research Department, OPPO Research Institute

Vice president：

Ying Du Vice Director of Mobile Communications Innovation Center of CAICT

Zhaoyang Zhang Vice President of Polytechnic Institute, Zhejiang University, Chair of IMT-2030 (6g) Wireless AI Group

Shi Jing Vice president of Southeast University

Jianmin Lu CEO of Huawei Wireless Technology Lab

Jia Shen Professorial Senior Engineer of OPPO Research Institute, Vice Chair of IMT-2030 (6g) Wireless AI Group

Members：

Zhiyong Feng Professor of Beijing University of Posts and Telecommunications

Chenyang Yang Professor of Beihang University

Pingzhi Fan Professor of Southwest Jiaotong University

YiFei Yuan Chief expert of CMCC Research Institute

Qingyang Wang Director of Mobile Communication Technology Research Institute, China Telecom Research Institute

Fuchang Li Director of Wireless Technology Research Center, China Unicom Research Institute, Professorial Senior Engineer

Jiandong Li Professor of Xidian University

Shuguang Cui Professor of The Chinese University of Hong Kong, Shenzhen

Feifei Gao Professor of Tsinghua University

Meixia Tao Professor of Shanghai Jiao Tong University

Zhi Chen Professor of University of Electronic Science and Technology of China

Yingchang Liang Professor of University of Electronic Science and Technology of China

Bo Ai Professor of Beijing Jiao Tong University

Chengxiang Wang Professor of Southeast University

Qihui Wu Professor of Nanjing University of Aeronautics and Astronautics

Liang Zhou Professor of Nanjing University of Posts and Telecommunications

Caijun Zhong Professor of Zhejiang University

Chongwen Huang Professor of Zhejiang University

Xiaoming Chen Professor of Zhejiang University

Jianhua Zhang Professor of Beijing University of Posts and Telecommunications

Lingyang Song Professor of Peking University

Wei Chen Professor of Beijing Jiaotong University

Wenchi Cheng Professor of Xidian University

Zhaocheng Wang Professor of Tsinghua University

Rong Li Technical Expert of Wireless Technology Lab, Huawei

Jian Wang Technical Expert of Wireless Technology Lab, Huawei

Shengchen Dai Technical Expert of Wireless Technology Lab, Huawei

Zhi Zhang Communications Standards Expert of OPPO Research Institute

Wenqiang Tian Senior Communications Standards Researcher of OPPO Research Institute

Jiamo Jiang Technical Expert of CAICT

Competition Task 1: Smart beam prediction and model transfer

◆ Task Background

Wireless Massive-MIMO technology significantly increases the capacity of communication systems, and in high carrier frequency scenarios, the intelligent beamforming with higher accuracy and lower overhead is the key to achieve even higher capacity increasing in future 6G communication systems. Proper MIMO beam selection is based on accurate beam measurement. However, as the number of beams increases, the overhead of scanning and measuring all beams is huge and unacceptable in real systems. A more practical solution would be to first perform sparse beam scanning measurements, then predict the remaining beams based on the measurement results, and finally select the best beam. How to achieve the beam prediction with high accuracy based on a limited measurement overhead by AI technology is a very important research topic in future 6G communications.

This task is related to the intelligent beam prediction, focusing on the key performance indicators such as prediction accuracy and generalization ability, and guiding the research direction of key technologies for 6G intelligent air interface.

◆ Competition Tasks

In this competition task, beam prediction and model transfer problems for MIMO systems are considered. The model transfer includes the transfer between different carrier frequency scenarios and the transfer of models from a generic transmission environment to a specific transmission environment.

Task 1 (beam prediction): For a communication system with carrier frequency f1, we consider a set of 64x4 beam pairs consisting of 64 transmit beams and 4 receive beams. For each receive beam, 8 of the transmit beams are scanned to obtain 8x4 beam pair measurements, and then the measurements of these 8x4 beam pairs are used as the input to the AI model, which is targeted at finding the K strongest beam pairs (K={1,3,5}). The training dataset contains 10,000 training samples, each of which is structured as <64x4 beam pair intensities, transmission environment map, base station (BS) location, and user equipment (UE) location>, where the transmission environment map gives the layout of the buildings in the scene, and the BS and UE may or may not be blocked by buildings, so these transmission environments may be NLOS or LOS environments. The test dataset contains 1000 test samples with the same data structure as the training samples. The average of the beam prediction accuracy (the probability that the selected K beam pairs contain the strongest beam pair) for three different values of K is calculated as Score1.

