Computer Aided Engineering in Augmented Reality: Flow Visualizations for Hydro Power Applications

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Augmented Reality (AR) technology has attracted a great deal of attention in a number of fields, including engineering. AR provides a unique opportunity to diversify the traditional methods implemented in engineering by overlaying digital information onto the physical world. Displaying CAD geometries in AR has already become a standard feature in building information modeling (BIM) or Industry 4.0. The visualization of Computer Aided Engineering (CAE) results in virtual, augmented, or mixed reality (VR, AR, XR) is not yet standard in most of the common engineering software packages. Our current work is therefore devoted to the development of an interface between multi-physics software and AR, where there is none yet.

The present contribution demonstrates that procedure for an example from Computational Fluid Dynamics (CFD), namely Pelton turbines. They convert the potential energy of water stored at high-altitude reservoirs into mechanical power. At the end of the penstock, which guides the water from the reservoir to the turbine, nozzles generate high-velocity water jets that act on the buckets of the Pelton turbine runner. When passing through the water jets, the buckets are admitted to the flow impulse and participate in the energy transfer. In consequence, CFD simulations of the runner need to consider the unsteady character of the jet-bucket interaction. This, together with the water-air multiphase fluid mixture, poses an inherent challenge for simulation and visualisation of the flow. However, by employing advanced techniques such as CFD in the early design phase, hydraulic engineers are given a very helpful tool to calculate the efficiency of a Pelton turbine runner and to study how a change of runner parameters affects the efficiency of the runner. Morevover, the number of costly experiments can be greatly reduced in the design and development phase of a turbine.

The simulation itself was carried out on High-Performance Computing (HPC) resources of the *Vienna Scientific Cluster (VSC)*, including a virtual desktop interface set up by the remote access software *NoMachine* for direct pre- and post-processing on cluster nodes. Aiming for a light-weight AR application (AR-App) on a tablet or mobile phone, the 3D Geometry and selected representations of the data (e.g., like in Fig. 1, an isosurface of one quantity colored by the value of another quantity) were copied to a local machine in order to build an Android AR-App by means of the game engine *Unity*.

For validation purposes, in addition to runner simulations executed in *ANSYS CFX 19.2*, efficiency measurements in the laboratory of Fluid Flow Machinery were conducted. This allowed us, to augment the *real world* experimental setup with simulation data, i.e., the time evolution of the water jet hitting the rotating runner, compare Fig. 1. As soon as the AR-App recognizes the real target, the projected AR object can be rotated and translated via touch screen. Due to the modest device requirements, the presented AR-App is well suited to be used on demand in presentations, to enrich the general understanding of the audience for a multi-physics topic. Further, the application is suited for academic teaching and research, as well as for public communication. Where the present approach requires to select data representations beforehand, our future investigations will explore the direct interaction of the XR engine with the data.

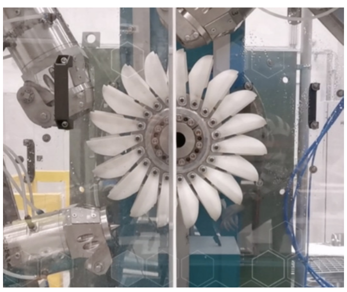

Fig. 1: Left: Test setup in the hydraulic laboratory of IET. Right: Isosurface of water coloured by the normalized flow velocity for one time step. The AR app visualizes the time series of the transient calculation results and provides the user a 3D view of the AR object, that can be zoomed and rotated.