ENGI 128

INTRODUCTION TO ENGINEERING SYSTEMS

Lec 15:
Global Coordinates

"Understand Your Technical World"

Review:
Local Coordinates

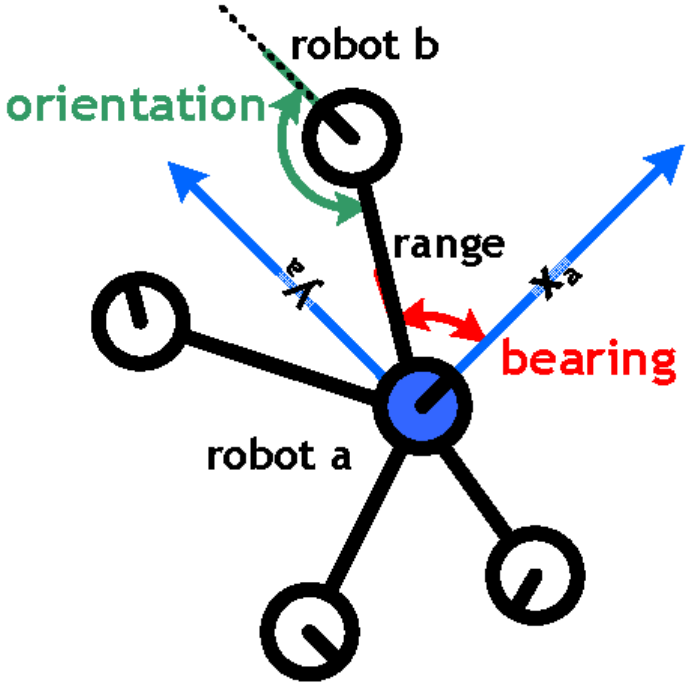
Local Coordinates

Measure *pose* of robot b in robot a's coordinate system

pose = (x, y, θ)

-or-

pose = (range, bearing, orientation)

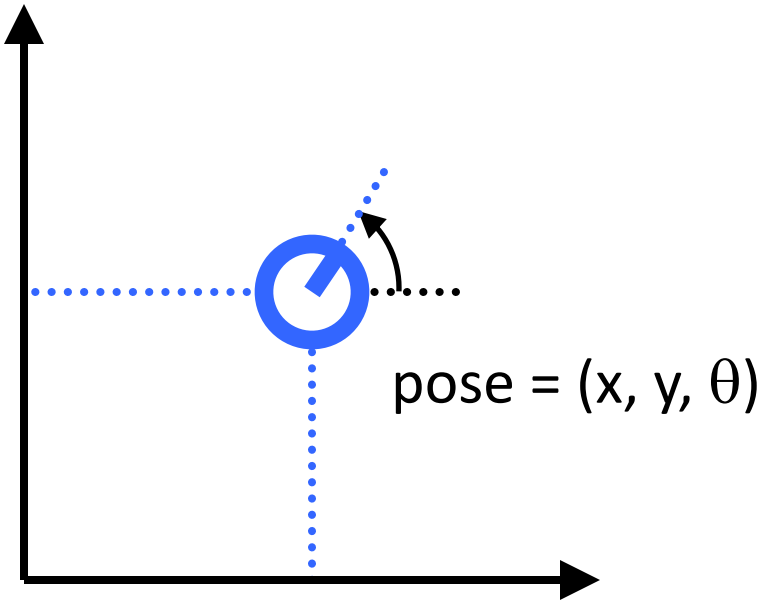


Gobal Coordinates

Global Coordinates

We can also describe the robot's pose in an external reference frame:

This is useful for getting the robots around in the world



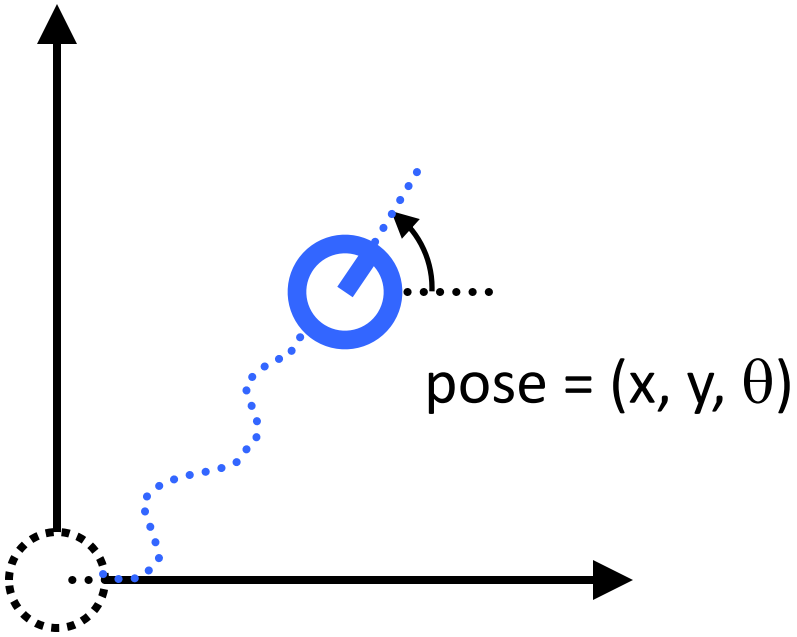
How can we compute this with the sensors the robots have?

Pose Estimation

We assume the robot starts at (0, 0, 0)

We compute incremental changes to the pose using the encoders

This is called *dead reckoning*



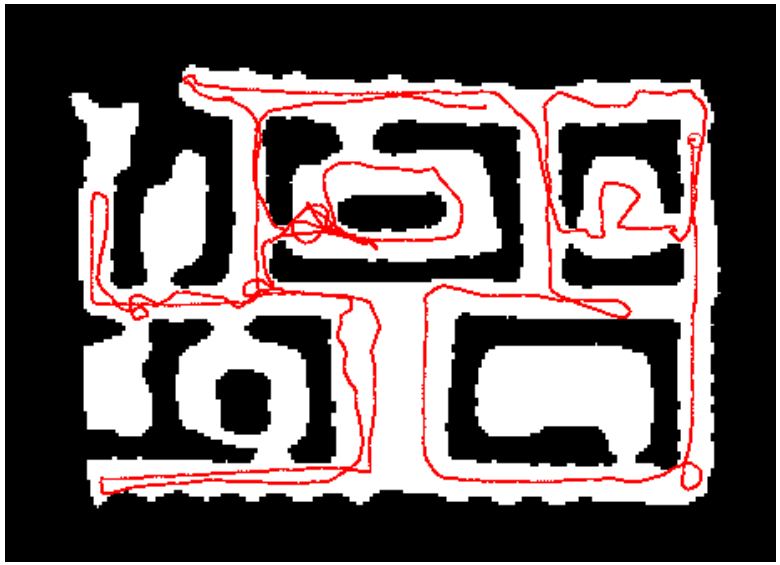
What is the drawback of this technique?

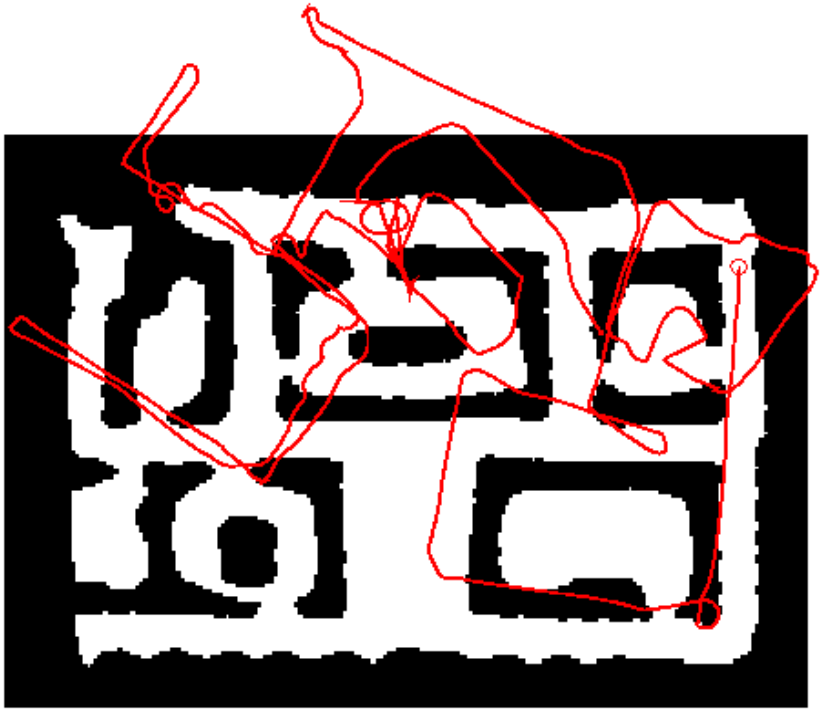
Wheel Slippage

Wheels are always slipping, therefore Dead Reckoning is always accruing errors

Even worse, the errors *integrate*, i.e. they increase little by little but have no bound. Soon the robot has **no idea** where it is.

We can do better, right?