Task 2 (carrier frequency transfer): For a communication system with a carrier frequency of f2, we consider a set of 128x4 beam pairs consisting of 128 transmit beams and 4 receive beams. For each receive beam, 8 of the transmit beams are scanned to obtain 8x4 beam pair measurements, and then the measurements of these 8x4 beam pairs are used as input of AI model to output K strongest beam pairs, where K={1,3,5}. The training dataset contains 1000 training samples, and the data structure of each training sample is <128x4 beam pair intensities, transmission environment map, BS location, UE location>. The test dataset contains 1000 test samples with the same data structure as the training samples. Participants are allowed and encouraged to use the training data or the model obtained from task 1 for transfer learning. The mean Score2 of the beam prediction accuracy for three different values of K is calculated.

Task 3 (Environment Transfer): For a communication system with carrier frequency f1, a set of 64x4 beam pairs consisting of 64 transmit beams and 4 receive beams is considered. The training dataset contains 1000 training samples, each with the data structure <intensity of 64x4 beam pairs, transmission environment map, BS location, UE location>. These training samples are generated in the same transmission environment, i.e., all training samples have the same "transmission environment map" in the data structure. Transfer learning is allowed and encouraged using the training data or the trained model from Task 1. The test dataset contains 1000 test samples with the same data structure as the training samples, and the same transmission environment as the transmission environment of the training samples. The average score3 of the beam prediction accuracy for three different values of K is calculated.

◆ Dataset introduction

The training dataset for Task 1 contains 10,000 training samples, each with a data structure of <64x4 beam pair intensities, transmission environment map, BS location, UE location>. These samples are generated from a communication system with a carrier frequency of f1. The test data set for task 1 contains 1000 test samples, each with the same data structure as the training samples and also generated from a communication system with a carrier frequency of f1.

The training dataset for Task 2 contains 1000 training samples, each with a data structure of <128x4 beam pair intensities, transmission environment map, BS location, UE location>. These samples were generated from a communication system with a carrier frequency of f2. The test data set for task 2 contains 1000 test samples, each with the same data structure as the training samples and also generated from a communication system with a carrier frequency of f2.

The training dataset for task 3 contains 1000 training samples, each with a data structure of <64x4 beam pair intensities, transmission environment map, BS location, UE location>. These samples are generated from a communication system with a carrier frequency of f1 and they have the same transmission environment. The test data set for Task 3 contains 1000 test samples, each with the same data structure as the training samples, and also generated from a communication system with a carrier frequency of f1 and the same transmission environment as the training samples.

Test datasets for all tasks are not available for participants and are used to evaluate scores.

◆ Submission Requirements

This competition uses Huawei Cloud Competition Platform as the evaluation platform. Participants can download the "Huawei Cloud competition Platform Instruction Document" and the "Intelligent Beam Prediction and Model Transfer Sample Code Instruction Document" from the official website to familiarize themselves with the whole process from training to submission.

Sample Code structure：

```
BM_baseline.zip
 └──data（dataset）
      └──task1（dataset for task1）
      └──task2（dataset for task2）
```

```
    └──task3（dataset for task3）
…
└──dataset.py（loading dataset）
└──model.py（model definition）
└──train.py（training）
└──util.py（basic classes and functions）
```

The participants should submit following files: 1. model file: model.pth 2. Model definition file: model.py. The uploaded file size should not exceed 200MB. Programming language: python. Macro package reference: pytorch, numpy, etc. After the participants submitting the model files, the platform will return the model inference results and generate ranking.

◆ Evaluation criteria

The competition uses the following formula to calculate the final score：

$$Score = (Score1 + Score2 + Score3) / 3$$

Score1 is the score of Task 1 (beam prediction), Score2 is the score of Task 2 (carrier frequency transfer), and Score3 is the score of Task 3 (environment transfer), as described in the competition tasks. A real-time score ranking will be published on the competition website for participants' reference.

◆ Competition Awards

According to the final ranking results, the finalists will be selected from the highest to the lowest score (excluding the teams related to organizers), and one first prize, two second prizes, three third prizes and five winning prizes will be awarded respectively. Each teams for the on-site awards will receive the following prizes.

