Adaptívne riadenie kroku štvornohého robota

Prezentácia - Projektový seminár (2)

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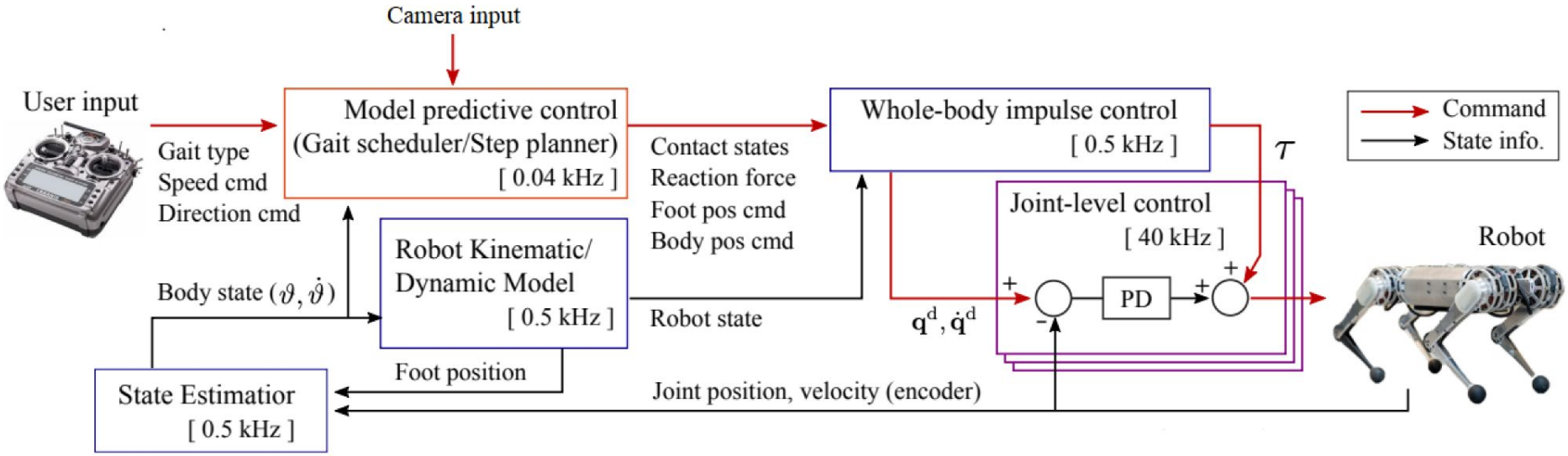
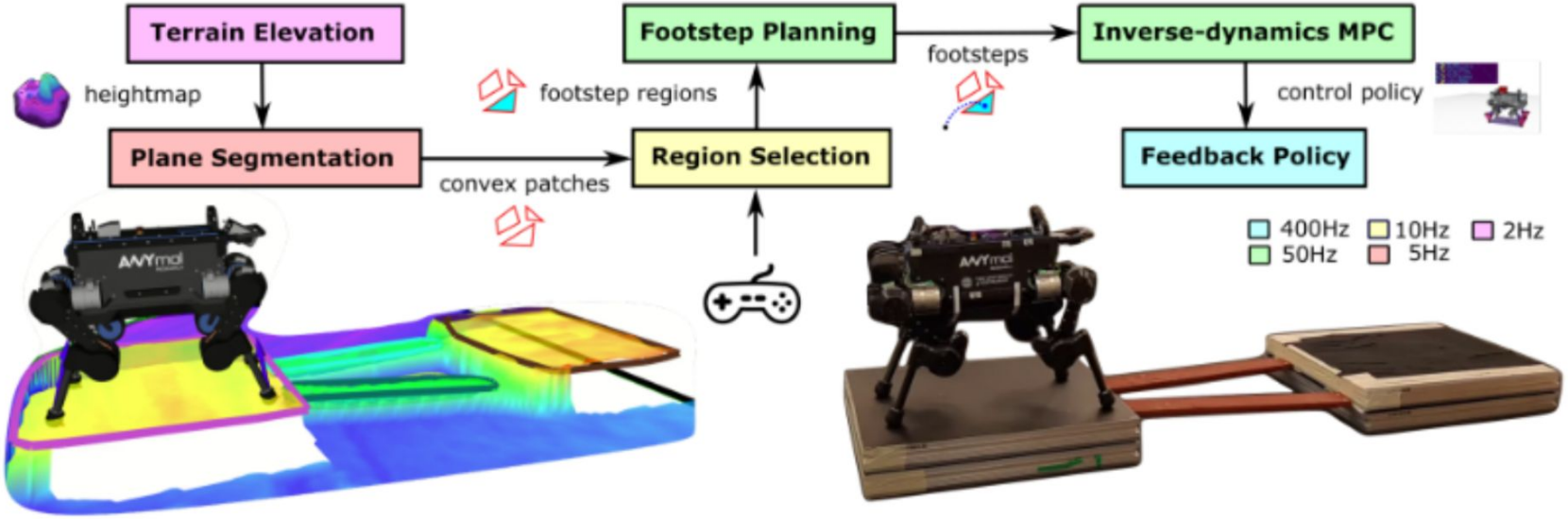
Ciele práce

