Chair of Computational Modeling and Simulation
TUM School of Engineering and Design
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Modeling:
Mathematics:
Programming:
Science:

Software Lab:

Concept Design of a Wheeled Quadruped Robot

Description

Biologically inspired robots can leverage evolutionary features developed in animals to perform complex motions and tasks. Wheeled quadruped robots [1] combine the stability and adaptability of four-legged animals with the efficiency and speed of wheeled locomotion. This hybrid design allows for enhanced mobility, making it possible to transverse both smooth and uneven terrains effectively. Unlike traditional quadrupeds, wheeled quadrupeds can achieve higher speeds on flat surfaces while still maintaining the ability to navigate complex environments. This capability is crucial for applications such as search and rescue missions, where rapid response and adaptability to diverse terrains are essential [2]. Additionally, the integration of digital twin technology enables real-time simulation and monitoring, enhancing the robot's performance and reliability in dynamic environments [3].

Task

In this project a simulation of a *Wheeled Quadruped Robot* will be created, simulated, and deployed using MATLAB® [4], Simulink® [5], and Simscape™ [6]. The robotic system should be capable of navigating both even and uneven terrain. The wheeled design allows for efficient movement on flat surfaces while maintaining adaptability to complex environments. A Model-Predictive Controller (MPC) or a similar control strategy may be employed for wheel-actuation, enabling the robotic system to dynamically adjust control inputs based on a given time horizon [7]. An example of such a robotic system is the platform developed by *Deep Robotics*, which incorporates advanced locomotion capabilities and sensor integration, see Figure 1.

Figure 1 Wheeled Quadruped developed at Deep Robotics [8]

When modeling and simulating this robotic system, it is crucial to consider different fidelity levels (e.g. an abstract and a refined design) to facilitate a detailed investigation of the most influential and critical parameters affecting the dynamic behavior. Such abstract and refined designs for the wheeled quadruped platform can be developed using Simscape™ Multibody [8]. It will be already provided a Simscape project where a standard quadruped (see for instance in Figure 2) can be already modeled and simulated, see Figure 3.

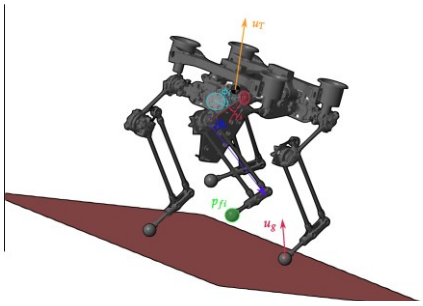

Figure 2 Refined design of the Husky Robot in Simscape™ [9]

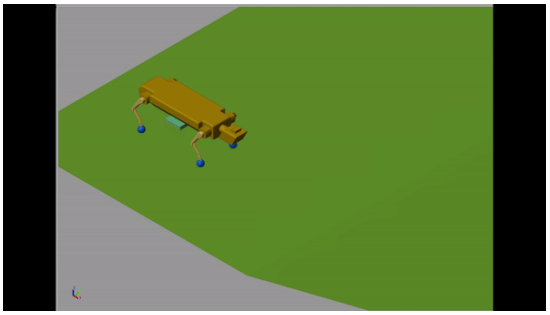

Figure 3 Quadruped robot modelled and simulated in Simscape™

For this project, the participants are expected to complete modeling and simulation tasks that may include (but not restricted to) the following ones:

- Create *Abstract Design* of a *Wheeled Quadruped Robot* in Simscape using basic blocks from Simscape Multibody™ and possibly also the existing model of the Walking Articulated Robot from Software Lab project in 2024,
- Tune controllers for the actuation of the wheels, enabling the Wheeled Quadruped Robot to perform basic maneuvers, e.g., move in a straight line on even terrain,
- Create (or otherwise obtain) an appropriate Computer-Aided Design (CAD) model and multibody system of a refined Design for the *Wheeled Quadruped Robot* using SolidWorks™ [8] or similar CAD software,
- Import the multibody system into Simscape Multibody™ using Simscape™ Multibody™ Link and perform validation testing,
- Identify a test scenario and engineering task for the robot, which may include navigating complex terrains or obstacle courses,
- Identify appropriate locomotion strategies that the CAD-based robot should use to navigate different terrains,
- Design controllers for the wheel motions based on the selected locomotion strategies, possibly also leveraging Model-Predictive Control [7], using the ROM, and then deploy these controllers on the refined design,
- Validate the developed simulation model for the Dynamic Wheeled Quadruped Robot on more complex pathways.

Supervisor

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The MathWorks, Inc.

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