Systèmes robotisés intelligents
Smart Robotic Systems

Localization

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Mobile robots Localization

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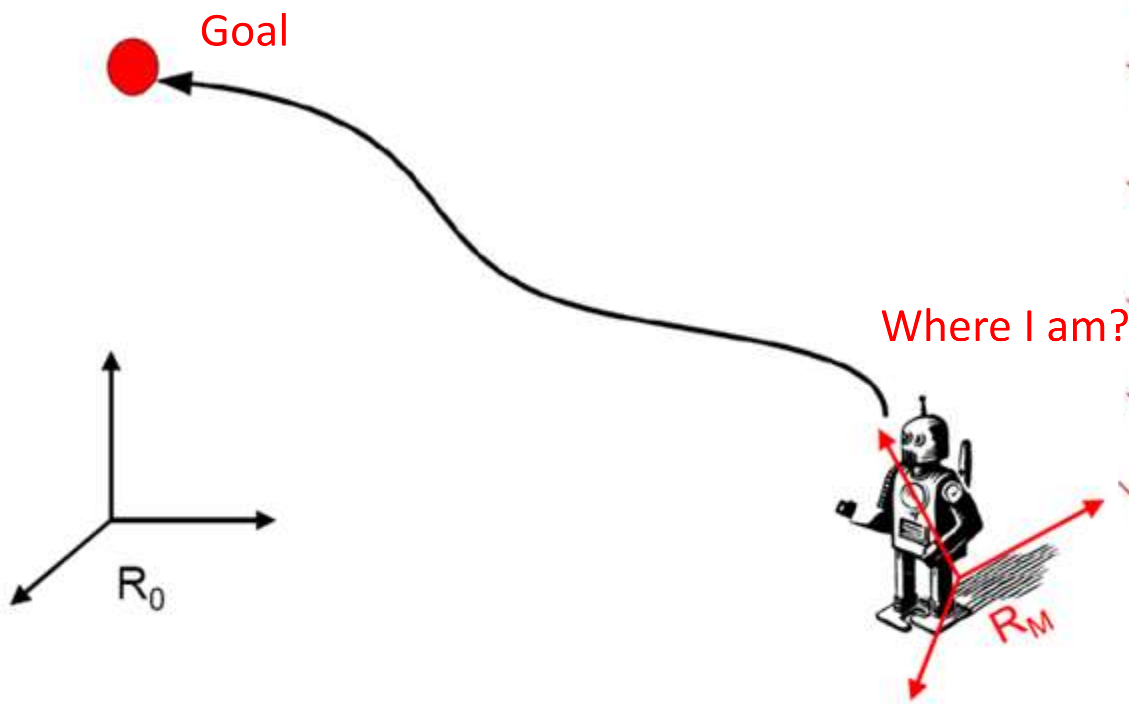
Goal of localization:

Determine the position and orientation of the robot in a so-called navigation landmark



Absolute localization
Relative localization

R0: Navigation Landmark
RM: Mobile Landmark

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Challenge: Determine the position and orientation of the robot in a so-called navigation landmark with a good:

- Precision
- Integrity
- Availability
- Continuity (availability over a period)

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Localization techniques:

Absolute localization	2D / 3D maps of the environment Prior development of the environment No need for an initialization phase Low (bad) sampling frequency Data availability issues (GPS signal, bitter)
Relative localization	odometry telemetry artificial landmarks (beacons)

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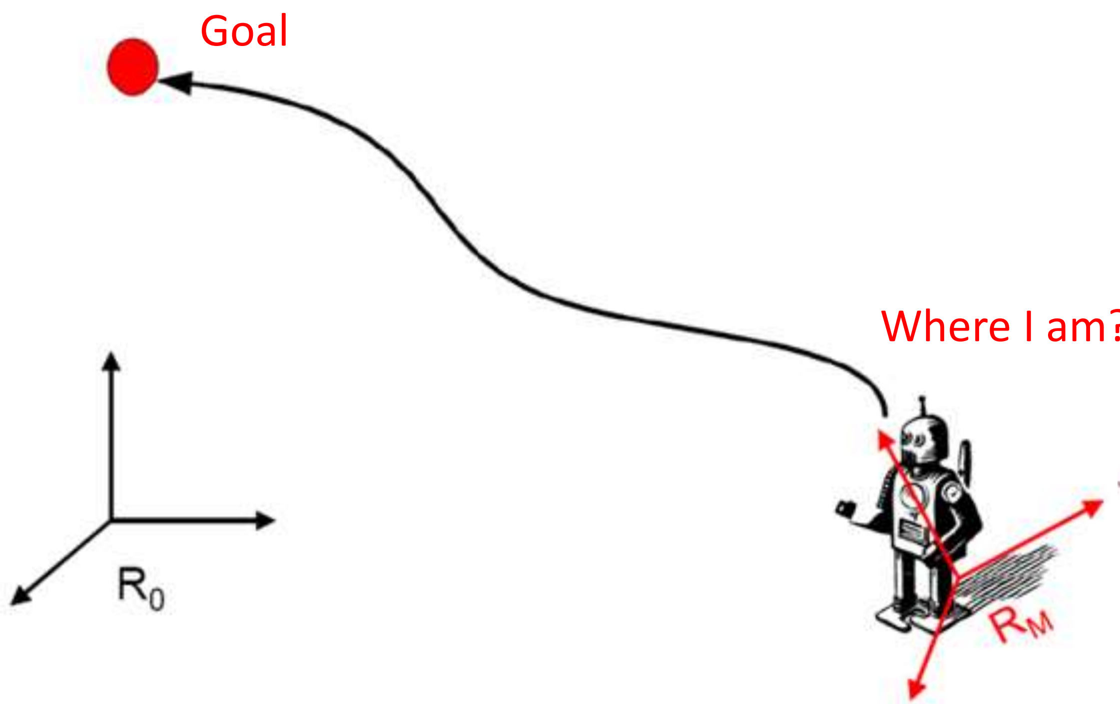
Terminology and change of Landmark in localization:

