

MV 3472 Graphical Simulation of Physical Systems in Virtual Worlds (3-2)

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Text Books (Optional)

1. *Automatic Control Systems*, Fifth Edition, Benjamin C. Kuo, Prentice Hall, 1987.
2. *The Student Edition of MATLAB 5 User's Guide*, The MathWorks, Inc., Prentice Hall, 1997.

Course Summary

Fundamental concepts and methods for real-time computer simulation of physical systems in graphical virtual worlds. Vector and matrix algebra, differential equations, state equations, solving linear differential equations using Laplace transform, numerical solutions of differential equations, rigid body kinematics and dynamics, and orbital mechanics. Matlab will be used in laboratory.

Prerequisites

CS2970 or CS2971 or CS2973 or equivalent. MA3042 or permission of instructor.

Grading

20% midterm exam, 40% lab and home assignments, and 40% final exam.

Course Syllabus

Chapter 1 Overview of physically Based Modeling

- 1.1. Traditional Graphics Modeling*
- 1.2. Physically Based Modeling*
- 1.3. Example - Pendulum*
- 1.4. Issues in Physically Based Modeling*

Chapter 2. Vectors and Matrices

- 2.1. Definition*
 - Matrix*
 - Square Matrix*
 - Vector – Special Form of Matrix*
- 2.2. Transpose*
- 2.3. Addition*
- 2.4. Scalar Multiplication*
- 2.5. Matrix Multiplication*
- 2.6. Inner Product*
- 2.7. Equal Matrices*
- 2.8. Basic Characteristics of Matrix Multiplication*
- 2.9. Special Matrices*
- 2.10. Linear System*
- 2.11. Inverse of Square Matrix*
- 2.12. Determinant*
- 2.13. Adjoint of a Matrix*
- 2.14. Computation of Inverse Matrix*

Chapter 3. Linear Systems

- 3.1. Definition*
- 3.2. Linear Systems of Equations*
 - Homogeneous Systems*
 - Geometric Interpretation*
- 3.3. Matrices and Systems of Linear Equations*
- 3.4. Matrix Algebra*

Chapter 4. Special Descriptions at Position and Orientation

- 4.1. *Descriptions of Position*
- 4.2. *Descriptions of Orientation*
- 4.3. *Rotation Matrix*
- 4.4. *How to describe {B} Relative to {A}?*
- 4.5. *Description of a Frame*
- 4.6. *Frame Mapping*

Chapter 5. Homogeneous Transform

- 5.1. *Definition*
- 5.2. *Special Homogeneous Transforms*
- 5.3. *Transformation Arithmetic*
- 5.4. *Inverse Homogeneous Transform*
- 5.5. *Transform Operators*
- 5.6. *Summary of Interpretations*

Chapter 6. Euler Angles

- 6.1. *Reference Position*
- 6.2. *X-Y-Z Fixed Angles*
- 6.3. *Z-Y-X Body Axis Rotations*
- 6.4. *Gimbal Angles*
- 6.5. *Euler Angle Conventions*
- 6.6. *Euler Angle Singularities*
- 6.7. *Equivalent Angle-Axis*

Chapter 7. Quaternion and Quaternion Rotations

- 7.1. *Complex Numbers*
- 7.2. *Complex Plane – Geometric Representation*
- 7.3. *Polar Form of Complex Numbers*
- 7.4. *Quaternion*
- 7.5. *Complex conjugate of a Quaternion*
- 7.6. *The norm or Length of a Quaternion*
- 7.7. *Inverse of a Quaternion*
- 7.8. *Special Quaternions*
- 7.9. *Composition of Rotations*
- 7.10. *Body-Fixed Rotation*

Chapter 8. Differential Equations

8.1. Algebraic and Differential Equations

8.2. Features of Ordinary Differential Equation (ODE)

8.3. Example One – Elastic Motion

8.4. Example Two – Pendulum

8.5. Classification of Differential Equations

8.6. Linear Differential Equations

8.7 Laplace Transform

Properties of the Laplace Transform

Application of the Laplace Transform

Partial Fraction Expansion

Partial Fraction Expansion with Repeated Factors in the

Denominator

Chapter 9. Numerical Methods for Solving Differential Equations

9.1. State Equations

9.2. Numerical Solutions

9.3. Small Step from t_0 to t_1

9.4.. Euler's Method

9.5. Henn's Method

Chapter10. Velocity

10.1. Position and Orientation

10.2. Two Simple Types of Motion of a Rigid Body

10.3. General Motion

10.4. Transforming Body Rates to Euler Rates

10.5. Transforming Body Rates to a Quaternion Rate.