EE 565: Position, Navigation and Timing Introduction to Navigation

Aly El-Osery Kevin Wedeward

Electrical Engineering Department New Mexico Tech Socorro, New Mexico, USA

In Collaboration with Stephen Bruder Electrical and Computer Engineering Department Embry-Riddle Aeronautical Univesity, Prescott, Arizona, USA

January 8, 2020

Aly El-Osery, Kevin Wedeward (NMT)	EE 565: Position, Navigation and Timing	January 8, 2020	1 / 8



 The process of determining a vehicle's "course" by geometry, astronomy, radio signal, or other means.
Often described by Position, Velocity, and Attitude (PVA)

Overview •	Dead Re 0000			
Aly El-Osery, Kevin Wedeward	(NMT)	EE 565: Position, Navigation and Timing	January 8, 2020	2 / 8



- The process of determining a vehicle's "course" by geometry, astronomy, radio signal, or other means.
 Often described by Position, Velocity, and Attitude (PVA)
- This can be accomplished via "position fixing" or "dead reckoning"

Overview ●				
Aly El-Osery, Kevin Wedeward	(NMT)	EE 565: Position, Navigation and Timing	January 8, 2020	2 / 8



- The process of determining a vehicle's "course" by geometry, astronomy, radio signal, or other means.
 Often described by Position, Velocity, and Attitude (PVA)
- This can be accomplished via "position fixing" or "dead reckoning"
 - Position fixing: Directly measuring location
 - Dead Reckoning: measures changes in position and/or attitude

Overview ●	Dead Ro 0000			
Aly El-Osery, Kevin Wedeward	(NMT)	EE 565: Position, Navigation and Timing	January 8, 2020	2 / 8



- The process of determining a vehicle's "course" by geometry, astronomy, radio signal, or other means.
 Often described by Position, Velocity, and Attitude (PVA)
- This can be accomplished via "position fixing" or "dead reckoning"
 - Position fixing: Directly measuring location
 - Dead Reckoning: measures changes in position and/or attitude
 - need to initialized and then "integrate" the $\Delta {\rm 's}$
 - Inertial sensors measure the Δ 's without requiring an external reference

Overview	Dead R	eckoning Navigatic	n Concept	Sensors
•	0000	O		o
Aly El-Osery, Kevin Wedeward	(NMT)	EE 565: Position, Navigation and Timing	January 8, 2020	2/8

Dead Reckoning: An Example 1



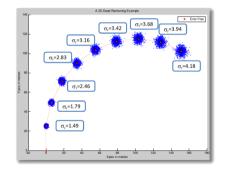
- At each epoch we measure Δx and Δy with noise ($\sigma = 1m$)
- Then add to the prior location

	Dead F ●000	Reckoning Navigation		
Aly El-Osery, Kevin Wedeward	(NMT)	EE 565: Position, Navigation and Timing	January 8, 2020	3 / 8



Dead Reckoning: An Example 1

- At each epoch we measure Δx and Δy with noise ($\sigma = 1m$)
- Then add to the prior location



	Dead Reckoning ●000			
Aly El-Osery, Kevin Wedeward (NM	AT) EE	565: Position, Navigation and Timing	January 8, 2020	3 / 8



PVA needed in terms of local datum

DARPA grand challenge



		eckoning Navigation		
	0000			
Aly El-Osery, Kevin Wedeward	(NMT)	EE 565: Position, Navigation and Timing	January 8, 2020	4 / 8



PVA needed in terms of local datum

DARPA grand challenge



SOCOM Robot (EE NMT project)



Overview Dead		n Concept Sensors
Aly El-Osery, Kevin Wedeward (NMT)	EE 565: Position, Navigation and Timing	January 8, 2020 4 / 8



Earth Centered Earth Fixed Coordinate System







Earth Centered Inertial Coordinate System







• There exists a wide variety of information sources (i.e., sensors)

• Inertial, Doppler, GPS, radar, compass, camera, odometry, barometric, ...

		oning Navigation Conce	pt Sensors
Aly El-Osery, Kevin Wede	eward (NMT)	EE 565: Position, Navigation and Timing	January 8, 2020 7 / 8



- There exists a wide variety of information sources (i.e., sensors)
 - Inertial, Doppler, GPS, radar, compass, camera, odometry, barometric, ...
- e How should I describe my location?
 - Position, velocity, and attitude?
 - attitude can be a bit tricky!!

Overview O	Dead R 0000	Reckoning Navigation	n Concept	Sensors
Aly El-Osery, Kevin Wedeward	(NMT)	EE 565: Position, Navigation and Timing	January 8, 2020	7 / 8



- There exists a wide variety of information sources (i.e., sensors)
 - Inertial, Doppler, GPS, radar, compass, camera, odometry, barometric, ...
- I How should I describe my location?
 - Position, velocity, and attitude?
 - attitude can be a bit tricky!!
- Solution When answering the question "where am I?" the *wrt* must be very clearly defined!!
 - Lead in to the notion of coordinate systems

Overview o	Dead R 0000	eckoning Navigation	Concept Sensor	's
Aly El-Osery, Kevin Wedeward	(NMT)	EE 565: Position, Navigation and Timing	January 8, 2020 7 ,	/ 8





Aly El-Osery, Kevin Wedeward (NMT)

EE 565: Position, Navigation and Timing

January 8, 2020 8 / 8

Sensors