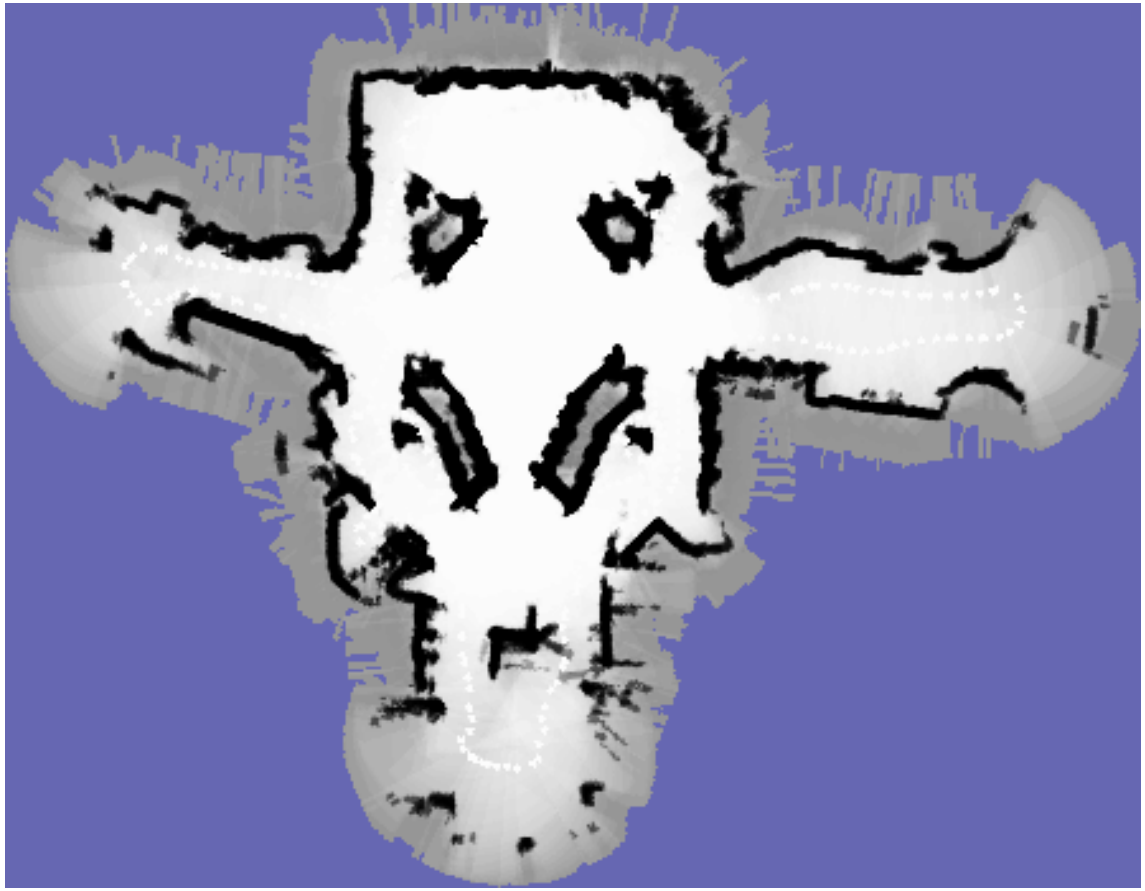




First, we make a map

Use laser scanner to detect obstacles

Use sensor model and “better pose” to produce a map



Particle Filter Localization

Produce lots of estimates of current position

Keep the good ones

KLD-Sampling: Adaptive Particle Filters. D. Fox. NIPS-01.

Particle Filter Localization

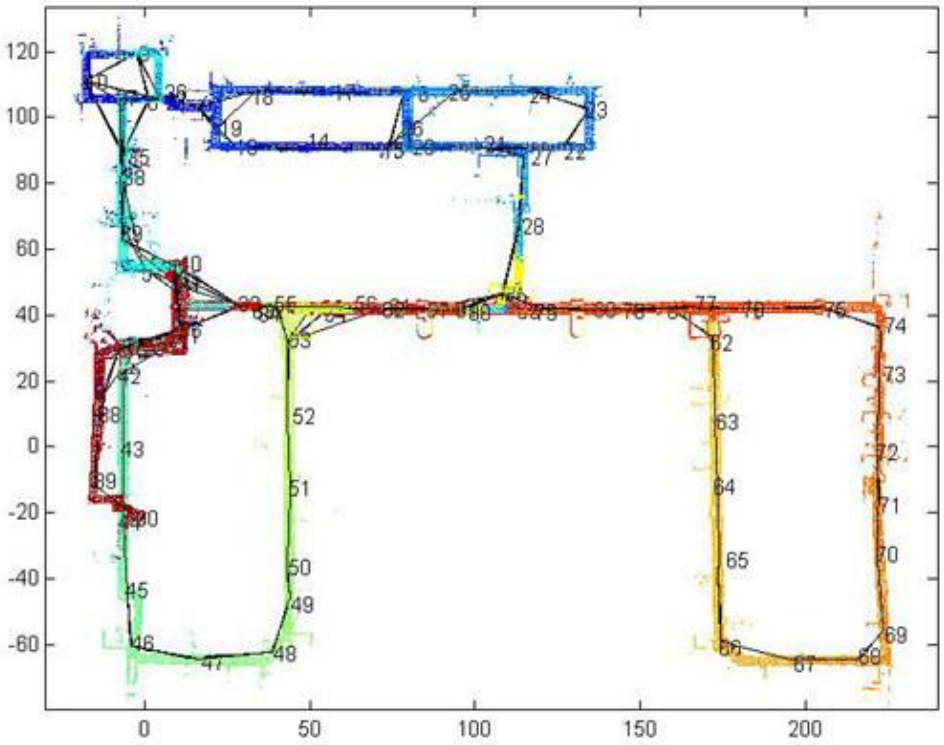
Produce lots of estimates of current position

Keep the good ones

KLD-Sampling: Adaptive Particle Filters. D. Fox. NIPS-01.

We can do them both at the same time

SLAM = Simultaneous Localization And Mapping



M. Bosse, P. M. Newman, J. J. Leonard, and S. Teller. SLAM in Large-scale Cyclic Environments using the Atlas Framework. International Journal of Robotics Research

SLAM in Large-Scale Cyclic Environments Using the Atlas Framework

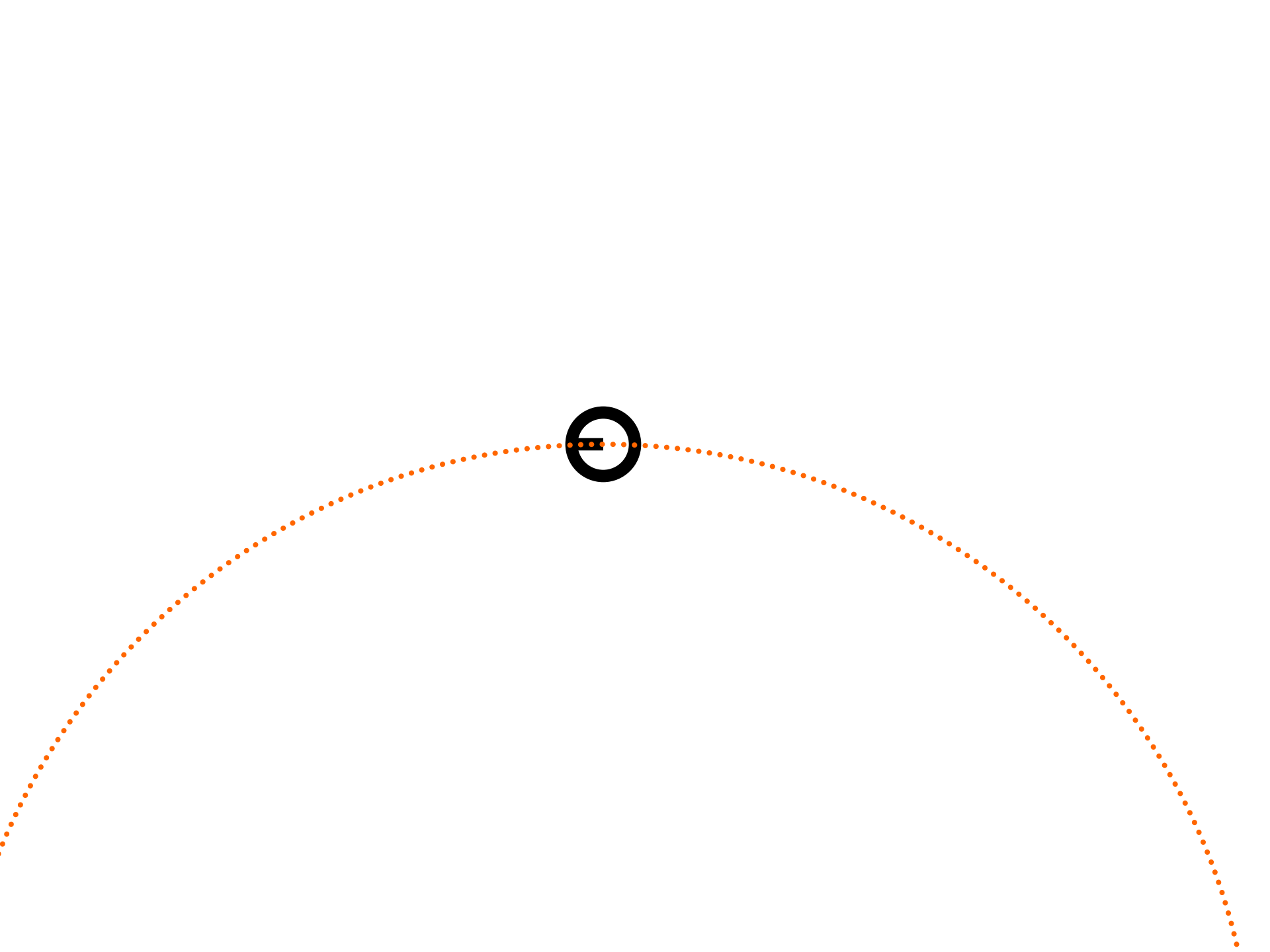
Michael Bosse, Paul Newman,
John Leonard, Seth Teller

