

# Introduction of the 2<sup>nd</sup> Wireless communication AI competition(WAIC)

CAICT, OPPO, vivo

IMT-2020 / CAICT / oppo / vivo

## Wireless Communication AI Competition (WAIC)

*AI enlightens wireless communication*

Host -- IMT-2020(5G) Promotion Group 5G+AI Work Group  
Organizer -- China Academy of Information and Communications Technology  
Guangdong OPPO Mobile Telecommunications Corp., Ltd  
vivo Mobile Communication Co., Ltd.

Competition platform -- DataFountain



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Track 1: AI-based CSI Feedback

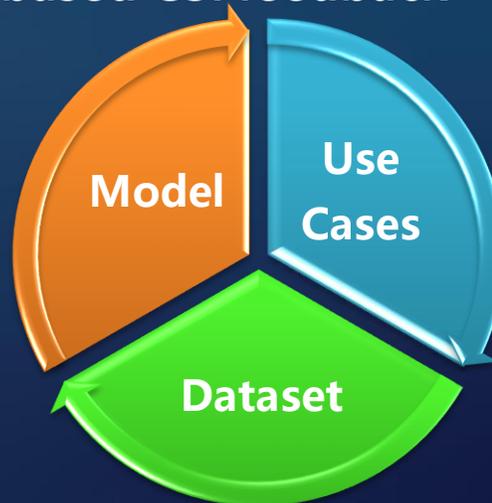
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Track 2: AI-based Channel Estimation

# Overviews

- Competition is an important way in AI area to promote the development of AI technologies
- IMT-2020(5G) Promotion Group host **Wireless Communication AI Competition (WAIC)** to promote the integration of 5G and AI technologies
  - 1<sup>st</sup> WAIC\*: 2021.01-03, AI-based Full-CSI feedback
  - 2<sup>nd</sup> WAIC\*\*: 2021.06-08, AI-based CSI feedback + AI-based Channel estimation

Provide typical AI models and explore the performance boundaries



Focus on classic wireless AI problems and extract proper use cases for real deployment

Build classic datasets for academic research, specification and product verification

\* RWS-210236 Introduction of the 1st Wireless communication AI competition(WAIC)

\*\* <https://www.datafountain.cn/special/IMT-2020-2/competition?lang=en-US>

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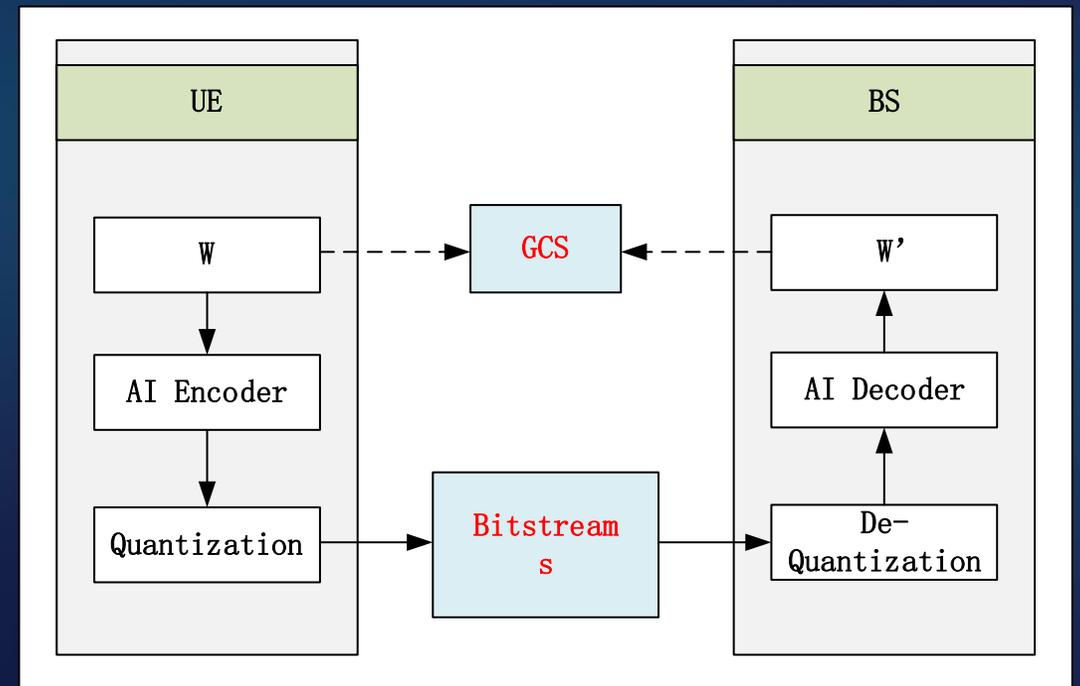
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Track 2: AI-based Channel Estimation

