Theory of Robotics Systems

Locomotion

Innovative Teaching Approaches in development of Software Designed Instrumentation and its application in real-time systems

Itasdi

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Mobilni sistemi na točkovima


Nedostaci: samo po ravnom terenu!

Prednosti: jednostavna konstrukcija, efikasan pogon, manji izazov sa stabilnošću (održanjem balansa)

Mobilni sistemi na točkovima

Statički balans – potrebne su 3 tačka oslonca, da je centar gravitacije (projekcija centra mase u poligonu koje formiraju 3 tačke oslonca)

Smanjenje broja točkova - moguće je održavati dinamički balans

Povečanje broja točkova – za više od 3 točka potreban je sistem vešanja, ali se mogu dobiti visoke performanse
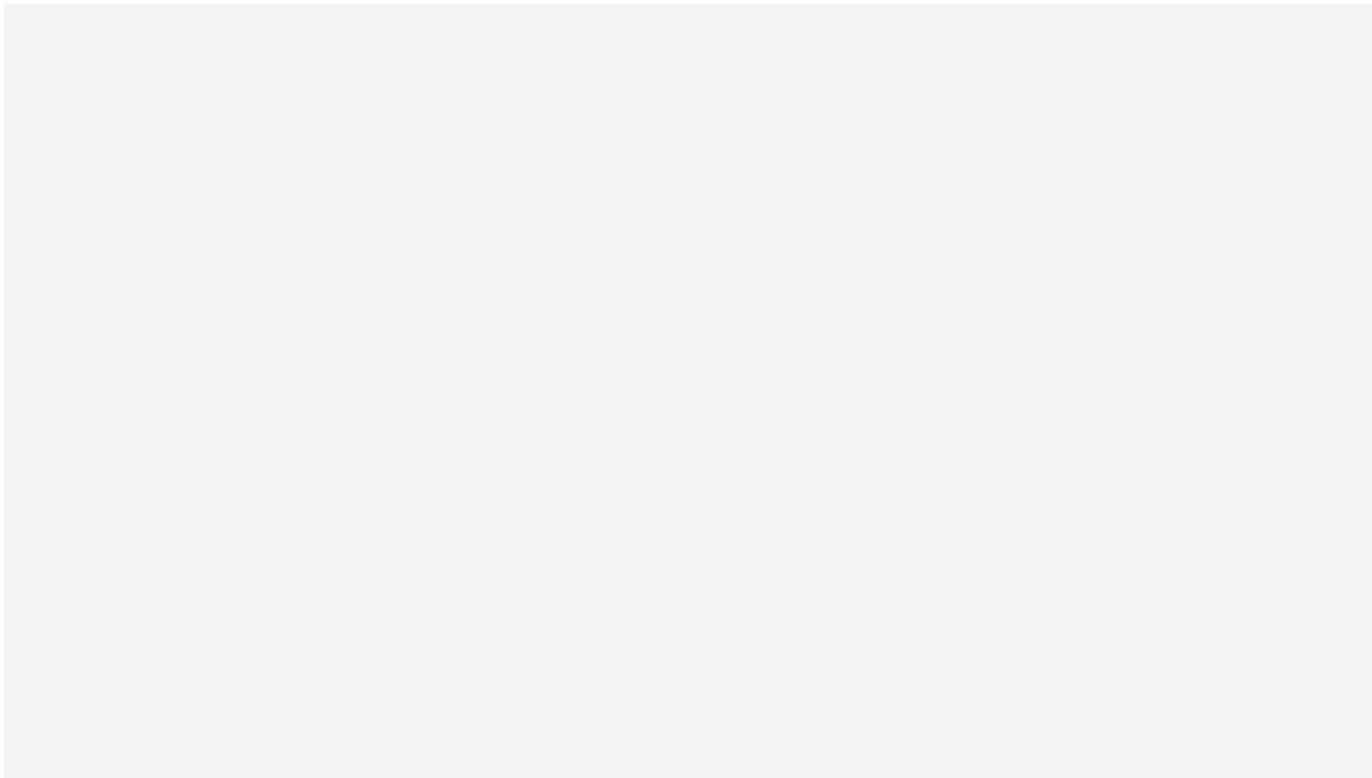
Honda UNI-CUB (V2) omnidirectional seated Segway

Mobilni sistemi na točkovima

Glavni izazovi:

➢ pogonska snaga (vuča)

