Gentle Introduction to Physics in Games and Demos

Jetro Lauha

Seminar presentation

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Contents

- Basic components of physical simulation
- Integration to the application
- Physics featured in demoscene releases and case study of *Stair Dismount* and sequels
- Questions & Answers

Basic Components of Physical Simulation

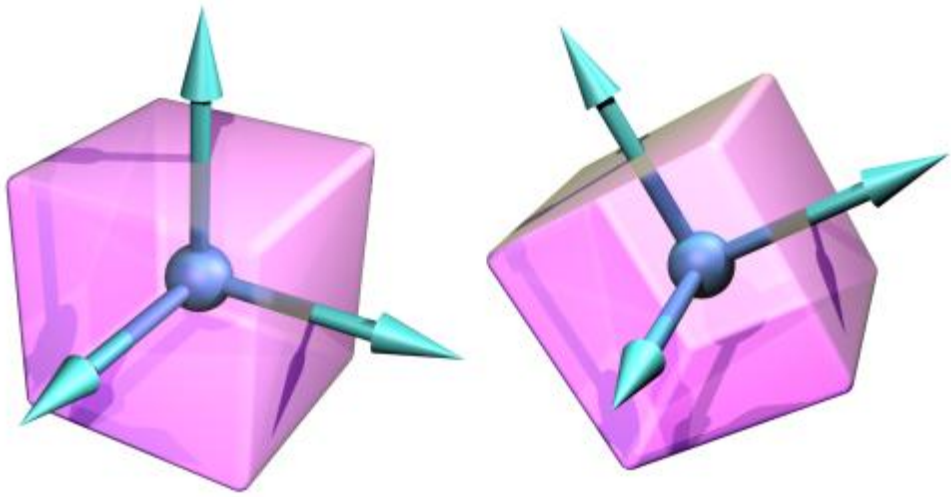
- Kinematics
- Rigid body dynamics
- Constraints and joints
- Collision detection

Kinematics

- Single particle
  - Mass
  - Position
  - Velocity
  - Applied forces (e.g. gravity)
- Can be joined together with springs or constraints
  - Jakobsen's Verlet-system as an example (later)

Rigid Body Dynamics

- Extension to particle physics
  - Orientation
  - Angular velocity
  - Shape
  - Center of mass
  - Inertia tensor

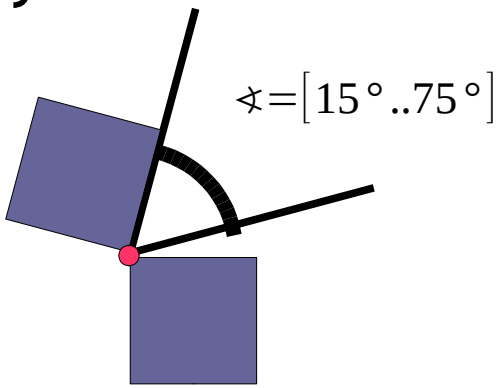


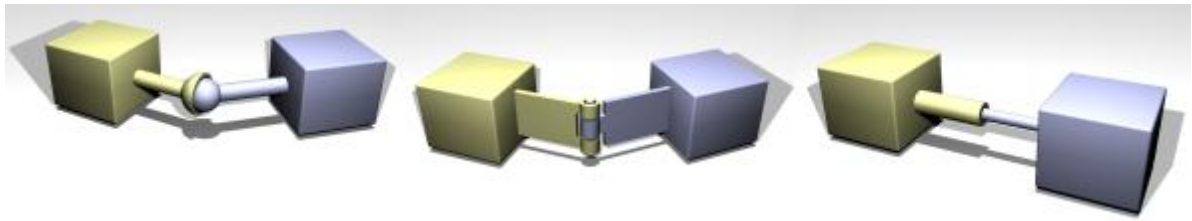
- Forces applied to arbitrary point
  - Relative to center (typically center of mass)

[Smi04]

Constraints and Joints

- Joints limit degrees of freedom
  - position: 3, orientation: 3 – collectively 6
- Constraints, examples:
  - limit position to given region
  - force position to given plane
  - limit angle of hinge joint between given minimum and maximum angle

