INFOMGP - Game Physics

GMT Master Program
Period III, 2018

Lecturer: Amir Vaxman
What is Game Physics?

- Understanding the laws of the real world and simulating them computationally.

Applications?

Science

BeamNG

Games

Movies

Industry

ModuleWorks GmbH

Position Based Fluids [Macklin and Müller 2013]

2012 (bullet)

Universiteit Utrecht

Game Physics – Introduction
Physics is Interaction

• Objects interact through forces:
  • Between remote objects (gravity, magnetism)
  • Between objects in contact (friction, collision).
  • Within an object (chemical ties).

• Game physics: analyzing and simulating interaction.
  • Kinematics: descriptions of motion.
    • Position, velocity and acceleration.
  
  • Dynamics: forces and their effect.
    • Mass, inertia, collisions, momentum, energy.
Challenges

• Discretization.
  • Stability & Convergence.
  • Preventing errors.

• “How deep do we go”?
  • Efficiency vs. accuracy.

• How to do “well enough”.
  • Visually convincing.
  • Reasonable approximation.

[Rick & Morty, Adult Swim, 2013]

[Liu et al., Fast Simulation of Mass-Spring Systems]
Control

• How do we control \textit{dynamics} to achieve a \textit{kinematic} effect?

• \textbf{Active} control.
  • Characters and hinges.
  • Simulator (driving, flying, engine).

• \textbf{Passive/resulting} control.
  • Collision detection & resolution.
  • Determining kinematics.
  • Soft deformation.

\cite{Deul et al., Position-Based Rigid Body Dynamics, 2014}
The Players in the Field

• **Objects** as collections of **points** (molecules).

• **Rigid** bodies.
  • Deform as a single piece.

• **Soft** bodies.
  • Each point deforms locally in a continuum.

• **Detachable** bodies.
  • Several objects either stick together or break apart.
There Will Be Math

• Linear Algebra.
  • Vector spaces and matrices.
  • Linear transformations.

• Multivariate Calculus.
  • Differential calculus.
  • Integration.

• Basic measurements.
  • SI units.
Learning Objectives & Deliverables

- **Understand** classical continuum mechanics, and **solve** theoretical problems in motion and dynamics.
- **Have a working knowledge** of multivariate & vector calculus and tensor algebra, in the context of game physics.
  - **Deliverable:** home exam.
- **Implement** game physics principles. **Deliverables:**
  - 3 practical assignments.
  - Free-form mini-project.
- **Note:** course has no written exam.
Lectures

• 13-14 frontal lectures.

• Topics:
  • Rigid-body physics & simulation.
  • Calculus and algebra.
  • Collision detection & resolution.
  • Time integration.
  • Space discretization.
  • Soft-body physics & simulation.
  • Fluid physics & simulation.
Home Exam

• Exercise sheets.
• 20% of grade.
• Individual work.
• First starts this week!
• Topics (roughly):
  • Continuous mechanics.
  • Math…
Practical Assignments

• Implement techniques shown in class.
  • GUI Skeleton given with many things already implemented.
• 3 × 20% of grade.
• Work in pairs.
• Topics:
  • rigid body motion & collision.
  • constraints & soft-body deformation.
  • fluid simulation.
• Checked in person with lecturer.
  • On dedicated lecture times.
  • 10 minutes slots.
  • Resubmission possibility: when faults are found.
Mini-project

• Freeform; any game physics subject you want.
• Work in pairs.
• Be creative, but modest!
• Project proposal must be approved by lecturer by 8/Mar/2018.
• Project presentation in class.
  • Instead of original exam date (12/Apr/2018).
• Grade: 20% basic (up to course 100%).
• Peer- and lecturer-reviewed 3 best places.
  • 10% - 5% - 3% bonus points to entire course!
“And Who Are You, The Proud Lord Said”

- Assistant Professor in group Geometric Computing.
- Researching: Geometry Processing
- GMT Projects/Master theses available:
  - Unconventional Meshes
  - Mesh Design & Deformation
  - Vector Fields
  - Architectural Design
  - Medical Visualization
  - Shape Analysis & Simulation