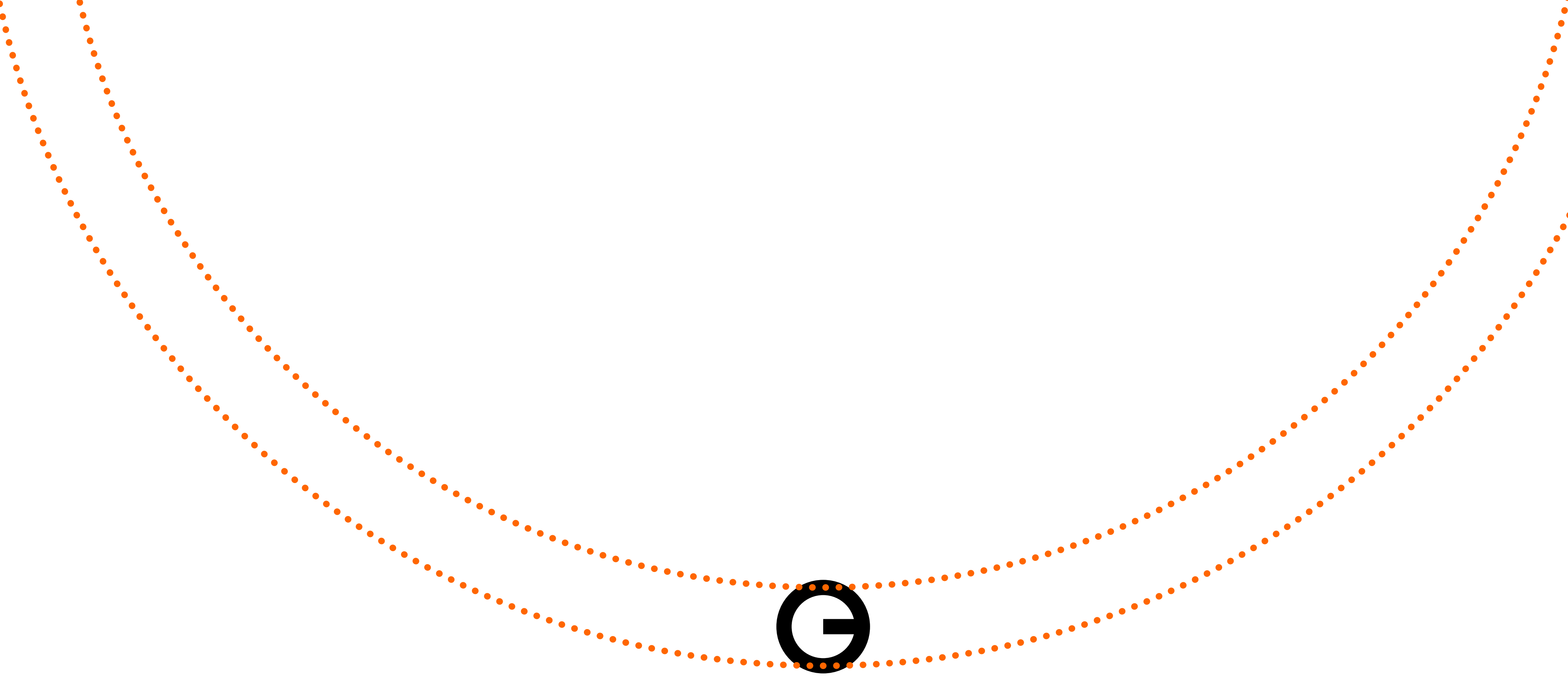
International Journal of Robotics Research
February, 2004

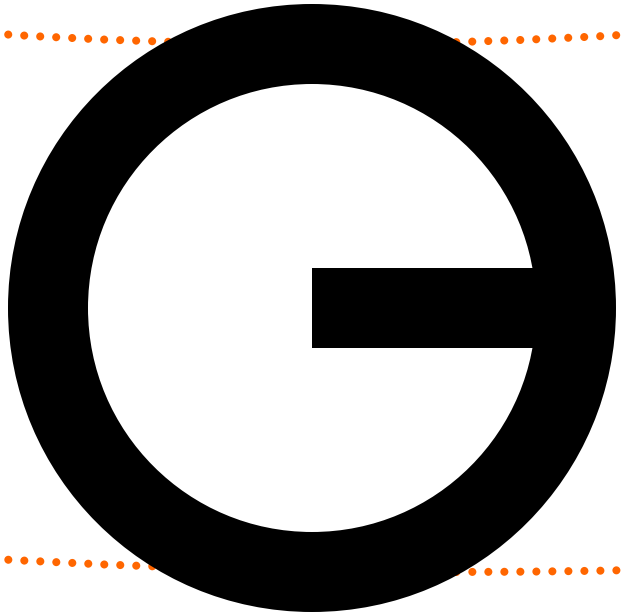
But what if we don’t have a laser range finder?

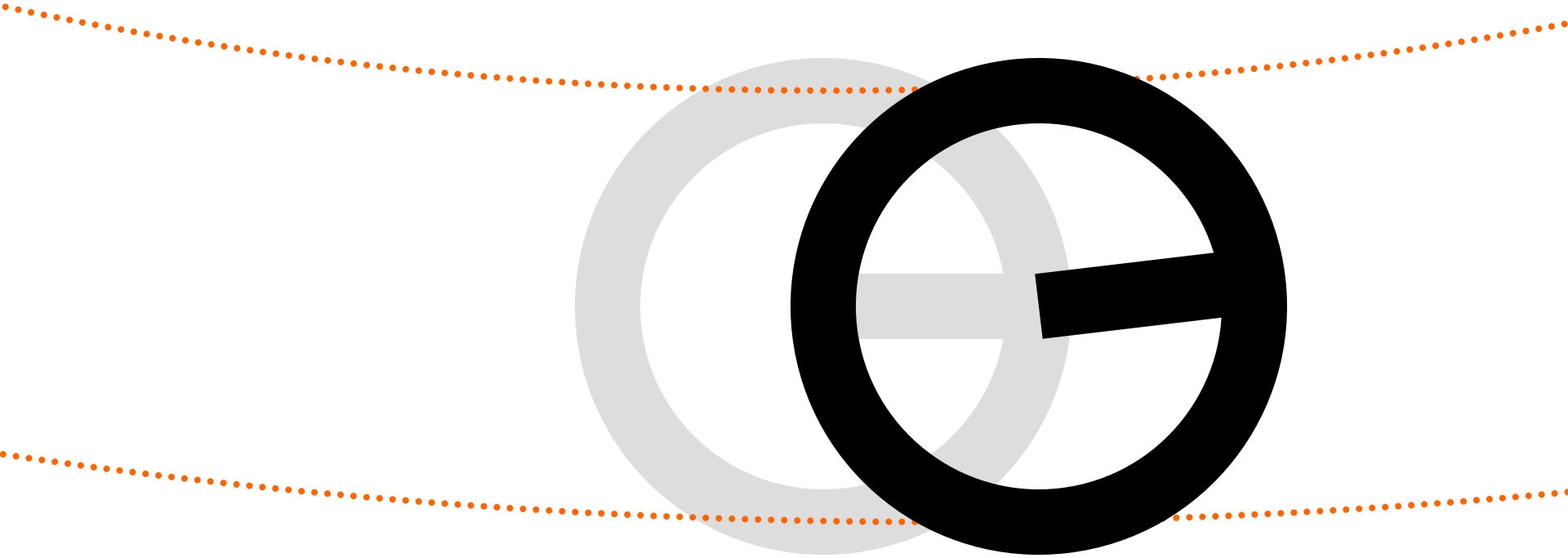
Then you’re stuck with odometry and dead reckoning.

