

Virtual Reality Tools

OSG - Open Scene Graph

ODE - Open Dynamics Engine

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Open Scene Graph



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Open Scene Graph - OSG

<http://www.openscenegraph.org/>

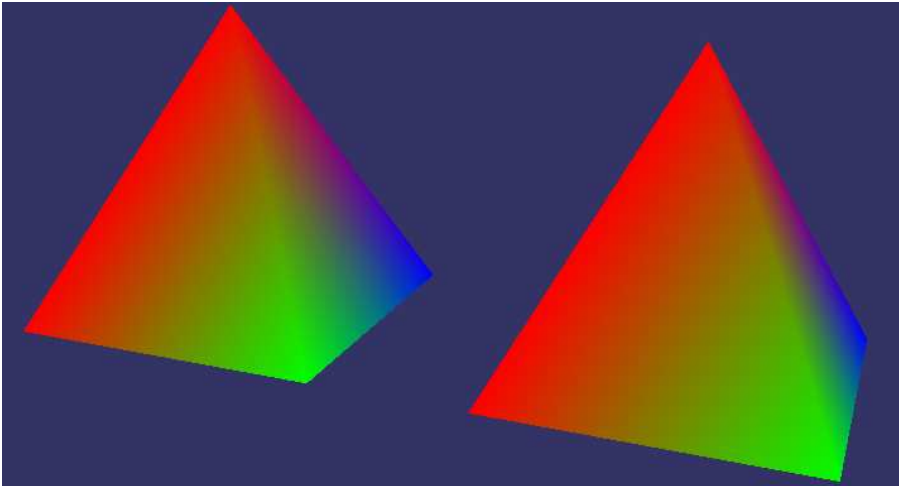
- OSG: Open and Free Software Object Oriented (C++) Software Library (API)
- The OSG Library is an abstraction layer over the OpenGL, allowing to easily create complex visual scenes
- With OSG you do not need to use other APIs like MFC, GTK or Glut (windows and device libs)
- With OSG you can read/show several 3D file formats as for example VRML, OBJ, DirectX (.X), OSG using textures, lights, particles and other visual effects
- OSG works in Windows and Linux Environments creating portable graphical applications

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Virtual Reality Tools
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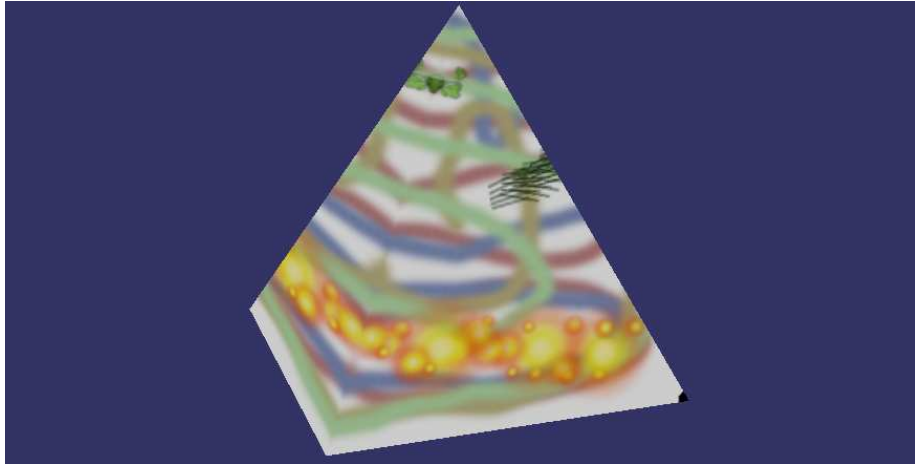
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OSG – Primitive Objects



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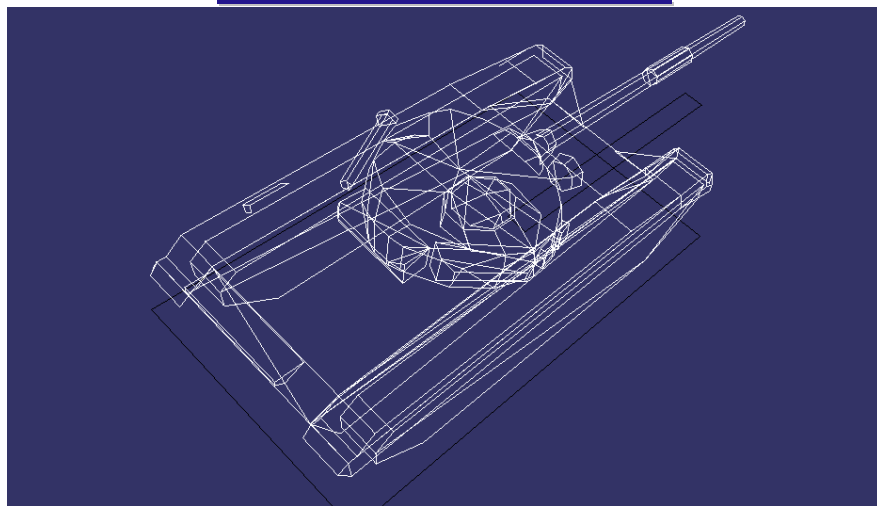
OSG – Textures



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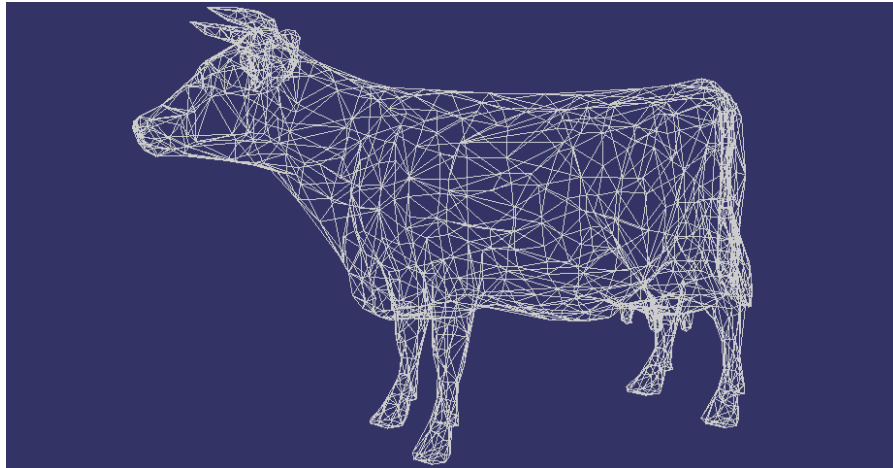
OSG – Wire frame