Awards	Amount	Bonus (Team)	Total Bonus
First prize	1	150,000 RMB	500,000 RMB
Second prize	2	90,000 RMB	
Third prize	3	40,000 RMB	
Winning prize	5	10,000 RMB	

Remarks: The above are pre-tax bonuses. Individual income tax or other forms of tax on prizes will be borne by the winners, and withheld and paid by the organizers of the competition on behalf of the winners. The distribution of the bonus in a team is settled among the team members, and the organizer or the committee will not be responsible for this.

◆ Contacts

Link to the competition tasks: https://developer.huaweicloud.com/contest/6g-wireless-ai.html

Email: IWCScontest@huawei.com

Wechat Group for participants: Please scan the QR code to add the wechat little helper, then reply "6G波束预测" (6G beam prediction) to enter the information exchange group. The key notifications will be published in the group, so please all the participants should enter this group.

Competition Task 2: Intelligent Distributed Radio Map Construction

◆ Task background

Radio map is a key tool for wireless communication systems to satisfy requirements of potential 6G scenarios such as smart cities and smart factories. Radio maps have a wide scope of applications in base station siting, user scheduling, transmission policy optimization, etc. However, constructing precise radio maps often requires processing huge amount of data, so AI-based methods are more suitable than traditional methods.

This task expects to find the intrinsic connection between user location and radio signal strength with the learning ability of neural network, then complete the construction of radio maps. Furthermore, a distributed learning architecture will be considered to utilize the data from user devices distributed in different geographical locations, jointly completing the map construction. In such scenario, how to improve the training efficiency and model accuracy of the distributed learning system while at the cost of a low communication overhead through effectively coordinating the data and model interactions between devices is one of the most important research problems for 6G-oriented intelligent wireless communication systems.

This task will address the radio map construction problem, explore the key technologies of 6G intelligent networks through distributed learning methods, and guide the research direction.

◆ Competition Task

This task is the construction of a radio map based on distributed learning. Four base stations are deployed in an area with the size of approximately 400 m x 400 m, with the approximate locations shown in Figure 1. The data structure of each sample in the training dataset is <location, signal strength>. The location of UEs are obtained by uniformly random scattering points within the map area. The signal strength data is the downlink signal strength between the user and the 4 base stations at the corresponding location coordinates. Depending on the wireless environment between the user and each base station, the user is not guaranteed to be reachable to all 4 base stations. Each user has at least one reachable base station, and there may be multiple (up to 4) reachable base stations for one user. For unreachable base stations, the corresponding signal strength is set to 0.

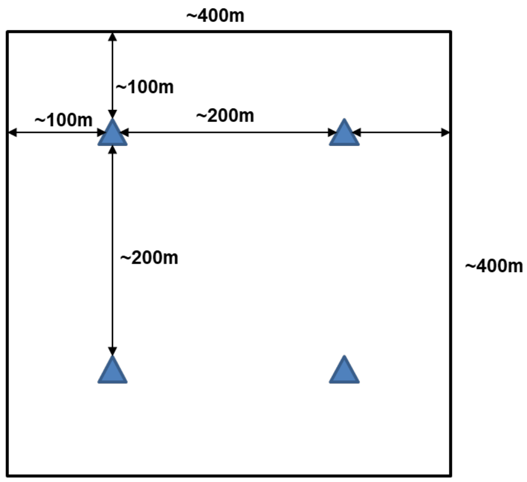

Figure 1. Radio map construction task

As shown in Figure 2, the above map is evenly divided into 25 regions. There are 9 groups of users in the system, and each group is active in a different region (i.e., the training samples in that region are available). The correspondence between user group IDs and their active areas is shown in the table below. Each group contains 10 users, and the 10 users in each user group are active in the same map area, but with different data samples. There are 90 users in the map, and the number of data samples for each user is slightly different due to the difference in active areas.

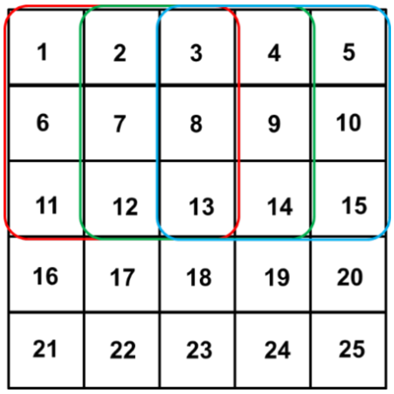

Figure 2. Dataset division of radio map construction task

Group ID	Active region

1	1,2,3,6,7,8,11,12,13
2	2,3,4,7,8,9,12,13,14
3	3,4,5,8,9,10,13,14,15
4	6,7,8,11,12,13,16,17,18
5	7,8,9,12,13,14,17,18,19
6	8,9,10,13,14,15,18,19,20
7	11,12,13,16,17,18,21,22,23
8	12,13,14,17,18,19,22,23,24
9	13,14,15,18,19,20,23,24,25

Each user trains a local model based on the data in their active area. The central node selects 5 users per round to upload their local models, aggregating then distributing the global model to all users, i.e., distributed (federated) learning.