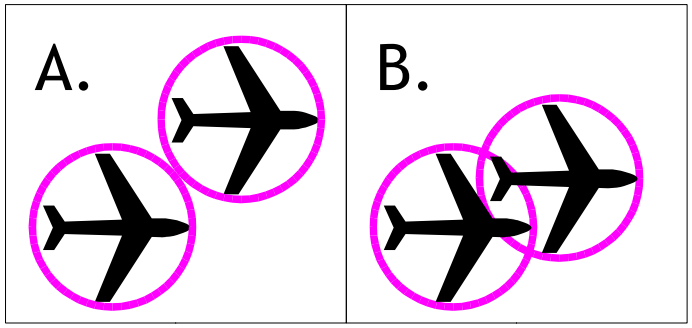


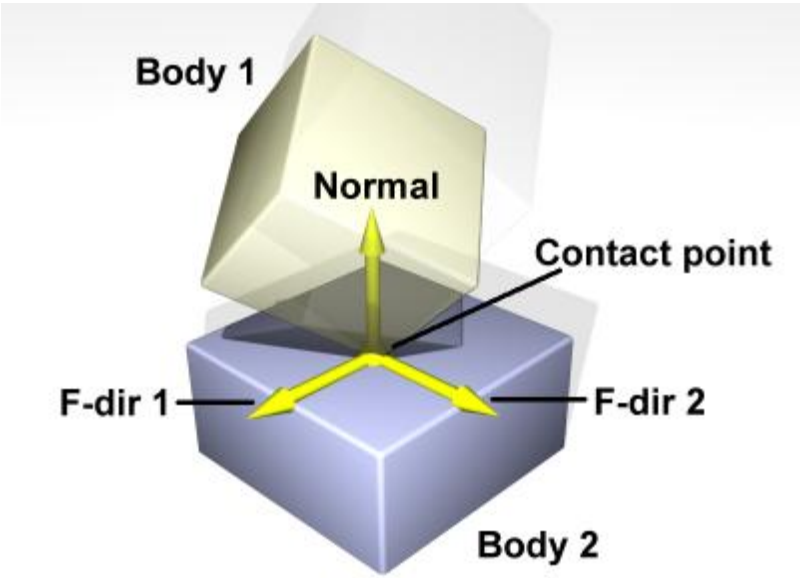


[Smi04]

Collision Detection

- Coarse test
- Detailed contact
  - position
  - normal vector
  - penetration depth
- Collision handling
  - body & surface material properties (bounciness, slippiness) => coefficient of restitution, friction forces





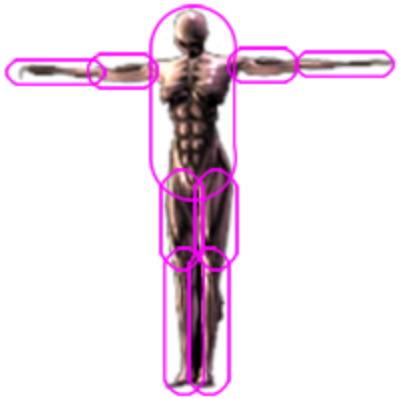
[Smi04]

Integration to the Application

- Proxy geometries
- Updating simulation
- Use of existing packages (Middleware)
- Verlet integration [Jak01]
  - Short look at one specific physics implementation technique

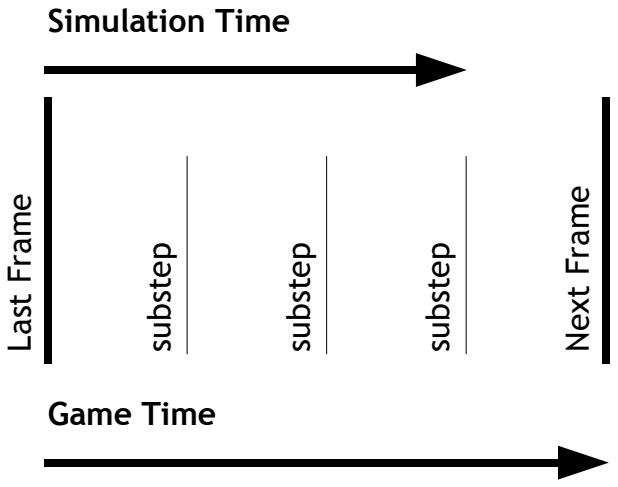
Proxy Geometries

- Primitive geometries
  - approximate given part of original detailed model
- Physics simulator's understanding of the model
  - Rendering code handles modification of detailed model to match with the proxy geometries (orientations, skinning)



Updating Simulation

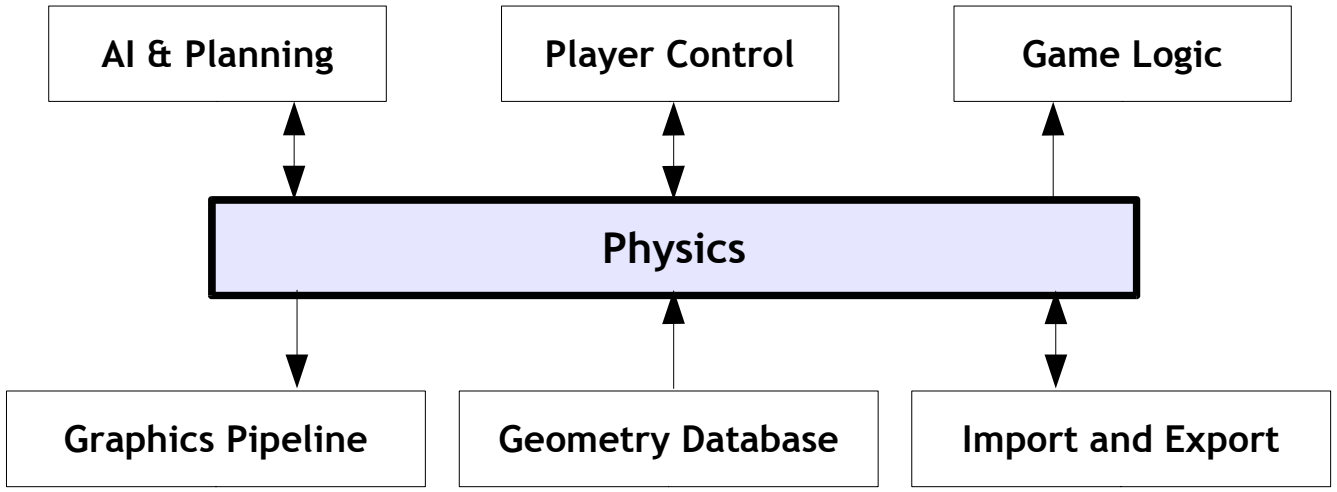
- Game applications contain several logical clocks
  - updating of game logic
  - physics simulation
  - rendering
- Use fixed size time step for physics simulation
  - Despite of several papers recommending dynamic one



