Instructions
(see also slide deck)

1. INSTALL WORKSHOP ENVIRONMENT

Choose one of the following options:

1.1. Install Binaries. Binaries from debian stretch with gcc-6, may or may not work on other distributions
   - cd into a workspace folder of your liking
   - wget https://stce.rwth-aachen.de/files/ofw19_binary.tar.gz
   - tar -xzf ofw19_binary.tar.gz
   - source discreteAdjointOpenFOAM-plus/etc/bashrc

1.2. Install the Docker environment. If you do not have docker installed, please follow the steps outlined in
   https://docs.docker.com/install/linux/docker-ce/ubuntu/
   If you can’t or don’t want to install docker, see Section 8 for alternatives.
   First we will set up the docker environment:
   - cd into a workspace folder of your liking
   - wget https://stce.rwth-aachen.de/files/ofw19_docker.tar.gz
   - tar -xzf ofw19_docker.tar.gz
   - if your user is not in the docker group you may need to run some of the following commands with sudo
     - ./create to create docker container from image (only needed once)
     - folder tutorial_data will be mounted within the container as $HOME
     - ./run to run and attach to /bin/bash within container
     - /opt/discreteAdjointOpenFOAM-plus/etc/bashrc will be sourced on startup by ~/.bashrc in adjoint mode DOF_AD_MODE=A1S
     - pyFoam is available within the container
     - you can type exit to close the container again
     - run paraView and other tools which need GUI (e.g. editors) on your local machine

1.3. Install VirtualBox VM. Binaries and tutorial data within a minimal XUbuntu 18.04 LTS. Requires Oracle VirtualBox.
   - cd into a workspace folder of your liking
   - wget https://stce.rwth-aachen.de/files/ofw19_vm.tar.gz
   - tar -xzf ofw19_vm.tar.gz
   - execute the VM with VirtualBox
2. ADJOINTSIMPLEFOAM

We start with the easiest possible, if slightly impractical, adjoint solver:

- cd $OFW_DATA/adjointSimpleFoam
- wmake
- cd referenceCase
- inspect and run ./Allrun
- if you run out of RAM reduce the number of time steps in system/controlDict
- disable SDLS on line 20 of system/fvSolution
- what's the impact to peak memory?

3. ADJOINTSIMPLECHECKPOINTINGFOAM

To reduce the memory impact we employ checkpointing:

- cd $OFW_DATA/adjointSimpleCheckpointingFoam
- wmake
- cd referenceCase or cd pitzDaily
- inspect and run ./Allrun
- try checkpointing methods equidistant and revolve in system/checkpointingDict
- alter the number of checkpoints
- what's the impact on run time?
- optional: try to run the solver in parallel

4. TOPOLOGY OPTIMIZATION WITH PIGGYOPTSIMPLEFOAM

Up until now we only calculated sensitivities. Let's use them to run an optimization:

- cd $OFW_DATA/piggyOptSimpleFoam
- wmake
- cd filter_case
- inspect and run ./Allrun

5. SHAPE OPTIMIZATION WITH PIGGYSHAPESIMPLEFOAM

Instead of using a penalty field, let's use all points on the boundary as parameters:

- inspect $FOAM_SRC/OpenFOAM/meshes/polyMesh/polyMesh.C
- cd $OFW_DATA/piggyShapeSimpleFoam
- wmake
- cd cylinderMirror
- inspect and run ./Allrun and ./optimize.sh
- enable or disable the volume constraint in system/fvSolution

6. IMPLEMENT FLOW UNIFORMITY COST FUNCTION

Let's try to optimize for flow uniformity. For simplicity we can assume that the mesh is uniform (orthogonal, cell volume constant).

- cd $OFW_DATA/flowUniformity
- implement $J_U$ such that $J_U = (\bar{||U||}_0 - \bar{||U||}_1)^2$ where $\bar{||U||}_0$ and $\bar{||U||}_1$ are the average velocities on outlet0 and outlet1 respectively. Hint: Use gAverage and use phi as a substitute for $U$.
- wmake
- go to cd flow_uniformity_case and run

Questions after the Workshop? Contact: towara@stce.rwth-aachen.de