

Navigation and Guidance: Principles and Methods

Introduction

The discipline of Navigation and Guidance is concerned primarily with the movement of living beings and other objects from one place to another. The subject involves methodologies and mechanisms that help in determining the position and strategies for reaching the desired destination. Living beings and objects (land, sea, air & space based), have a continuous requirement of moving from one place to another, with specific motion objectives. In this regard, we need to note that any general motion scenario involves answering the following two questions; (1) Where am I currently; and (2) How should I move to reach the desired destination? Navigation and guidance disciplines comprise different mechanisms to find answers to the above questions.

Navigation and Guidance Discipline

As per the dictionary, to navigate means, “to direct the way a craft will travel” OR “to find a direction across, along or over an area of land, sea etc.”. In living beings, the navigation is born out of homing instinct. Further, typically, Navigation starts at the beginning of the journey and ends when the journey ends. Navigation, in a broader sense, can refer to any skill or study that involves the determination of position and direction in relation to the time.

Guidance, on the other hand, is the process of calculating the changes in position, velocity, attitude, and/or rotation rates of a moving object, which are required to follow a certain trajectory and/or attitude profile. Guidance takes input from the navigation system (where am I) and uses targeting information (where do I want to go) to send signals to a control system that allows the vehicle to reach its destination (within the operating constraints of the vehicle). Therefore, in an overall sense, Guidance is the “*driver*” to the next location, while the Navigation is the current “*location finder*”. The participants to the course can expect to understand various techniques for determining the present location as well as strategies for travelling to the intended destination.

Course Objectives

To provide exposure to basic concepts in Navigation, including methodologies for positioning.

To introduces the concept of Guidance and techniques for arriving at solutions for the paths.

Course Contents

Module-1: Fundamentals of Navigation - Historical Perspective and basic Navigation Process. (4 Hours).

Module-2: Basic Navigation Strategies - Stellar or Celestial Navigation, Radio & Radar based Navigation methods. (6 Hours).

Module-3: Dead Reckoning (DR) Based Systems - Ranging and Bearing based methods, Inertial Navigation System (INS) as a special case of DR Strategy. (6 Hours).

Module-4: Satellite Based Navigation Methods - GNSS based Navigation, GPS and other similar navigational systems including GLONASS, IRNSS, GAGAN etc. (6 Hours).

Module-5: Fundamentals of Guidance - Route and Path Planning concepts, Map based guidance strategies. (4 Hours).

Module-6: Basic Guidance Strategies - Intercept Geometry, Line of Sight and Collision Triangle concept. Proportional Navigation & Guidance (PNG) and Determination of Miss Distance, Augmented PNG and its comparison with PNG. (6 Hours).

Module-7: Advanced Guidance Methods - Command to LOS and pulsed guidance methods, Beam Rider Guidance, Lambert's Guidance techniques. (6 Hours).

Pre-requisites

Course does not have any formal pre-requisites. However, good familiarity with basic mechanics and, in particular, kinematics, including concept of rotating frames of reference, is useful. Also, exposure to solution of ordinary differential equations, including numerical techniques for solving differential equations, will be beneficial.

Text/References

Anderson, 'The Principles of Navigation', Hollis & Carter, London, 1966.

Bauss, 'Radio Navigation System for Aviation and Maritime Use', Pergamon, 1962.

Sonnenberg, 'Radar and Electronic Navigation', 6th Ed., Butterworths, 1988.

Hofmann-Wellenhof, 'Navigation: Principles of Positioning and Guidance', Springer-Wien, 2003.

Jekeli, 'Inertial Navigation Systems with Geodetic Applications', Walter de Gruyter, 2000.

Zarchan, 'Tactical & Strategic Missile Guidance', Progress in Aeronautics and Astronautics Series, 5th Ed., Vol. 219, AIAA Publication, 2007.

Biezad, 'Integrated Navigation and Guidance Systems', AIAA Education Series, AIAA, 1999.

Shneydor, 'Missile Guidance and Pursuit: Kinematics, Dynamics and Control', Woodhead Pub., 1998.

Parkinson (Ed.), 'GPS: Theory and Applications', Vol. I, Progress in Aeronautics & Astronautics, Vol. 163, AIAA, 1996.

Gleason, 'GNSS Applications and Methods', AIAA Education Series, AIAA, 2009.

Grewal, Weill & Andrews, 'Global Positioning Systems, Inertial Navigation and Integration', 2nd Ed., John Wiley, 2007.

Hofmann-Wellenhof, Lichtenegger & Collins, 'Global Positioning System: Theory and Practice', 2nd Ed., Springer-Verlag, 1993.

Mode of Conduct and Delivery

The course is planned to be conducted fully in the on-line format, with two hours per week engagement. Further, it will be run in a module-wise sequence.