mmCEsim:

Task-oriented mmWave Channel Estimation

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Introduction

With the approaching 6G era, reconfigurable intelligent surface (RIS) and metaprisms are among promising future technologies that will form a **complex cascaded channel in millimeter wave** (mmWave). However, the channel estimation problem is an obstacle due to a large number of RIS elements resulting in the high channel dimension. For a complex cascaded channel model with multiple RISs and MetaPrisms, the channel is harder to estimate and even formulate. Therefore, we propose a **task-oriented** mmWave channel estimation scheme and develop the simulator **mmCEsim**.

mmCEsim

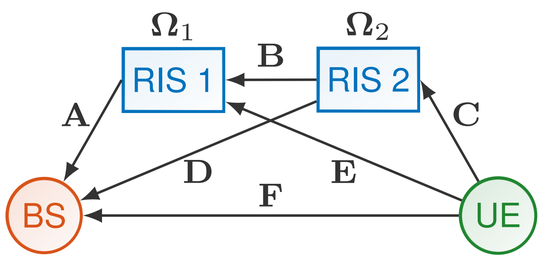
Millimeter Wave Channel Estimation Simulation

Build mmCEsim CLI passing | license MIT | DOI 10.5281/zenodo.6912824

The simulator is **open source** on GitHub under the MIT license.

Task-oriented Concept

The user only needs to know the system settings and will be then able to compare different channel estimation schemes. To migrate the algorithm to a different system, for example from single-user MISO to multi-user MIMO, simply change the system settings without affecting your algorithms. (Of course, your algorithm may also be specific to a certain system setting.) What makes the application even more powerful is that there is an **auto estimation scheme** that is both efficient and effective. This scheme is specially catered to the **cascaded channel** consisting of RISs and MetaPrisms, and even more complicated scenarios like **multi-RISs**. Thus, the evaluation of channel estimation performance in mmWave is significantly simplified. For example, a double RIS channel model in Fig. 1 can be easily simulated in mmCEsim.



$$\mathbf{H} = \mathbf{A}\boldsymbol{\Omega}_1\mathbf{B}\boldsymbol{\Omega}_2\mathbf{C} + \mathbf{D}\boldsymbol{\Omega}_2\mathbf{C} + \mathbf{A}\boldsymbol{\Omega}_1\mathbf{E} + \mathbf{F}.$$

Fig. 1. Double RIS uplink channel model example.

One of the prerequisites is our proposed **beam pattern and reflection pattern design** (Y. You, W. Zhao, L. Zhang, X. You and C. Zhang, "Beam pattern and reflection pattern design for channel estimation in RIS-assisted mmWave MIMO systems," *IEEE Trans. Veh. Technol.*, 2022, to be published), which will ensure the sparsity of the compressed channel.

The workflow of mmCEsim is shown in Fig. 2. Users can generate configuration files through GUI app, and then **export**, **simulate** and finally generate **report**s.

