

RotorLib FDM

RotorLib FDM® (flight dynamics model) is a real-time C++ helicopter flight dynamics simulation library for flight training devices and flight simulators. RotorLib FDM is a model library which implements a generic mathematical model for helicopters. It can be parametrized to simulate a specific helicopter type (e.g. UH60, Bell 206 etc.). The flexible software architecture allows developers to extend the system by adding custom models as C++ classes for ground contacts, engines and flight control system components.

Features:

- High fidelity helicopter simulation model
- Generic turbine engine model that can be configured with performance data
- Blade element theory based rotor model which supports auto-rotation
- Autopilot model
- Aerodynamic interferences between components (e.g. main rotor and fuselage)
- Ideal for pilot-in-the-loop applications such as flight training devices
- Fully reconfigurable using XML configuration files
- Supports saving and loading simulation state
- Faster or slower than real-time simulation and pausing the simulation supported
- Deterministic simulation model (i.e. it is possible to repeat scenarios)
- High fidelity landing gear simulation capable of simulation of taxiing
- Extensible control system architecture
- Easy to use C++ API
- Low cost
- Available on Windows® and Linux®

Applications:

RotorLib FDM has a wide variety of applications, including but not limited to:

- Pilot training
 - Desktop trainers
 - Procedure and system trainers
 - Screening simulator
 - Mission rehearsal
 - Part task trainer
 - Full flight trainer
 - UAV operator trainer
- Engineering simulators
 - Aircraft systems development
 - Academic research
 - UAV systems development
- Entertainment
 - Entertainment simulators
 - Computer games



Flight Dynamics Model

RotorLib FDM has a component based architecture where several mathematical models interact with each other.

Rotor Models

RotorLib FDM includes two rotor models which are described below. Both models output information regarding induced velocity and rotor wake angle. This information is used by other models (such as fuselage model) to simulate interference effects.

Blade Element Model

Blade Element Model breaks down each blade to smaller parts (blade elements) and computes the forces and moments acting on these parts. The forces and moments acting on the hub are found by integrating the element forces and moments. Each blade is a separately simulated object and each blade element is simulated individually. Blade element model takes non-uniform induced velocity distribution, yawed flow, compressible flow, wind, turbulence and ground effect into account and supports auto-rotation.

Momentum Theory Model

Momentum theory based rotor model uses a combination of momentum theory and a simplified form of blade element theory to compute the forces and moments. It takes wind, turbulence and ground effect into account. This model has a lower fidelity but requires less computational performance and is easier to configure.

Fuselage and Stabilizers

Fuselage and stabilizer models support using coefficient tables that are obtained with wind tunnel tests or CFD simulation. Both of these models can simulate interference with rotors and with each other. As with the rotor models, effects of wind and turbulence are taken into account during simulation.

Engine Models

Generic Turbine Engine

RotorLib FDM has a generic, reconfigurable turbine engine model which is available as an add-on. This model can be configured with engine configuration and performance data. The model computes certain parameters itself using the performance data and hence reduces the configuration effort. Outputs of the model include gas generator RPM, power turbine RPM, shaft torque, power output, fuel flow, fuel pressure, oil temperature, oil pressure and exhaust gas temperature.

Constant RPM Engine

Constant RPM Engine is an easy to use engine model which is available out-of-the-box. The model contains a controller which maintains a given RPM respecting user provided power and torque limits.

Drive Train Model

RotorLib FDM provides a reconfigurable mathematical model to simulate drive trains. It can connect multiple engines to multiple rotors. Moreover it is possible to use multiple drive trains within a model, e.g. it is possible to create two engines which drive two rotors through two completely separate drive trains.

An important part of the model is the freewheeling unit which disconnects the rotors from engines automatically in case engines do not produce positive torque (e.g. engine failure). Simulation of the freewheeling unit improves the fidelity of the simulation of emergency procedures such as single engine failure.

Control System

RotorLib FDM supports a component based flight control system architecture. This architecture allows different components to be connected to each other in a cascade. Outputs of a component are inputs of the next component in the cascade.

Following control system components are available with the library.

Generic Control System

Generic Control System is a very powerful and versatile control system component. It is a programmable (i.e. not only reconfigurable) component where the control law itself can be changed using XML configuration files. This reduces or eliminates the need for using C++ to develop new control systems.

Generic Control System allows the developers to define a program that consists of sequentially executed operations which operate on simulation variables. Supported operations include 1D and 2D table look-up, PID controller, and generic mathematical expressions.

Autotrim Controller

This control system component is used to trim the helicopter automatically and hence remove the coupling between controls (e.g. collective / pedal coupling). It translates pilot inputs to requested heading, pitch and roll rates or to requested side slip angle and controls the actuators to achieve the desired state.

Autotrim controller is suitable for simulators where simple input devices, such as a joystick, are used.

Rotation Damper

This control system component is used to dampen the rotational motion in all three axes. It contains a PD controller for each rotational degree of freedom.

Autopilot Model

A complete, reconfigurable autopilot model is available as an add-on. The model contains control system components that can be reconfigured by the developers to simulate the autopilot systems of specific helicopter types. Autopilot model supports following modes:

- V/S (Vertical speed hold)
- ALT (Altitude hold)
- ALT.A (Altitude acquire and hold)
- SPD (Speed acquire and hold)
- HDG (Heading hold)
- HVR (Hover)
- H.HT (Hover height)
- T.UP (Transition up)
- T.DWN (Transition down)
- NAV (navigation)
- Turbulence