➢ manevrabilnost

➢ upravljanje/planiranje kretanjem

➢ stabilnost
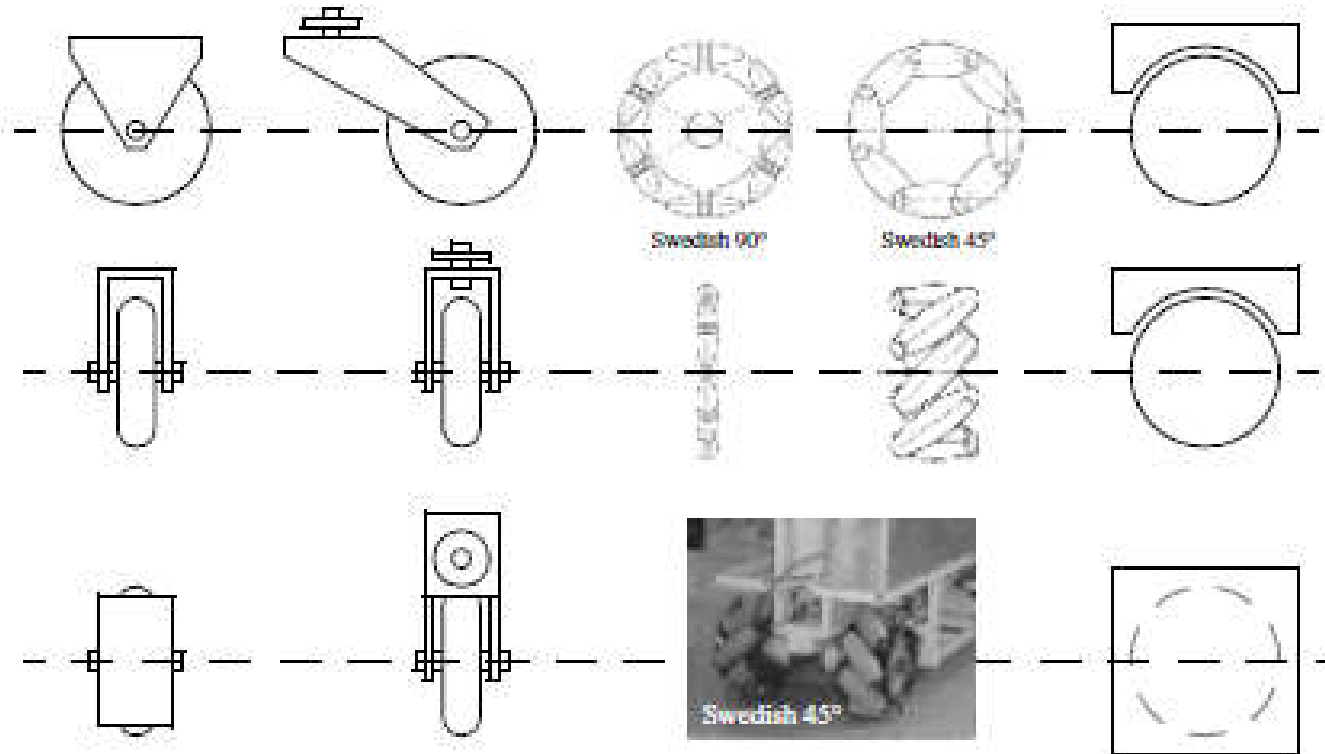
Mobilni sistemi na točkovima

Glavni izazovi:

➢ pogonska snaga (vuča)

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➢ stabilnost

Parametri za razmatranje:

➢ izbor vrste točkova

➢ broj točkova

➢ konfiguracija (raspored točkova)

➢ pogon točkova

Mobilni sistemi na točkovima

Izbor vrste točkova:

Swedish 90° Swedish 45°

Swedish 45°

klasičan   kastor   švedski (omnidirekcioni)   sferični (kugla)
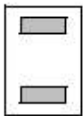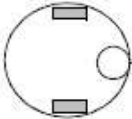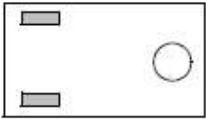
Mobilni sistemi na točkovima
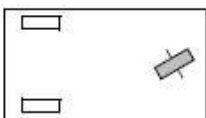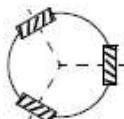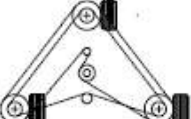
Konfiguracija mobilnog sistema (raspored i broj točkova):

➢ korelacija sa izborom vrste točka

➢ zavisna od terena i okruženja u kome se kreće
- automobili – svi istu konfiguraciju jer se svi kreću po čvrstom i ravnom terenu
- roboti se kreću po istom terenu, ali vrlo retko koriste konfiguraciju kao automobil

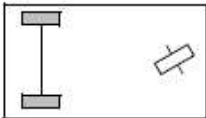| Icons for the each wheel type are as follows:	
○	unpowered omnidirectional wheel (spherical, castor, Swedish);
▨	motorized Swedish wheel (Stanford wheel);
▭	unpowered standard wheel;
▬	motorized standard wheel;
▬○	motorized and steered castor wheel;
⊥	steered standard wheel;
⊟	connected wheels.