1. naštudovanie problematiky riadenia robotov
2. implementácia častí riadenia
3. testovanie riešenia

Riadenie robotov - Champ

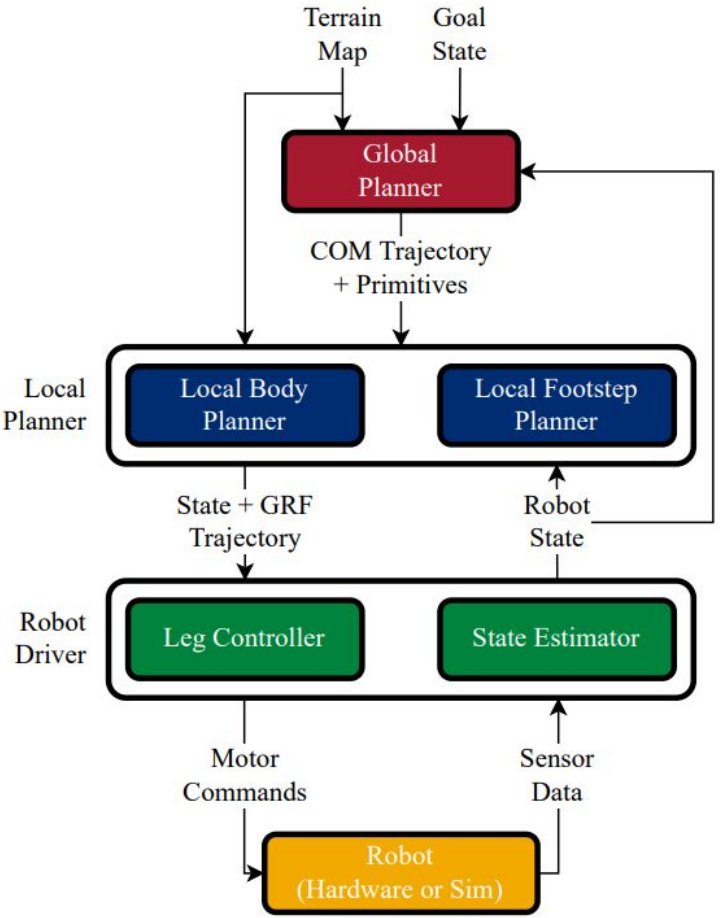


Riadenie robotov - ANYmal

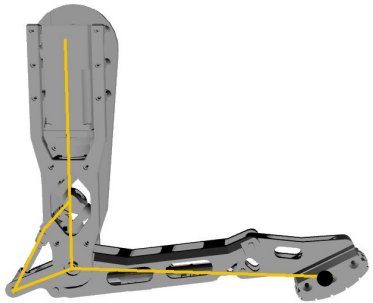


Quad SDK

PD control pozície nohy
+
Inverzná dynamika

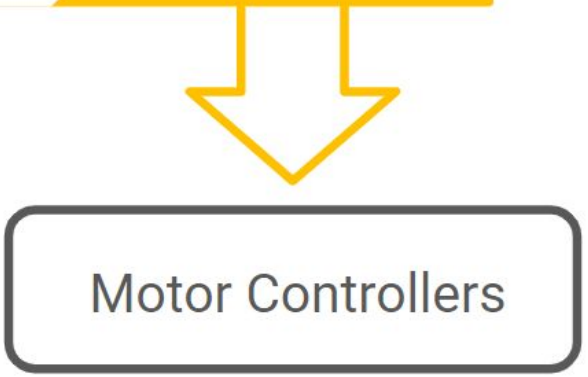


PD control pozície nohy



desired position
- (x, y, z)

actual position
(x, y, z)



Dynamický model

$$\boldsymbol{\tau} = \boldsymbol{H}(\boldsymbol{q})\,\ddot{\boldsymbol{q}} + \boldsymbol{C}(\boldsymbol{q}, \dot{\boldsymbol{q}})$$

Forward dynamics: given the forces, work out the accelerations.

$$\ddot{\boldsymbol{q}} = \mathrm{FD}(model, \boldsymbol{q}, \dot{\boldsymbol{q}}, \boldsymbol{\tau})$$