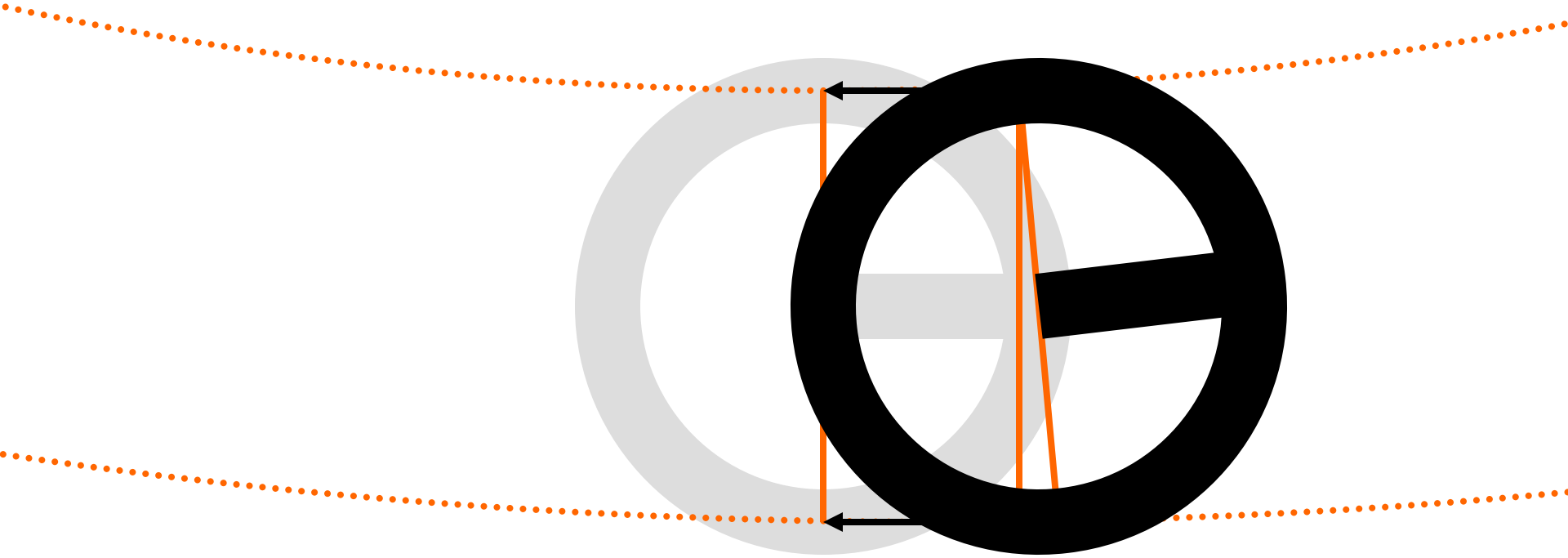
But at least the math is easier…





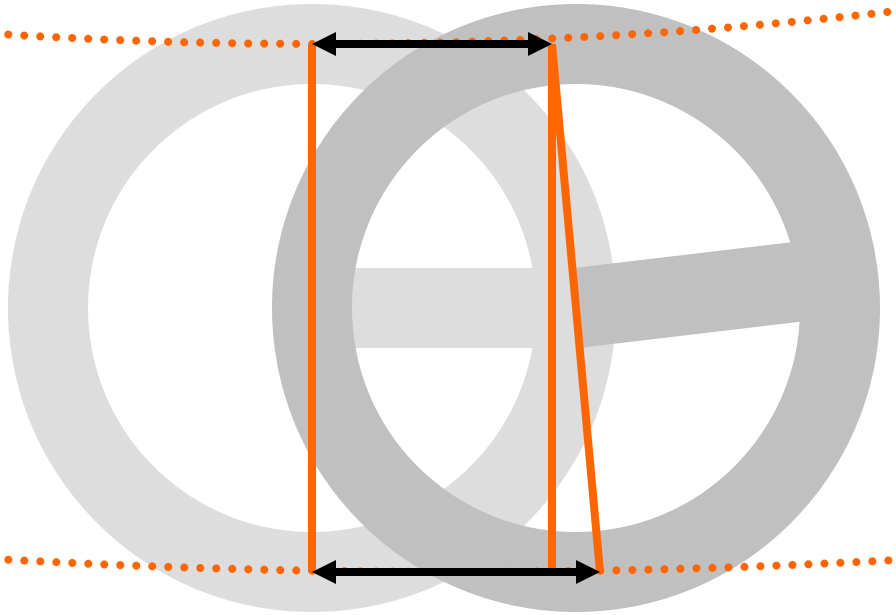






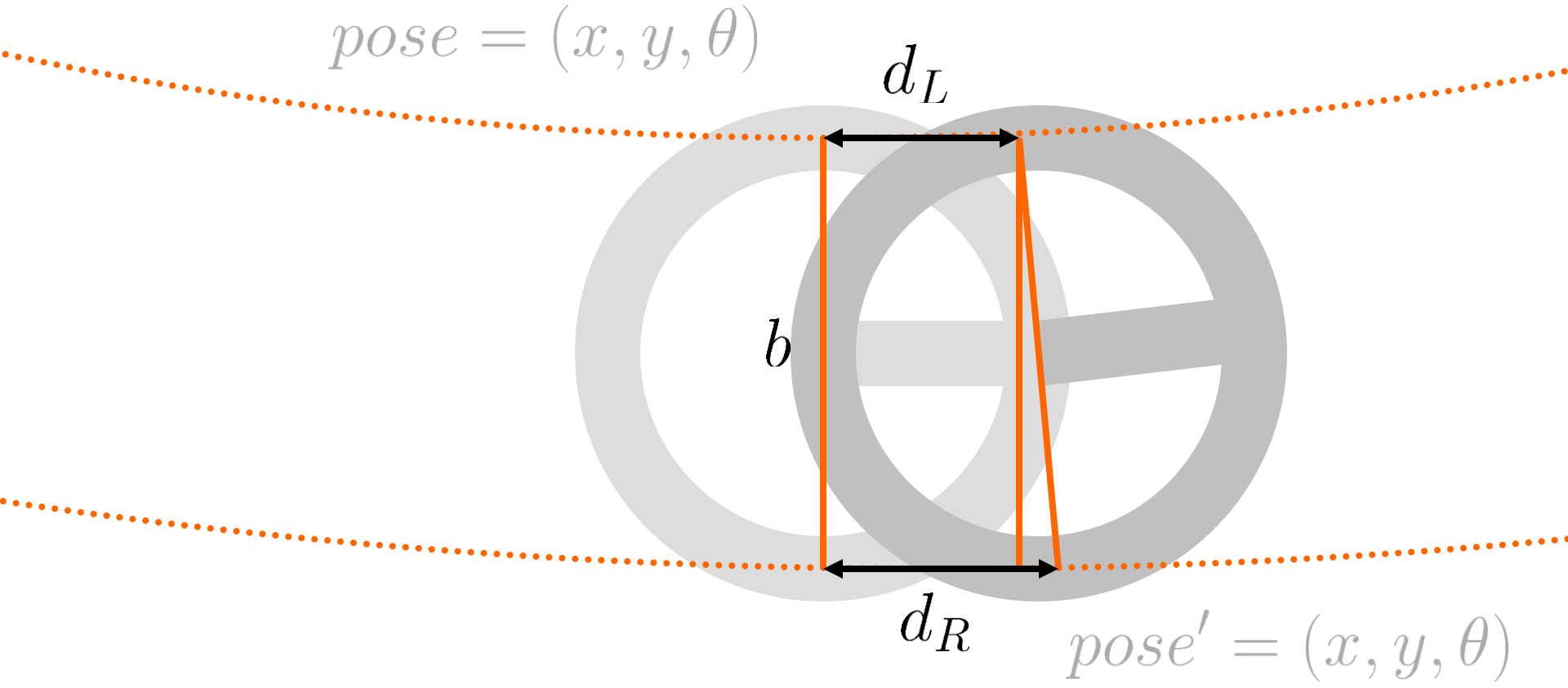
Goal: Update the Pose

$$pose = (x, y, \theta)$$

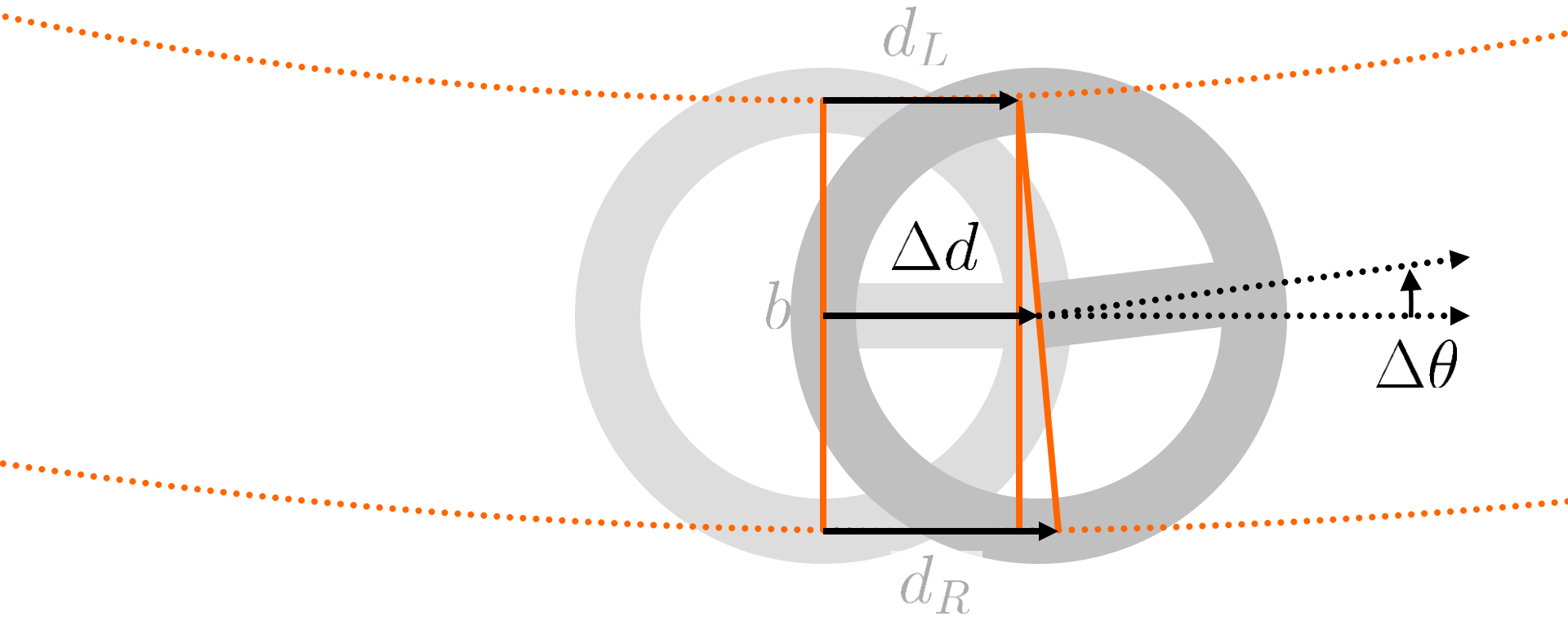


$$pose' = (x', y', \theta')$$

Parameters we know



Parameters we want to compute



Pose estimation from odometry

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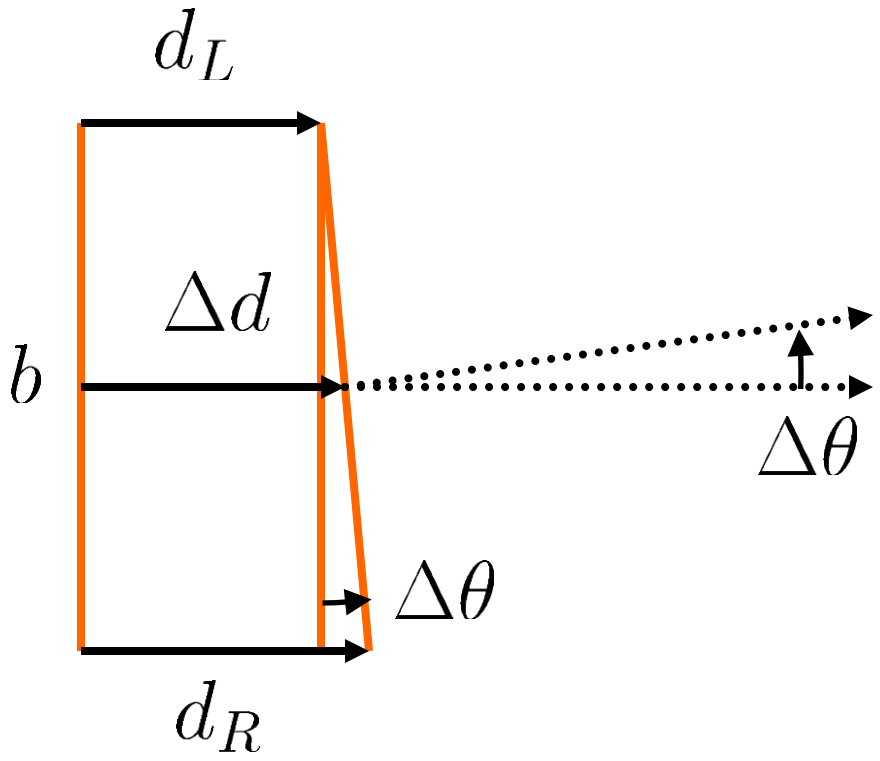
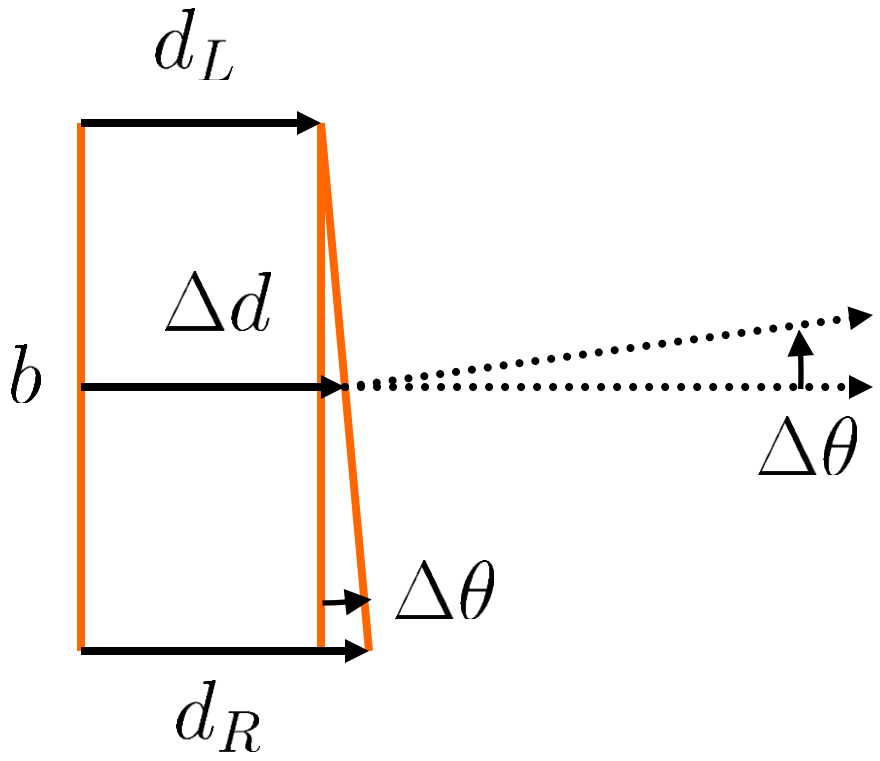


Change in Pose