# Subject of the 2<sup>nd</sup> WAIC-Track 1

## AI-based Channel State Information Feedback (Eigenvector-based)

- UE obtains Eigenvector  $W$  from the full channel  $H$
- UE encodes  $W$  to a  $M$ -dimensional bitstream  $s$  through an AI-Encoder and forwards it to the BS
- The BS decodes the received bitstream  $s$  to  $W'$  through an AI-decoder to recover the extracted CSI information  $W$
- The square of generalized cosine similarity (GCS) is used as the criterion to evaluate the difference between the recovered channel and original channel



# Dataset – CSI feedback

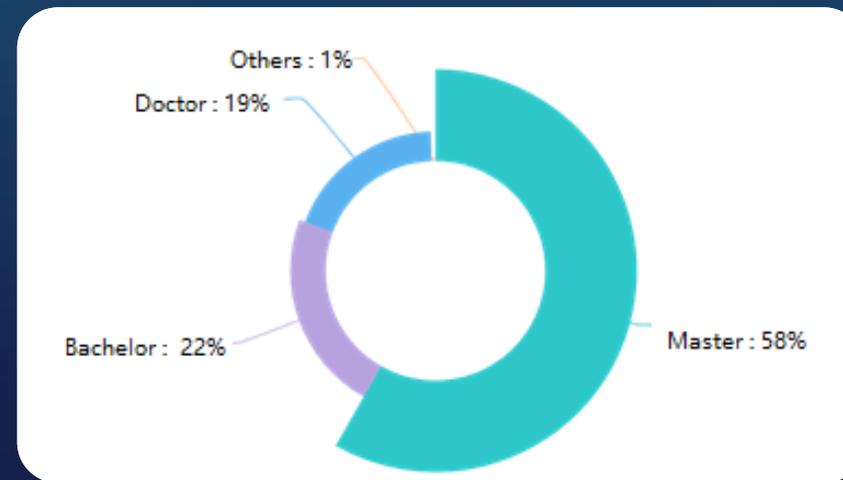
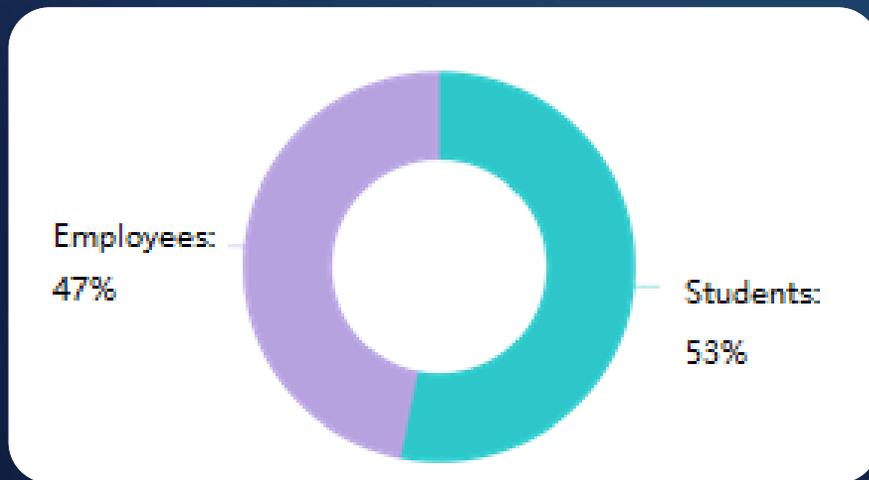
## 3GPP Uma scenario

- Small scale fast fading with 100% NLOS is considered
- 3000 (UEs)\* 200 (slots)=600000 samples are used for training set, where the 200 slots are uniformly sampled with a interval of 100 slots.
- Full channel info  $H$  has been extracted into  $W$  with 12 subbands and 32-length eigenvector
- 48 bits feedback and 128 bits feedback are evaluated separated in CSI Track