[McL03, adaptation]

Use of Existing Packages (Middleware)

- Saves implementation time
- Saves development costs
- Applicability to be carefully evaluated



[McL03, adaptation]

Verlet Integration

[Jak01]

- Simple, fast, relatively stable
- Single particles, clothes, plants, ragdolls
- Rigid bodies
  - Combined from particles with constraints
  - Simple basic building blocks used to create more complex systems
- Used in *Hitman*
  - Developer by IO Interactive, published by Eidos

Verlet Integration

[Jak01]

- Euler integration

$$x = x + v \cdot \Delta t$$

$$v = v + a \cdot \Delta t$$

- Verlet integration

$$x' = 2x - x^* + a \cdot \Delta t^2$$

$$x^* = x$$

$F = ma$

x^* previous position

$$2x - x^* = x + (x - x^*)$$

$$x - x^* \sim v$$

Verlet Integration

[Jak01]

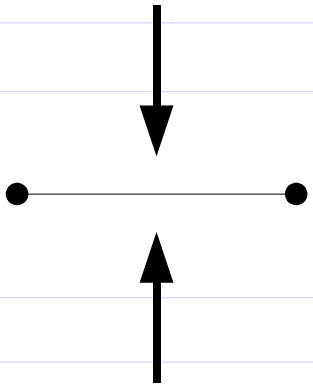
```
#define DAMPING    (0.999)
#define TIMESTEPSQ (0.02 * 0.02)

...

// pos,oldPos = position and previous position
// accumForces = combined forces affecting
//               the particle

Vector3 pos, oldPos, accumForces;

...

pos += DAMPING * (pos - oldPos) +
       accumForces * TIMESTEPSQ;
```

Verlet Integration

[Jak01]

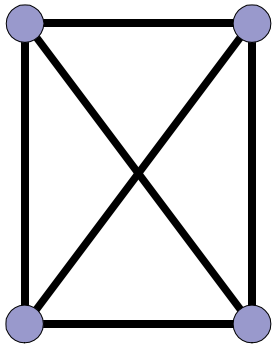
Particles too close each other

Constrained to fixed distance



Particles too far from each other

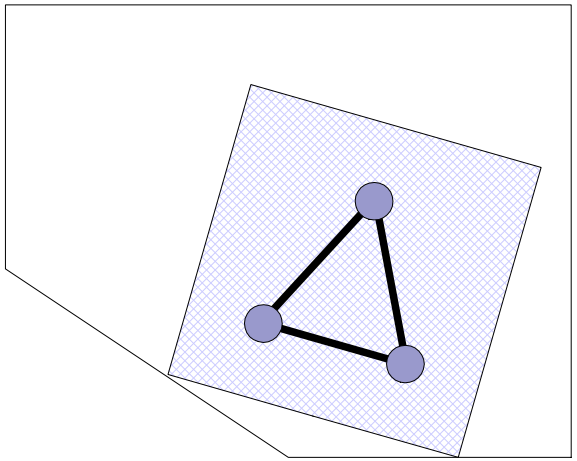
Body built of particles and constraints



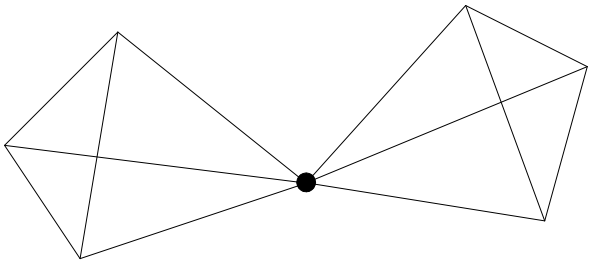
Verlet Integration

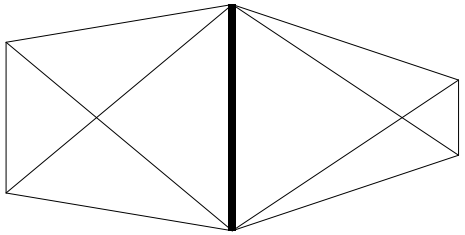
[Jak01]

Separate collision system with particle system used to define body rotation



Pin joint (ball-and-socket)

