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

Theory of Robotics Systems

Kinematic control of differential drive mobile robot

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

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

Teorija Robotskih Sistema

Kinematska kontrola

mobilnih robota sa diferencijalnim pogonom

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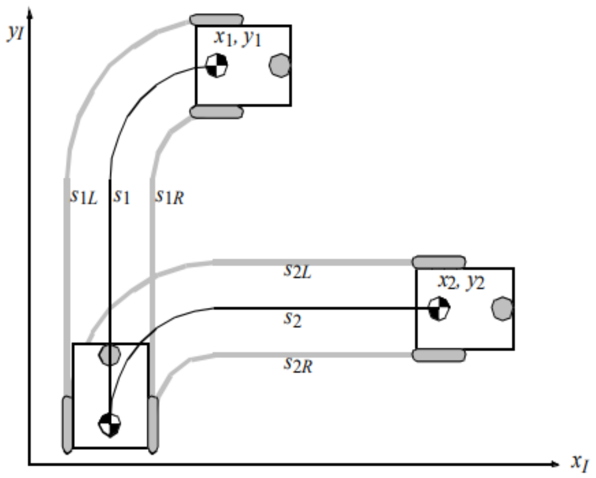
Kinematika mobilnih robota

- Kinematika manipulatora vs kinematika mobilnih robota
  - Predstavljaju odnoso između unutrašnjih i spoljašnjih koordianta
  - Kod mobilnih robota, očitavanja sa enkodera ne mapiraju kretanje u jedinstvenu poziciju u prostoru – Ne postoji direktan način merenja pozicije robota već se pozicija dobija integraljenjem i zavisi pređenog puta.



Introduction to Autonomous Mobile Robots Roland Siegwart and Illah R. Nourbakhsh

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Forward Kinematics – Inverse Kinematikcs

- Forward Kinematics:
  - Vrši transformaciju iz unutrašnjih koordinata u spoljašnje:

    brzina točkova ➡ brzina robota
- Inverse Kinematics:
  - Transformacija iz spoljašnjih koordinata u unutrašnje (potrebna je za implementaciju kontrolera):

    brzina robota ➡ brzina točkova

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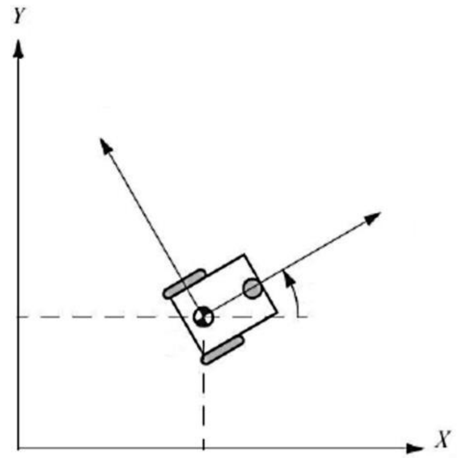
Kinematika mobilnog robota sa diferencijalnim pogonom

- Imamo kontrolu nad ugaonim brzinama levog i desnog točka, a želimo da kontrolišemo *x*, *y* poziciju robota i njegovu orijentaciju u toj poziciji.
- Odnos brzina točkova određuje na koji će se način robot kretati.



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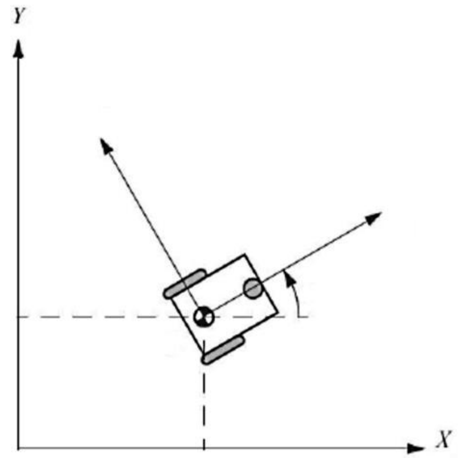
Feedforward kontrola

- Upotreba: Udaljena kontrola robota, predefinisan oblik trajektorije.
- $v = \frac{r\dot{\varphi}_R + r\dot{\varphi}_L}{2}, \omega = \frac{r\dot{\varphi}_R - r\dot{\varphi}_L}{l}$
- Putanja se mora podeliti u jasne segmente: prave linije ili delove kruga.
- Izračunavanje brzina točkova prema zadatoj putanji pre pokretanja programa.
- Nedostaci:
  - Izračunavanje ostvarive trajektorije nekada može da bude težak zadatak.
  - Adaptacija na dinamičke promene u okruženju nije moguća.
  - Rezultujuća trajektorija u krajnjem slučaju nije glatka.