Pose: Position and attitude (heading angle) of the mobile relative to the navigation Landmark



R0: Navigation Landmark
RM: Mobile Landmark

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Terminology and change of Landmark in localization:

Homogeneous coordinates: useful for making landmark changes or develop models

When we know the coordinates of a point jP in a landmark Rj and that we wish to express them in another landmark Ri, just do: $^{i}P = {}^{i}T_{j} . {}^{j}P$

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Terminology and change of Landmark in localization:

Homogeneous coordinate system

$$\mathrm{Rot}(x,\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathrm{Trans}(a,b,c) = \begin{bmatrix} 1 & 0 & 0 & a \\ 0 & 1 & 0 & b \\ 0 & 0 & 1 & c \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathrm{Rot}(y,\theta) = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathrm{Rot}(z,\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Composition of transformations

$$^{0}T_k = {}^{0}T_1 . {}^{1}T_2 . \ldots {}^{k-1}T_k$$

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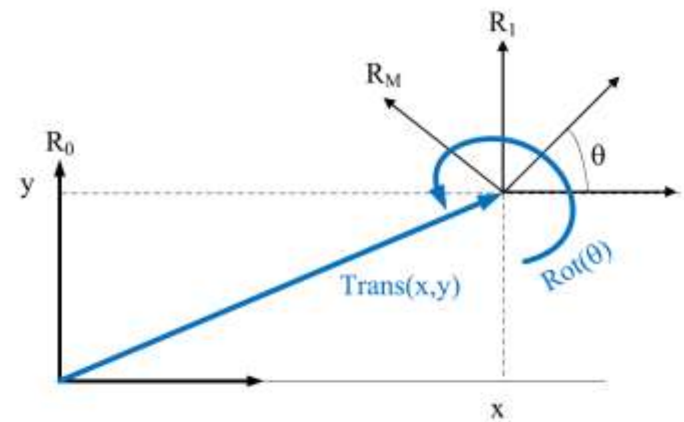
Practical case generally encountered: 2D Pose example

$$^{0}q_M = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix}$$

$$^{0}T_M = \mathrm{Trans}(x, y).\mathrm{Rot}(z, \theta)$$



$$\boxed{^{0}T_M = \begin{bmatrix} \cos\theta & -\sin\theta & x \\ \sin\theta & \cos\theta & y \\ 0 & 0 & 1 \end{bmatrix}}$$

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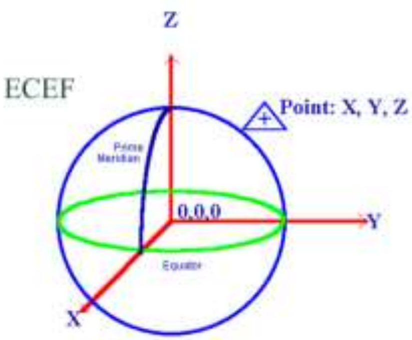
Components used for localization:

GPS

24 satellites
The transmitter generates two respective frequency waves 1575.42 MHz and 1227.60 MHz
3 Signals needed (4 more robust)
Outdoor Navigation
Useful for occasional readjustments
Low frequency <5Hz, typically 1Hz
DGPS: Precision centimeter



Earth Centered, Earth Fixed X, Y, Z

GLONASS, Galileo

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Components used for localization:

Odometry (localization sensors)

Telemetry

Navigable map (digital map of the environment)

Exteroceptive sensors (Lidars Cameras)

Bitter (Thumbnail images / maps)

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Robust localization:

- Multi-sensor fusion
- Simple recalage (odometer + GPS recalage)
- Merging of data by weighted average
- Data merge by Kalman filtering

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Localization dual problems:

- Map construction (local, topological)
- Occupation Grids
- Simultaneous Localization And Mapping (SLAM)