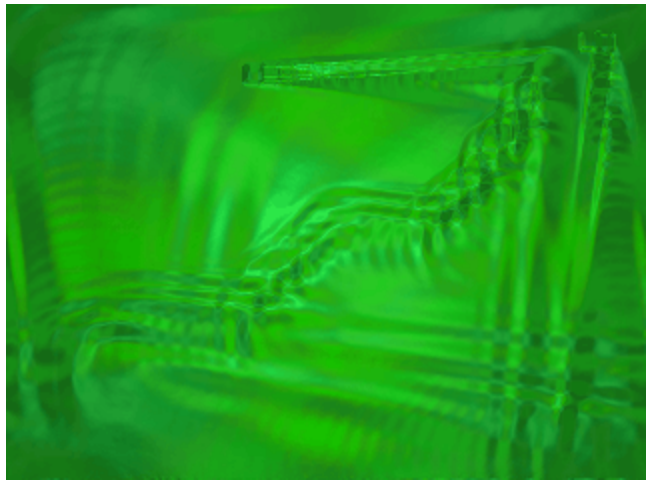




Hinge joint

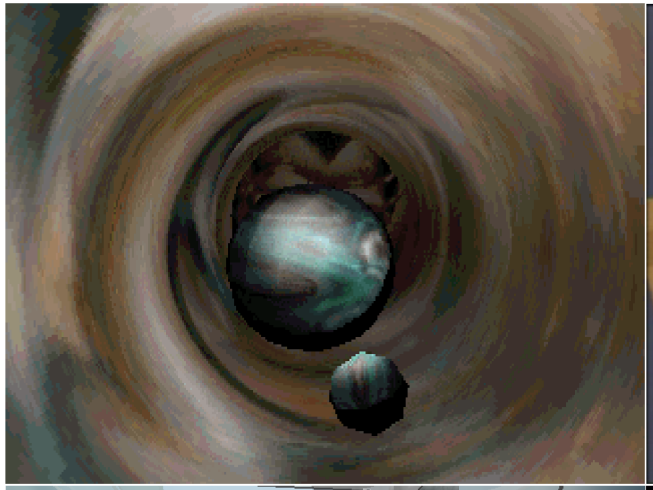
Physics Featured in Demoscene Releases

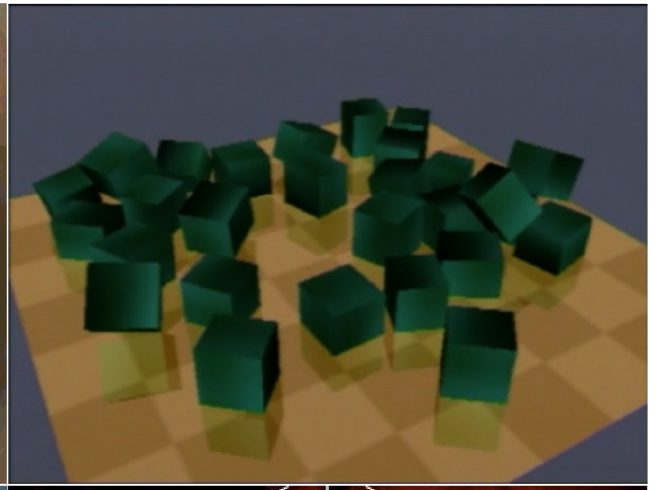
- Some demos featuring physics simulation
- Case study: *Stair Dismount* and sequels