The total number of rounds of distributed training is limited to 500 (one local model upload + one global model distribution is counted as one round). The maximum number of local training at distributed nodes is limited as 10 rounds. Participants are required to design their own node selection algorithm, neural network structure, as well as sparsification algorithm for model uploading and broadcasting. After the training is completed, the signal strength estimation error is evaluated by a test set of data samples which is also obtained by uniformly random scattering points within the same area.

◆ Dataset Introduction

The training set consists of 125,000 <location, signal strength> data samples in 25 regions and is allocated to 90 users according to the above user-region correspondence table. The test set consists of data from about 6000 random location points in the whole map. Each data sample contains <location, signal strength> information, where the location information indicates the location of the user at the current sample point, and the signal strength information indicates the signal strength of the user at the current sample point to the four base stations, which is set to 0 when a base station is not reachable for the current user. Participants can split the validation set from the training set in any proportion for evaluation.

Test dataset is not available for participants and are used to evaluate scores.

◆ Submission Requirements

This competition uses Huawei Cloud Competition Platform as the evaluation platform. Participants can download the "Huawei Cloud competition Platform Instruction Document" and the "Intelligent Beam Prediction and Model Transfer Sample Code Instruction Document" from the official website to familiarize themselves with the whole process from training to submission.

Sample code structure:

```
RM_baseline.zip
└──data (dataset)
    └──train (training dataset)
…
└──dataset.py (loading dataset)
└──model.py (model definition)
└──train.py (training)
└──util.py (basic classes and function)
```

The participants should submit following files: 1. model file: model.pth 2. Model definition file: model.py. The uploaded file size should not exceed 200MB. Programming language: python. Macro package reference: pytorch, numpy, etc. After the participants submitting the model files, the platform will return the model inference results and generate ranking.

Evaluation Criteria

The key performance indicators considered in this task are model performance (signal strength estimation error), uplink communication (local model upload) overhead and downlink communication (global model downlink) overhead.

In particular, the signal strength estimation error is scored as $-10\log_{10}\text{mean}(\text{NMSE})$, where NMSE is the normalized mean square error of the real signal strength of a sample and estimated signal strength of the sample. When $\text{NMSE} > 1$, we set $\text{NMSE} = 1$. The lower the signal strength estimation error, the higher the ranking. The competition website will publish the ranking of the performance (signal strength estimation score) in real time for the participants' reference.

The uplink and downlink communication overheads should be also considered in this task. The total uplink communication overhead is the sum of the uplink communication overhead of all rounds. The uplink communication overhead for each round is the sum of the number of neural network parameters (or gradients) sent uplink by all users that are scheduled in this round. The total downlink communication overhead is the sum of the downlink communication overhead of all rounds. The downlink communication overhead for each round is the sum of the number of neural network parameters (or gradients) sent by the base station to all users scheduled in the current round. Participants are encouraged to publish their total uplink/downlink overheads in Wechat group for reference after submitting solutions to the platform.

The final ranking of this task will be determined by the organizer based on the final uploaded source code. The scores of performance and uplink/downlink communication overhead are ranked separately. Then the weighted average of the three rankings will be used as the final ranking, with the weight of 4:4:2. If the weighted average is the same, the final ranking will be determined by referring to the sub rankings in the order of model performance score, uplink communication overhead and downlink communication overhead.

◆ Competition Awards

According to the final ranking results, the finalists will be selected from the highest to the lowest score (excluding the teams related to organizers), and one first prize, two second prizes, three third prizes and five winning prizes will be awarded respectively. Each teams for the on-site awards will receive the following prizes.

Awards	Amount	Bonus (Team)	Total Bonus
First prize	1	150,000 RMB	500,000 RMB
Second prize	2	90,000 RMB	
Third prize	3	40,000 RMB	
Winning prize	5	10,000 RMB	

Remarks: The above are pre-tax bonuses. Individual income tax or other forms of tax on prizes will be borne by the winners, and withheld and paid by the organizers of the competition on behalf of the winners. The distribution of the bonus in a team is settled among the team members, and the organizer or the committee will not be responsible for this.

