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Simple flight controller based on FlowPro-Matlab coupling

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The aim of this work is the development of an interface between CFD software FlowPro and computing environment Matlab. FlowPro and Matlab coupled with the aid of the interface can be used to simulate complex problems such as fluid-structure interaction (FSI) problems. The fluid dynamics is managed by FlowPro and the structure dynamics is implemented in Matlab. FlowPro is an open-source CFD software based on the discontinuous Galerkin method [1, 2], which has been and is being developed by the authors of this study. FlowPro is capable of simulating complex fluid flow problems including turbulent fluid flow in oscillating blade cascade [3], FSI problems, shape optimalisation problems, etc. The main idea behind FlowPro-Matlab interface is to provide FlowPro, a very powerful CFD software, to Matlab users. In case of FSI simulations, the problem is split into two parts. The calculation of the fluid flow field, mesh deformation and forces acting on the bodies is performed by FlowPro. The solution of rigid body movement equations is left for the user of Matlab. The interface presented in this work manages the data transfer between FlowPro and Matlab.

Java sockets were found to be the most viable solution for the data transfer. The server is implemented in Matlab and the client is integrated in FlowPro. The simulation starts when the user executes the given Matlab script. The script launches the fluid flow simulation in FlowPro automatically. FlowPro performs one time step, computes forces acting on the bodies and sends them back to Matlab. Using these forces, new position of the bodies are established in Matlab. The new position are sent back into FlowPro, where the mesh deformation is computed. This process repeats until the computation is terminated. This type of fluid-structure interaction is known as weak coupling algorithm.

The usage of the developed interface is illustrated on the example of a flight controller of a simple 2D plane model, see Fig.1. The plane model consists of two NACA0012 airfoils of different sizes. The rotation of the smaller airfoil (angle β) is controlled by the PID regulator,

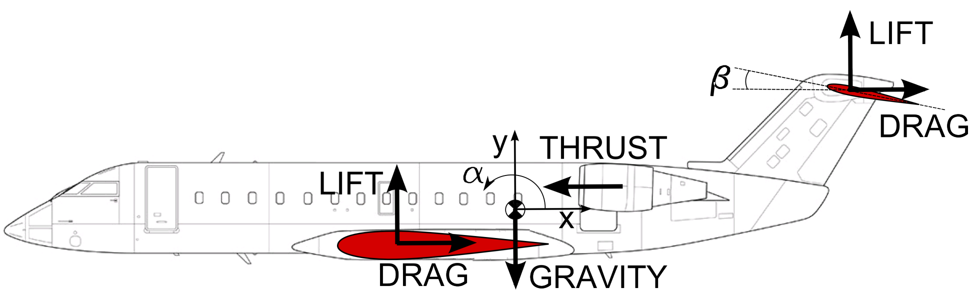

Fig. 1. Simple plane model with highlighted external forces

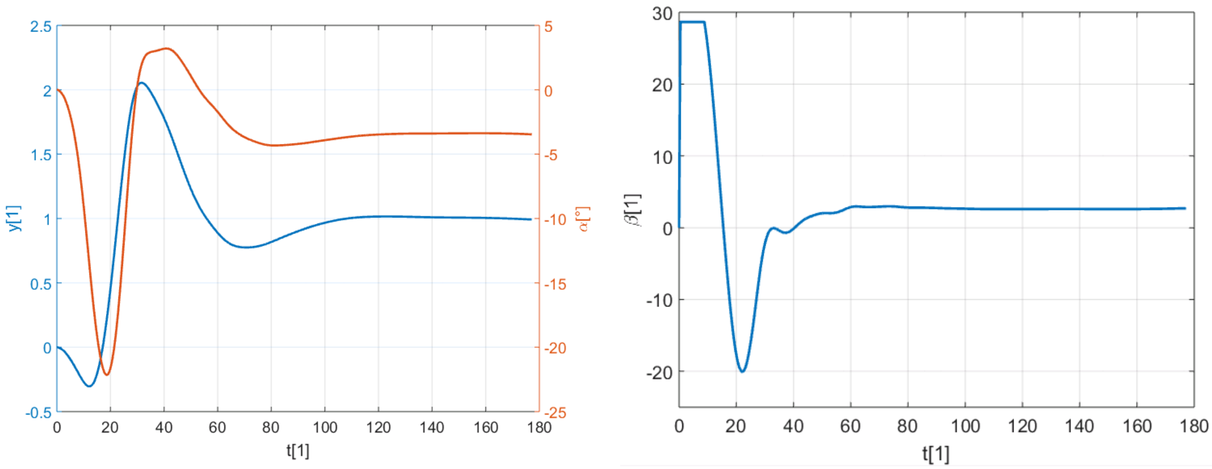

Fig. 2. Altitude y and pitch α of the plane vs. time (*left*); controlled angle β vs. time (*right*)

whose parameters were set empirically. The initial position of plane's gravity center is $x = 0$, $y = 0$ and $\alpha = 0$. The aim of the simulation is to reach the target altitude $y = 1$. The altitude y and pitch α of the plane with respect to dimensionless time are shown on the left-hand side of Fig. 2. The target altitude $y = 1$ is reached at time $t = 100$. The angle β, which is controlled by PID regulator, is shown on the right-hand side of Fig. 2.

The presented example shows that it is possible to use the developed interface for a variety of FSI problems. The advantage of this approach is that it provides a very accurate evaluation of non-linear forces acting on the bodies as opposed to simplified linear expressions, which are typically used.

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