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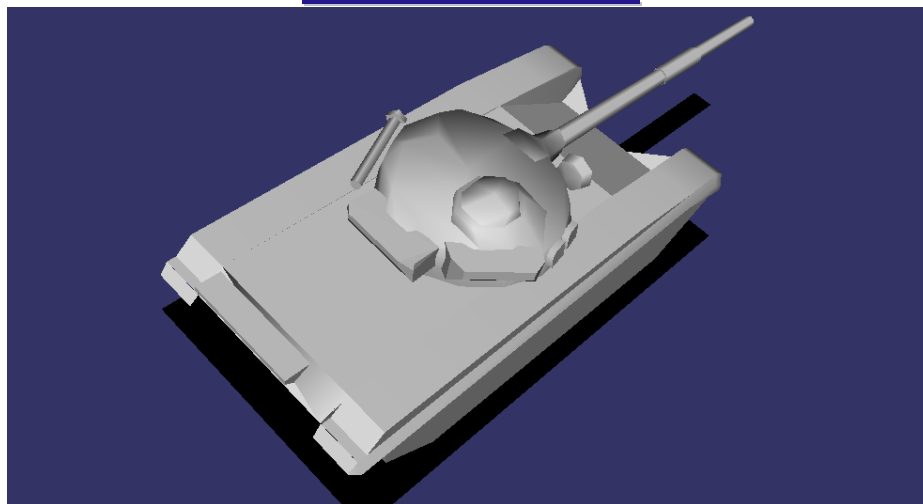
OSG – Wire frame



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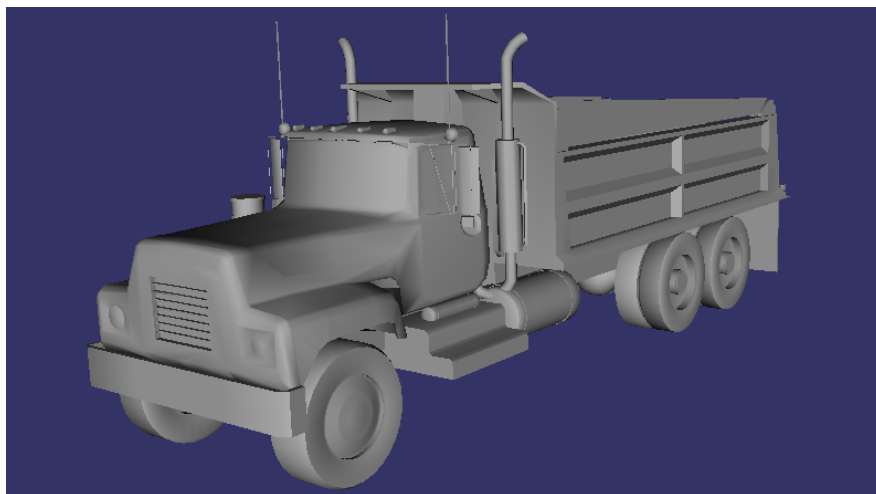
OSG – Faces



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OSG – Faces



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OSG – Textures



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OSG – Scenes: Objects + Terrain



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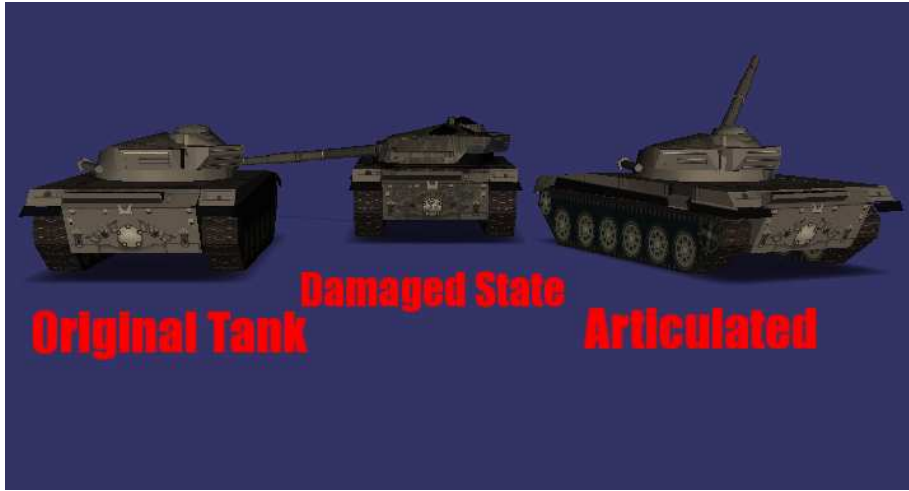
OSG – Text output



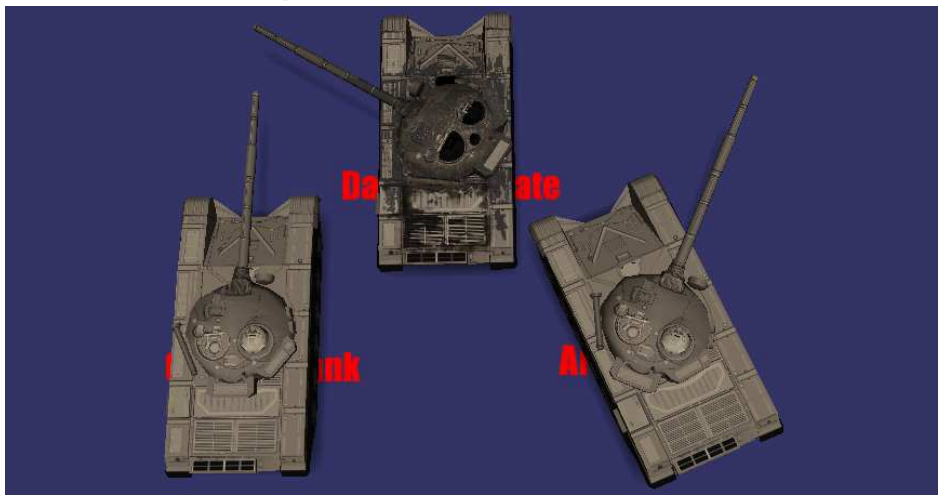
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OSG – Text Output



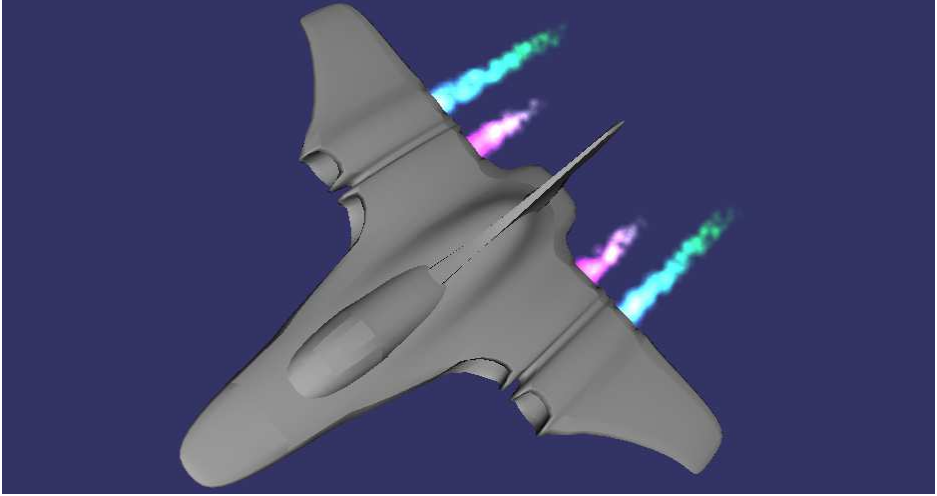
OSG – Specific Individual Textures



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OSG – Particles Effects




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OSG – Particles Effects




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OSG – Particles Effects



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Open Scene Graph - OSG

Concluding...

