Virtual Reality Tools

OSG - Open Scene Graph

ODE - Open Dynamics Engine

M.Sc. Milton Roberto Heinen - Unisinos / UFRGS
E-mail: miheinen@gmail.com

Dr. Fernando S. Osório - Unisinos
E-mail: fosorio@unisinos.br

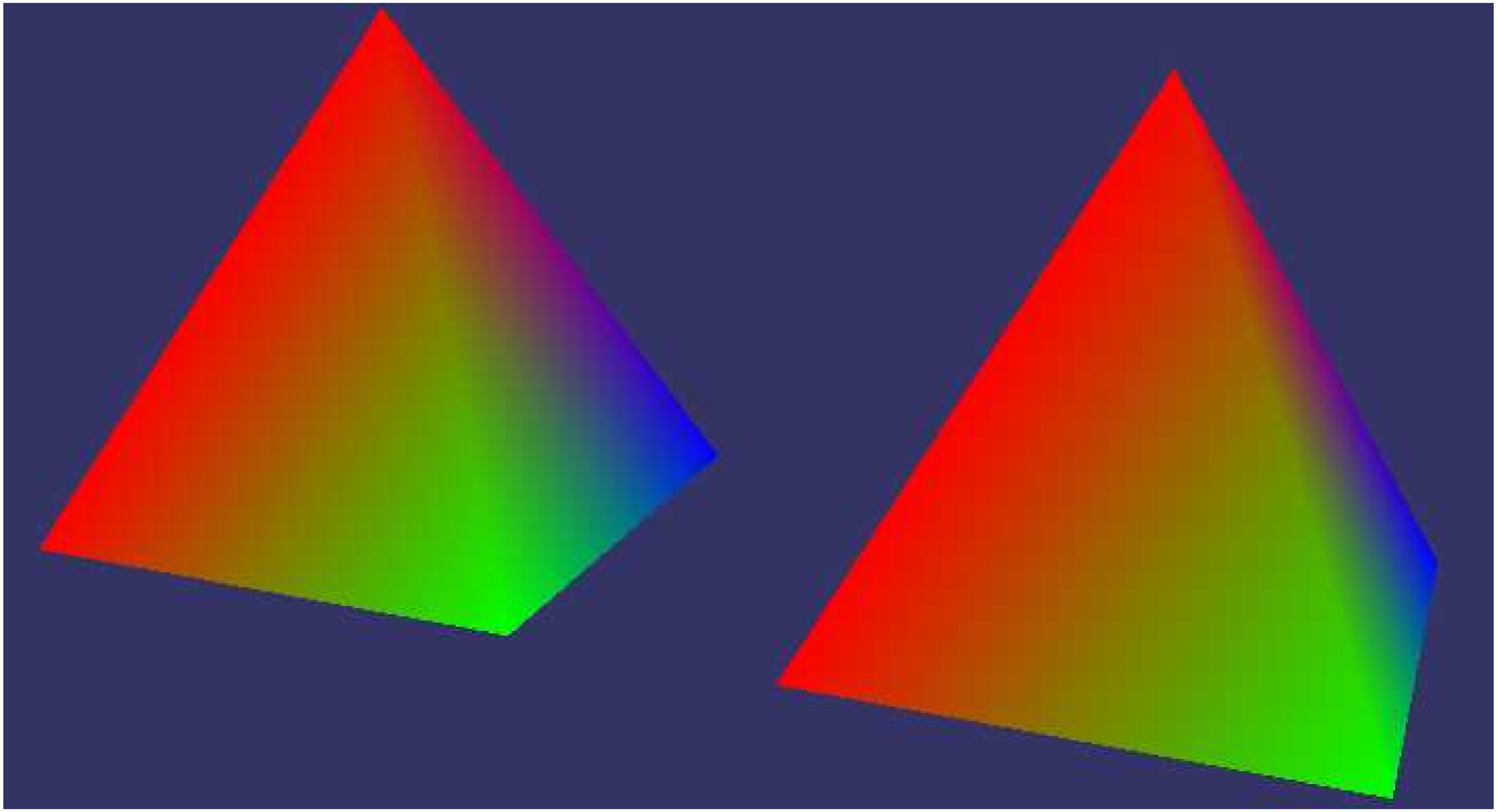
Open Scene Graph

Open Scene Graph - OSG