◆ Contacts

Link to the competition tasks： https://developer.huaweicloud.com/contest/6g-wireless-ai.html

Email： IWCScontest@huawei.com

Wechat Group for participants： Please scan the QR code to add the wechat little helper, then reply “6G无线电地图”（6G radio map）to enter the information exchange group. The key notifications will be published in the group, so please all the participants should enter this group.

Competition Task 3: Wireless AI Design for Scenario Adaptive and Online Requirements Renewable in Small Sample Condition

◆ Task Background

Recently, as an important direction of 6G pre-research, AI-based wireless communication systems have received extensive attention and research in academia and industry. Although the data-driven approach brings high performance, AI-based solutions also face the generalization problem for different scenarios, i.e., they need to bear higher data collection costs and longer training time to obtain models that fit to the corresponding scenarios, which poses a challenge to the deployment of AI-based solutions. To address such problems, the 6G AI competition will focus on the topic of " Wireless AI Design for Scenario Adaptive and Online Requirements Renewable in Small Sample Condition" and rely on the sub-topic of AI-based CSI feedback to find a more practical solution for wireless AI in target scenarios that limited by small samples.

◆ Competition Tasks

This task exploits the information compression ability of AI, compressing the channel feature information and recovering the information at the Rx for the base station to choose the best scheduling policy. In particular, this task expects the participants to design the model transferring procedure with certain target scenarios under the condition of small samples.

Specifically, the features of this competition task are as follows.

a. Through AI-based compression and feedback, the CSI obtained from the UE side is extracted and encoded by an AI encoder into a bit stream with fixed overhead of 30 bits and then fed back to the network side. The network side recovers the CSI from the bit stream in high accuracy with the designed AI decoder.

b. Based on the basic requirements of wireless communication, this task focuses on the gain of the channel feature information feedback and recovery procedure in different field test scenarios, i.e., two small sample datasets are provided, and the final score is the weighted sum of them.

c. Both scenarios should use the same model structure, but different model parameters is allowed.

d. It is encouraged to use meta-learning, transfer learning, data augmentation and other techniques. It is allowed to use mathematical model based dataset for pre-training, then fine-tuning with the small sample dataset. But the use of external field test datasets for pre-training is prohibited. The participants are encouraged to design the solution for small sample training in a knowledge-driven approach.

e. In order to ensure the original design intention of "reducing the cost of field test data and improving the generalization performance", the use of any external field test dataset is prohibited in scheme design and model training; If the scheme uses external data, the participants will be required to provide the sources of used simulated data and detailed instructions in the process of manual review and reproduction after the competition. It will be careful and rigorous in the manual review stage to ensure above design intension and the fairness of the competition.

◆ Dataset Introduction

In this task, the two frequency domain channel data (H1.mat and H2.mat) are measured in the MIMO scenario configured with 8 transmit antennas and 4 receive antennas (8T4R), and the channel dimension is 1000 samples*4 receive antennas*8 transmit antennas*52 resource blocks for both scenarios. The channel is divided into 13 subbands within the transmission bandwidth and the corresponding CSI data are generated for constructing the CSI feedback model, which are given by W1.mat and W2.mat with the dimension of 1000 samples*8 feature vector length*13 subbands. The conversion process from frequency domain channel data to CSI data is given by cal_eigenvector.py, which is used as additional information along with frequency domain channel data for participants' reference. Specifically, the following materials will be provided by the organizer.

tf_template.zip： TensorFlow version training template folder

├── modelTrain.py： TensorFlow version training sample code

└── modelDesign.py： TensorFlow version model definition sample code

tf_evaluation_inference.zip： TensorFlow version local evaluation sample code

├── modelEvalEnc.py： TensorFlow version local evaluation sample code for encoder

└── modelEvalDec.py： TensorFlow version local evaluation sample code for decoder

pt_template.zip： Pytorch version training template folder

├── modelTrain.py： Pytorch version training sample code

└── modelDesign.py： Pytorch version model definition sample code

pt_evaluation_inference.zip： Pytorch version local evaluation sample code

├── modelEvalEnc.py： Pytorch version local evaluation sample code for encoder

└── modelEvalDec.py： Pytorch version local evaluation sample code for decoder

data.zip： dataset folder

├── cal_eigenvector.py： Example code for converting channel in frequency domain to CSI data