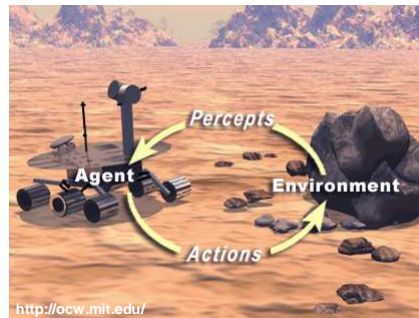
- OSG is a very powerful, fast and simple API used to create Games and VR applications
- Simple: few commands used to load, visualize and compose 3D scenes
- Limited: OSG can only visualize scenes. User needs to *define object movements* and animations. Even the *collision detection/reaction* usually should be carefully programmed by the user!

<http://www.openscenegraph.org/>

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Simulation in VR

- Perception
- Action
- Kinematics
- Dynamic
- Collision



Simulation in VR

- Elements:
 - ⇒ Perception
 - ⇒ Action
 - ⇒ Kinematics
 - ⇒ Dynamics
 - ⇒ Collision
- Realistic simulation: virtual must behave
 - ⇒ Physics Laws should be respected... specially kinematics and dynamics (rigid body)
 - ⇒ Considering: Gravity, Acceleration, Inertia, Collision, Energy Conservation, Friction, etc.



Open Dynamics Engine - ODE

[www.ode.org]

- ODE is a physically based simulation tool
Open source and free - C/C++ compatible
- API written in C (procedural)
- Simulation of physics laws:
 - ⇒ Gravity, acceleration, friction, collision
user can apply forces and torques to bodies
- Collision treatment:
 - ⇒ Collision: objects x ground
 - ⇒ Friction, bounce and rigid body kinematics
- Different joints (connections between objects) and
Different actuators (vector of forces applied to objects)

Open Dynamics Engine - ODE

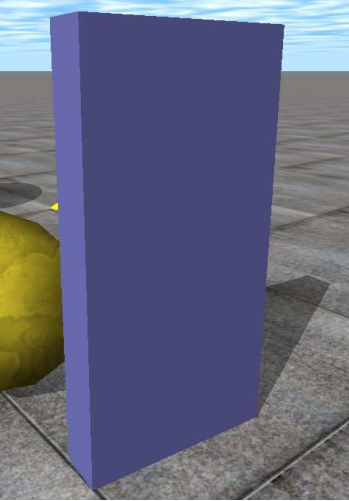
- Supported Objects:
 - ⇒ Cubes, spheres, cylinders, capped cylinders and
composed objects (linked w/joints)
- Complex objects can be used...
but the collision detection complexity will increase!
- ODE computational complexity: $O(n^2)$,
where n is the number of objects
- Simulation loop: physical steps with a "step duration"
pre-defined (can be measured in seconds)
 - ⇒ The greater the step is, the faster the simulation will
be performed, BUT for big steps the simulation can
generate big errors and instability.

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ODE - Supported Objects

- Cubes




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ODE - Supported Objects

- Spheres



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ODE - Supported Objects

- Cylinders



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ODE - Supported Objects

- Capped Cylinders



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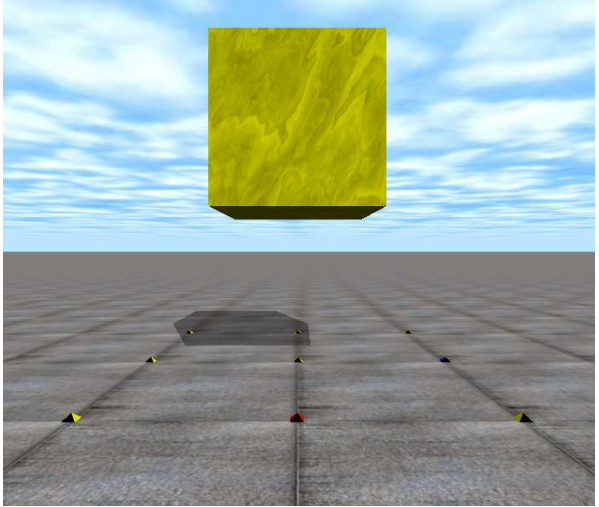
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Open Dynamics Engine - ODE

Pure Computer Graphics:
No Physics!

If you do not code a program to move this cube... it can stays forever "floating" in the space!



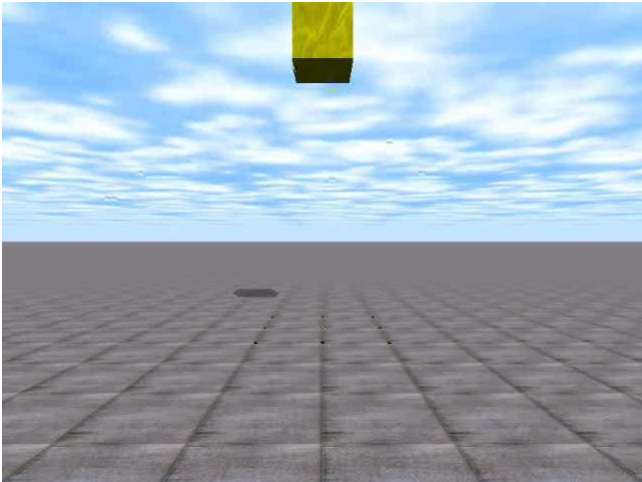
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Simulation Using ODE:
This cube will be affected by the gravity...
We can specify the cube mass and even an specific gravity force value!



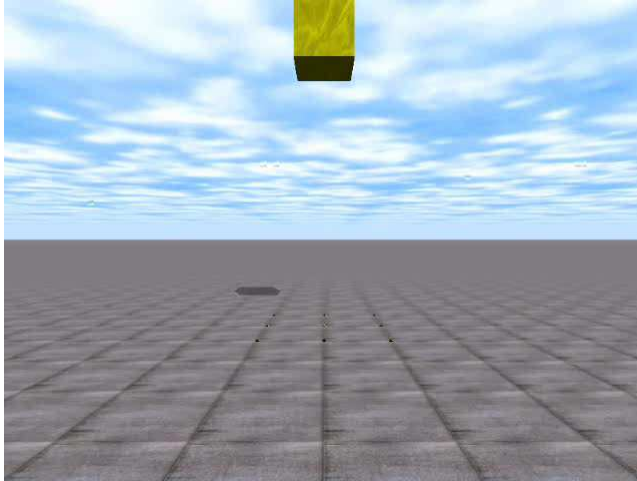
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Collisions should be treated...