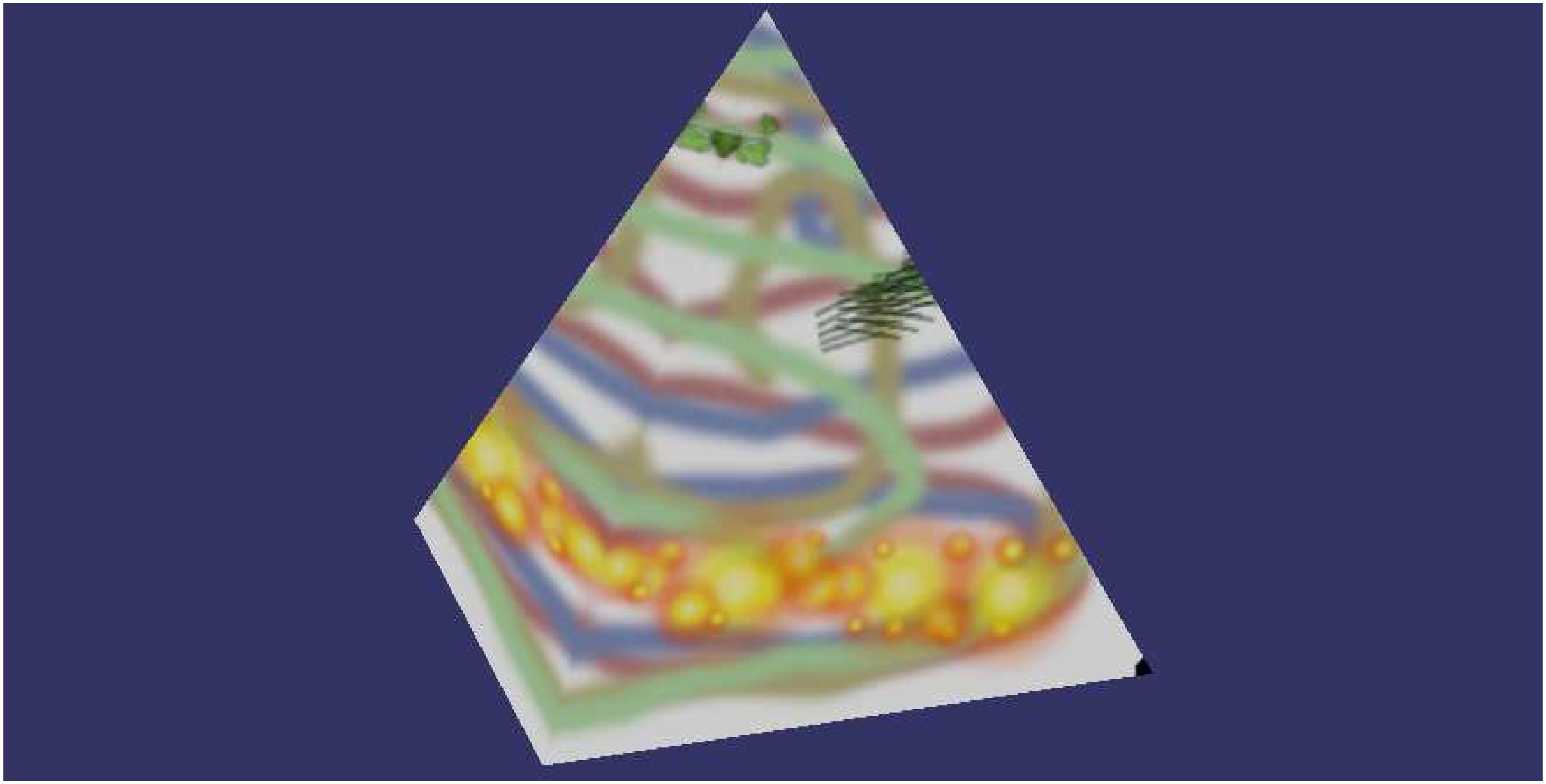
http://www.openscenegraph.org/

- 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

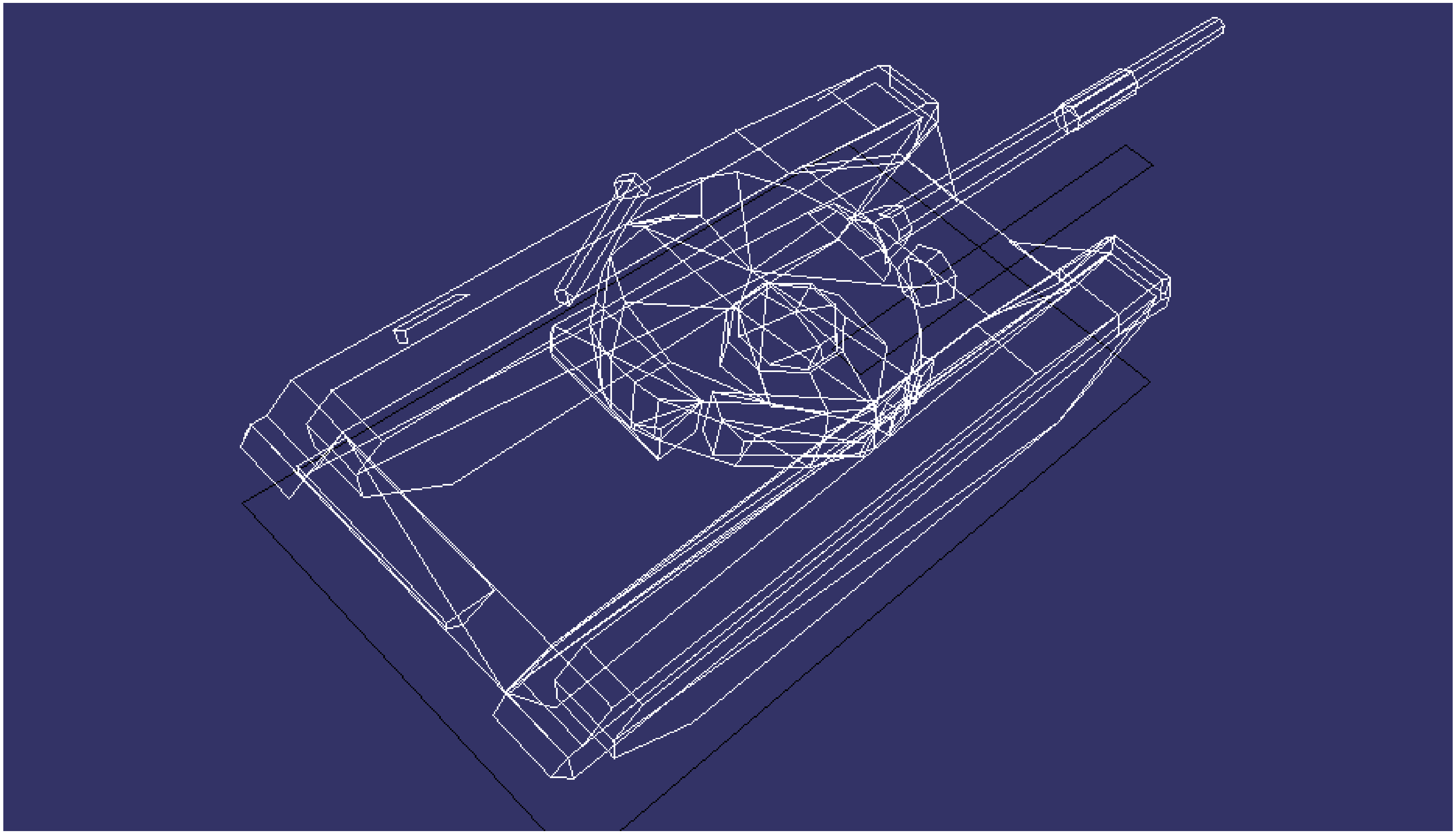
OSG – Primitive Objects



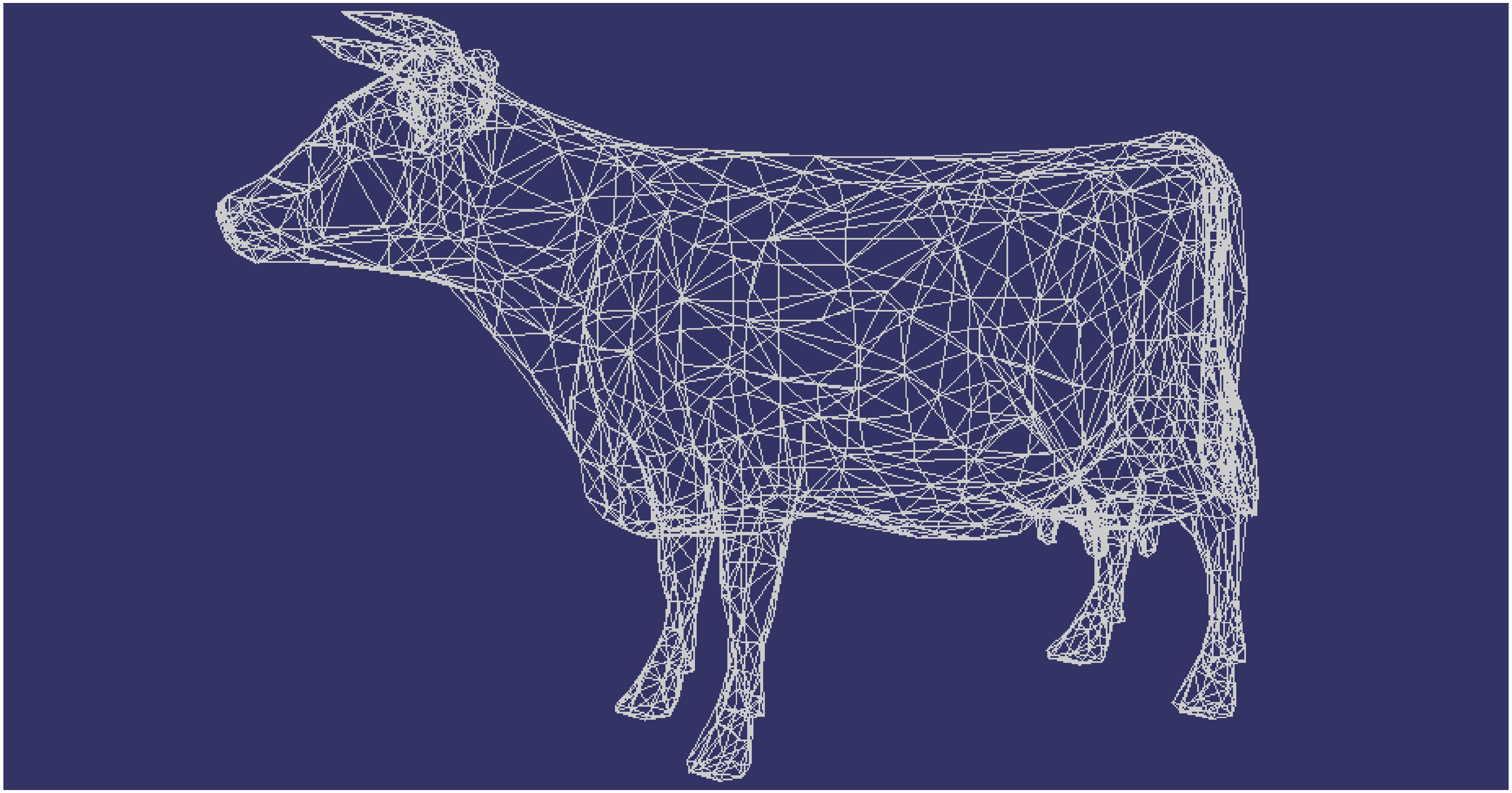
OSG – Textures



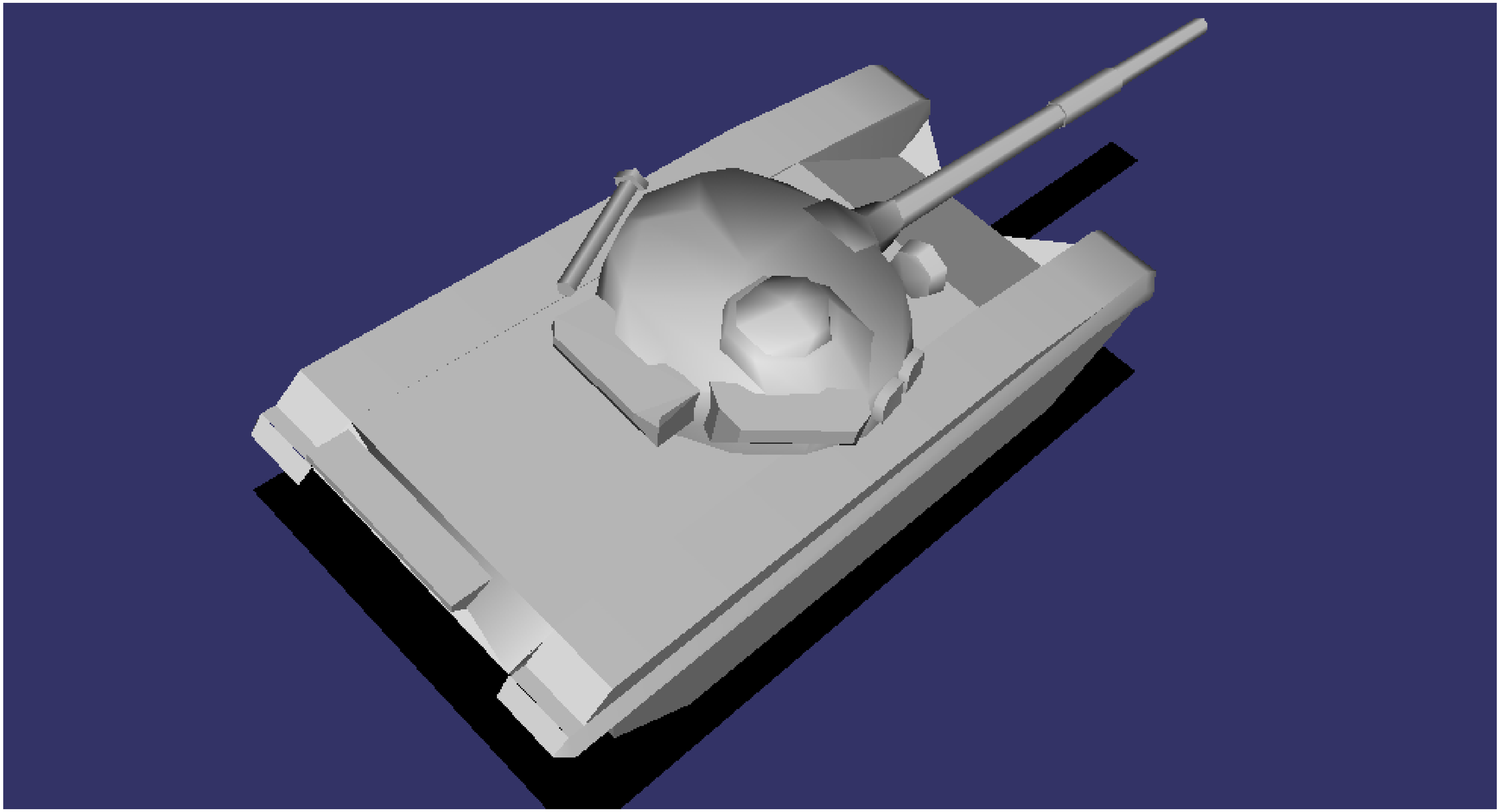