Mobilni sistemi na točkovima

Konfiguracija mobilnog sistema (raspored i broj točkova):

# of wheels	Arrangement	Description	Typical examples
2		One steering wheel in the front, one traction wheel in the rear	Bicycle, motorcycle
		Two-wheel differential drive with the center of mass (COM) below the axle	Cye personal robot

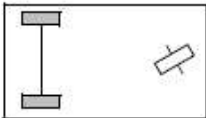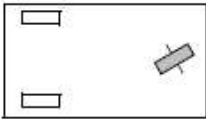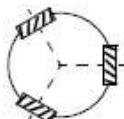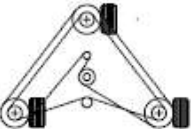| # of wheels	Arrangement	Description	Typical examples
3		Two-wheel centered differential drive with a third point of contact	Nomad Scout, smartRob EPFL
		Two independently driven wheels in the rear/front, 1 unpowered omnidirectional wheel in the front/rear	Many indoor robots, including the EPFL robots Pygmalion and Alice
		Two connected traction wheels (differential) in rear, 1 steered free wheel in front	Piaggio minitrucks
		Two free wheels in rear, 1 steered traction wheel in front	Neptune (Carnegie Mellon University), Hero-1
		Three motorized Swedish or spherical wheels arranged in a triangle; omnidirectional movement is possible	Stanford wheel Tribolo EPFL, Palm Pilot Robot Kit (CMU)
		Three synchronously motorized and steered wheels; the orientation is not controllable	"Synchro drive" Denning MRV-2, Georgia Institute of Technology, I-Robot B24, Nomad 200

Mobilni sistemi na točkovima

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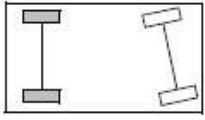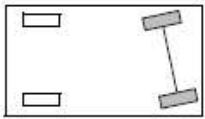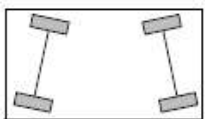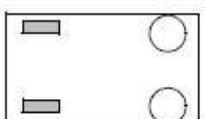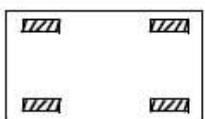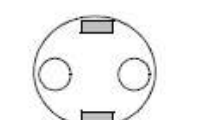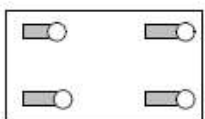| # of wheels	Arrangement	Description	Typical examples
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Mobilni sistemi na točkovima

Konfiguracija mobilnog sistema (raspored i broj točkova):

# of wheels	Arrangement	Description	Typical examples
4		Two motorized wheels in the rear, 2 steered wheels in the front; steering has to be different for the 2 wheels to avoid slipping/skidding.	Car with rear-wheel drive
		Two motorized and steered wheels in the front, 2 free wheels in the rear; steering has to be different for the 2 wheels to avoid slipping/skidding.	Car with front-wheel drive
		Four steered and motorized wheels	Four-wheel drive, four-wheel steering Hyperion (CMU)
		Two traction wheels (differential) in rear/front, 2 omnidirectional wheels in the front/rear	Charlie (DMT-EPFL)
		Four omnidirectional wheels	Carnegie Mellon Uranus
		Two-wheel differential drive with 2 additional points of contact	EPFL Khepera, Hyperbot Chip
		Four motorized and steered castor wheels	Nomad XR4000

# of wheels	Arrangement	Description	Typical examples
6		Two motorized and steered wheels aligned in center, 1 omnidirectional wheel at each corner	First
		Two traction wheels (differential) in center, 1 omnidirectional wheel at each corner	Terregator (Carnegie Mellon University)

Mobilni sistemi na točkovima

Stabilnost/balans mobilnih sistema na točkovima:

➢ za održanje **statičkog balansa** minimum tri točka
➢ centar gravitacije (projekcija centra mase) bude u okviru oslonačkog poligona

➢ za održanje **dinamičkog balansa** ZMP unutar oslonačkog poligona

V. Antoska, K. Jovanovic, V. Petrovic, N. Bascarevic, M. Stankoviski, "Balance Analysis of the Mobile Anthropomimetic Robot Under Disturbances – ZMP Approach", *International Journal of Advanced Robotic Systems*, Vol 10(paper 206), 2013, pp 1-10.