So the cube will not pass through the ground.

Impacts should be realistic.



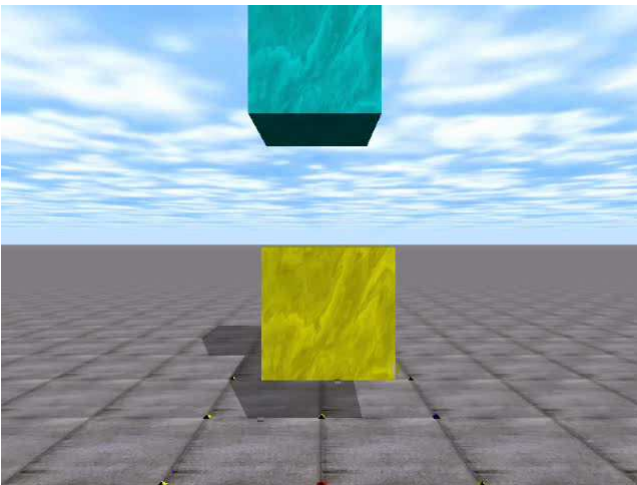
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Collision between objects should also be treated...

In Computer Graphics applications (and some games) it is not rare to see objects passing walls!



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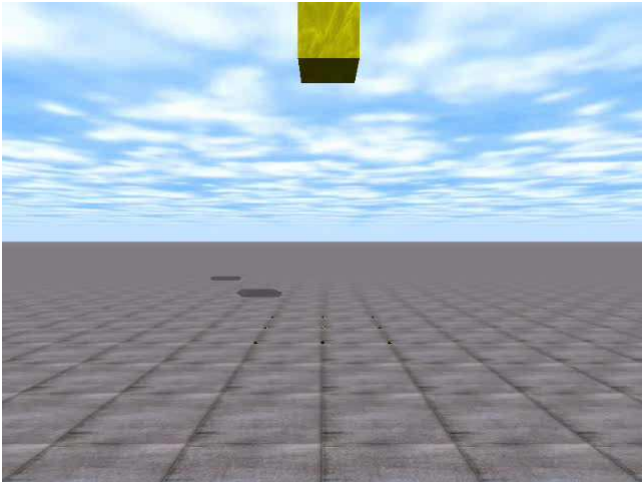
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If the collision is well treated, then the scene becomes more realistic...

ODE can do this in automatically!



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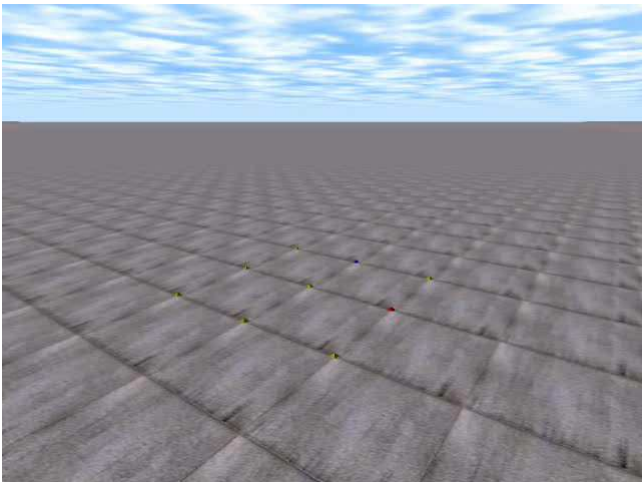
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This scene shows several objects falling down...

Some of them are "composed objects" (formed by the connection of more than one)



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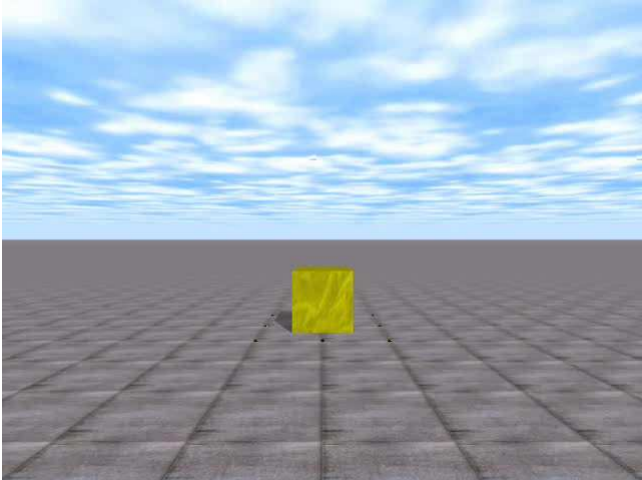
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Using ODE we can also apply forces to the objects...

Force: It is a vector with a direction, an orientation and Intensity



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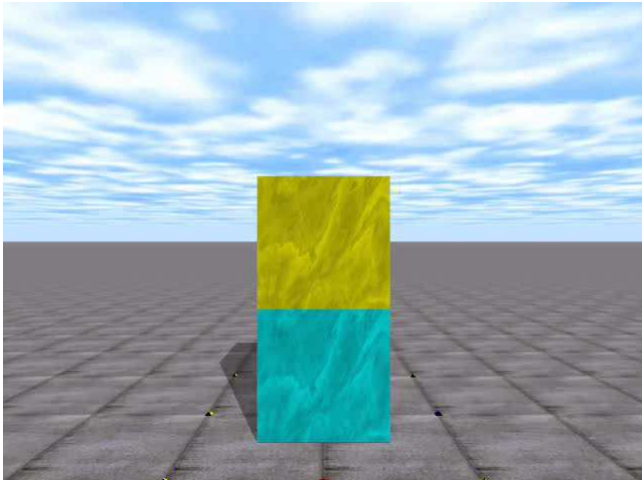
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Interaction between objects occurs in a natural way...

One object can be throw into an other: for an action we can obtain a reaction!