OSG – Wire frame



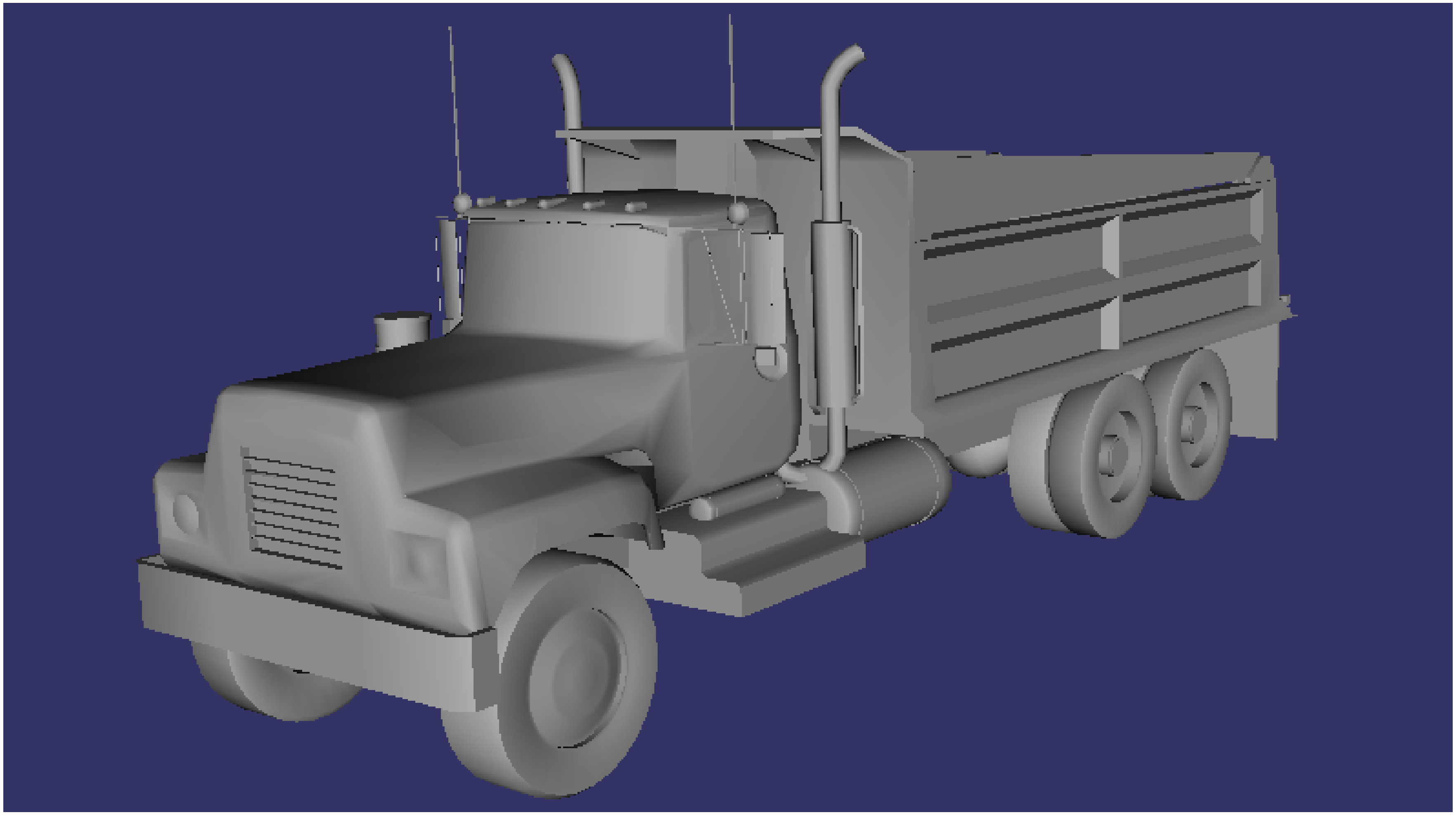
OSG – Wire frame



OSG – Faces



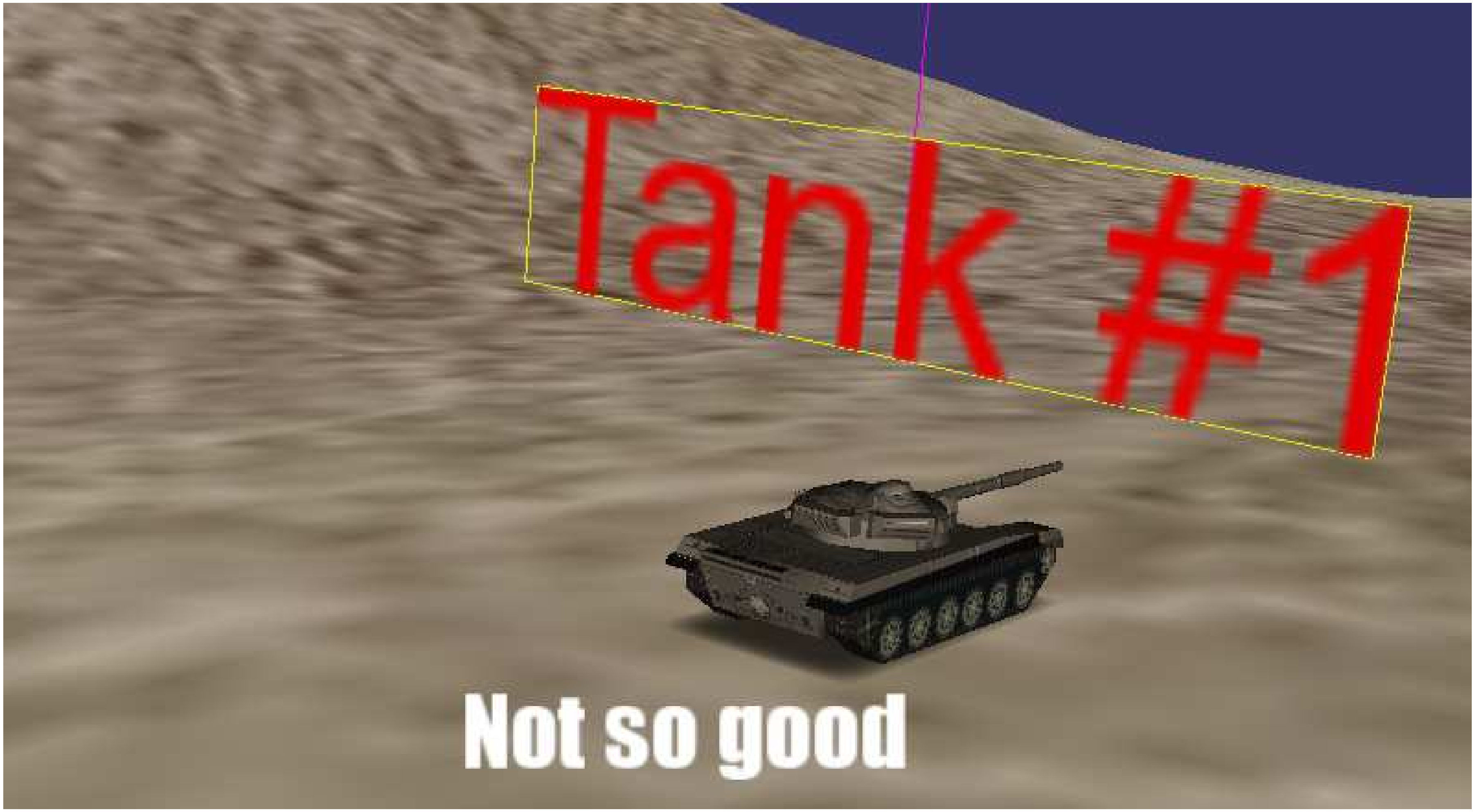
OSG – Faces



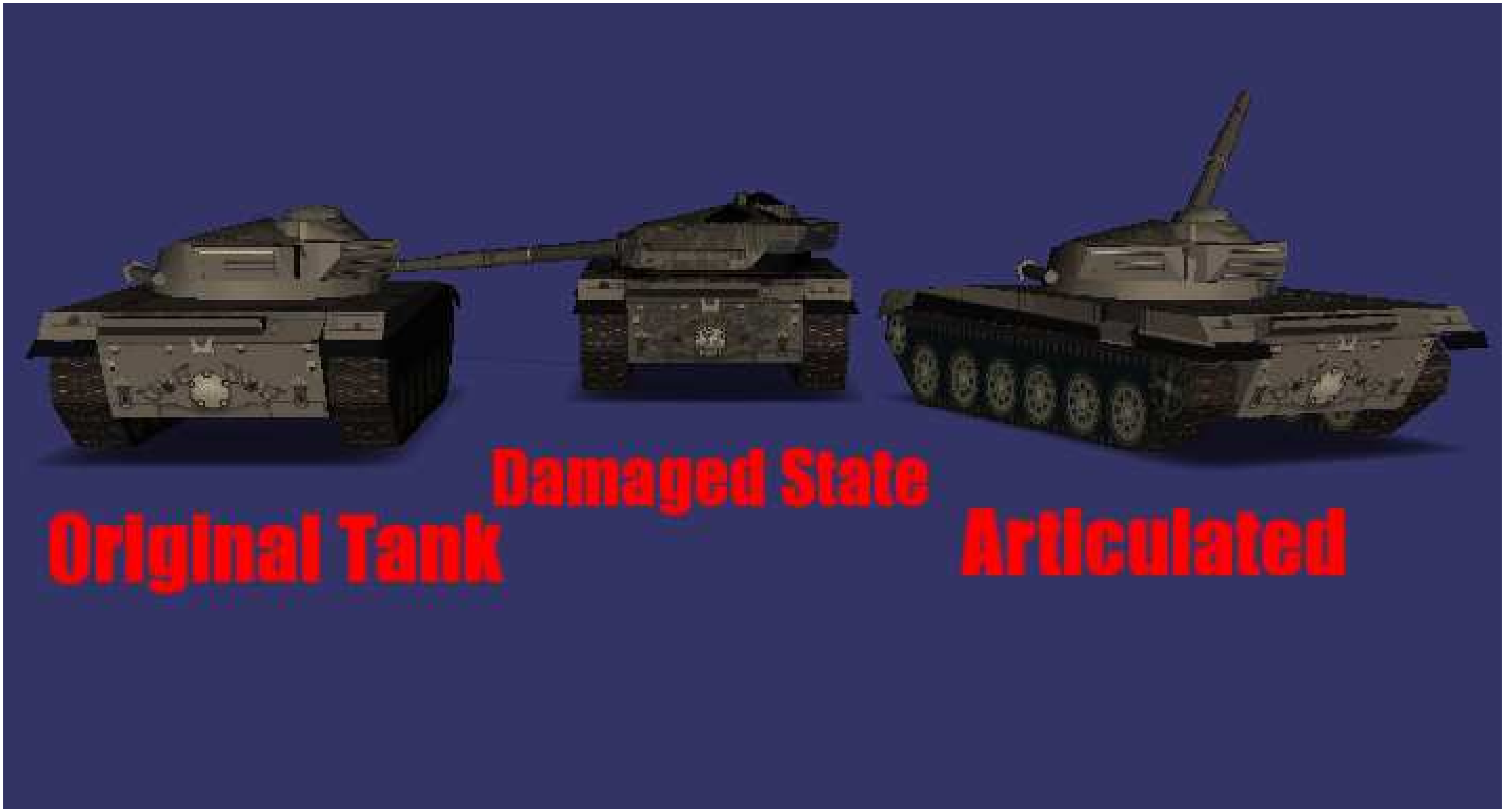
OSG – Textures

OSG – Scenes: Objects + Terrain

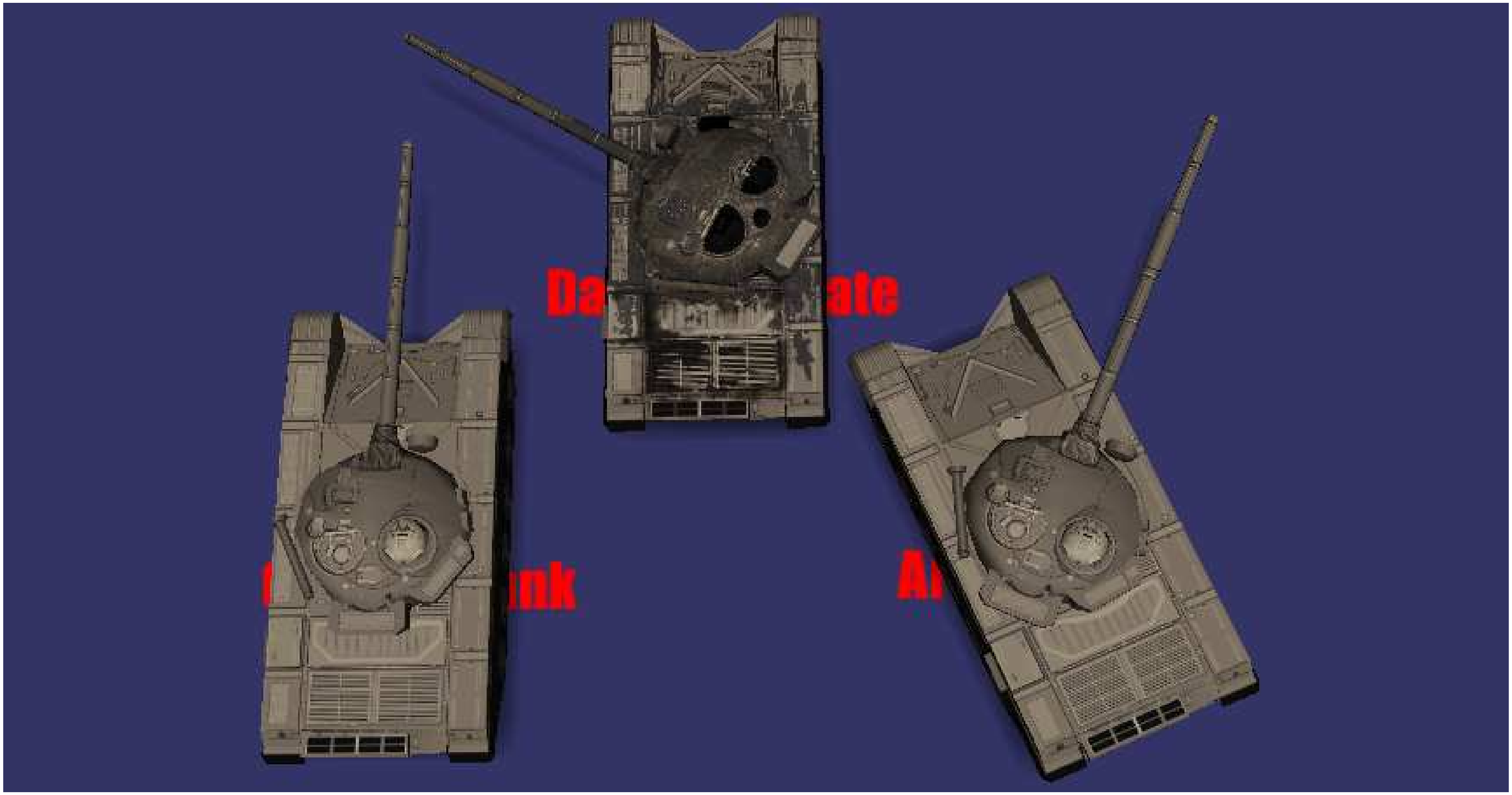