Some Demos Featuring Physics Simulation

Trauma:
Mindtrap
08/1997

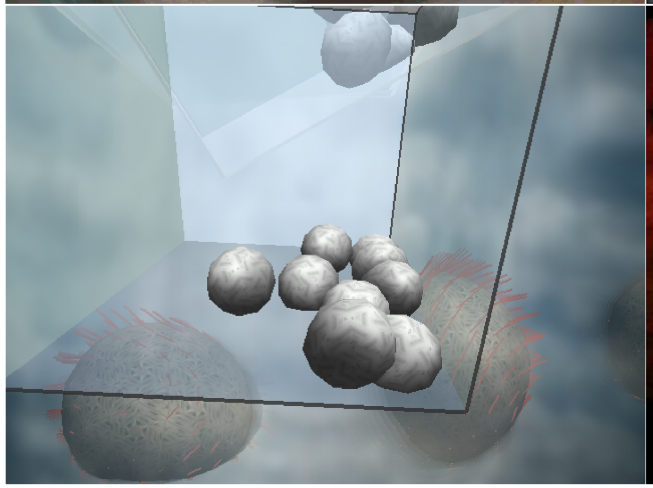


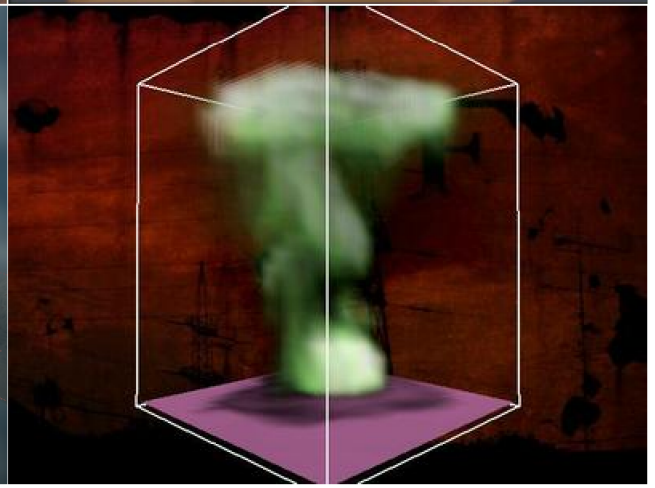


tAAt:
Laatukauraa - Quality Oat
08/2002

PlayStation 2

Floppy:
Dream Equation
10/2002
&
Dream Equation II
07/2003



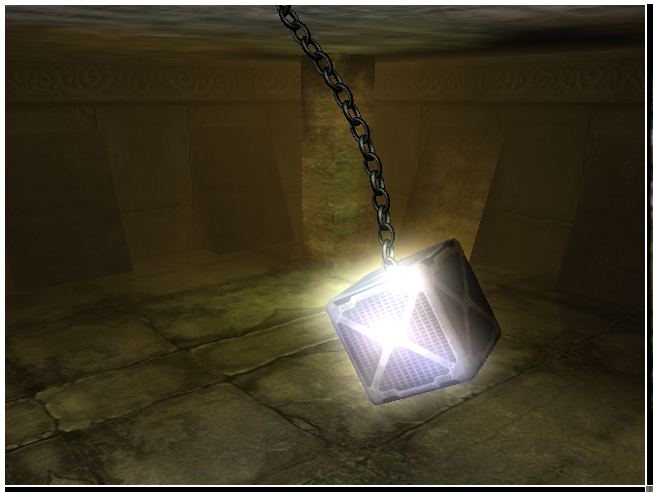


Faktory:
Feed your machine
08/2003
&
47'111.0
08/2004

Screenshot from pouet.net

Some Demos Featuring Physics Simulation

Fairlight:
Digital Dynamix
08/2003

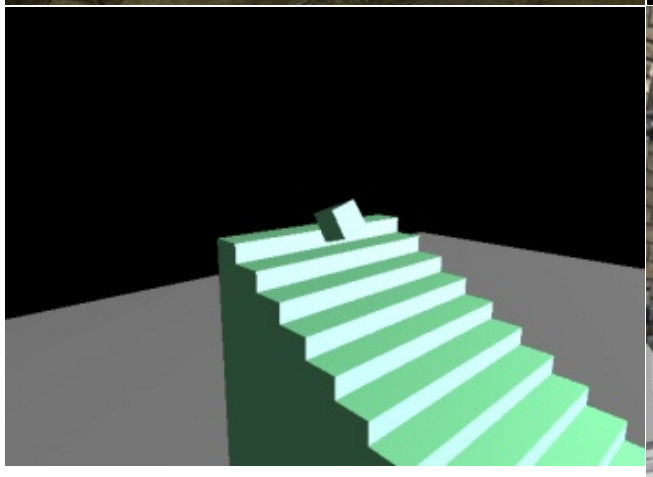


Screenshot from pouet.net

Mayoneez and the boys:
MOPED
08/2004

Lonely Coders:
Cubic Revolution
08/2004

4 KB intro



Screenshot from pouet.net

Screenshot from pouet.net

Nesnausk!:
in.out.side: the shell
05/2005

Case Study: *Stair Dismount* and Sequels

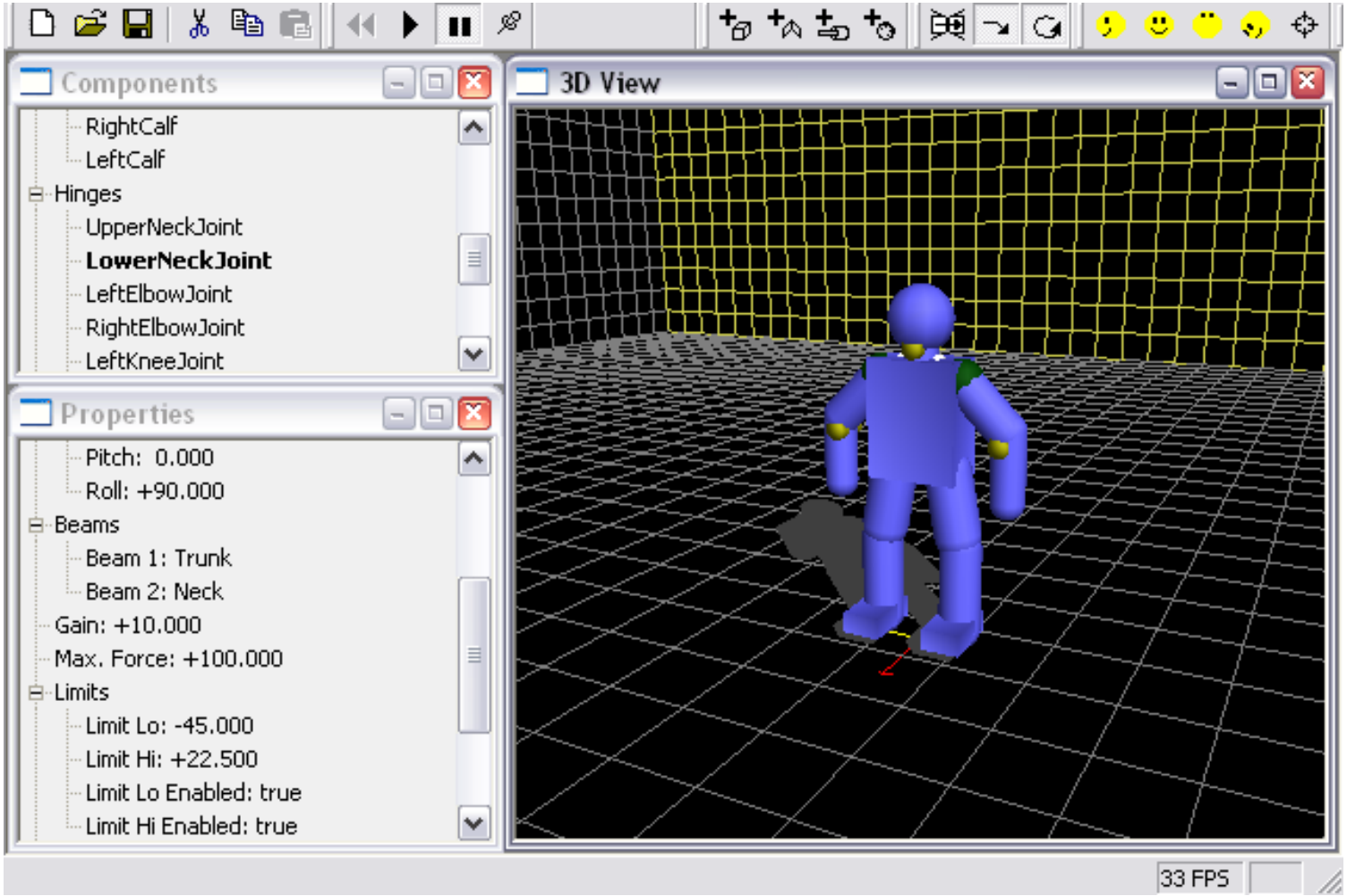
- Porrasturvat (Stair Dismount) – Assembly'02
  - Stairs and a ragdoll
- Rekkaturvat (Truck Dismount) – Assembly'03
  - Truck and the ragdoll, mini editor (ramps etc.)
- Dismount Levels (Preview) – Assembly'04
  - Generic editor, integrated scripting language
  - Still in development (looking for contributors)
  - Has small community