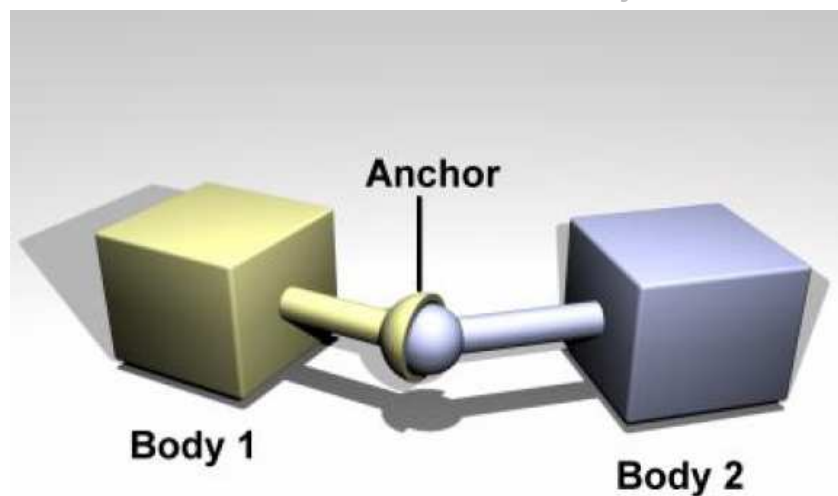


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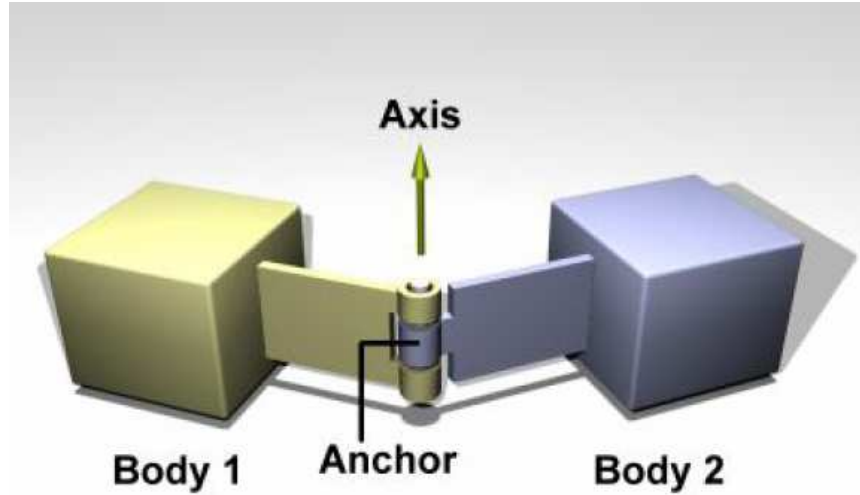
ODE Joints

- Joint types:
 - ⇒ Ball and socket, Hinge, Slider, Universal, Contact, etc
 - ⇒ Joints can have axes (one or more) and sometimes are limited in range (min-max angles)
 - ⇒ We can obtain the actual angle from the joints (encoder)
 - ⇒ We can NOT set directly the angle for one specific joint. In order to change the angle, we must apply forces and use actuators (motors).
- Angular Motors:
 - ⇒ User (manual) and Euler (automatic)
 - ⇒ We can specify the actuator rotation axe, the velocity and the maximum force in each motor.

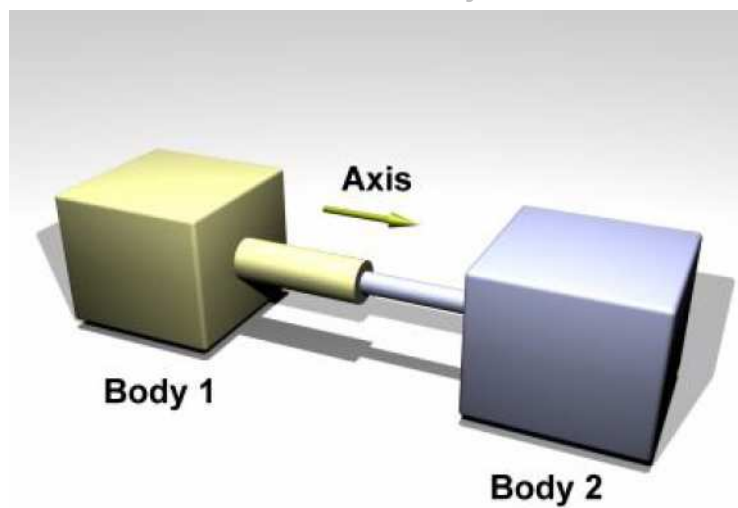
ODE: Ball and socket joint



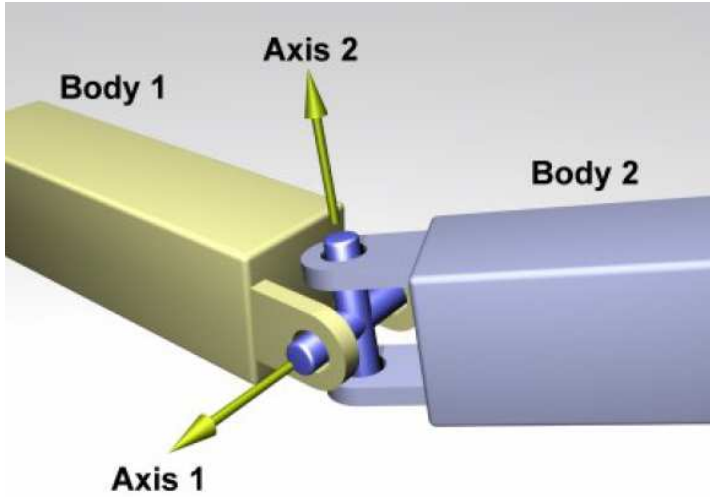
ODE: Hinge joint



ODE: Slider joint



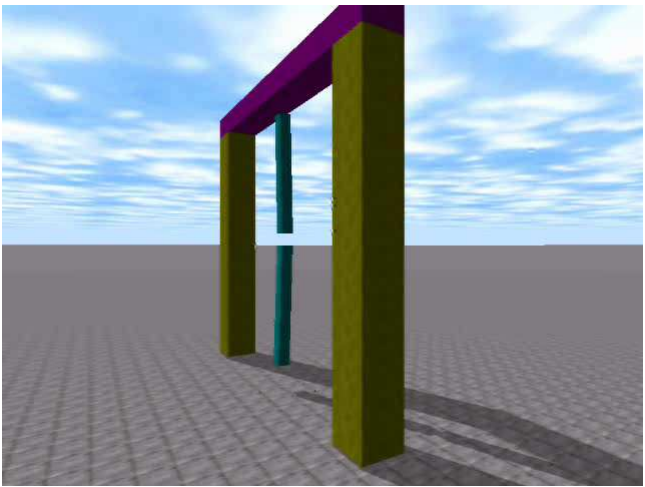
ODE: Universal joint



Open Dynamics Engine - ODE

Joints can connect and link together the objects.

Joints have a connection point, freedom degrees (axes), and limits (min-max range values).



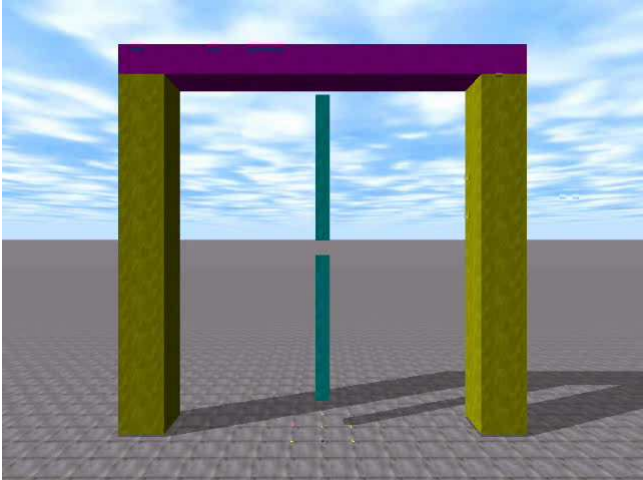
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Forces can be applied to joint objects...