├── H1.mat： channel data in scenario1

├── H2.mat： channel data in scenario2

├── W1.mat： CSI data in scenario1

└── W2.mat： CSI data in scenario2

submit_tf.zip： TensorFlow version submitting example（structure refers to "Submission Requirements"）

submit_pt.zip： PyTorch version submitting example（structure refers to "Submission Requirements"）

◆ Submission Requirements

Each participant should complete the scheme design according to the following requirements and upload the compressed result file to the competition platform:

1.Reference coding language： Python 3.6；

2. Reference macro package version： tensorflow 2.4.0； pytorch > 1.0.0； Numpy 1.18.1； h5py 2.10.0

3. Limit of the upload file size： File size must not exceed 200MB；

4. Limit of the data generation time： Time must not exceed 400seconds。

This competition supports the submission of results for both TensorFlow and Pytorch versions, see the following submission example for details.

For the TensorFlow version, modelDesign.py, encoder_*.h5, and decoder_*.h5 should be submitted. Please compress and archive the files in the following structure and upload them, for example,

```
submit_tf .zip
 └── submit（Folder）
      └── modelDesign.py（model definition file）
      └── modelSubmit（Folder）
           ├── encoder_1.h5（Scenario1, encoder weights）
           ├── decoder_1.h5（Scenario1, decoder weights）
           ├── encoder_2.h5（Scenario2, encoder weights）
           └── decoder_2.h5（Scenario2, decoder weights）
```

For Pytorch version, modelDesign.py、encoder_*.pth.tar and decoder_*.pth.tar should be submitted. Please compress and archive the files in the following structure, rename the file with the team ID then upload, for example,

```
submit_pt.zip
 └── submit（Folder）
      └── modelDesign.py（model definition file）
      └── modelSubmit（Folder）
```

├── encoder_1.pth.tar（Scenario1, encoder weights）

├── decoder_1.pth.tar（Scenario1, decoder weights）

├── encoder_2.pth.tar（Scenario2, encoder weights）

└── decoder_2.pth.tar（Scenario2, decoder weights）

◆ Evaluation Criteria

For each scenario, the score is the squared value of the correlation between the channel feature information before transmission and after recovery, i.e.

$$score = \frac{1}{N_{sp}} \sum_{j=1}^{N_{sp}} \frac{1}{N_{sb}} \sum_{i=1}^{N_{sb}} \frac{||\mathbf{w}_{i,j}^{\mathrm{H}} \mathbf{w'}_{i,j}||^2}{||\mathbf{w}_{i,j}||^2 ||\mathbf{w'}_{i,j}||^2}$$

where N_{sp} is the number of test samples, N_{sb} is the number of subbands per sample, $w_{i,j}$ and $w_{i,j}'$ are the true feature vector and recovered feature vector of i^{th} subband and j^{th} sample, respectively. $(\cdot)^{H}$ denotes the Hermitian transpose.

The final contest score is the average of the two scenario scores as follows.

Combined score = (Scene 1 score + Scene 2 score)/2

Both the final score and the single-scene score will be displayed on the leaderboard, and the ranking will be based on the final score. Players can check the single scene score and the combined score for each submission in the submission log.

◆ Competition Awards

According to the final ranking results, the finalists will be selected from the highest to the lowest score (excluding the teams related to organizers), and one first prize, two second prizes, three third prizes and five winning prizes will be awarded respectively. Each teams for the on-site awards will receive the following prizes.

Awards	Amount	Bonus (Team)	Total Bonus
First prize	1	300,000 RMB	500,000 RMB
Second prize	2	50,000 RMB	
Third prize	3	20,000 RMB	
Winning prize	4	10,000 RMB	

Remarks: The above are pre-tax bonuses. Individual income tax or other forms of tax on prizes will be borne by the winners, and withheld and paid by the organizers of the competition on behalf of the winners. The distribution of the bonus in a team is settled among the team members, and the organizer or the committee will not be responsible for this.

◆ Contacts

Link to the competition tasks: https://www.datafountain.cn/competitions/624

Email: liujia@datafountain.cn

Wechat Group for participants:

If the Wechat group exceeds 200 members, please scan the QR code to add the operations assistant, and reply *Wireless AI Design in Small Sample Condition* to enter the group. All participants are encouraged to enter this group in order to follow the most up-to-date competition information.