Case Study: *Stair Dismount* and Sequels

- *Juice* used to model ragdoll
- Use of open source libraries have saved a lot of effort and time with development
  - SDL, SDL_image, SDL_mixer, FMOD, zlib, CFL, libpng, libjpeg, ODE, libcurl, expat, libogg, AngelScript, TinyXml, Mersenne Twister
  - Turska – limited but simple framework/UI library as spin off from the games, features-added-as-needed

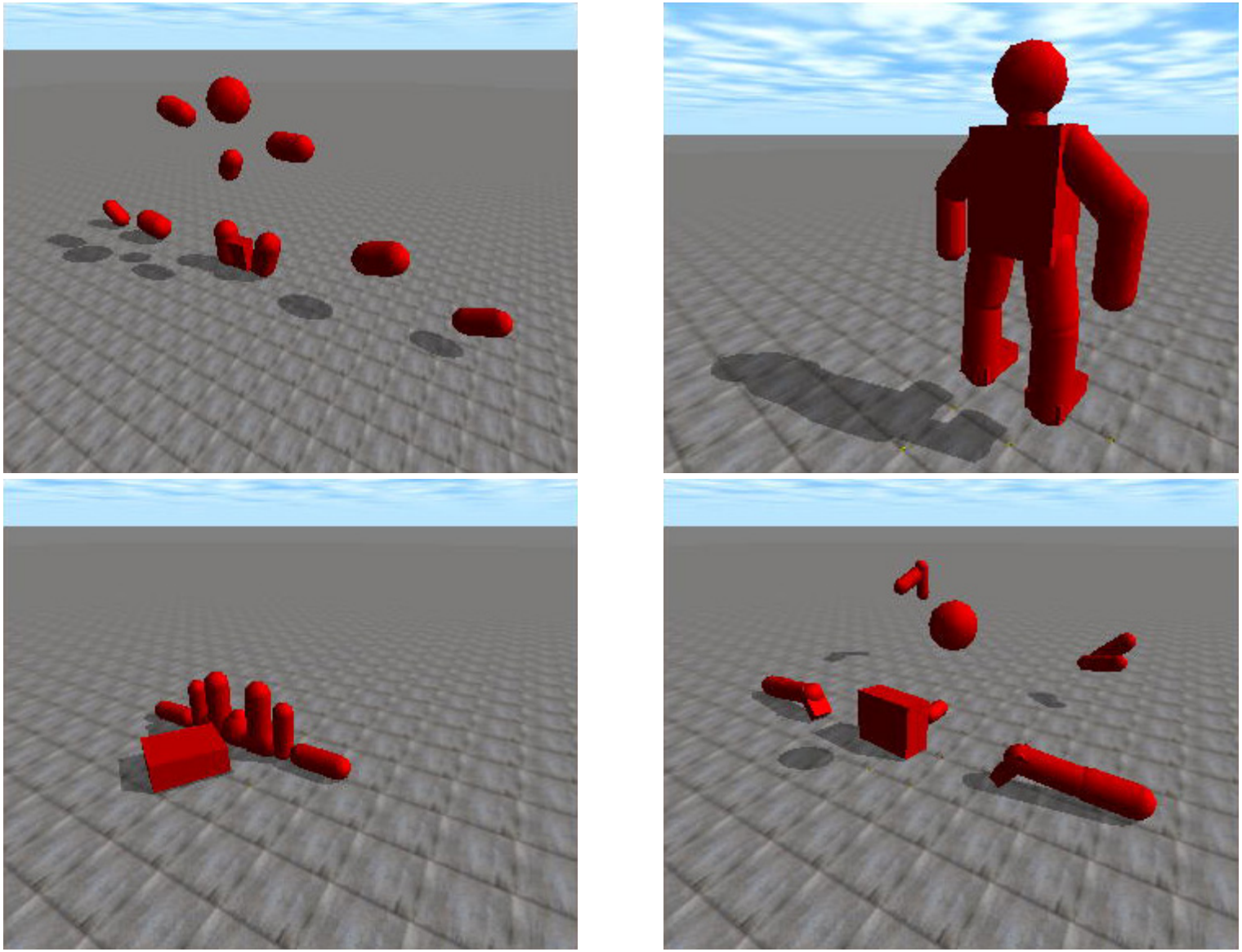
    http://turska.sourceforge.net (v0.1.1)