As they are linked, the force applied to one extremity will affect the other object which is connected to it.



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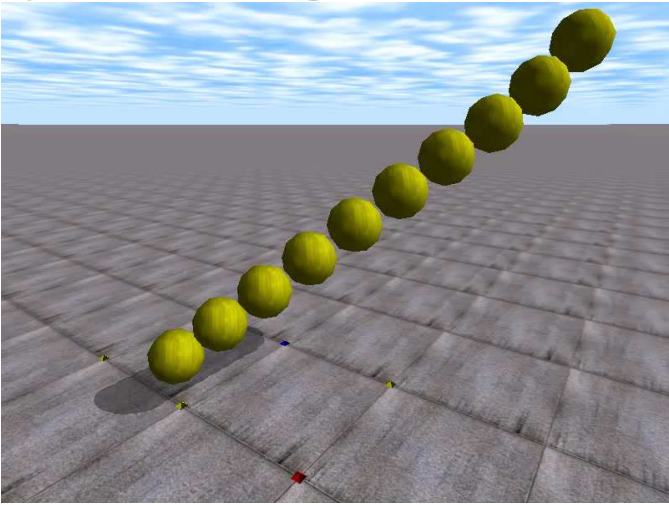
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Several objects can be connected by an universal joint...

The result can be seen in this video: we obtained a "virtual string"



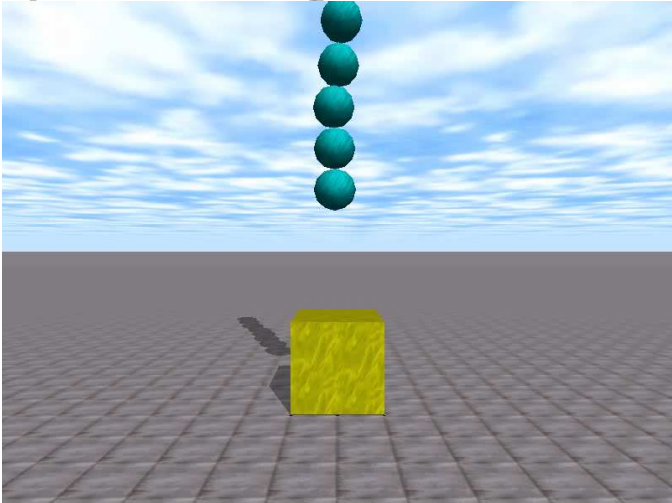
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The "virtual string" of connected spheres can also be affected by forces like the gravity



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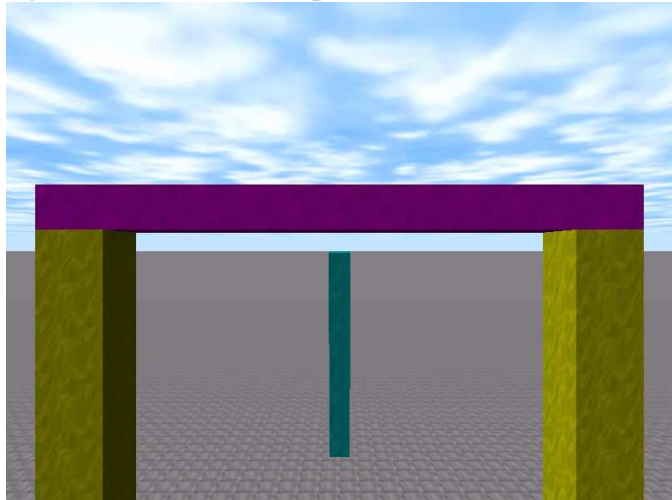
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Angular Motors and Joints:

Used to create Vehicles and Walking Robots



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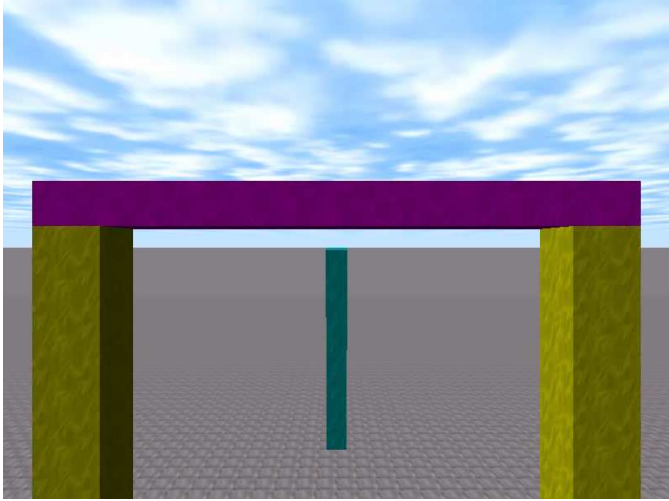
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User controlled forces...

How to control the system:
Intelligent Control Simulation



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Simulating Realistic Vehicles

Physics: Kinematics + Dynamics

Mobile Robots: Sensors + Actuators



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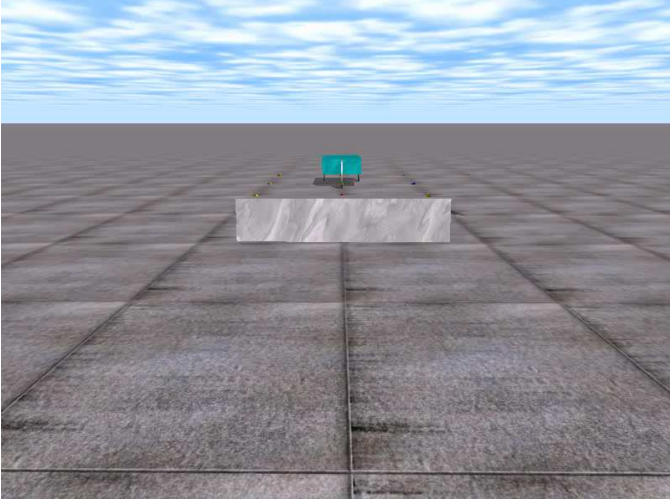
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Simulating Realistic Vehicles

Physics: Kinematics + Dynamics

Mobile Robots: Sensors + Actuators

Other point of view



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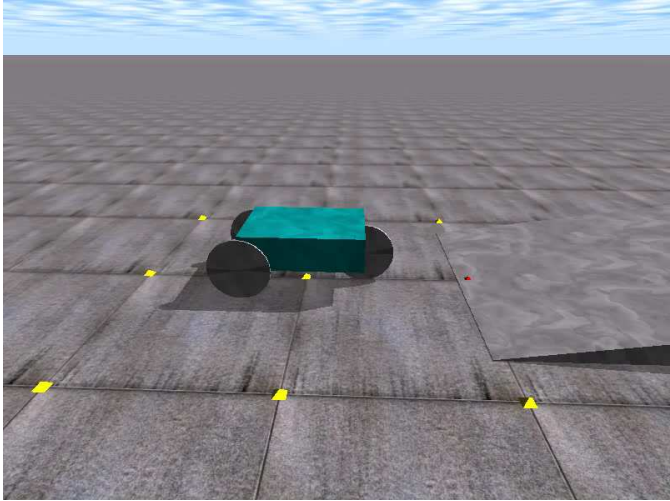
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Look the vehicle touching the ground...