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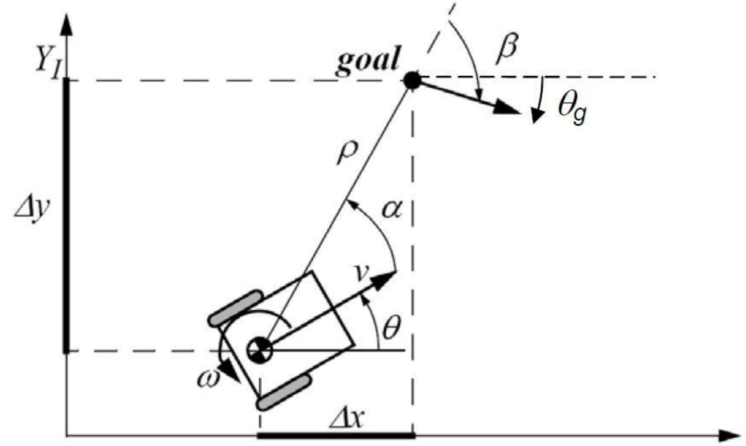
Upravljanje u zatvorenoj sprezi

$$\begin{bmatrix} v(t) \\ \omega(t) \end{bmatrix} = K \cdot e = K \cdot {}^{R}\begin{bmatrix} x \\ y \\ \theta \end{bmatrix}$$

Potrebno je pronaći takvu matricu K,
koja će određenog vremena dovesti grešku na nulu.



$$\rho = \sqrt{\Delta x^2 + \Delta y^2}$$

$$\alpha = -\theta + \mathrm{atan2}(\Delta y, \Delta x)$$

$$\beta = -\theta - \alpha$$

Transformacija u polarne koordinate

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Upravljanje u zatvorenoj sprezi

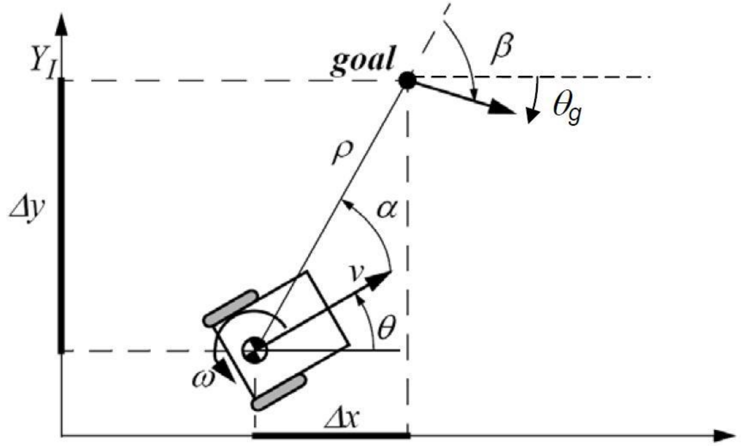
Prelaskom na polarne koordinate translatornu i rotacionu izražavamo:

$$v = k_\rho \rho \qquad \omega = k_\alpha \alpha + k_\beta \beta$$

Gde sistem u zatvorenoj sprezi ima oblik:

$$\begin{bmatrix} \dot{\rho} \\ \dot{\alpha} \\ \dot{\beta} \end{bmatrix} = \begin{bmatrix} -k_\rho \rho \cos\alpha \\ k_\rho \sin\alpha - k_\alpha \alpha - k_\beta \beta \\ -k_\rho \sin\alpha \end{bmatrix}$$

$$k_\rho > 0 \ ; \quad -k_\beta > 0 \ ; \quad k_\alpha - k_\rho > 0$$



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TurtleBot3 paketi

- Instalacija svih ROS paketa na koje se oslanjaju TurtleBot3 paketi:
  - Neki od paketa su: kontrola džojstikom, kontrola LIDAR-a, podrška za arduino platformu, paketi za mapiranje i navigaciju, …
- Instalacija svih potrebnih paketa za rad sa realnim i simuliranim robotom.

Link sa detaljnim uputstvom.