OSG – Text output



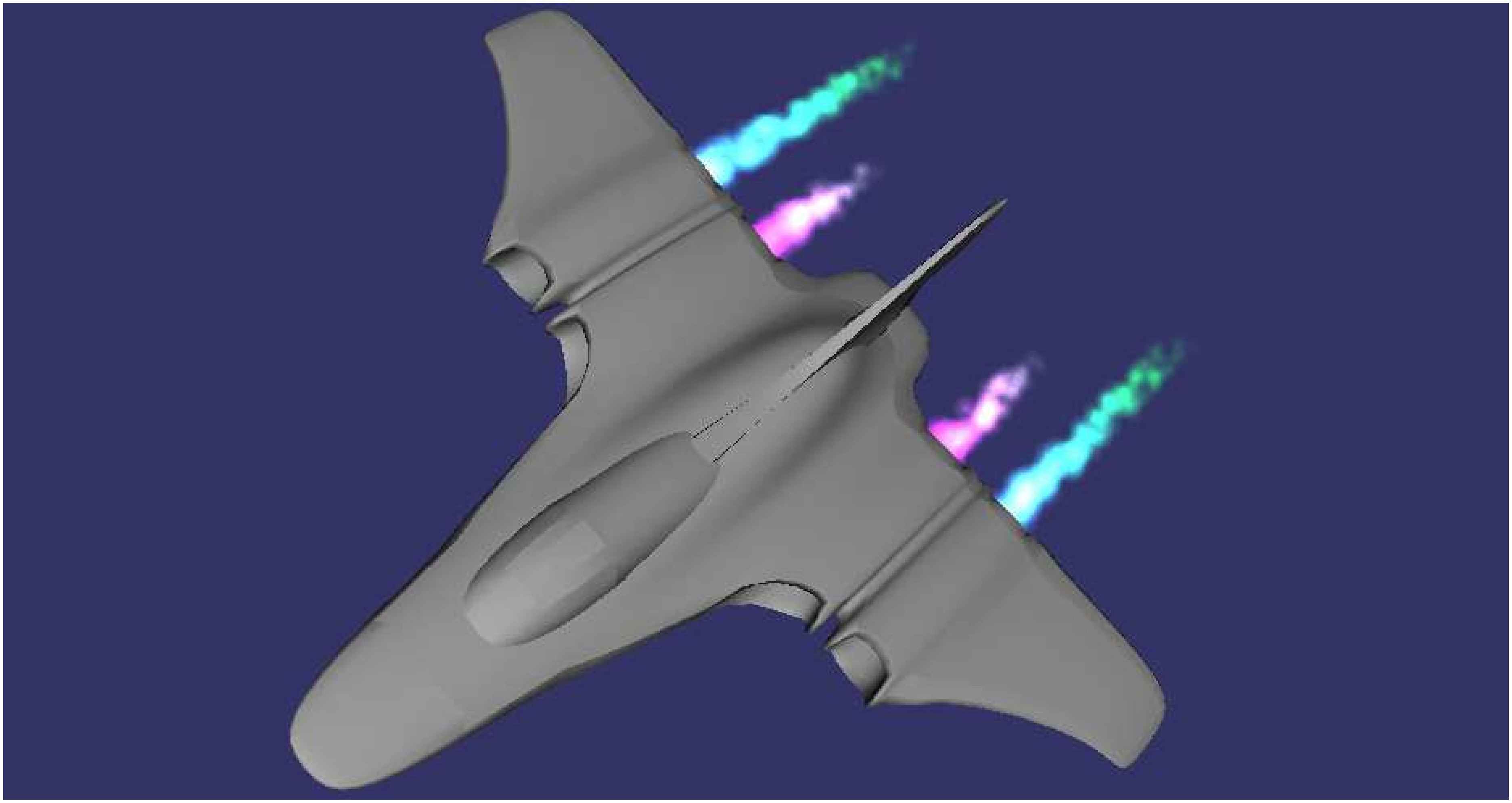
OSG – Text Output



OSG – Specific Individual Textures



OSG – Particles Effects



OSG – Particles Effects

OSG – Particles Effects

Open Scene Graph - OSG

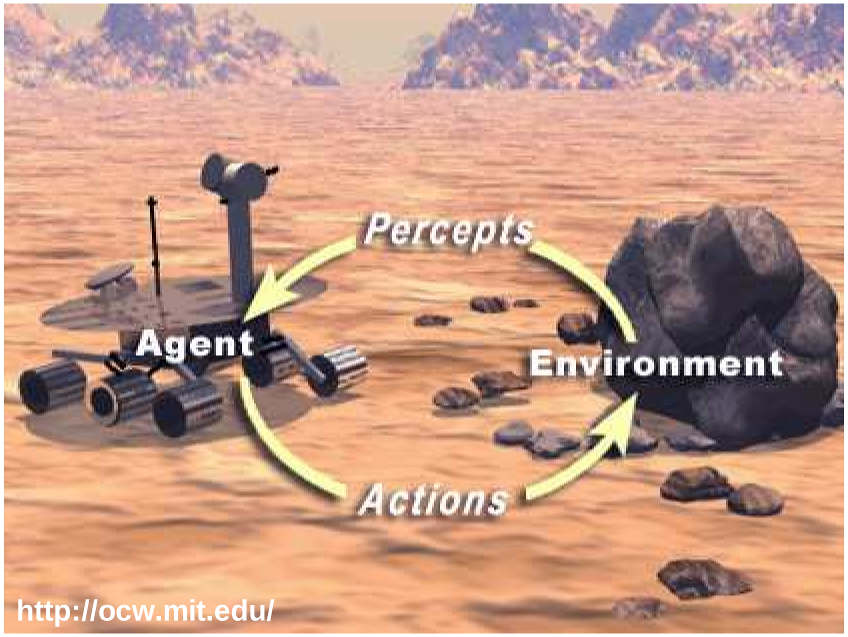
Concluding...