Seems realistic?



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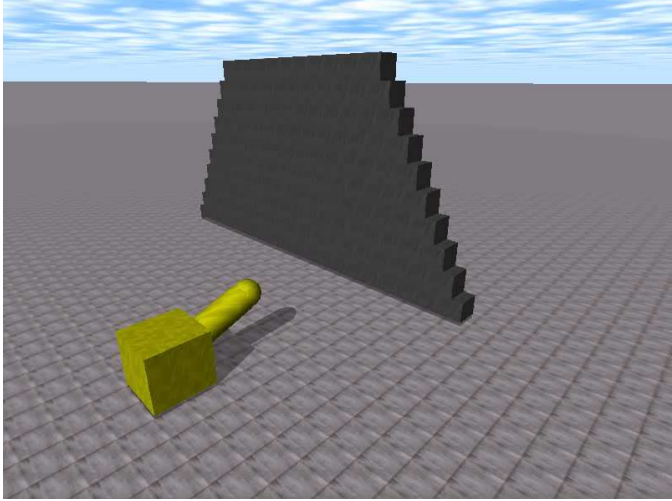
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Virtual Simulation:

Collision with many objects



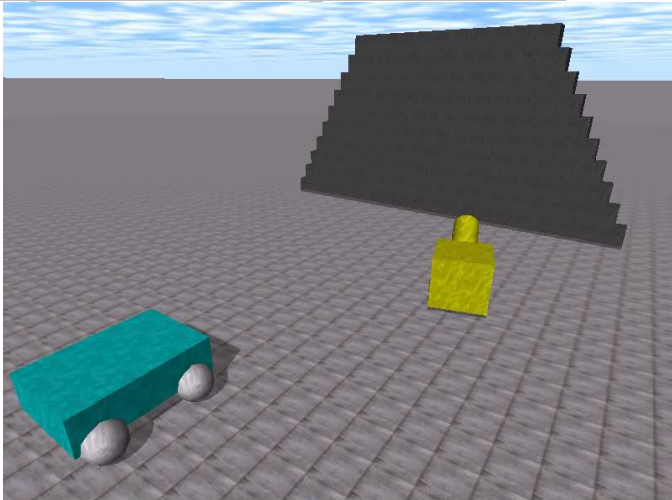
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Real-Time Simulation in a Physically Based Virtual Reality Environment



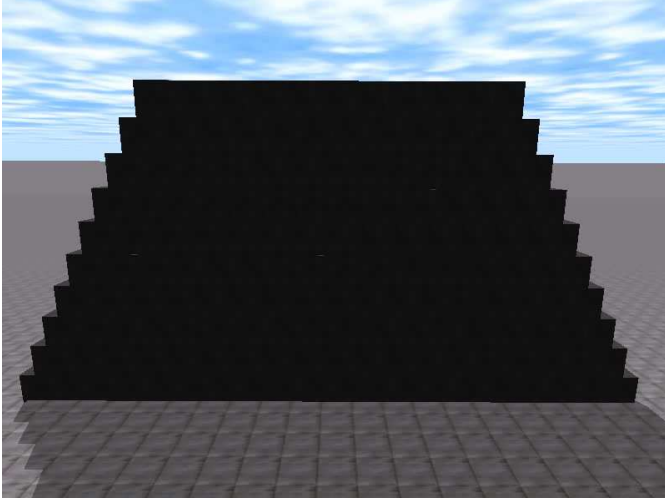
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From an other point of view...




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Intelligent Autonomous Control

- How to interact with the realistic simulated environment: Autonomous Agents that Perceive and Act
- Perceive the environment (sensors)
- Decide how to act (deliberate) Intelligent Control
- Execute sequence of actions (act)
- Intelligent autonomous control techniques:
 - ⇒ Automata (FSA)
 - ⇒ Artificial Neural Networks
 - ⇒ Genetic Algorithms



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VR Simulation - Practical Applications

- Vehicle Simulation
 - ⇒ SimRob3D (Unisinos)
 - ⇒ Seva3D (Unisinos)
- Walking Robots
 - ⇒ LegGen (Unisinos)
 - ⇒ Juice
 - ⇒ Webots
- Games

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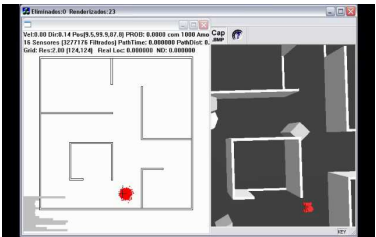
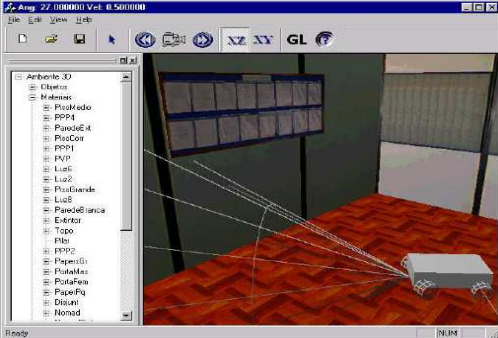
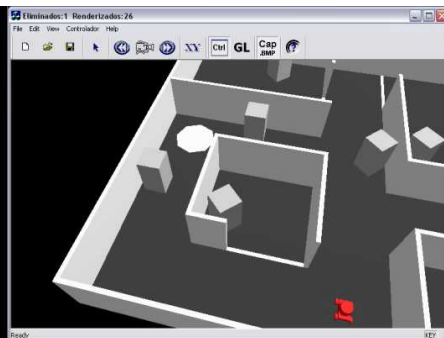


Intelligent VR Environment

3D SIMULATOR + CONTROL ARCHITECTURES [Heinen 2002]

COHBRA: Integration of Perception, Action, Sensor model, Kinematic Model, Maps and Planning