Inverse dynamics: given the accelerations, work out the forces.

$$\boldsymbol{\tau} = \mathrm{ID}(model, \boldsymbol{q}, \dot{\boldsymbol{q}}, \ddot{\boldsymbol{q}})\,.$$

Inverzná dynamika s kinematickou slučkou

$$\boldsymbol{H}\ddot{\boldsymbol{q}} + \boldsymbol{C} = \boldsymbol{\tau} + \boldsymbol{\tau}^{c} + \boldsymbol{\tau}^{a}$$

$$\boldsymbol{\tau}_{\mathrm{ID}} = \mathrm{ID}(\boldsymbol{\gamma}(\boldsymbol{y}), \boldsymbol{G}\dot{\boldsymbol{y}}, \boldsymbol{G}\ddot{\boldsymbol{y}} + \boldsymbol{g})$$

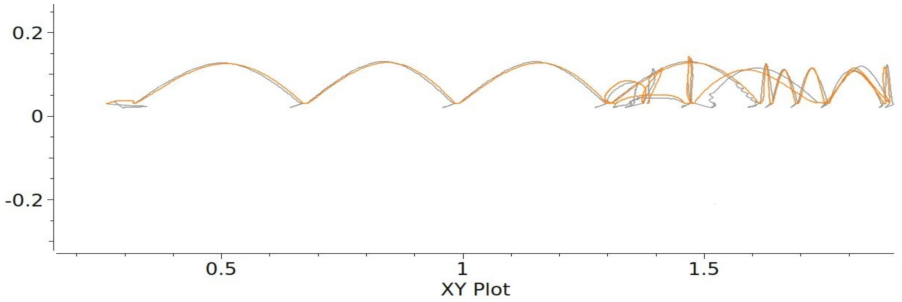
Inverzná dynamika s kinematickou slučkou a s pohonom na vybraných kĺboch

$$\boldsymbol{u} = \boldsymbol{G}_u^{-\mathrm{T}} \boldsymbol{G}^{\mathrm{T}} \boldsymbol{\tau}_{\mathrm{ID}}$$