- 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/

Simulation in VR

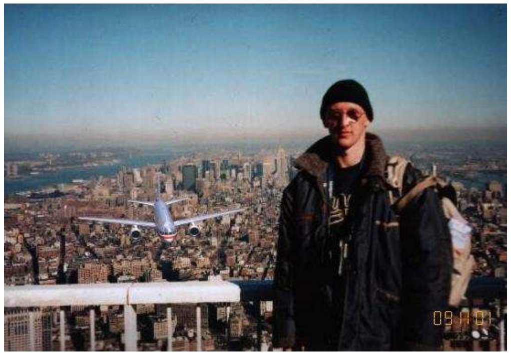
- Perception
- Action
- Kinematics
- Dynamic
- Collision



http://ocw.mit.edu/

Simulation in VR

- Elements:
  - ⇨ Perception
  - ⇨ Action
  - ⇨ Kinematics
  - ⇨ Dynamics
  - ⇨ Collision



- Realistic simulation: virtual must behav
  - ⇨ 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]

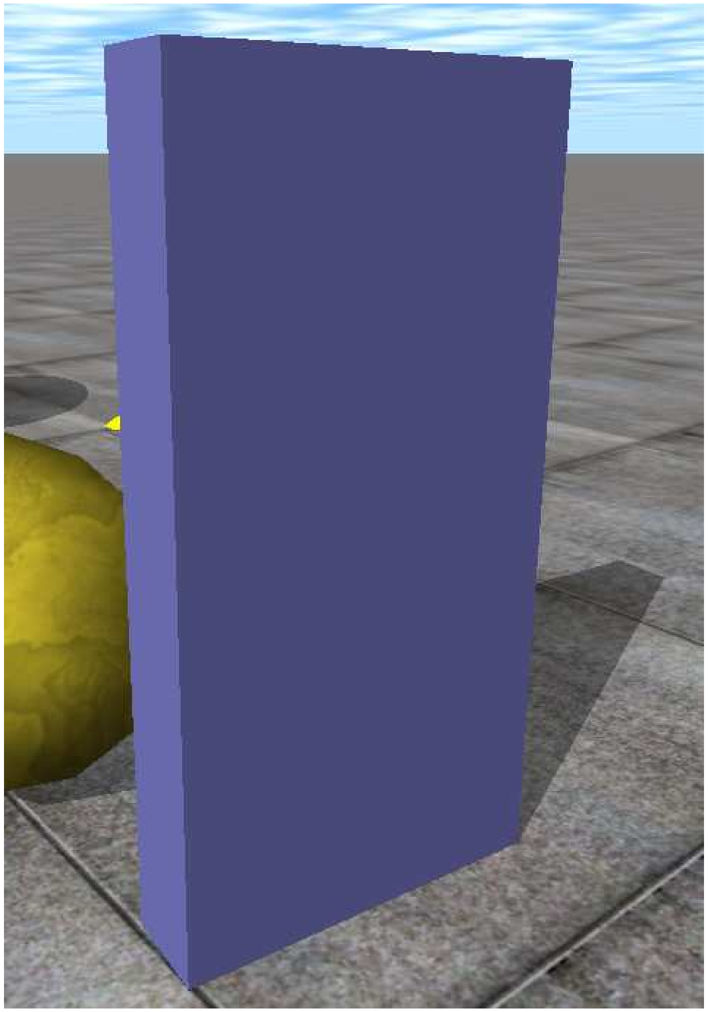
- ODE is a physically based simulation tool
  Open source and free - C/C++ compatible
- API written in C (procedural)
- Simulation of physics laws:
  - ⇨ Gravity, acceleration, friction, collision
    user can apply forces and torques to bodies
- Collision treatment:
  - ⇨ Collision: objects x ground
  - ⇨ 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.