Hybrid Robotic Applications

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COHBRA

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Modeled Vehicle



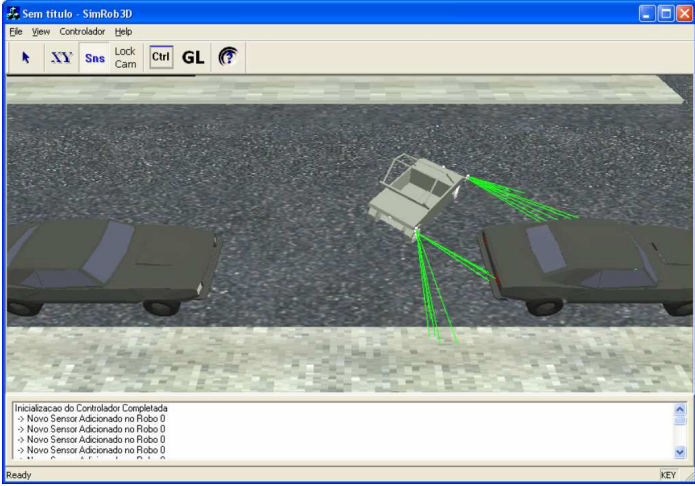
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SEVA 3D Simulator




- 3DS modeled environment
- Sensorial Simulation Model
- Ackerman Kinematics
- Autonomous Control
- Automatic Parking

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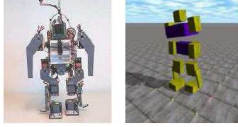
Autonomous Walking/Legged Robots




Robô Lynxmotion Hexapod II




Robô Genghis-II




(a) Robô real (b) Robô simulado




(a)




(b)




(a) Honda Asimo



(b) Sony SDR-4X



(c) Kawada H6



(d) Fujitsu HOAP-2

Figura 27: Modelos de Robôs Sony Aibo [95]


The Sony Dream Robot in the real world
The Sony Dream Robot simulated into Webots

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Virtual Reality Tools
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LegGen Simulator


- Walking autonomous legged robots




(a) HexaL3J



(b) TetraL3J



(c) HexaL2J



(d) TetraL2J

- 3D Virtual Environment for Simulation (IVRE) using ODE lib (physics simulation)
- Uses Genetic Algorithms and Artificial Neural Networks to implement an intelligent robot control mechanism

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Virtual Reality Tools
OSG (Open Scene Graph) + ODE (Open Dynamics Engine)

UNISINOS

Obtained Results

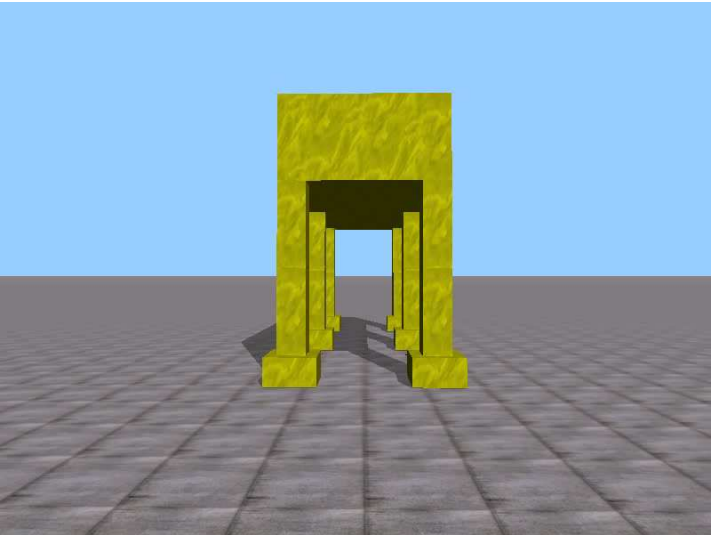


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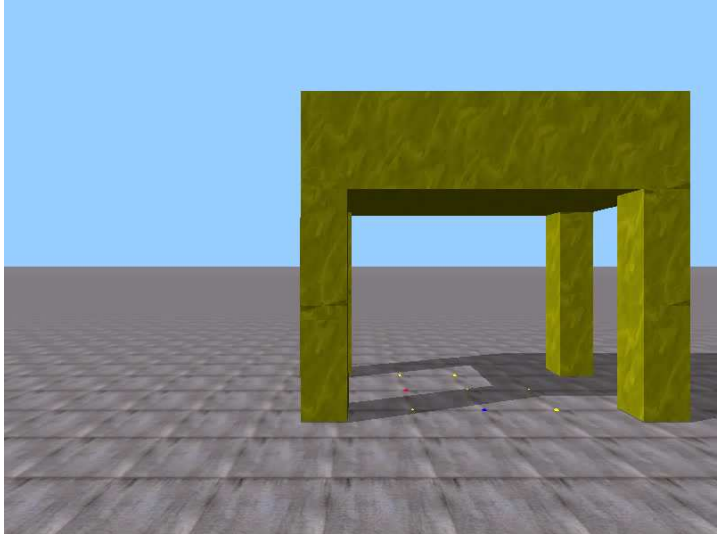


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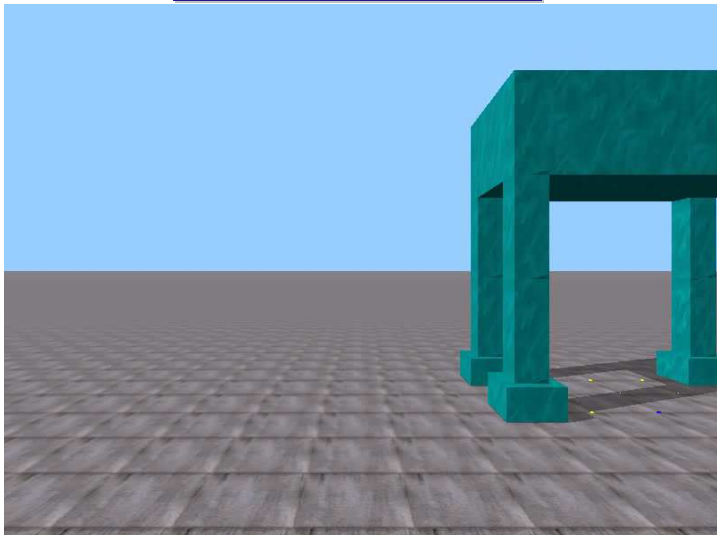


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Games

- Several games are being developed using the ODE library.
- One of them is the game FragFist
 - ⇒ Vídeo: [ode-videos\fragfist_trailer_gc05.avi](#)

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Physically based Simulation The Future

- New hardware:
 - ⇒ AGEIA PhysX
PPU = Physics co-processor card, like GPU
 - ⇒ Multi-core processors with a dedicated processor only to physics simulation (PS3)
 - ⇒ GPU accelerated processing (NVIDIA, ATI)
Use the GPU to accelerate physics processing

Physically based Simulation The Future

- Real-Time Complex Physics Processing
- Videos:
 - ⇒ [ode-videos\physx_bundle.avi](#)
 - ⇒ [ode-videos\divxphysxairtight720x400.avi](#)
 - ⇒ [ode-videos\Movie-AGEIA.wmv](#)

Virtual Reality Tools
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