Mobilni sistemi na točkovima

➤ za održanje **dinamičkog balansa** ZMP unutar oslonačkog poligona
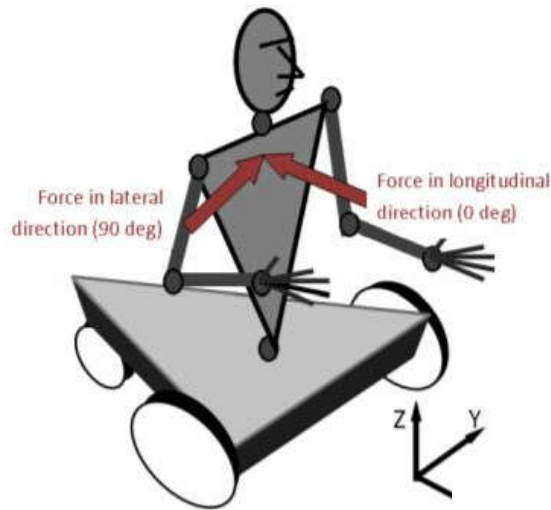
➤ Ubrzano kretanje

➤ Neravni-talasast teren

➤ Skretanje

➤ Sila-impulsna

➤ Sila trajna

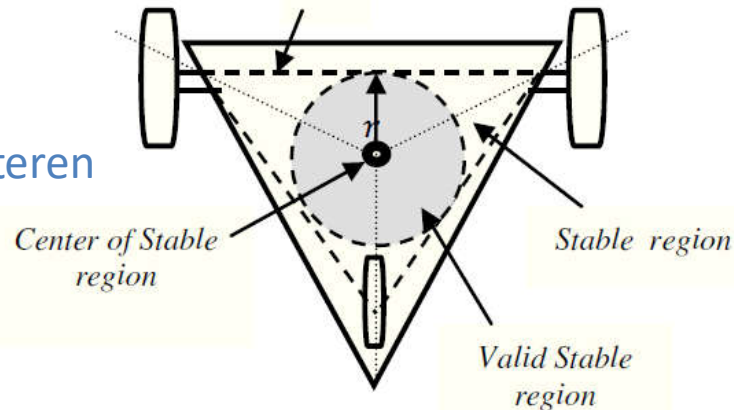$$S: \quad x_{zmp}^2 + y_{zmp}^2 \le r^2$$