$$\Delta d = \frac{d_R + d_L}{2}$$

$$\Delta\theta = \frac{d_R - d_L}{b}$$



Pose Update Equations

$$\Delta d = \frac{d_R + d_L}{2}$$

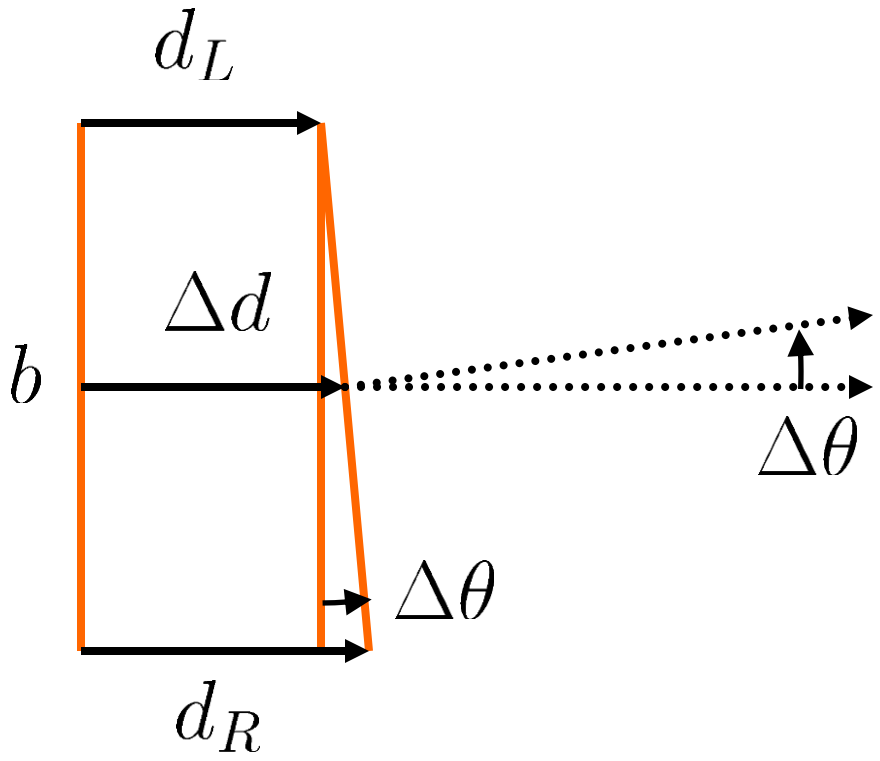
$$\Delta\theta = \frac{d_R - d_L}{b}$$

$$x' = x + \Delta d \cdot cos(\theta)$$

$$y' = y + \Delta d \cdot sin(\theta)$$

$$\theta' = \theta + \Delta\theta$$

$$\boxed{pose' = (x', y', \theta')}$$



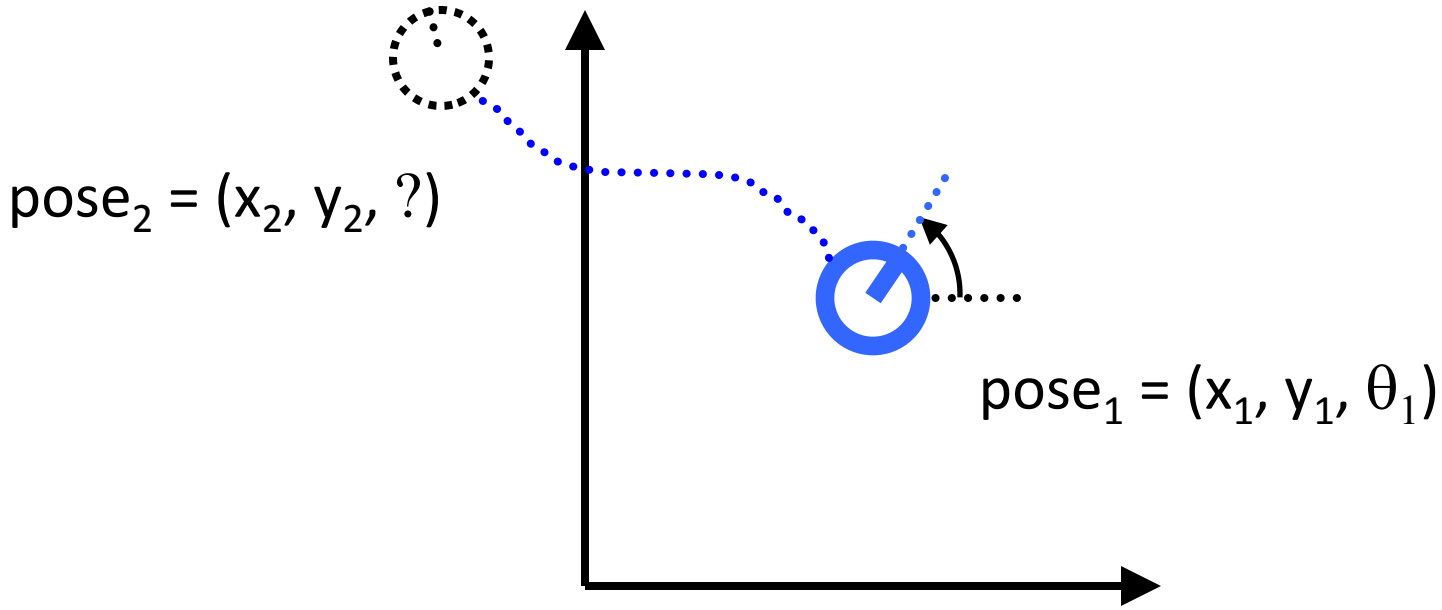
Waypoint Navigation

Waypoint Navigation

We assume that we know our current pose

How can we get from one point to another?

