Introduction to Robotics
CSCI/ATRI 4530/6530

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1. Announcements

2. A quick recap

3. For today

4. For next class
Announcements
Next class - Monday (08/27) - Guest Lecture by Prof. Prashant Doshi (Sensors model - Rangefinders)

ROS Practicals for next week is Tuesday (not Thursday if you follow the schedule) - so please bring your laptops on Tuesday (08/28)
A quick recap
Kinematics - basics

- Frames of references
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  - I - Inertial (world, non-moving), R - Robot frame (moving), W - Wheel frame
Frames of references

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Coordinate transformation

Ex: For a point P on the Wheel, vector from origin O to the P is:
\[ \mathbf{I}_r \mathbf{O}P = \mathbf{I}_r \mathbf{O}R + \mathbf{I}_r \mathbf{R}P \]

What if all the vectors are not in the same frame of reference?

\[ \mathbf{I}_r \mathbf{R}P = \mathbf{R}_I \mathbf{R}_r \mathbf{R}P \]

What is \( \mathbf{R}_I \mathbf{R}_r \) here?

How about velocities?

\[ \mathbf{I}_v \mathbf{O}P = \mathbf{I}_v \mathbf{O}R + \mathbf{I}_v \mathbf{R}P \]

Velocity of point P in a moving frame (R):
\[ \mathbf{I}_v \mathbf{O}P = \mathbf{I}_v \mathbf{O}R + \mathbf{I}_v \mathbf{R}P \]
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- Coordinate transformation
- Ex: For a point P on the Wheel, vector from origin O to the P is:
  \[ i\mathbf{r}_{OP} = i\mathbf{r}_{OP} + i\mathbf{r}_{OR} + i\mathbf{r}_{RP} \]
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  - Ex: For a point P on the Wheel, vector from origin O to the P is:
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- What if all the vectors are not in the same frame of reference?
• Frames of references
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• Ex: For a point P on the Wheel, vector from origin O to the P is:
  \[ I\vec{r}_{OP} = I\vec{r}_{OP} + I\vec{r}_{OR} + I\vec{r}_{RP} \]
• What if all the vectors are not in the same frame of reference?
• \[ I\vec{r}_{RP} = R_{RI} R\vec{r}_{RP} \] - What is \( R_{RI} \) here?
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- What if all the vectors are not in the same frame of reference?
  \[ \text{i} \overrightarrow{r_{RP}} = \text{R}_{\text{RI}} \text{R} \overrightarrow{r_{RP}} \] - What is \( \text{R}_{\text{RI}} \) here?
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- Ex: For a point P on the Wheel, vector from origin O to the P is:
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- What if all the vectors are not in the same frame of reference?
- \[ i\mathbf{r}_{RP} = R_{RI} \mathbf{r}_{RP} \] - What is \( R_{RI} \) here?
- How about velocities?
- \[ i\dot{\mathbf{r}}_{RP} = R_{RI} \dot{\mathbf{r}}_{RP} \]
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    \[ i\vec{r}_{OP} = I\vec{r}_{OP} + I\vec{r}_{OR} + I\vec{r}_{RP} \]
  - What if all the vectors are not in the same frame of reference?
    \[ i\vec{r}_{RP} = R_{RI} R\vec{r}_{RP} \] - What is \( R_{RI} \) here?
- How about velocities?
  - \[ i\dot{r}_{RP} = R_{RI} R\dot{r}_{RP} \]
- Velocity of point P in a moving frame (R): \[ i\dot{r}_{OP} = I\dot{r}_{OR} + \omega_{IR} r_{RP} \]
Kinematics - basics - summary

- Translations \( \mathbf{r}_{OP_i} = \mathbf{r}_{OB} + \mathbf{r}_{BP_i} \)

- Rotations \( \mathbf{r}_{OP_i} = \mathbf{R}_{BI} \mathbf{r}_{BP_i} \)

- Homogeneous transformation \( \begin{pmatrix} \mathbf{r}_{OP_i} \\ 1 \end{pmatrix} = \begin{bmatrix} \mathbf{R}_{IB} & \mathbf{r}_{OB} \\ 0 & 1 \end{bmatrix} \begin{pmatrix} \mathbf{r}_{BP_i} \\ 1 \end{pmatrix} \)

- Angular velocities \( \mathbf{\omega}_{IC} = \mathbf{\omega}_{IB} + \mathbf{\omega}_{BC} \)

- Differentiation of (position) vectors \( \frac{d}{dt} \mathbf{r} = \mathbf{\omega}_{IB} \times \mathbf{r} \)
### Kinematics - wheeled robot platform - constraints

- **Rolling constraint**
  \[
  \begin{bmatrix}
  -\sin \alpha + \beta \\
  \cos \alpha + \beta \\
  l \cos \beta
  \end{bmatrix} R(\theta) \dot{\xi}_I - \dot{\phi} r = 0
  \]

- **No-sliding constraint**
  \[
  \begin{bmatrix}
  \cos \alpha + \beta \\
  \sin \alpha + \beta \\
  l \sin \beta
  \end{bmatrix} R(\theta) \dot{\xi}_I = 0
  \]

\[
\begin{bmatrix}
  w \\
  v_{IW}
\end{bmatrix} = \begin{bmatrix}
  0 \\
  \dot{\phi} r \\
  0
\end{bmatrix}
\]
- no-sliding constraint
- rolling constraint
- planar assumption
For today
Today’s topics

• Kinematics - Degree of Manuverability - Attached slides from EdX
• Probability basics - Additional slides
For next class
Next class - Monday 08/27/2018

- Sensors model - Laser range scanners - Prof. Doshi