V. Antoska, K. Jovanovic, V. Petrovic, N. Bascarevic, M. Stankoviski, "Balance Analysis of the Mobile Anthropomimetic Robot Under Disturbances – ZMP Approach", *International Journal of Advanced Robotic Systems*, Vol 10(paper 206), 2013, pp 1-10.
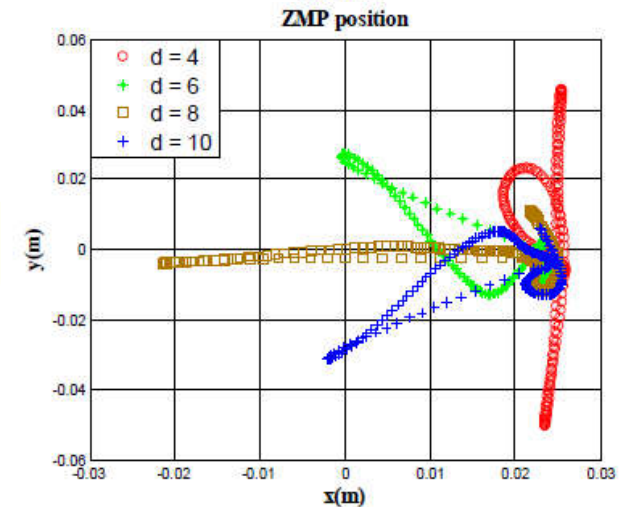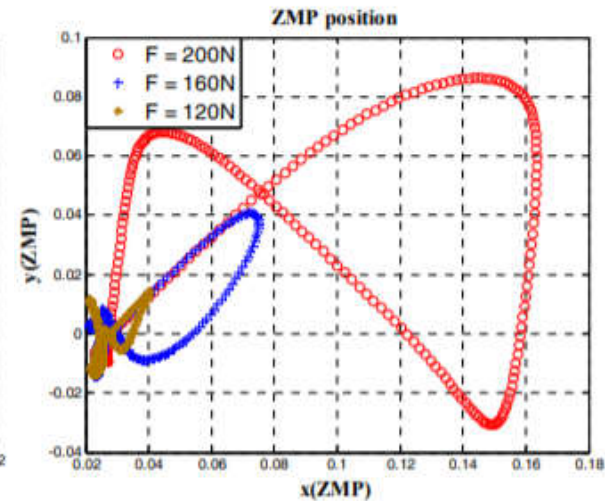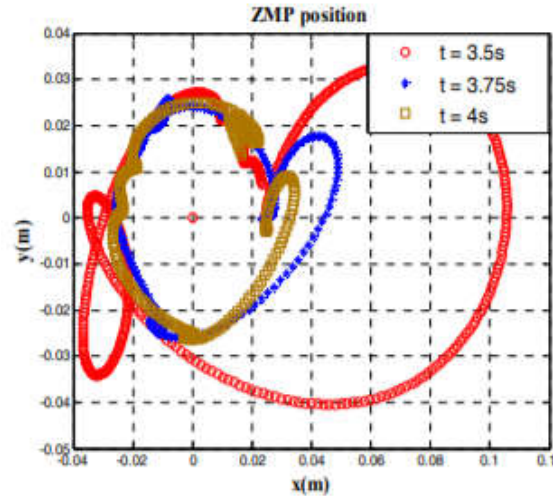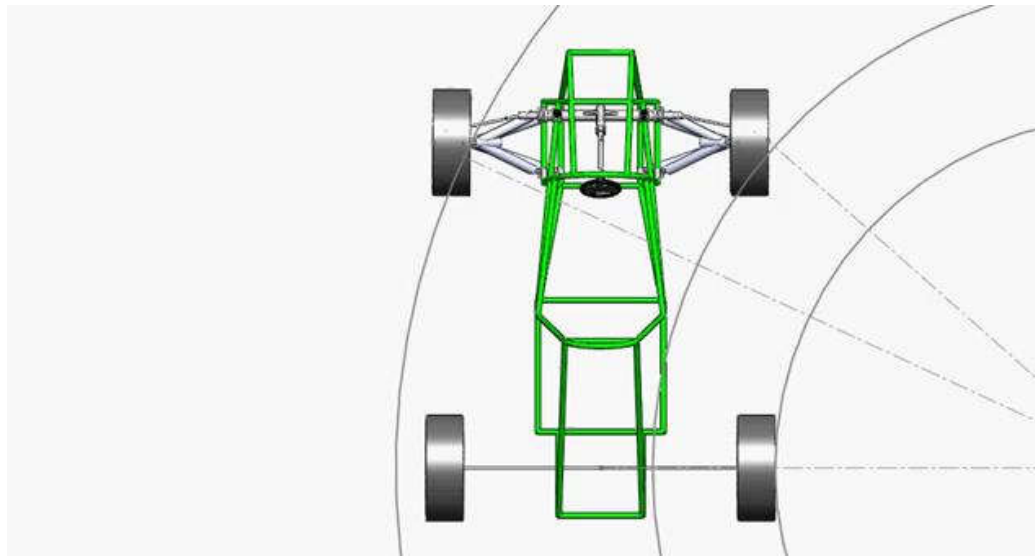
Mobilni sistemi na točkovima

Manevrabilnost mobilnih sistema na točkovima:

➢ Manevrabilnost (MV) – promena pravca kretanja robota i njegove orijentacije

➢ Tri tipične konfiguracije robota sa svojim osobinama manevrabilnosti:

1. Robot sa diferencijalnim pogonom (mobilni roboti - MV↑)
2. Robot sa Akermanovim pogonom (automobili - MV↓)
3. Roboti sa omnidirekcionim točkovima (Švedski točak - MV↑)

Mobilni sistemi na točkovima

Kontrolabilnost mobilnih sistema na točkovima:

➢ Kontrolabilnost podrazumeva da se održi željeno kretanje (pravac i orijentacija)

➢ Glavni problem je proklizavanje!!!
  ➢ tipičan problem kod omnidirekcionih točkova
  ➢ ravnoća terena – kontakt između točka i podloge

➢ Konfiguracija točkova
     primer održavanja pravca
     Akerman Vs. diferecnijalni pogon