Deutsches Zentrum
für Luft- und Raumfahrt

The DLR Robotic Motion Simulator

Figure 4: The DLR Robotic Motion Simulator

Motion simulators aim to create the sensation of operating or being on a real vehicle within a simulation environment. To achieve this goal, the human senses have to be provided with sensory input as real as possible. Typically, simulations focus on vision and hearing, and in the case of motion simulators also include motion cues.

The DLR Robotic Motion Simulator (RMS) is an interactive motion simulator based on an industrial robot. Additionally to the six axes of the robot, a seventh linear axis increases the workspace (to 10 m lateral) and allows redundancy for movements. At the tool center point, a simulator cell is mounted sitting the pilot, see figure 1. The setup inside the cell consists of exchangeable instruments, input devices, two projectors and safety equipment. The simulator can be used for several scientific tasks, e.g. driving or flying simulation or testing new input devices.

The current design of the DLR Robotic Motion Simulator is the direct result of the experiences made with earlier versions of the simulator at the institute. Although the workspace for linear movements is considerably larger compared to the workspace of Stewart platforms of the same weight and size, an additional linear axis is an easily available way to increase the workspace in a defined direction.

Utilizing two slip rings, one in axis 1 (the first rotational axis in yaw direction) and another in axis 6 (last axis before the simulator cell) it is possible to rotate unrestricted around the yaw and roll axis. This can be used for example to display yaw and roll motions of cars or airplanes directly without scaling down the resulting angular velocities.

In order to deceive the human motion perception organ, the vestibular system, so called Washout filters are used to generate a perception of long lasting accelerations and angular velocities by scaling and filtering them, as otherwise they would exceed the workspace of the simulator quickly.

To generate the visualization for the passenger, the entry hatch (light grey part, see figure 2) is also used as screen for two stereo projectors, installed at the rear side of the cabin. To compensate for the dome's concave, irregular form, the projected images are corrected geometrically. The large screen allows a viewing angle of about 120 degree in horizontal direction. Furthermore, 3D stereo vision is supported by using wavelength multiplexing of RGB color triplets in combination with interference filtering glasses.

For different simulation scenarios, different kinds and arrangements of control instruments and gauges are needed. In the modular simulator cell, the cockpit instrumentation is an independent package that can be exchanged easily for different simulations providing the according control instruments. This allows the DLR Robotic Motion Simulator to be used for a multitude of scenarios while implementing a complete replica of the simulated cockpit. The only two connections of the instrument package are defined as 230V AC power supply and two Ethernet lines. All necessary hardware to control the instruments, as computer systems, power supplies etc. are included into the instrumentation package. This allows the double use of the instrumentation packages as fixed space, stand-alone simulators without the motion simulator platform by simply adding a visualization screen in front of it.
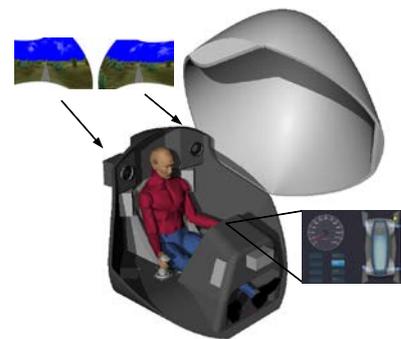

Figure 5: The simulator cell with projectors, sidestick and instrumentation

Possible applications range from HMI studies or dynamic simulations of aircraft or ground vehicles to evaluations of training tasks or the research of human factors during the operation of said vehicles. The large workspace enables the one-to-one display of some maneuvers, e.g. lane change maneuvers.

Figure 6: The simulator cell in flight simulator configuration (instrument panel removed)

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