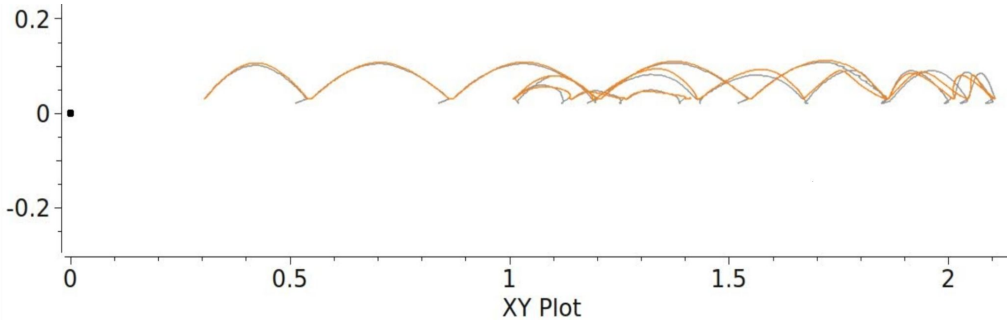
$$\boldsymbol{\tau}_{\mathrm{ID}} = \mathrm{ID}(\boldsymbol{\gamma}(\boldsymbol{y}), \boldsymbol{G}\dot{\boldsymbol{y}}, \boldsymbol{G}\ddot{\boldsymbol{y}} + \boldsymbol{g})$$

Výsledky

Chôdza bez inverznej dynamiky



Chôdza s inverznou dynamikou na predných nohách

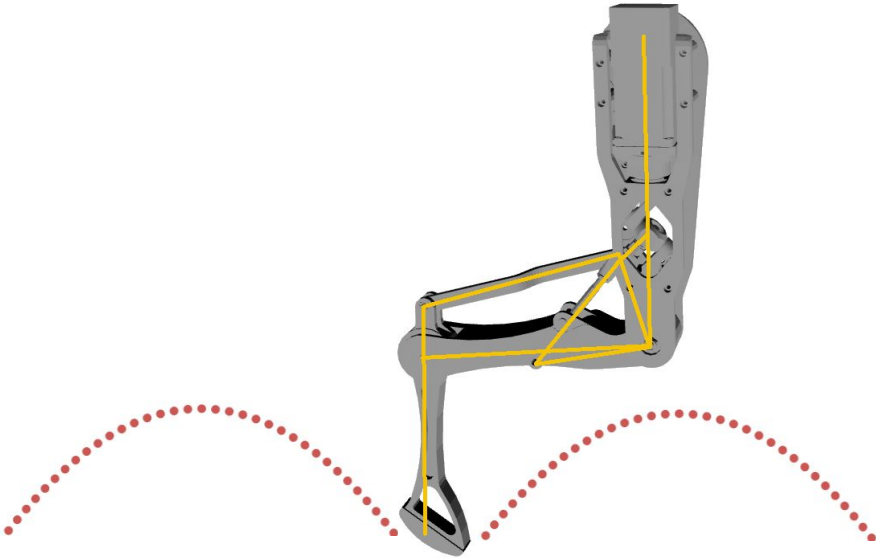


Zdroje

- Roy Featherstone. Rigid Body Dynamics Algorithms, pages 161-165. Springer New York, NY, 2007
- Quad SDK
- Highly Dynamic Quadruped Locomotion via Whole-Body Impulse Control and Model Predictive Control
- Inverse-Dynamics MPC via Nullspace Resolution

Ďakujem za pozornosť

Feedforward position control



Zdroje

1. Dynamic Locomotion in the MIT Cheetah 3 Through Convex Model-Predictive Control
2. Highly Dynamic Quadruped Locomotion via Whole-Body Impulse Control and Model Predictive Control

Hotové riešenia?

1. Real-time Model Predictive Control for Versatile Dynamic Motions in Quadrupedal Robots
2. Multi-Layered Safety for Legged Robots via Control Barrier Functions and Model Predictive Control
3. Perceptive Locomotion through Nonlinear Model Predictive Control
4. Inverse-Dynamics MPC via Nullspace Resolution
5. CROCCODYL
6. Fast Contact-Implicit Model-Predictive Control