ODE - Supported Objects

- Cubes

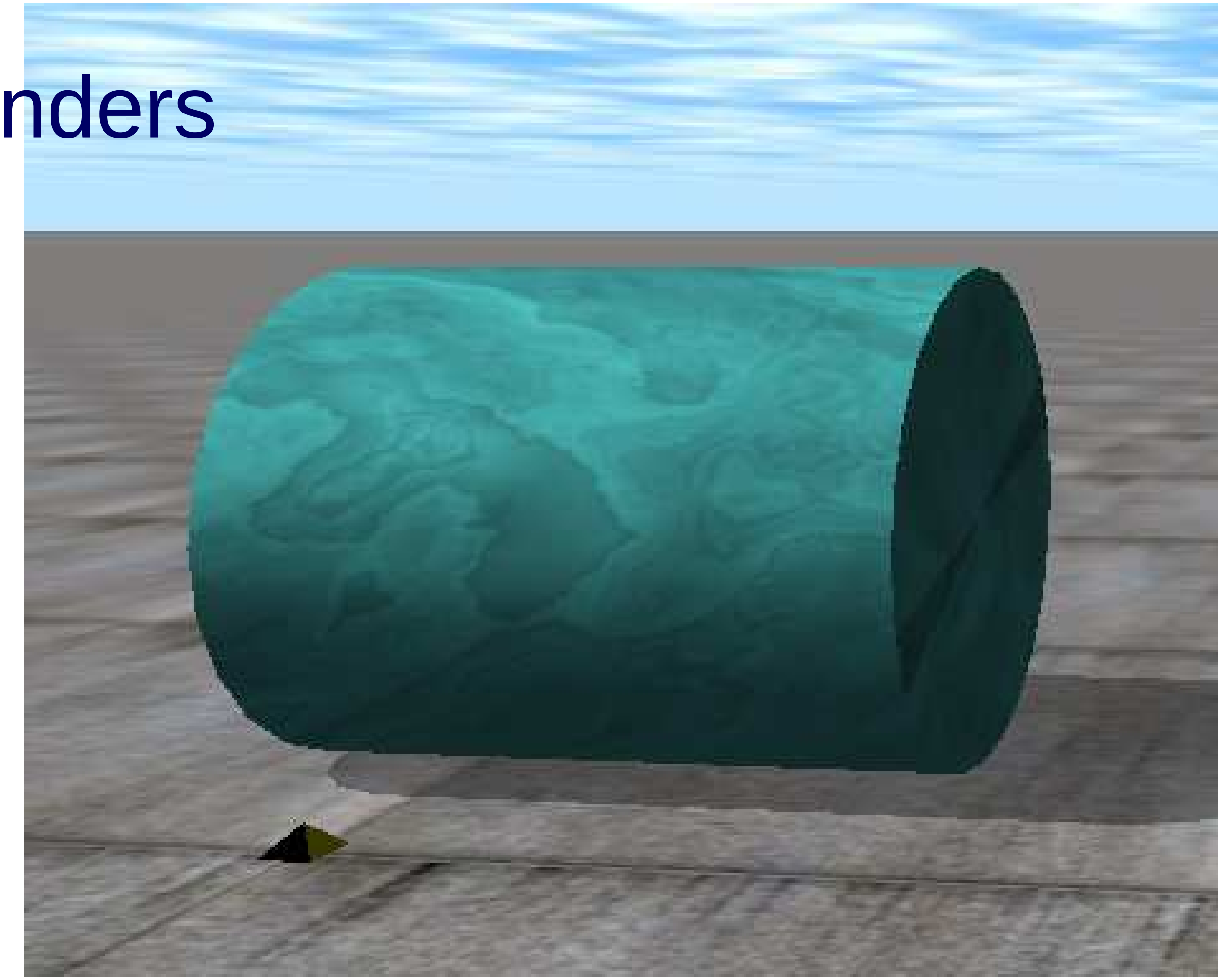


ODE - Supported Objects

- Spheres

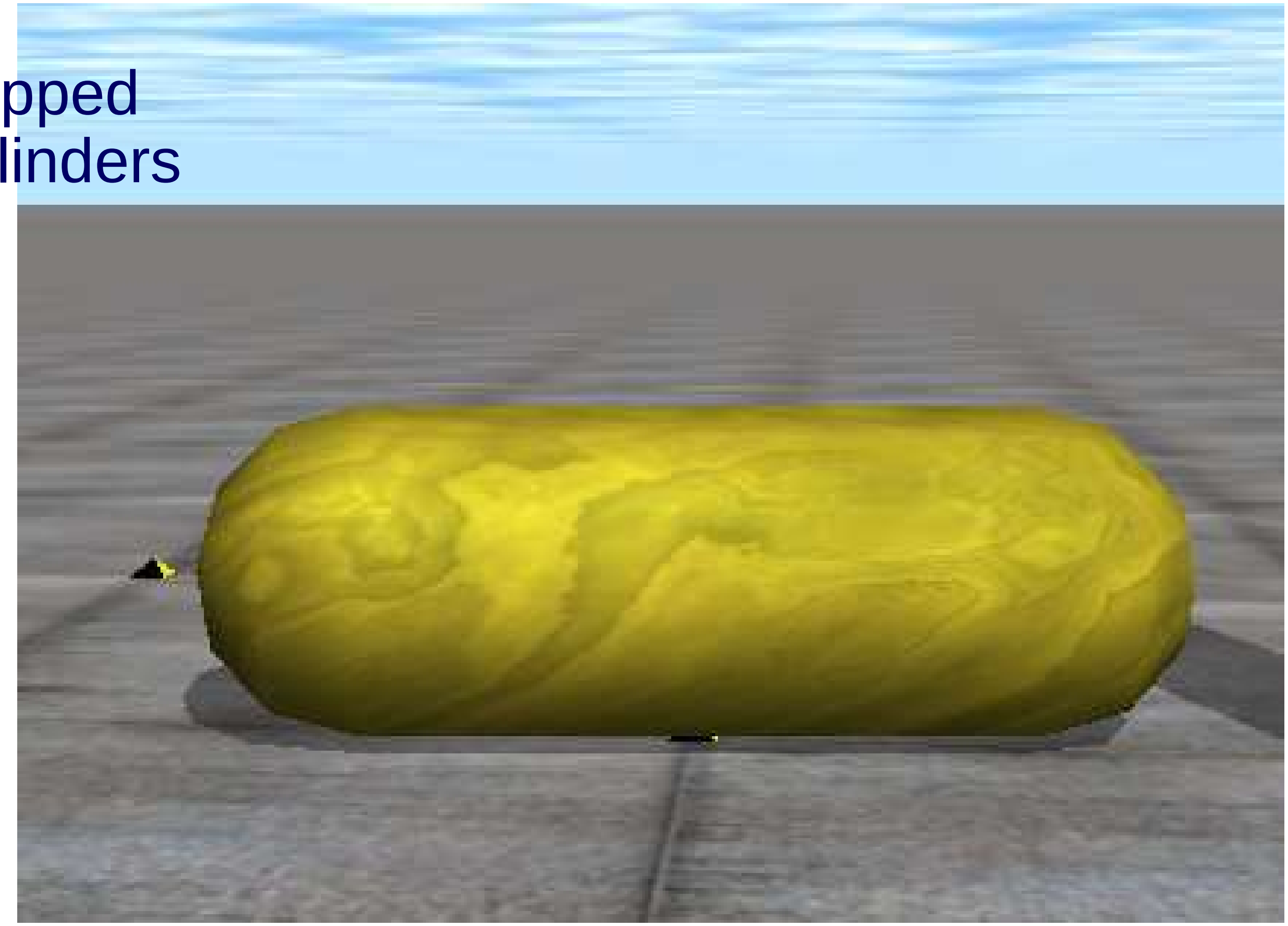
ODE - Supported Objects

- Cylinders



ODE - Supported Objects

- Capped Cylinders

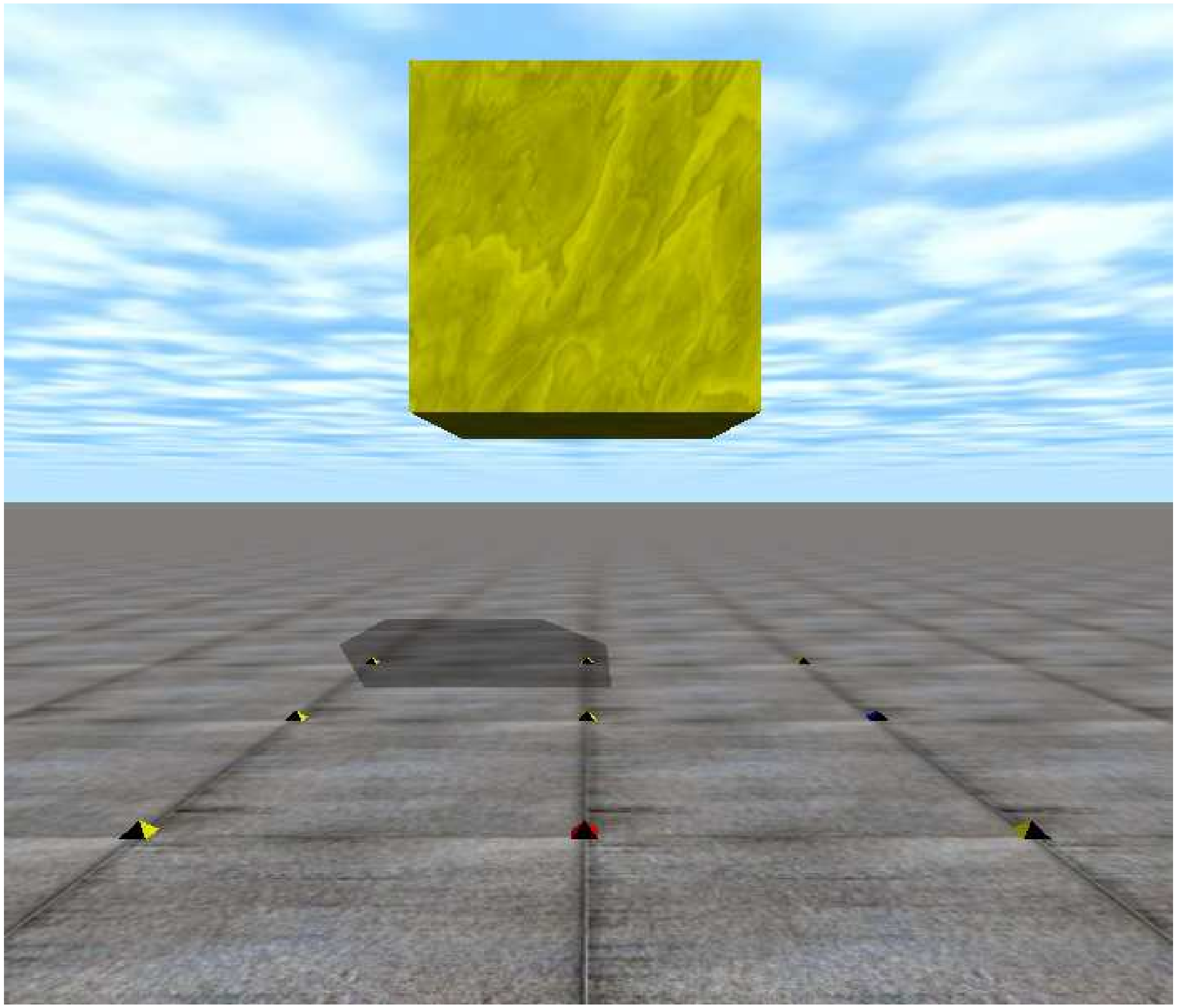


Open Dynamics Engine - ODE

Pure Computer Graphics:

No Physics!

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

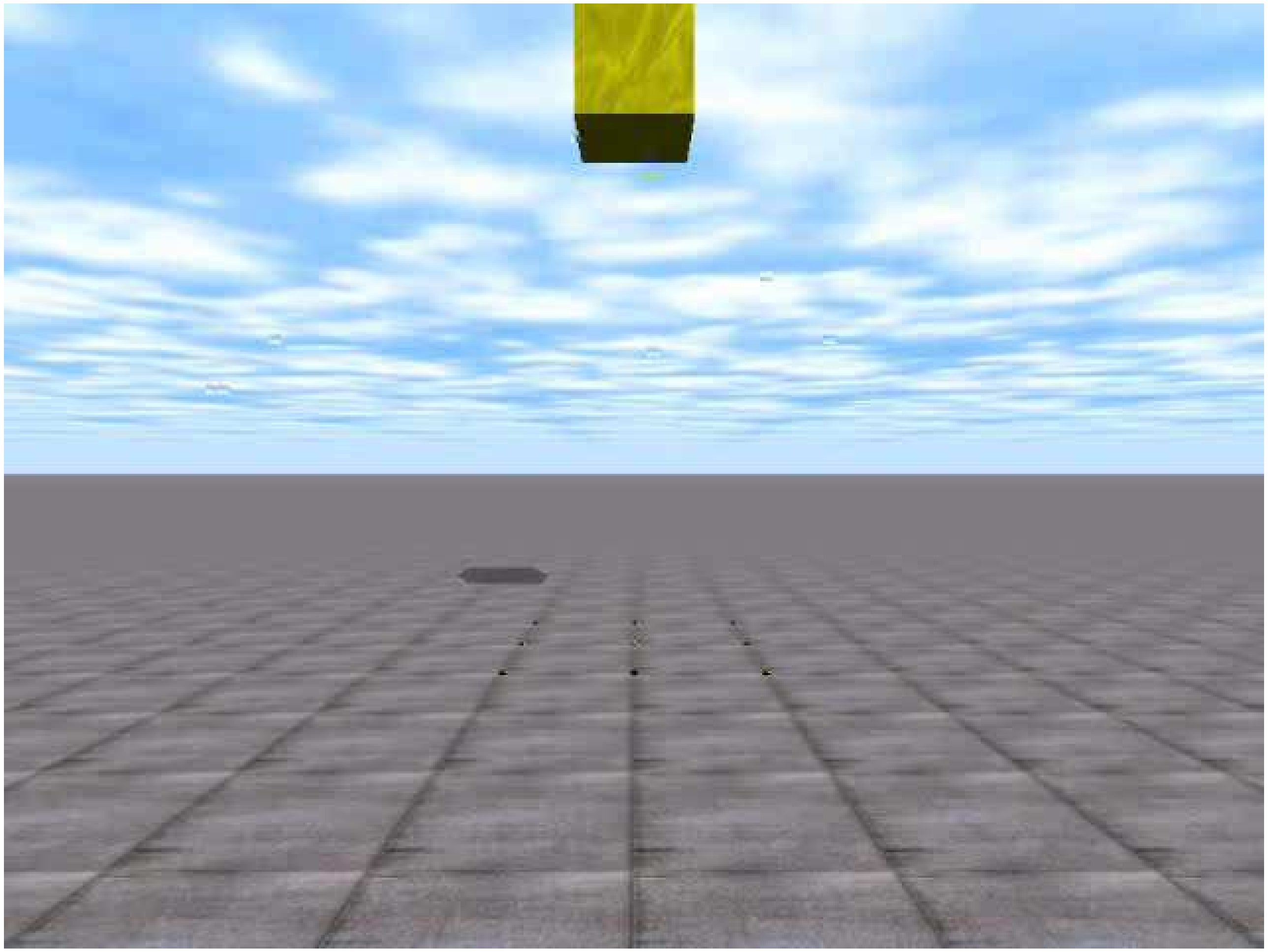


Open Dynamics Engine - ODE

Simulation Using ODE:

This cube will be affected by the gravity...

We can specify the cube mass and even an specific gravity force value!

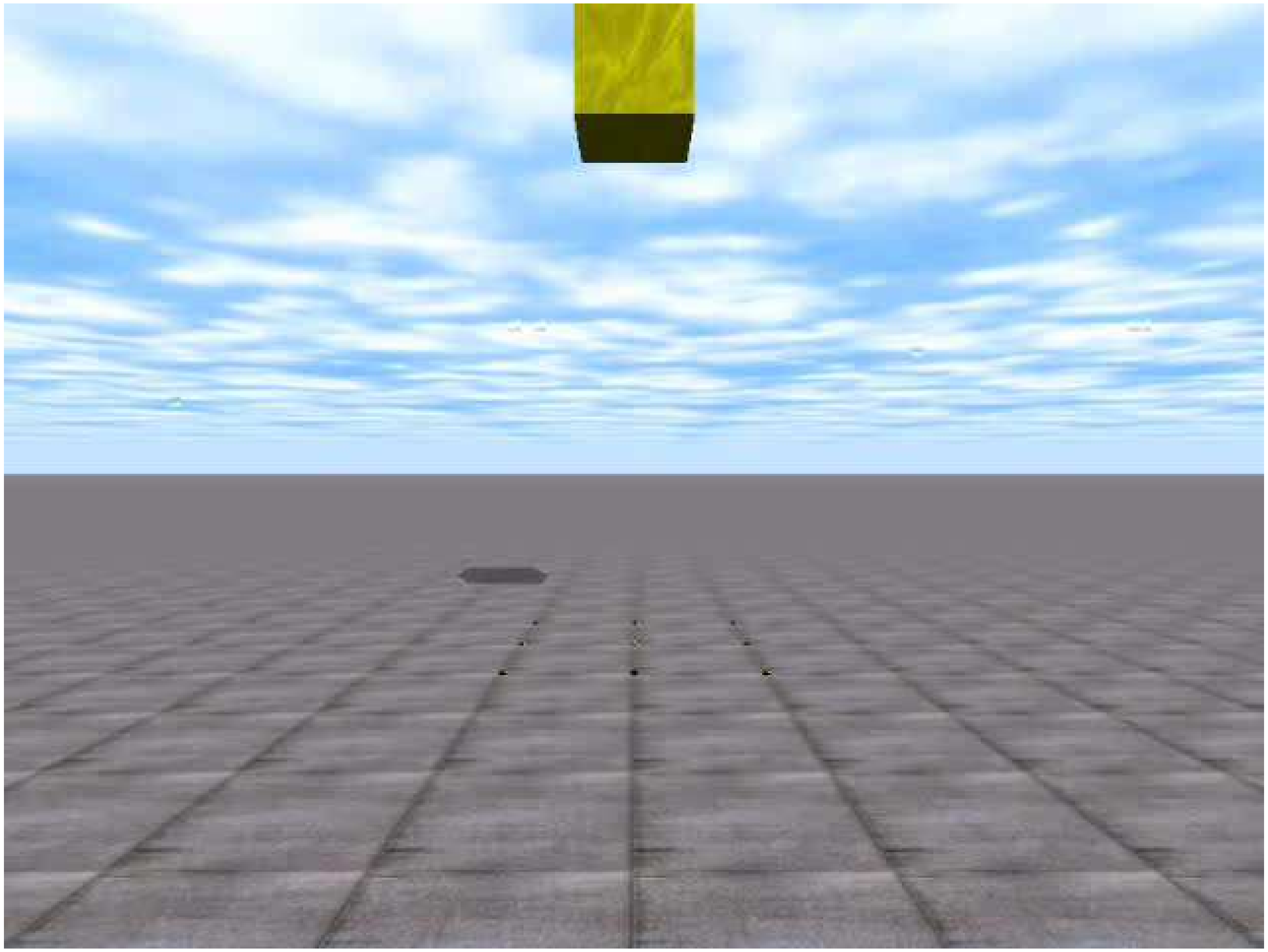


Open Dynamics Engine - ODE

Collisions should be treated...