Case Study: *Stair Dismount* and Sequels

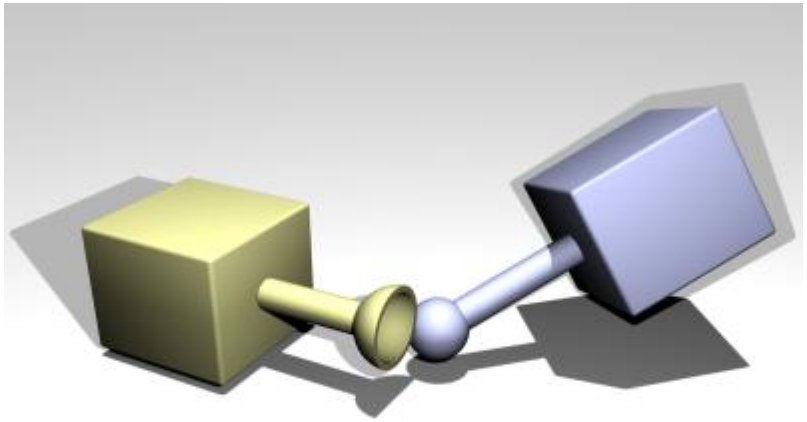


Ragdoll model in *Juice*

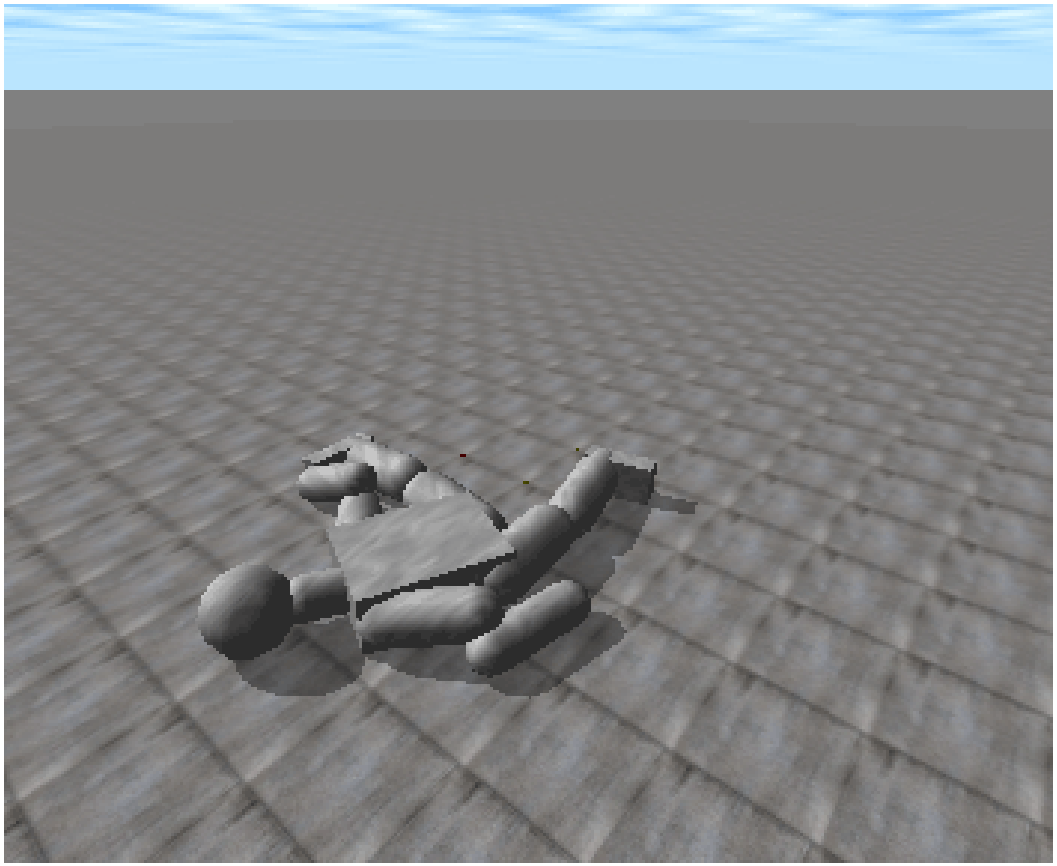
Case Study: *Stair Dismount* and Sequels



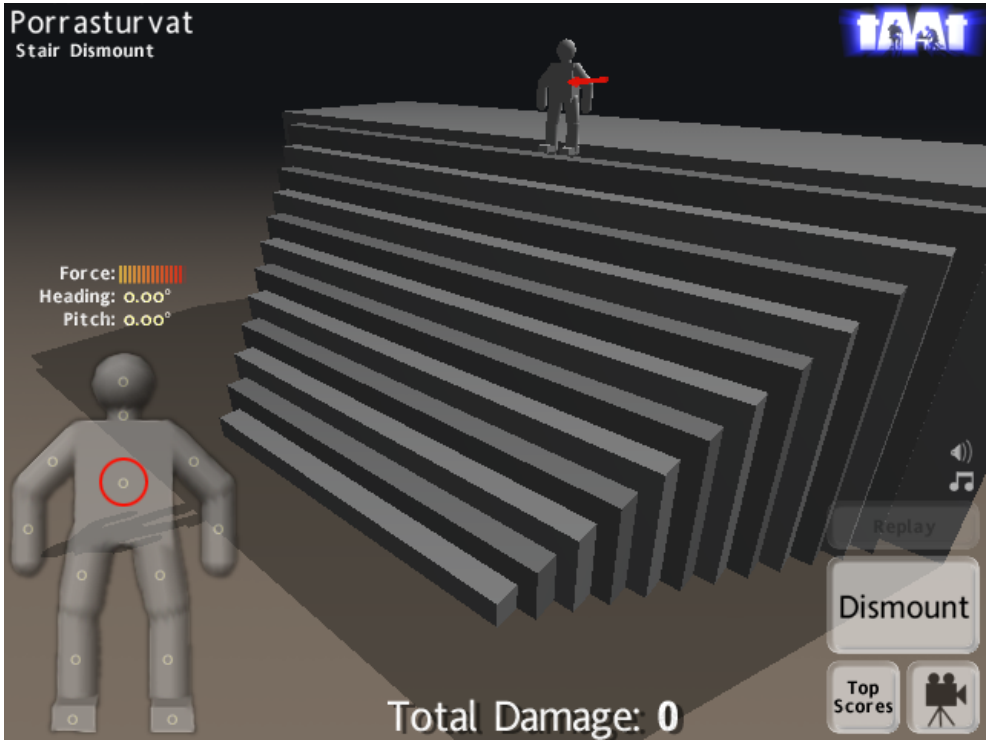
Case Study: *Stair Dismount* and Sequels



