KONKURS NA NAJLEPSZE PRACE DYPLOMOWE WIMiR

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AGH

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Generacja trajektorii dla dwunożnych robotów kroczących

Optimization - based trajectory generation for compliant bipedal robots

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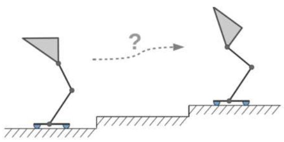
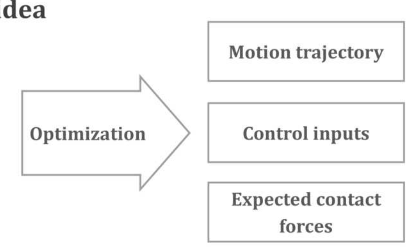
Streszczenie: The thesis presents an offline trajectory generation method for compliant bipedal robots. The approach is tailored for acquiring trajectories for highly dynamic tasks, such as walking, running, stepping on the obstacles or jumping. Presented method uses a large-scale optimization methods and utilizes an implicit contact model based on complementarity constraints, which allows to find efficient contact switching pattern and trajectories that fully utilize dynamic capabilities of the compliant system.

The approach is general for variety of behaviors and does not require any task-specific adjustments or heuristic-based initial guesses. Effectiveness of presented approach was demonstrated in physical simulations and experiments with C-Runner - a compliant bipedal robot developed in the German Aerospace Center.

Trajectory generation idea



User-defined task (e.g. move from point A to B in given terraing)

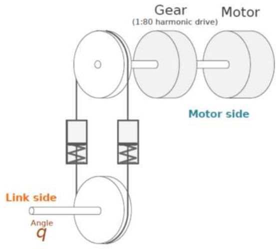


The thesis presents a novel trajectory generation method for compliant bipedal robots. The method allows to generate and optimize a motion that fulfills given task (e.g. jumping, walking, running, acrobatic motions) with minimum heuristics or manual adjustments. Resulting trajectories utilize elastic structure of the robot to perform very dynamic, energy-effective motions.

Series elastic actuators

Series elastic actuators may significantly improve otherwise very limited performance of the bipedal robot, providing:

- **energy conservation** (efficient periodic motions)
- **controlled energy dissipation** and mechanical robustness
- **better performance** for explosive motions (longer „torque burst" periods)

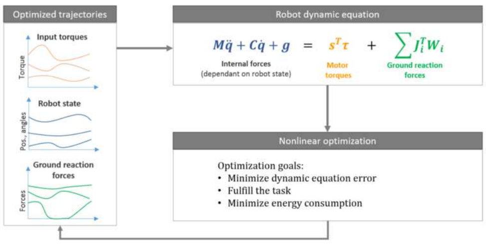


Series elastic actuator kinematics

- **Mass:** 50 kg
- **Segment length:** 40cm
- **Degrees of freedom:** 3 floating base, 6 actuated (SEA)
- **Power:** 10kW

C-Runner — compliant bipedal robot (German Aerospace Center)

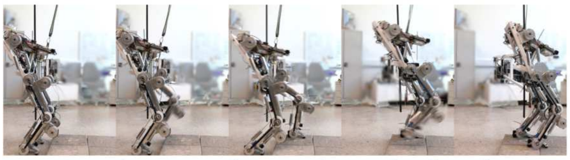
Method



The method uses a collocation-based optimization strategy and utilizes an implicit contact model based on complementarity constraints. This approach allows to find optimal contact switching pattern alongside the trajectory and control signals.

Resulting motions fully utilize the capabilities of the elastic actuators, alowing to perform quick, efficient motions.

Results

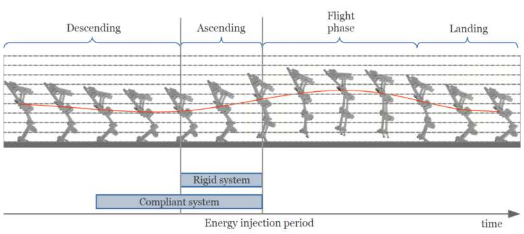


Experiments result—stepping on the obstacle

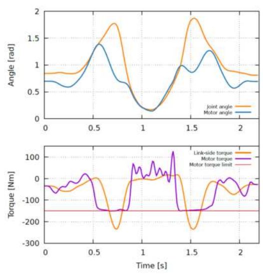
Simulation result—somersault

Efectiveness of the method was proven in a set of simulations and experiments on the C-Runner robot. Successfuly tested scenarios included: walking motions, stepping on stairs, movement in uneven terrain, running, jumping, backflips and frontflips.

Advantages of the approach



Main advantage of the method is ability to utilize series elastic actuators to exceed torque and velocity limitations of electic motors, through storing the the energy in elastic elements.



Plot on the left presents quantities of the knee link and motor angle during the single jump motion, showing how the springs were used to improve the performance. Compliant actuators allowed to perform long energy-injection phase and release the energy in short torque burst that exceeds motors limis.

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