So the cube will not pass through the ground.

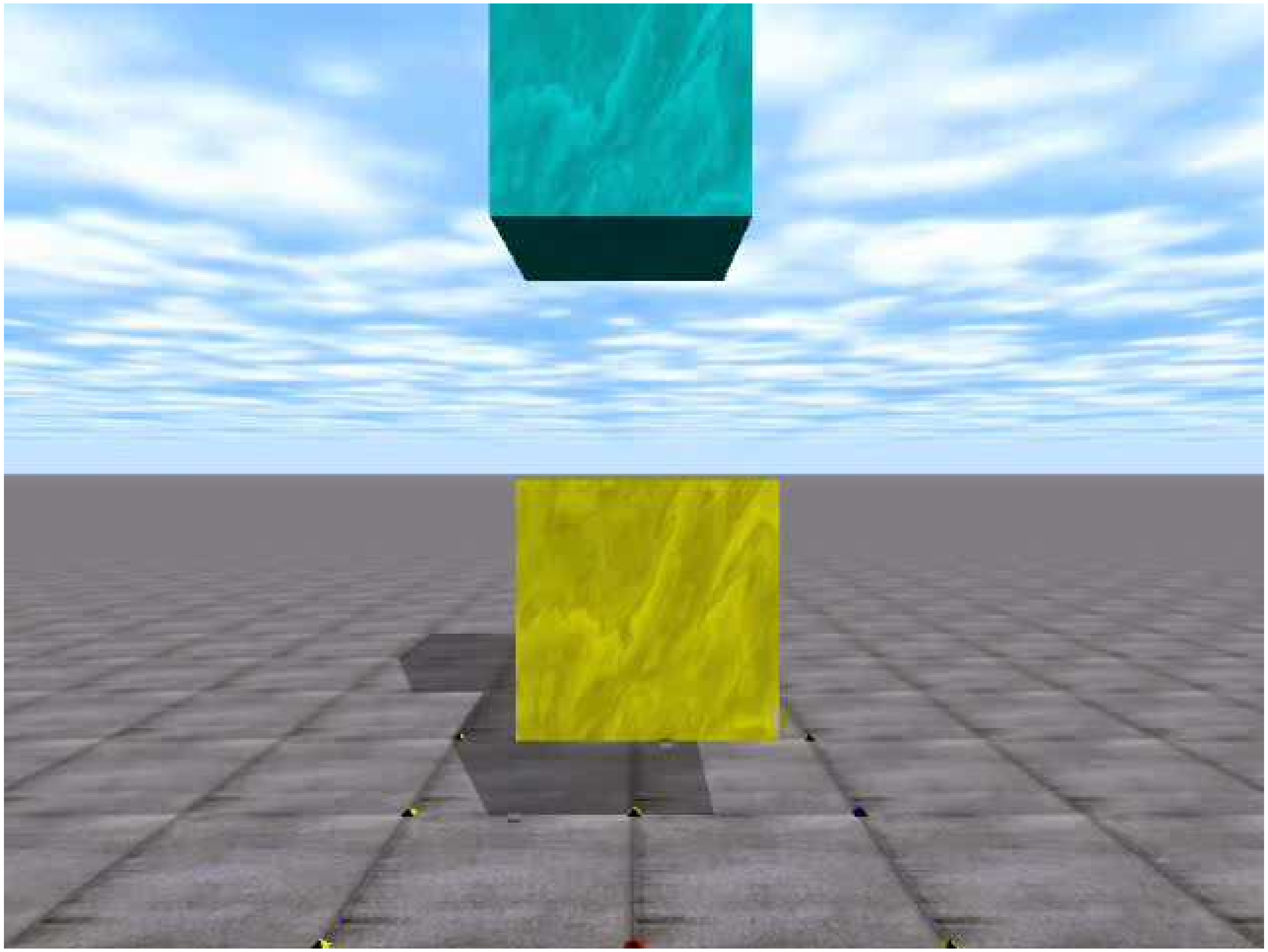
Impacts should be realistic.



Open Dynamics Engine - ODE

Collision between objects should also be treated...

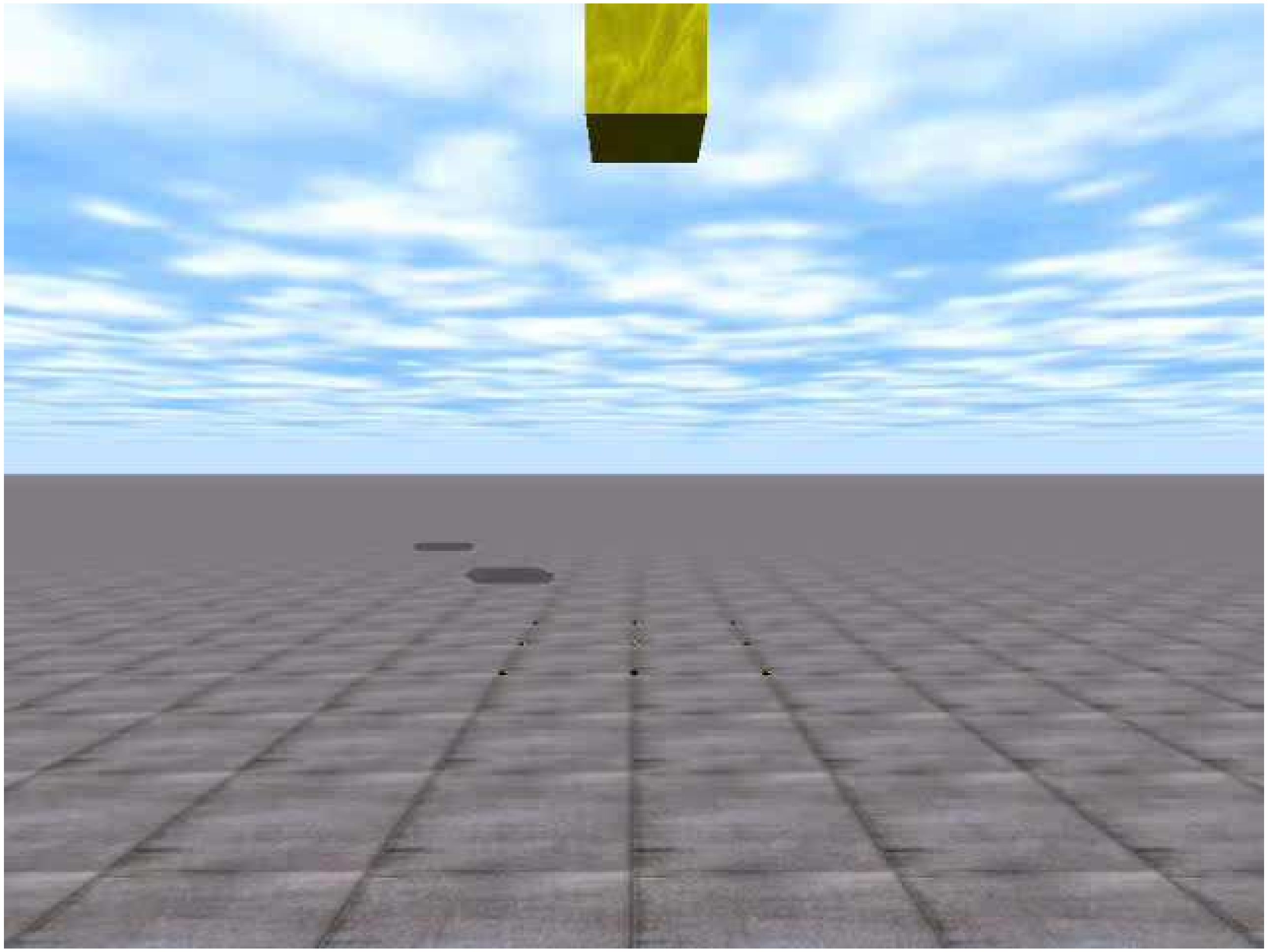
In Computer Graphics applications (and some games) it is not rare to see objects passing walls!