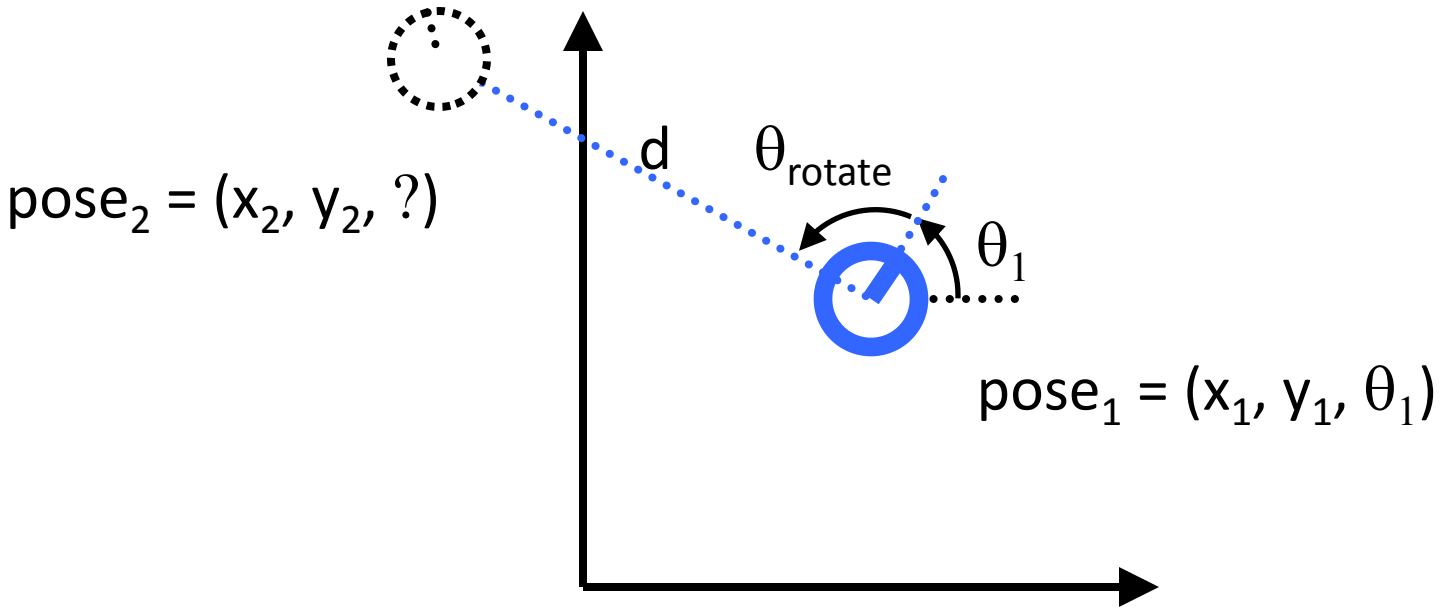
We don't want to specify θ_2, just (x_2, y_2)



Waypoint Navigation

1. Compute θ_{rotate} and d

2. Rotate, then move a fixed distance

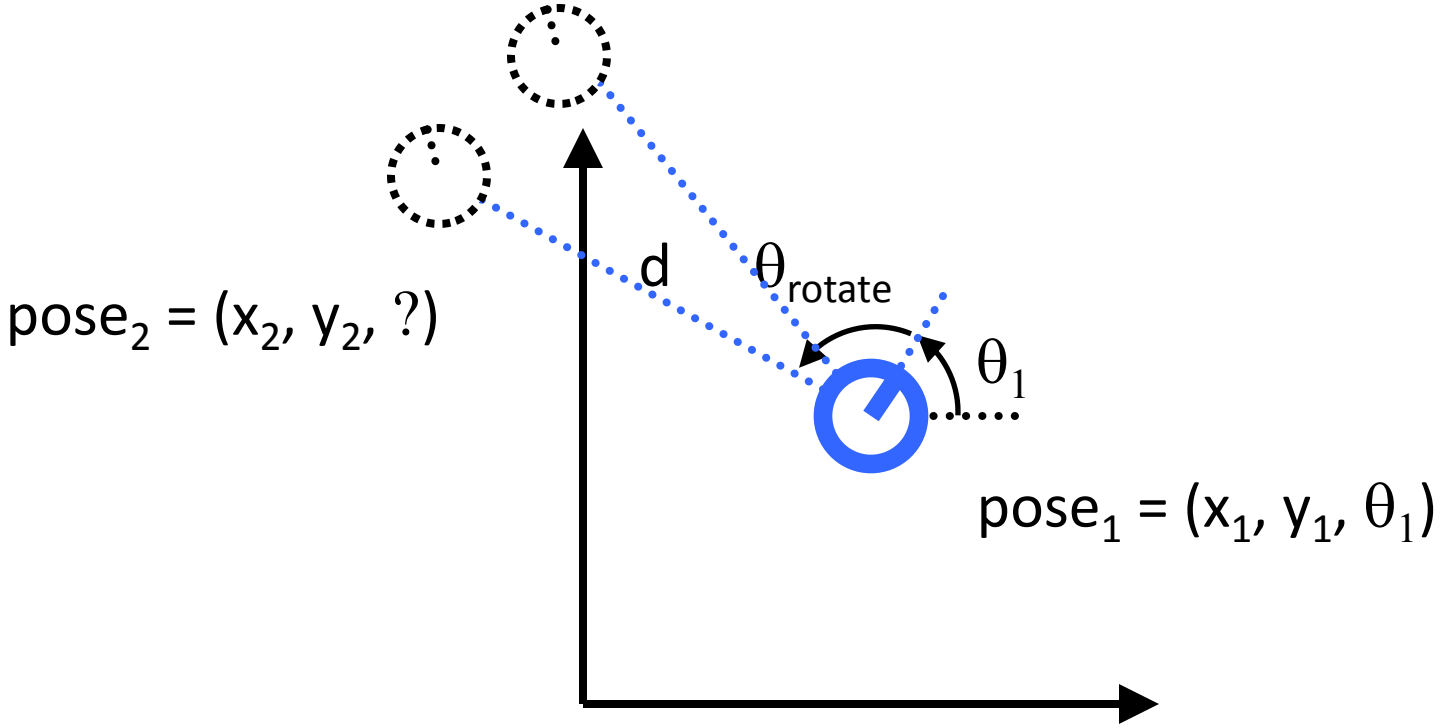


Will this work? Will it work well?

No

Small angular errors will be magnified over long d

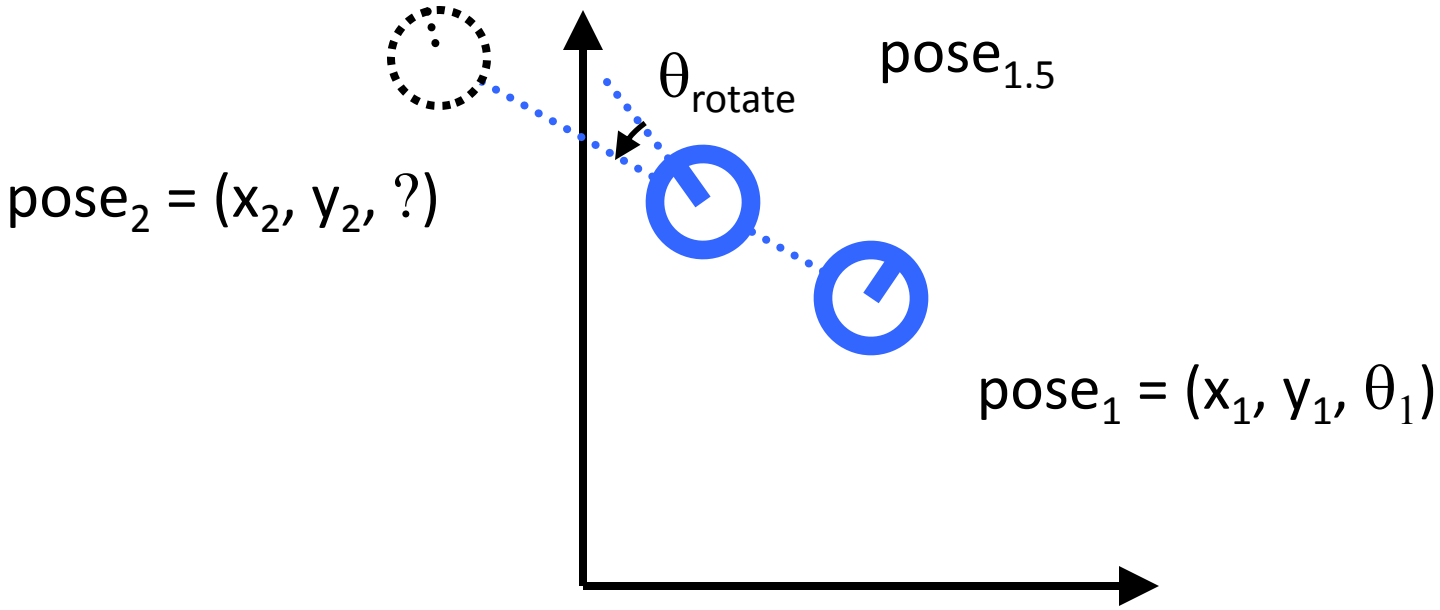
But we know how to deal with errors: a feedback controller



But what information do we feedback on?