Parameter	Value
Channel model	UMa & NLoS
Carrier frequency $F_c$	3.5GHz
Subcarrier spacing $B_{sc}$	15KHz
Number of resource block $N_{RB}$	48
Number of Tx antennas $N_t$	32
Number of Rx antennas $N_r$	4
Number of clusters $N_d$	24
Number of cells $N_c$	57
Number of UEs in training set $N_{train}$	3000
Number of UEs in testing set $N_{test}$	400
Number of sampling slots $N_{slot}$	200
Number of interval slots $T$	100

# Overviews of the CSI feedback Trank

- More than **300 teams** from companies, universities and research institutes participating in the competition
- Engineers from worldwide companies are full of enthusiasm and account for **nearly 50%** of the participants



# Overviews of the CSI feedback Trank

- As the 1<sup>st</sup> WAIC, **well data analysis, excellent model design and proper quantization method** are the key point to obtain a good performance gain in 2<sup>nd</sup> WAIC as well
- Guided by the reference paper from on 1<sup>st</sup> WAIC, most of the competitors utilized **Transformer based approaches to design their models**, and this could be used as a baseline model to analyze related CSI AI issues

No.	score_sum	score_48bit	score_128bit
1	0.907	0.877	0.938
2	0.900	0.865	0.935
3	0.890	0.850	0.930
4	0.888	0.850	0.926
5	0.887	0.851	0.924
6	0.886	0.849	0.922
7	0.883	0.844	0.922
8	0.882	0.843	0.922
9	0.882	0.839	0.925
10	0.881	0.842	0.921
11	0.881	0.845	0.918
12	0.879	0.842	0.917



1. with the same feedback overhead, AI based approaches could obtain 10%~20% performance gain compare to eTYPE2
2. with the same performance gain in the square of generalized cosine similarity, about 50%~60% feedback bits can be reduced compare to eTYPE2

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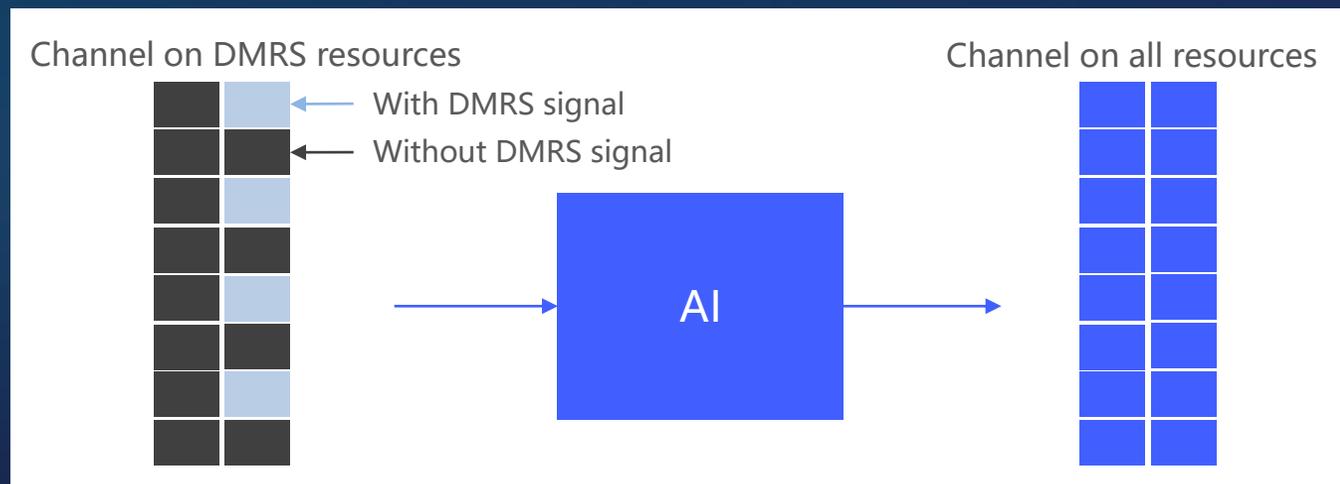
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Track 2: AI-based Channel Estimation

