CLAIMS:

1. A method of channel estimation comprising:

receiving, by a receiver device, MIMO reference signals using a receiver-MIMO-reference-signal-pattern; wherein the receiver-MIMO-reference-signal-pattern contains a receiver-MIMO-reference-signal-placement; wherein the receiver-MIMO-reference-signal-placement is a non-uniform pattern of resources in space, time, frequency, and/or code and is calculated from a prior knowledge, wherein the prior knowledge is obtained from a plurality of MIMO channel samples associated to a region;

estimating, by the receiver device, MIMO channel from channel measurement on the reference signals and the prior knowledge.

2. A method of channel estimation comprising:

transmitting, by a transmitter device, multiple input multiple output (MIMO) reference signals using a transmission-MIMO-reference-signal-pattern, wherein the transmission-MIMO-reference-signal-pattern contains a transmission-MIMO-reference-signal-placement; wherein the transmission-MIMO-reference-signal-placement is a non-uniform pattern of resources in space, time, frequency, and/or code and is calculated from a prior knowledge; wherein the prior knowledge is obtained from a plurality of MIMO channel samples associated to a region.

3. The method of claim 1, further comprising:

transmitting, by the receiver device, feedback based on channel measurement on the reference signals.

4. The mehod of claim 2, further comprising:

receiving, by the transmitter device, feedback based on channel measurement on the reference signals;

estimating, by the transmitter device, MIMO channel from the feedback and the prior knowledge.

5. The method of claim 1 or 2 wherein the prior knowledge is represented by a channel space basis matrix *U*; wherein the channel space basis matrix *U* consists of a plurality of

orthonormal channel basis vectors and is obtained from a plurality of MIMO channel samples vectorized from a multiple-dimensional MIMO channel form including space, time, frequency, and/or code.

6. The method of claim 5 wherein the prior knowledge represented by a channel space basis matrix *U* is associated to a region, and different prior knowledges represented by different channel space basis matrixes *U* associated to different regions.

7. The method of claim 6 wherein a plurality of MIMO channel samples for each of a plurality of different regions are reshaped, and arranged into a channel training matrix *A* composed of vectorized MIMO channel samples of length *n*:

the channel space basis matrix *U* based on a rank-reduced truncated singular value decomposition (SVD) of channel training matrix *A* according to:

$$\text{SVD}(A) = U\Sigma V^H$$

where the SVD on the training matrix *A* is truncated by keeping the largest *r* singular values, wherein *r* is a defined rank, and the channel space basis matrix *U* has size *n*-by-*r*.

8. The method of claim 2, further comprising,

obtaining, by the transmitter device, a region to which the transmitter device and receiver device belong, the prior knowledge represented by a channel space basis matrix *U* associated to the region, and a transmission-MIMO-reference-signal-pattern.

9. The method of claim 8 wherein the transmission-MIMO-reference-signal-pattern contains at least one of:

a transmission-MIMO-reference-signal-placement including reference signal positions, each of which indicates on which subcarrier and on which transmitter antennas in a MIMO channel space a reference signal to be transmitted;

transmitted signal value for each reference signal; or

multiplexing scheme for each reference signal.

10. The method of claim 8, further comprising:

obtaining, by the transmitter device, a transmission-MIMO-reference-signal-placement and transmission-placement-to-pattern-generation method.

11. The method of claim 10, further comprising:

obtaining, by the transmitter device, a basic-MIMO-reference-signal-placement and basic-to-transmission-placement-generation method.

12. The method of any one of claims 1, 3, 5, 6, 7further comprising:

obtaining, by the receiver device, a region to which the transmitter device and receiver device belong, the prior knowledge represented by a channel space basis matrix *U* associated to the region, and a receiver-MIMO-reference-signal-pattern.

13. The method of claim 12 wherein the receiver-MIMO-reference-signal-pattern contains at least one of:

a receiver-MIMO-reference-signal-placement includes reference signal positions, each of which indicates on which subcarrier, on which transmitter antenna, and on which receiver antennas in a MIMO channel space a reference signal to be transmitted;

transmitted signal value for each reference signal; or

(de)multiplexing scheme for each reference signal.

14. The method of claim 12, further comprising:

obtaining, by the receiver device, a receiver-MIMO-reference-signal-placement and receiver-placement-to-pattern-generation method.

15. The method of claim 14, further comprising:

obtaining, by the receiver device, a basic-MIMO-reference-signal-placement and basic-to-receiver-placement-generation method;

and/or

obtaining, by the receiver device, a transmission-MIMO-reference-signal-placement and transmission-to-receiver-placement-generation method.

16. The method of claim 11 or claim 15, wherein r pivot positions obtained from the channel space basis matrix U^H, the r pivot positions corresponding to the basic-MIMO-reference-signal-placement, each defining a reference signal position in a MIMO channel space by a subcarrier, a transmitter antenna, and a receiver antenna, where U^H is the Hermitian transpose of U; wherein a MIMO channel space includes the number of subcarriers, number of transmitter antennas, and number of receiver antennas.

17. The method of claim 10, wherein transmission-placement-to-pattern-generation method specifies transmitted signal value and multiplexing scheme for each reference signal in transmission-MIMO-reference-signal-placement; wherein the multiplexing scheme includes time-multiplexing, frequency-multiplexing, and/or code-multiplexing.

18. The method of claim 14, wherein receiver-placement-to-pattern-generation method specifies transmitted signal value and (de)-multiplexing scheme for each reference signal in receiver-MIMO-reference-signal-placement; wherein the (de)-multiplexing scheme includes time-(de)-multiplexing, frequency-(de)-multiplexing, and/or code-(de)-multiplexing.

19. The method of claim 11, wherein basic-to-transmission-placement-generation method merge any two reference signal positions in a basic-MIMO-reference-signal-placement that share the same subcarrier and the same transmitter antenna but has different receiver antennas one reference-signal position in the transmission-MIMO-reference-signal-placement.

20. The method of claim 15, wherein basic-to-receiver-placement-generation method includes a basic part and may include an augmentation part into a receiver-MIMO-reference-signal-placement from a basic-MIMO-reference-signal-placement; or transmission-to-receiver-placement-generation method includes a basic part and include an augmentation part into a receiver-MIMO-reference-signal-placement from a transmission-MIMO-reference-signal-placement.

21. The apparatus of any one of claims 1 to 20, wherein the apparatus comprises a processor and a memory; the memory coupled to the processor; and memory stores instructions; when the instructions executed, cause the processor to perform the steps of transmitter device.

22. The apparatus of any one of claims 1 to 20, wherein the apparatus comprises a processor and a memory; the memory coupled to the processor; and memory stores instructions; when the instructions executed, cause the processor to perform the steps of receiver device.

23. A computer readable medium of any one of claims 1 to 20, wherein the computer readable medium has stored thereon computer executable instructions that when executed by the processor cause the apparatus to perform to perform the steps of receiver device.

24. A computer readable medium of any one of claims 1 to 20, wherein the computer readable medium has stored thereon computer executable instructions that when executed by the processor cause the apparatus to perform to perform the steps of transmitter device.