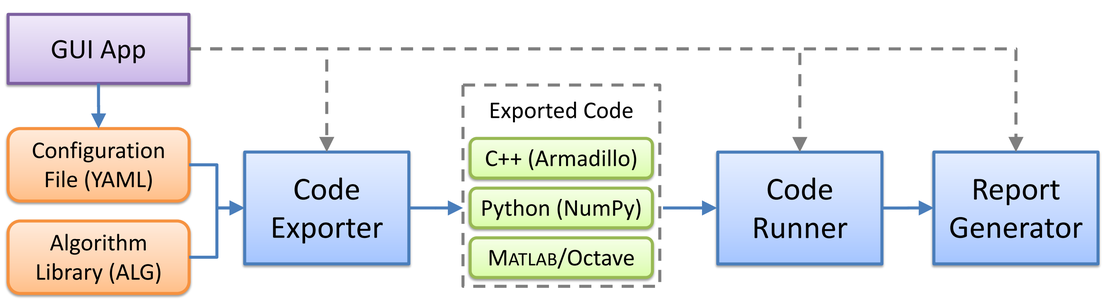


Fig. 2. Workflow of mmCEsim.

```yaml
nodes:
  - id: BS # this should be unique
    role: receiver
    gains:
      mode: normal
      mean: 0
      variance: 1
    num: 1 # this is the default value
    size: [8, 4] # UPA with size 8x4
    beam: [4, 2]
    grid: same # the same as physics size
  - id: UE # user
    role: transmitter
    num: 1 # a single-user model
    size: [8] # ULA with size 8
    beam: [2]
    grid: 16
channels:
  - id: H
    from: BS
    to: UE # 'from -> to' specifies the channel direction
    sparsity: 5
```

The configuration is in YAML format, with a code snippet in Fig. 3. Algorithms are defined in our designed ALG language, which is able to be exported to C++, Python, MATLAB/Octave. There are also predefined algorithms in the standard library of mmCEsim.

Fig. 3. Channel configuration code snippet (in YAML format).

GUI Application

The graphic user interface (GUI) is implemented using Qt calling the CLI app. The GUI app supports Linux, macOS and Windows.

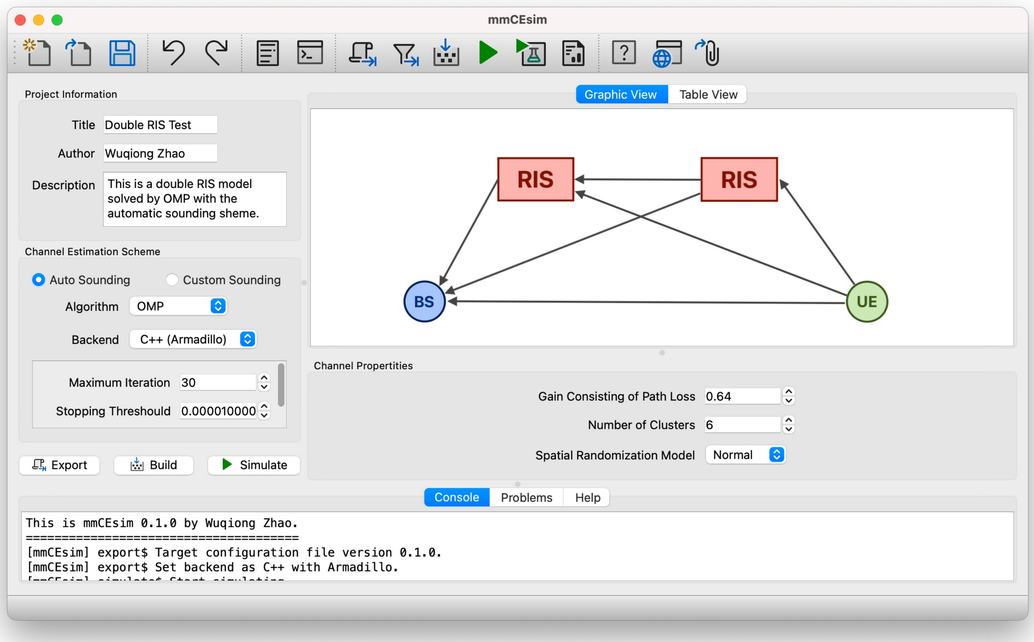


Fig. 4. mmCEsim GUI application on macOS.

Conclusion

In this work, we develop an open-source millimeter wave channel estimation simulator. The simulator is capable of simulating complex cascaded channels consisting of multiple RISs and MetaPrims. As a task-oriented simulator, we also propose an accompanying auto channel estimation scheme which is efficient and flexible. The use of the mmCEsim simulator will enable a more efficient research and provide a standard platform for easy comparisons.

Project Links

1. **Official Website:** https://mmcesim.org
2. **Web Application:** https://app.mmcesim.org
3. **Project Blog:** https://blog.mmcesim.org
4. **GitHub Organization:** https://github.com/mmcesim
5. **CLI App Repository:** https://github.com/mmcesim/mmcesim
6. **GUI App Repository:** https://github.com/mmcesim/mmcesim-gui

Citation

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