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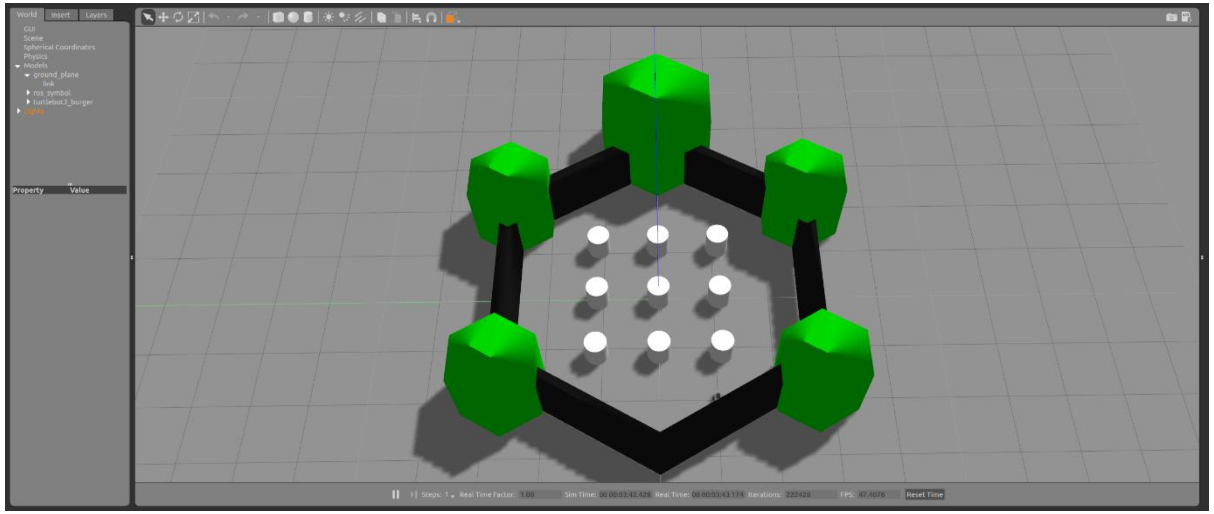
TurtleBot3 i Gazebo

- export TURTLEBOP3_MODEL=Burger
- Roslaunch turtlebot3_gazebo turtlebot3_world.launch



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Povezivanje sa TurtleBot3 robotom

- Više uređaja preko mreže može činiti jednu celinu ROS sistema.
- PC podešavanja:
  - bashrc : export ROS_HOSTNAME=ip_of_remote_PC
    export ROS_MASTER_URI=http:// ip_of_remote_PC:11311
- TurtleBot3 podešavanja:
  - bashrc: export ROS_HOSTNAME=ip_of_TURTLEBOT
    export ROS_MASTER_URI=http://ip_of_remote_PC:11311

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Povezivanje sa TurtleBot3 robotom

- Pokrećemo master nod: roscore
- Pristupamo konzoli na robotu: ssh username@IPadresaRobota

  ssh vitezkoja@192.168.0.5 (pass: zamlata)

  - Iz terminala koji je povezan sa robotom poziva se osnovni nod koji pokreće sve funkcionalnosti robota: roslaunch turtlebot3_bringup turtlebot3_robot.launch
- Nakon toga se mogu pozivati nodovi koji će komunicirati sa robotom
  - roslaunch turtlebot3_teleop turtlebor3_teleop_key.launch

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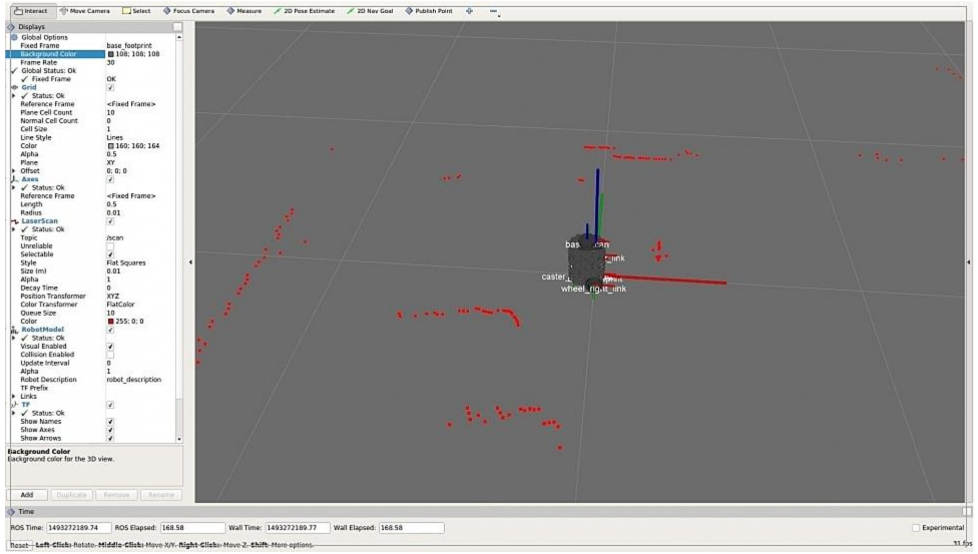
Vizuelizacija sa senzora

- export TURTLEBOT3_MODEL=Burger
- Roslanuch turtlebot3_bringup turtlebot3_remote.launch
- Rosrun rviz rviz –d `rospack find turtlebot3_description`/rviz/model.rviz



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