[Smi04]



Case Study:
Stair Dismount and Sequels



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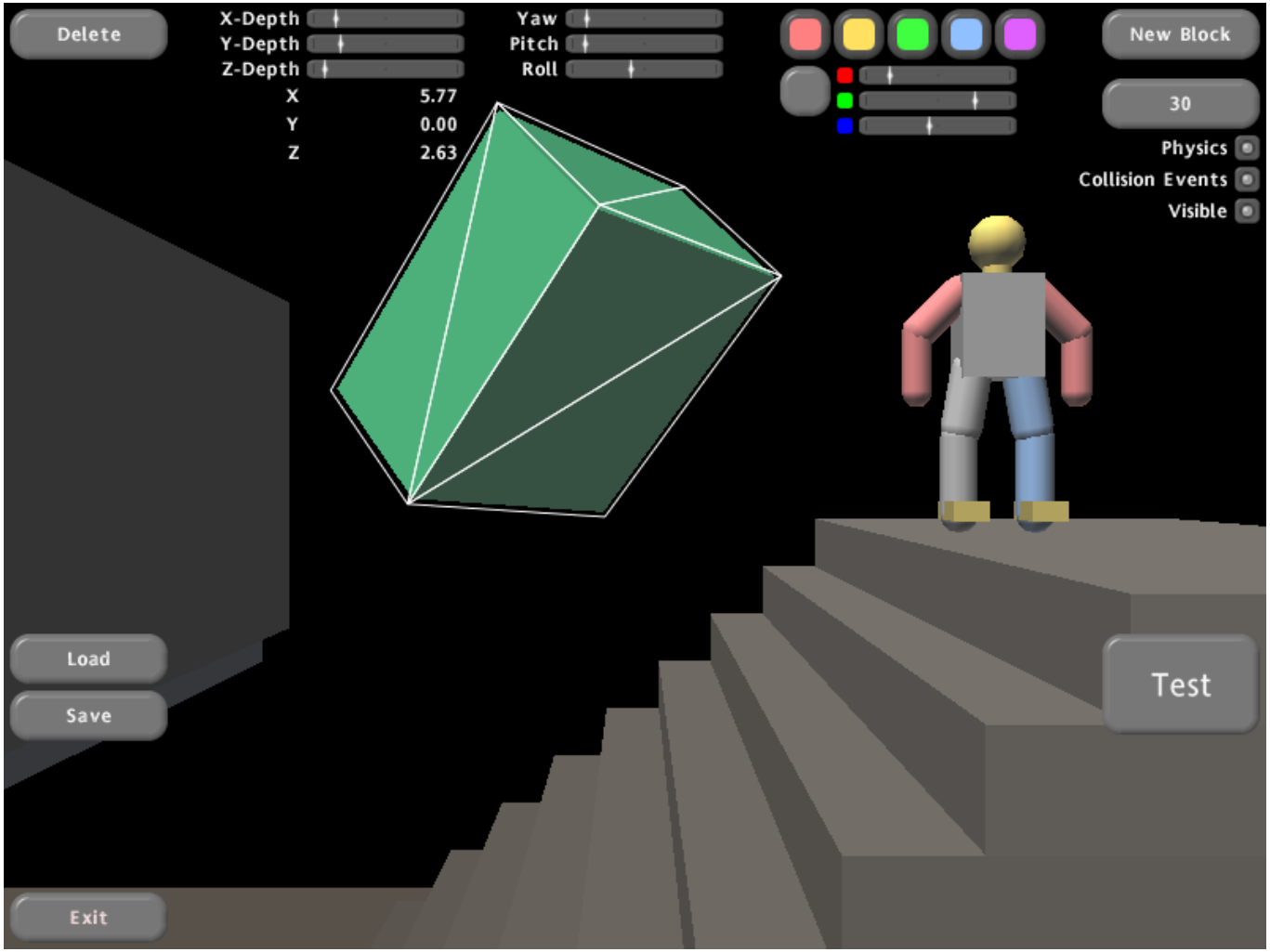
Stair Dismount and Sequels



Questions & Answers

- My home page: http://jet.ro
  - This presentation will be available there.
- Other links
  - ODE: http://ode.org
  - Dismount games: http://jet.ro/dismount/
  - Juice: http://www.natew.com/juice/

Jak01 Jakobsen, T., *Advanced Character Physics*, Game Developers Conference, 2001.
http://www.gdconf.com/archives/2001/ [2005-06-21]
http://www.gamasutra.com/resource_guide/20030121/jacobson_01.shtml [2005-06-21]

McL03 McLaurin, M., *Outsourcing Reality: Integrating a Commercial Physics Engine*, 2003.
http://www.gamasutra.com/resource_guide/20030121/maclaurin_01.shtml [2005-06-21]

Smi04 Smith, R., *Open Dynamics Engine User Guide*, 2001-2004.
http://ode.org/ode-latest-userguide.html [2005-06-21]