Waypoint Navigation with a controller

1. While d > ε:
2. Compute θ_{rotate} and d
3. Rotate while translating



Global Localization Throughout History

Dead Reckoning in Ancient times

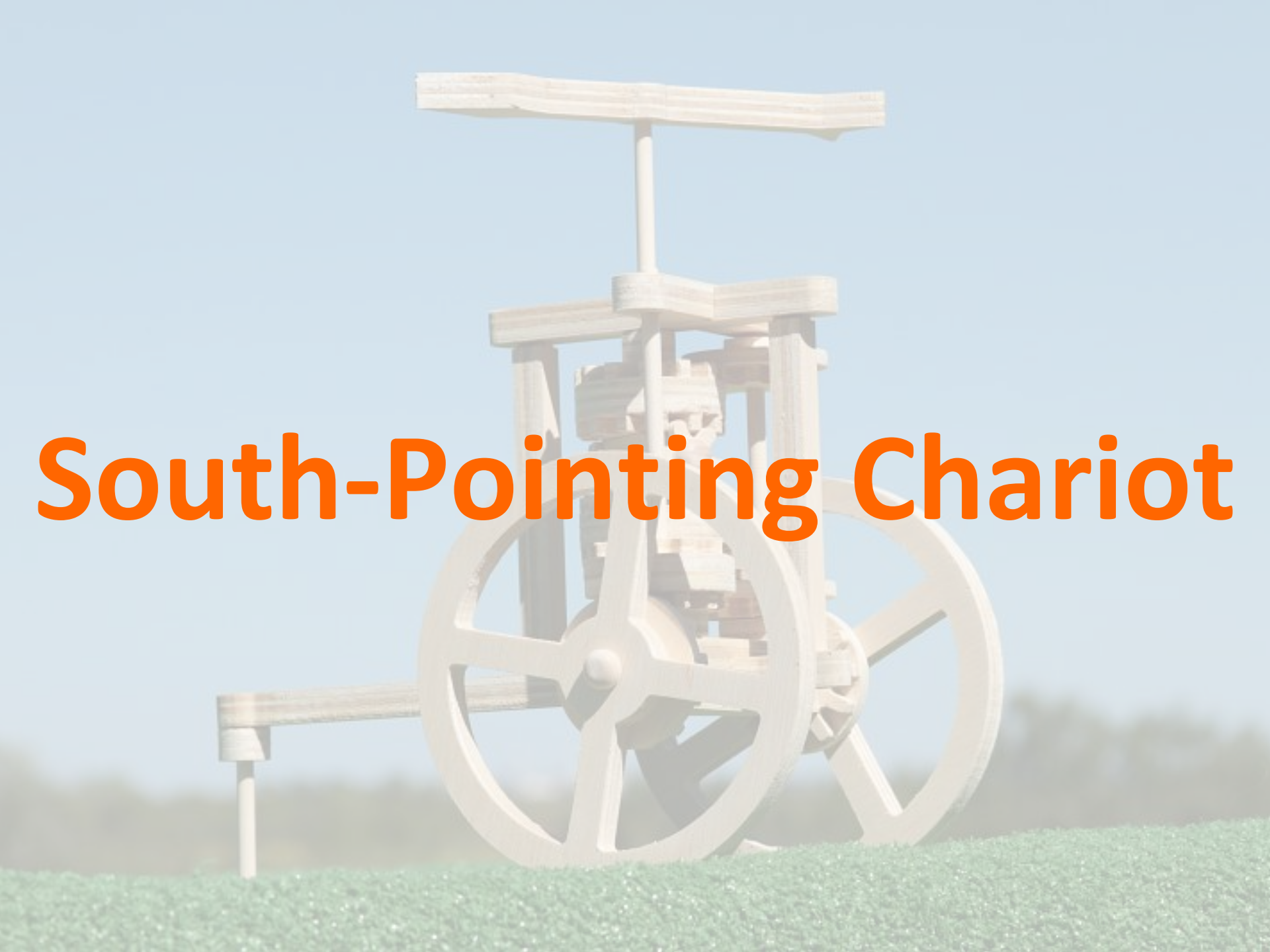
Like, before 1980.

How far back does the idea go?

a. 1961-1963?

b. 1624-1647?

c. 200–265?



South-Pointing Chariot

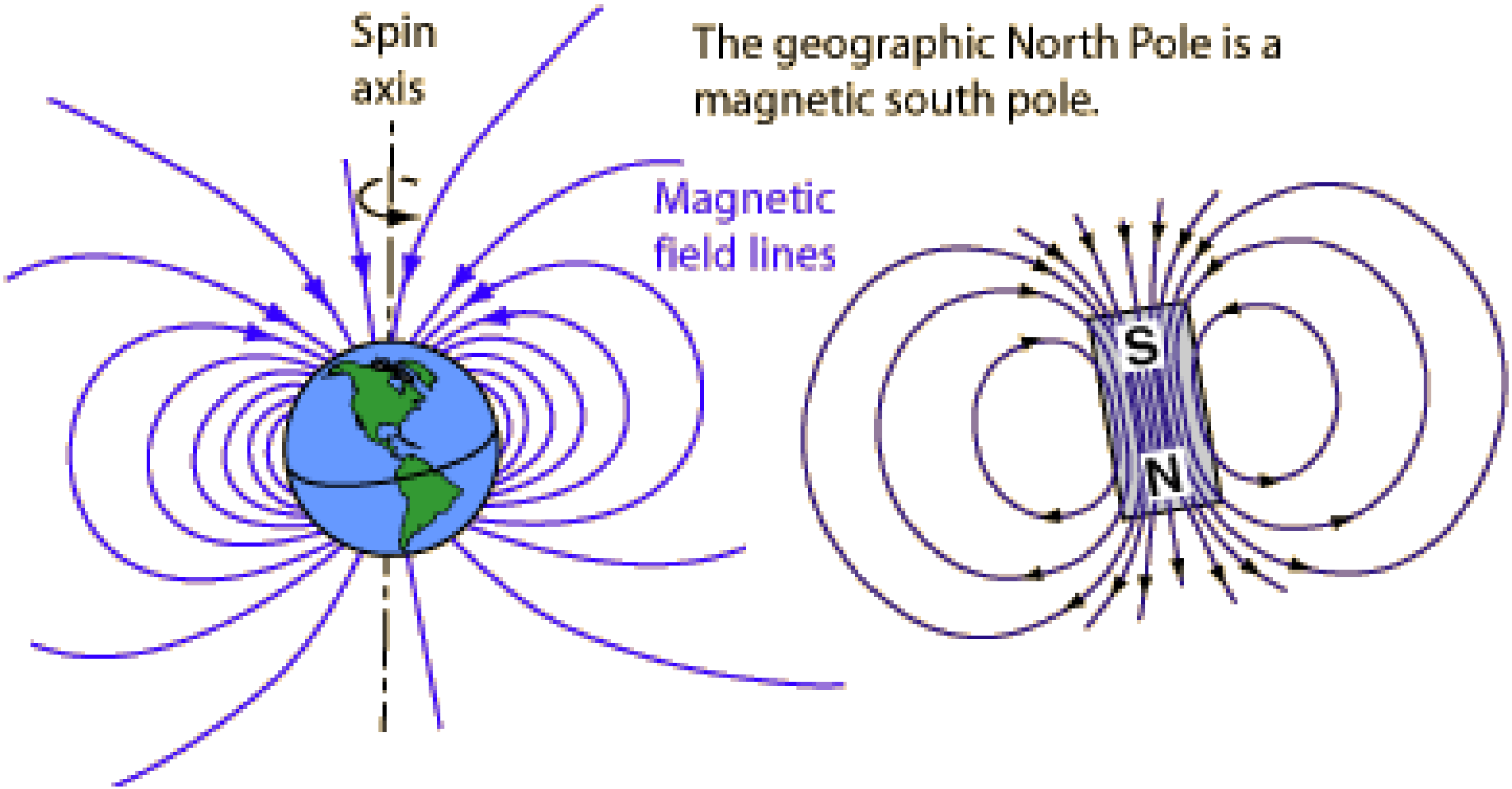
But dead reckoning is limited

Why?