# Subject of the 2<sup>nd</sup> WAIC-Track 2

## DMRS channel estimation

- The input of AI module is the estimated channel information on DMRS resource elements
- The output of AI module is the channel information on all resource elements
- A normalized MSE is used as the criterion to evaluate the difference between the recovered channel on all resources and input channel on DMRS resources



# Dataset - Channel Estimation

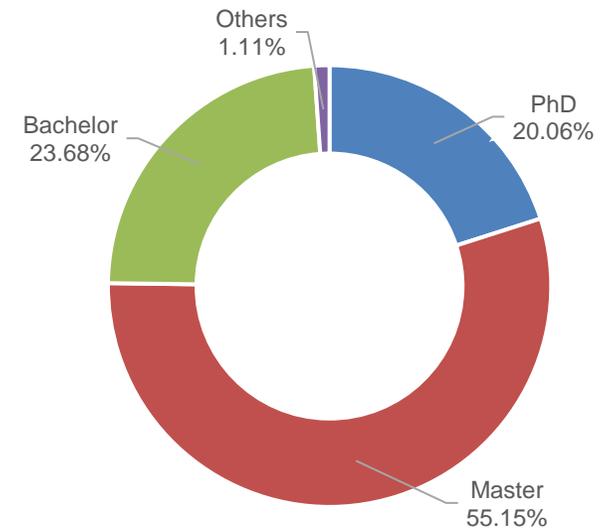
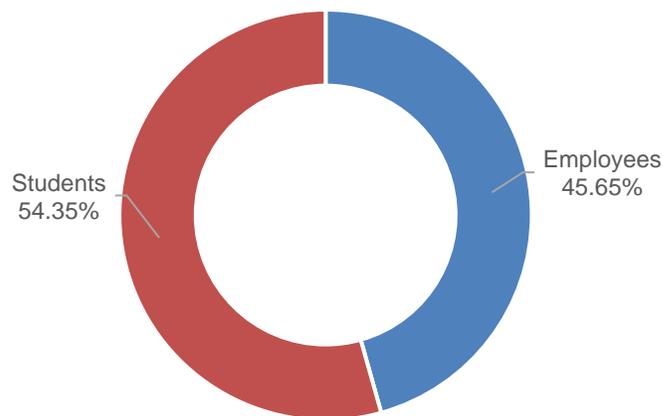
## 3GPP CDL scenario

- The channel conditions are randomly selected, such as the channel model, the delay spread, UE speed, SNR.
- The same transmit beamforming vector is used for all sub-carriers. The samples only represent the channel information of the first receive antenna.
- The number of data samples is 210000.

Parameter	Value
Channel model	Mixed CDL model, randomly select from CDL-A, CDL-B, CDL-C, CDL-D and CDL-E
Delay spread	0~300 ns
SNR	0~20 dB
Speed	0~60 km/h
Carrier frequency	3.5GHz
Subcarrier spacing	15KHz
Number of resource block	8
Number of Tx antennas	32
Number of Rx antennas	2

# Overviews of the Channel Estimation Trank

- There are more than **317 teams** involving **378 contestants** from 120 companies, 150 universities and research institutes participating in the competition
- Students from worldwide universities are full of enthusiasm and account for 54.35% of the participants



# Overviews of the Channel Estimation Trank

- To achieve good performance, **well data analysis, proper data enhancement, and excellent model design** are the key points.
- Many competitors build the AI/ML model with **multiple convolution layers with small convolution kernels and multiple Squeeze-and-Excitation blocks**. Some competitors utilize **the orthogonality between the frequency domain and the time domain**.
- The models used by the top competitors could be considered as reference models for AI based channel estimation.

No.	Final score	Score of 0dB	Score of 5dB	Score of 10dB	Score of 15dB	Score of 20dB
1	43.00	40.11	42.40	43.34	44.74	44.42
2	42.25	39.39	41.74	42.60	43.49	44.03
3	41.89	39.39	41.35	42.32	42.87	43.54
4	41.85	39.64	41.65	42.32	42.62	43.00
5	41.57	38.35	41.08	41.83	43.00	43.62
6	41.51	38.86	41.11	41.83	42.71	43.03
7	39.95	36.71	39.10	40.31	41.38	42.26
8	39.94	36.12	39.72	40.53	41.66	41.68
9	39.83	36.68	39.26	40.14	41.47	41.61
10	39.28	35.40	38.63	39.76	41.00	41.60

