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

Software Lab:

Digital Twin of a Walking Articulated Robot

Description

Biologically inspired robots can leverage evolutionary features developed in animals to perform complex motions and tasks. For instance, quadruped robots with appropriate articulation can assimilate the movements of four-legged animals. Moreover, cats and monkeys are able to use their spines and tails to balance themselves while walking on narrow paths, thus maintaining *motion stability* [1]. It is important to develop such robotic systems that can safely move and navigate along uneven terrains and narrow pathways, especially for *rescue missions* among other [2].

Task

In this project a digital twin for a *Walkling Articulated Robot* will be created, simulated, and deployed using MATLAB® [3], Simulink® [4], and Simscape™ [5]. The robotic system should be able to mode along even and uneven terrain. Moreover, the robotic articulated legs may be designed in such a way that they can cross over each other, such that walking on a narrow pathway (e.g. a thin line) can be achieved, if desired. Finally, a *Model-Predictive Controller* (MPC) or similar for the joint-actuation may be employed, such that the robotic system adjusts control inputs dynamically based on a given time horizon [3]. Such a robotic system is for instance the *Husky Carbon Platform* developed at the *Northeastern University* in Boston, Massachusetts [6], see Fig. 1. This robotic platform comprises many joints, brushless motors, a Jetson board, and a camera among other, to allow for performing independent tasks while moving along narrow pathways.

Figure 1 Husky Carbon Platform developed at the Northeastern University in Boston, Massachusetts [6]

When modeling and simulating such a robotic system one must consider different fidelity levels (e.g. an abstract and a refined design) to allow for a detailed investigation of the most influential and critical parameters affecting dynamic behavior. Such an abstract and a refined design for the aforementioned *Husky Carbon Platform* based on Simscape™ Multibody [7] are developed in [6]. See Figs. 2 and 3 below as reference.

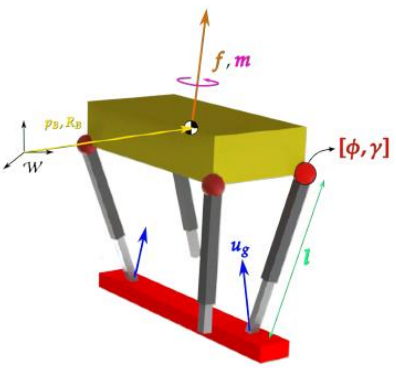

Figure 2 Abstract design of the Husky Robot [6]

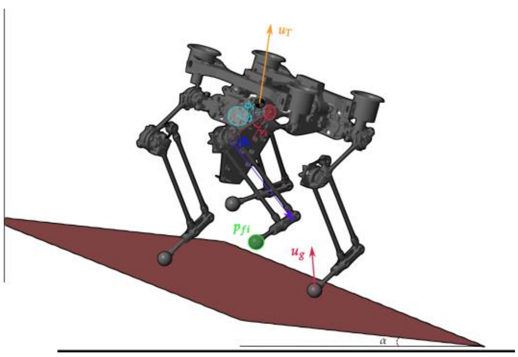

Figure 2 Refined design of the Husky Robot in Simscape™ [6]

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

- Create an *Abstract Design* of a *Walking Articulated Robot* in Simscape using basic blocks from Simscape Multibody™,
- Tune controllers for the actuation of the joints, such that the simple *Walking Articulated Robot* can move along simple gaits (e.g. move on a straight line on an even terrain),
- Create (or otherwise obtain) appropriate Computer-Aided Design (CAD) model and multibody system of a *Refined Design* for the Walking Articulated 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 that *may* include the motion on a narrow pathway
- Identify appropriate gaits that the CAD-based robot should use to move,
- Design controllers for the joint motions based on the selected gaits, possibly also by leveraging *Model-Predictive Control* [9], using the ROM and then deploy these controllers on the refined design,
- Validate the developed simulation model for the Dynamic Narrow Path Walking Articulated Robot on more complex pathways.

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The MathWorks, Inc.

References

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[2] Delmerico, Jeffrey, et al. "The current state and future outlook of rescue robotics." Journal of Field Robotics 36.7 (2019): 1171-1191.

[3] MATLAB® https://www.mathworks.com/products/matlab.html

[4] Simulink® https://www.mathworks.com/products/simulink.html

[5] Simscape™ https://www.mathworks.com/products/simscape.html

[6] Krishnamurthy, K. V. (2023). Towards dynamic narrow path walking on NU’s Husky. Master's Thesis, Department of Mechanical and Industrial Engineering, Northeastern University, Boston, Massachusetts.

[7] Simscape Multibody™ https://www.mathworks.com/products/simscape-multibody.html

[8] SolidWorks® https://www.solidworks.com/

[9] What is Model Predictive Control? https://www.mathworks.com/help/mpc/gs/what-is-mpc.html, MathWorks Inc.