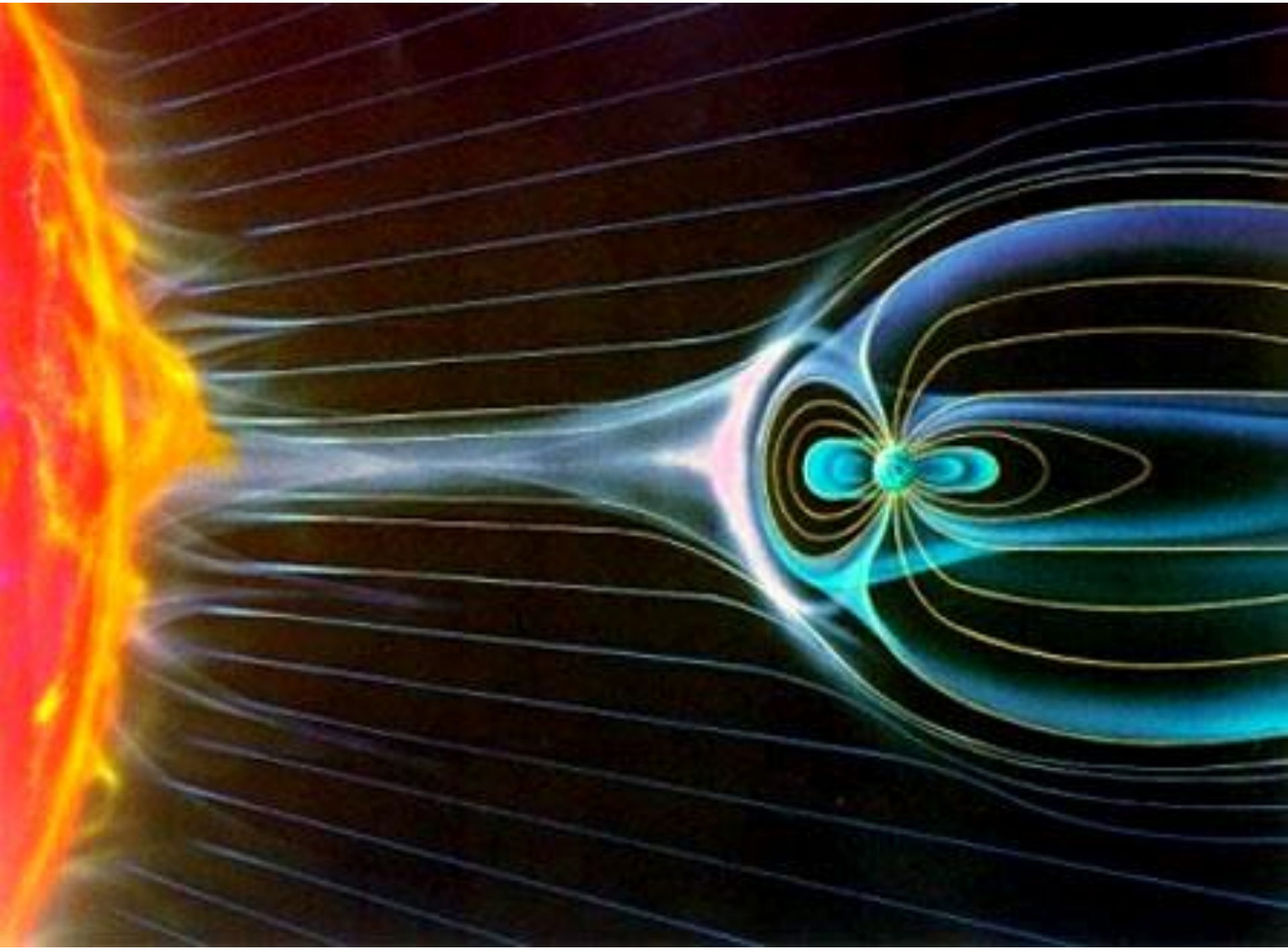
What about feedback?

What can you measure to give you position feedback?

Earth's Magnetic Feild



Compass




NW
NE
W
E
SW
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S
Goulven
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R. Aber Vrach
R. Aber Benoit
Lanilis
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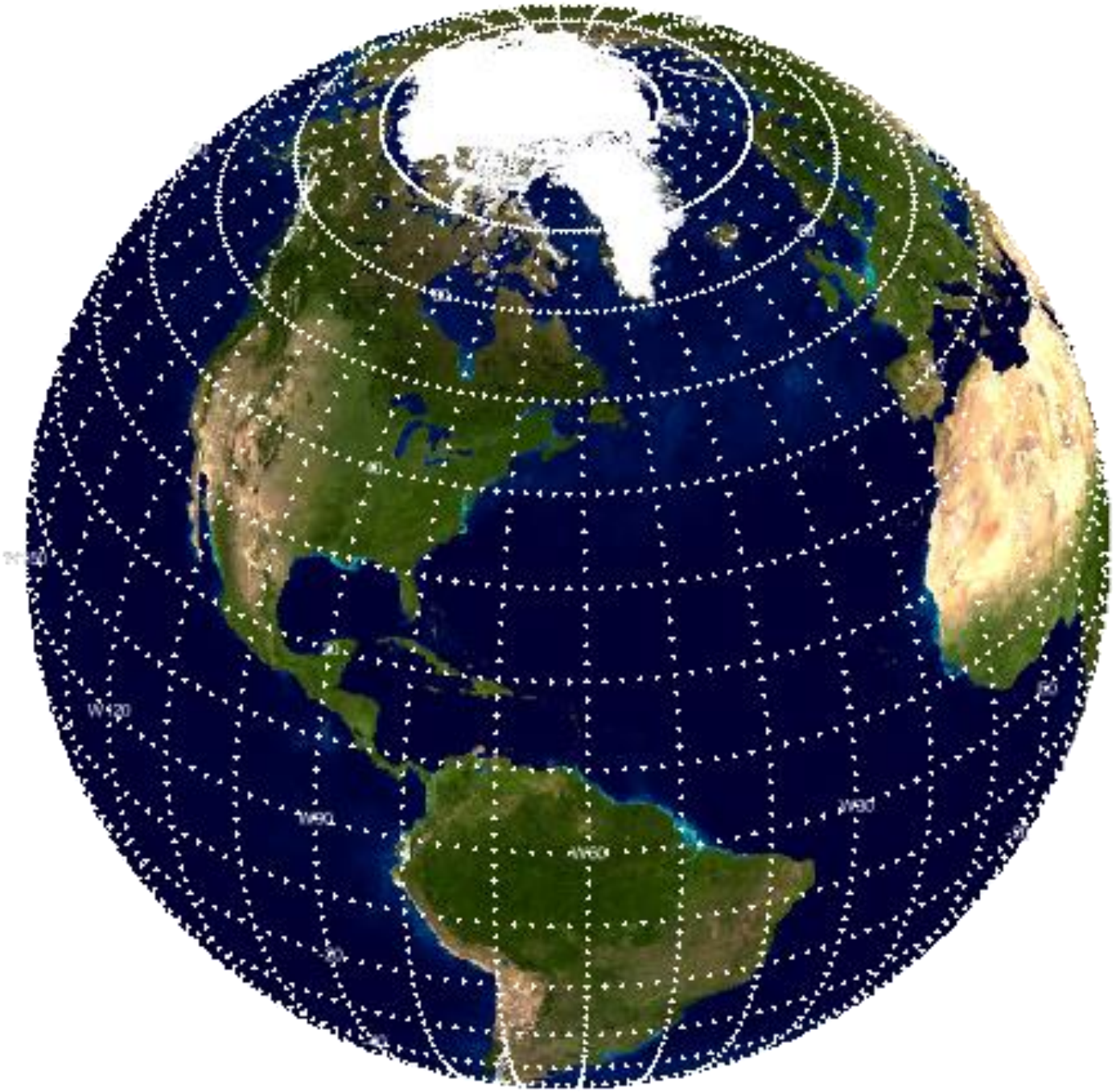
Vierge Island Light
red flash, and each
by short eclipses.
channel to Aber
outer one of which
Point Light revolves at
is visible at the distance of
succeed each other every half
total when
Le Coq
Pte de Toulinguet
Parquete
La Vandree
B. du Lis
Les Tas de Pois
Toulinguet
Dinant
Canaret
Grozon
Black Sor
Broken and


Longitude


60
W120
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W30
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We take the lines on the earth for granted…

But getting them on the globe was one of the biggest scientific problems on the modern age

Latitude (North/South) is easy. Wait until dark and look up…

NORTH
NE
NW
EAST
WEST
SE
SW
SOUTH
URSA MAJOR
Big Dipper
LYNX
URSA MINOR
Little Dipper
DRACO
HERCULES
LYRA
CEPHEUS
CASSIOPEIA
CAMELOPARDALIS
GEMINI
AURIGA
CYGNUS
LACERTA
PERSEUS
ANDROMEDA
SAGITTA
AQUILA
DELPHINUS
EQUULEUS
PEGASUS
Great Square of Pegasus
MONOCEROS
ORION
Moon Dec 3
TAURUS
TRIANGULUM
ARIES
ECLIPTIC
Moon Nov 30
Saturn
PISCES
EQUATOR
LEPUS
CETUS
Jupiter
Moon Nov 26
AQUARIUS
CAPRICORNUS
ERIDANUS
FORNAX
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
PHOENIX

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Latitude (North/South) is easy. Wait until dark and look up…

Longitude, (East/west), well now this is hard.

Very hard…