Open Dynamics Engine - ODE

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

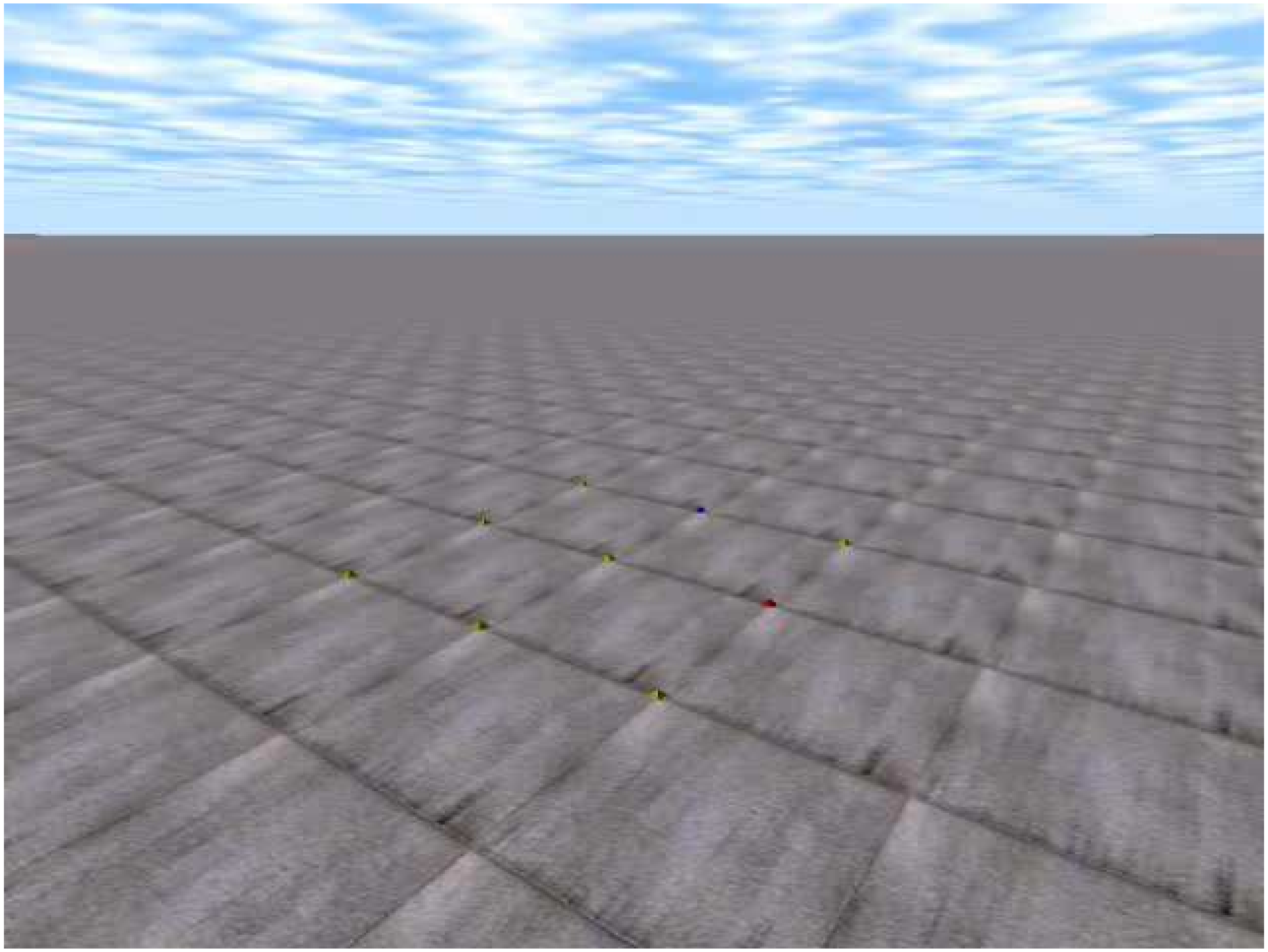
ODE can do this in automatically!



Open Dynamics Engine - ODE

This scene shows several objects falling down...

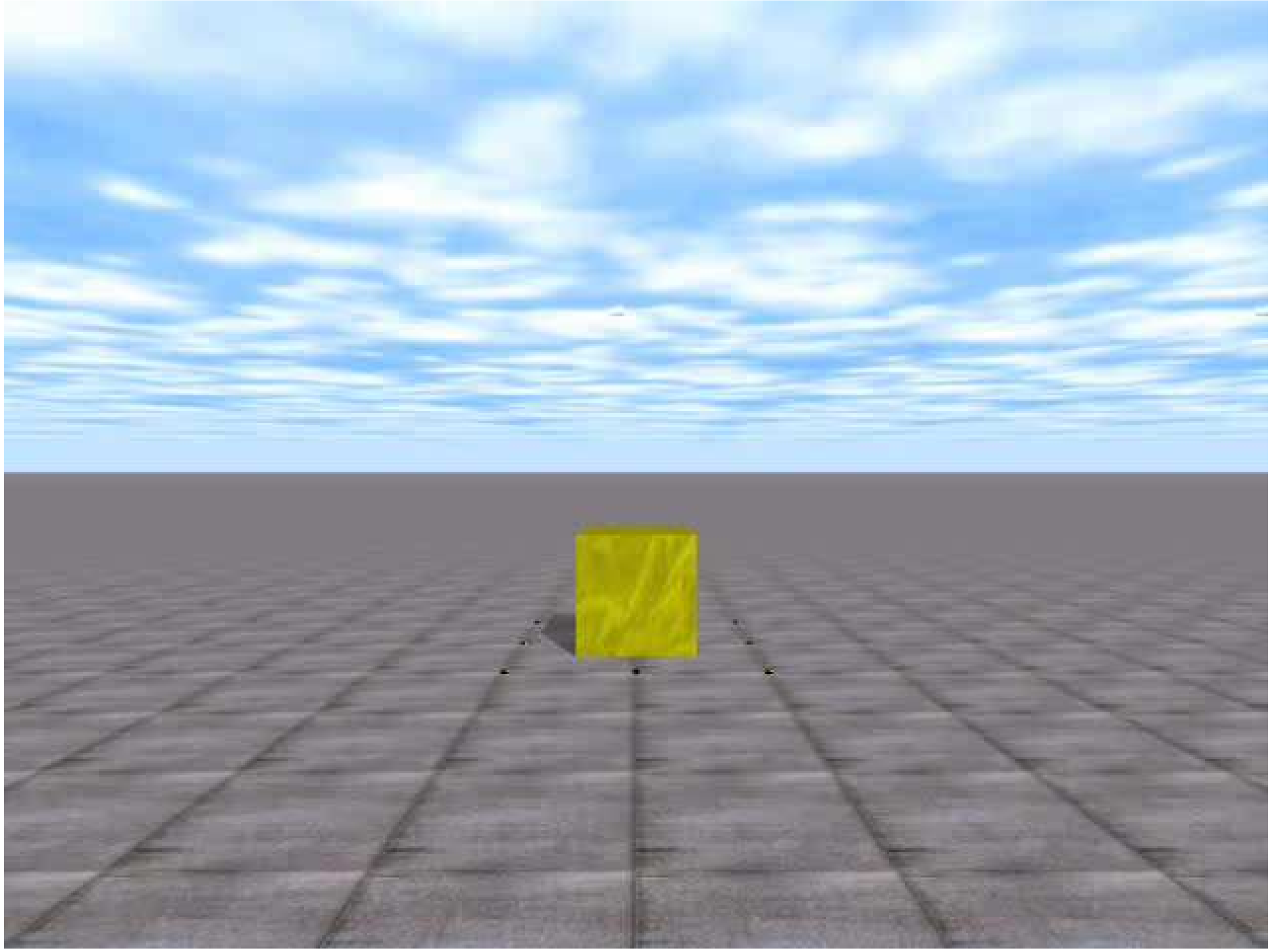
Some of them are "composed objects" (formed by the connection of more then one)



Open Dynamics Engine - ODE

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

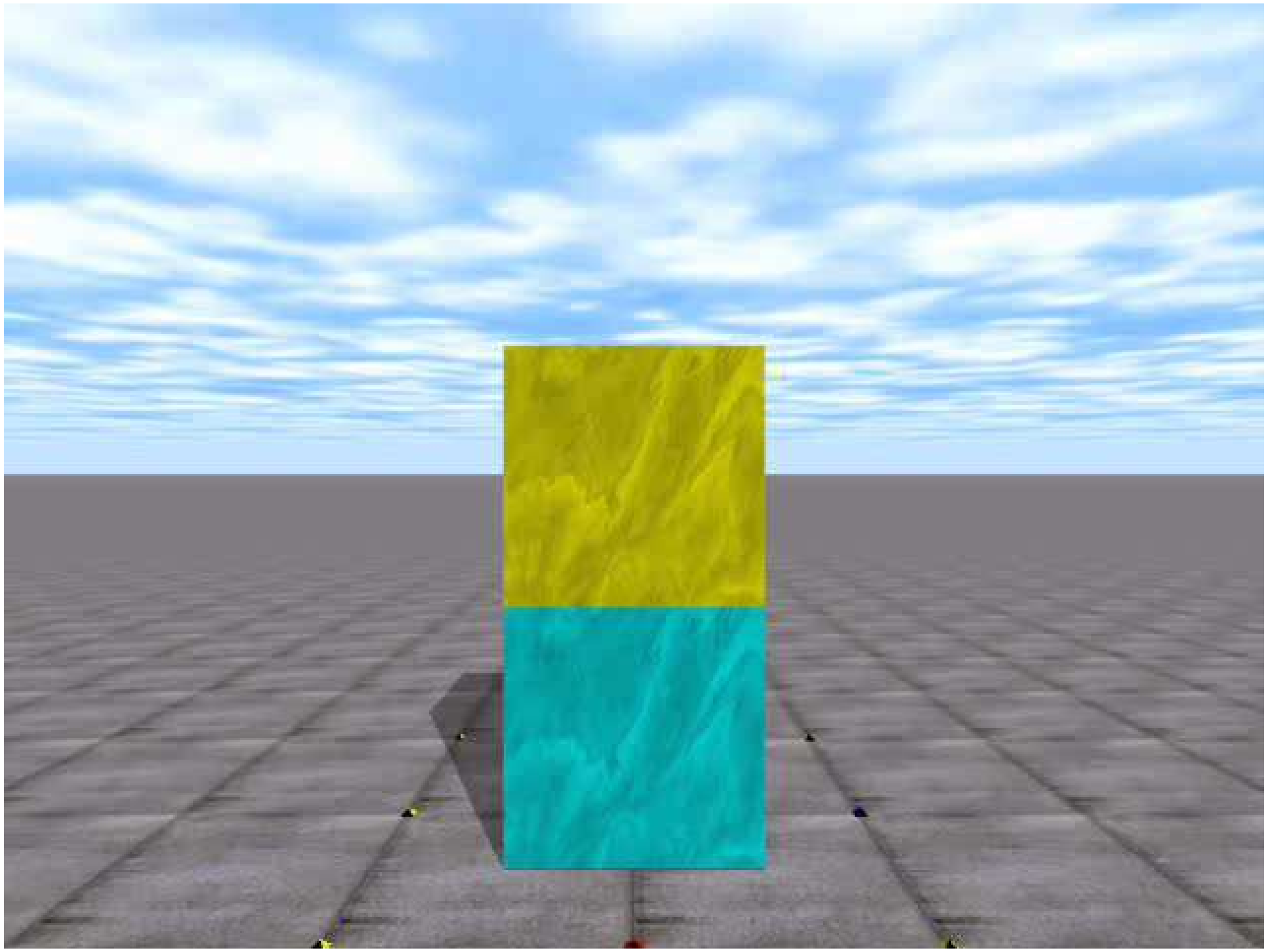
Force: It is a vector with a direction, an orientation and Intensity



Open Dynamics Engine - ODE

Interaction between objects occurs in a natural way...

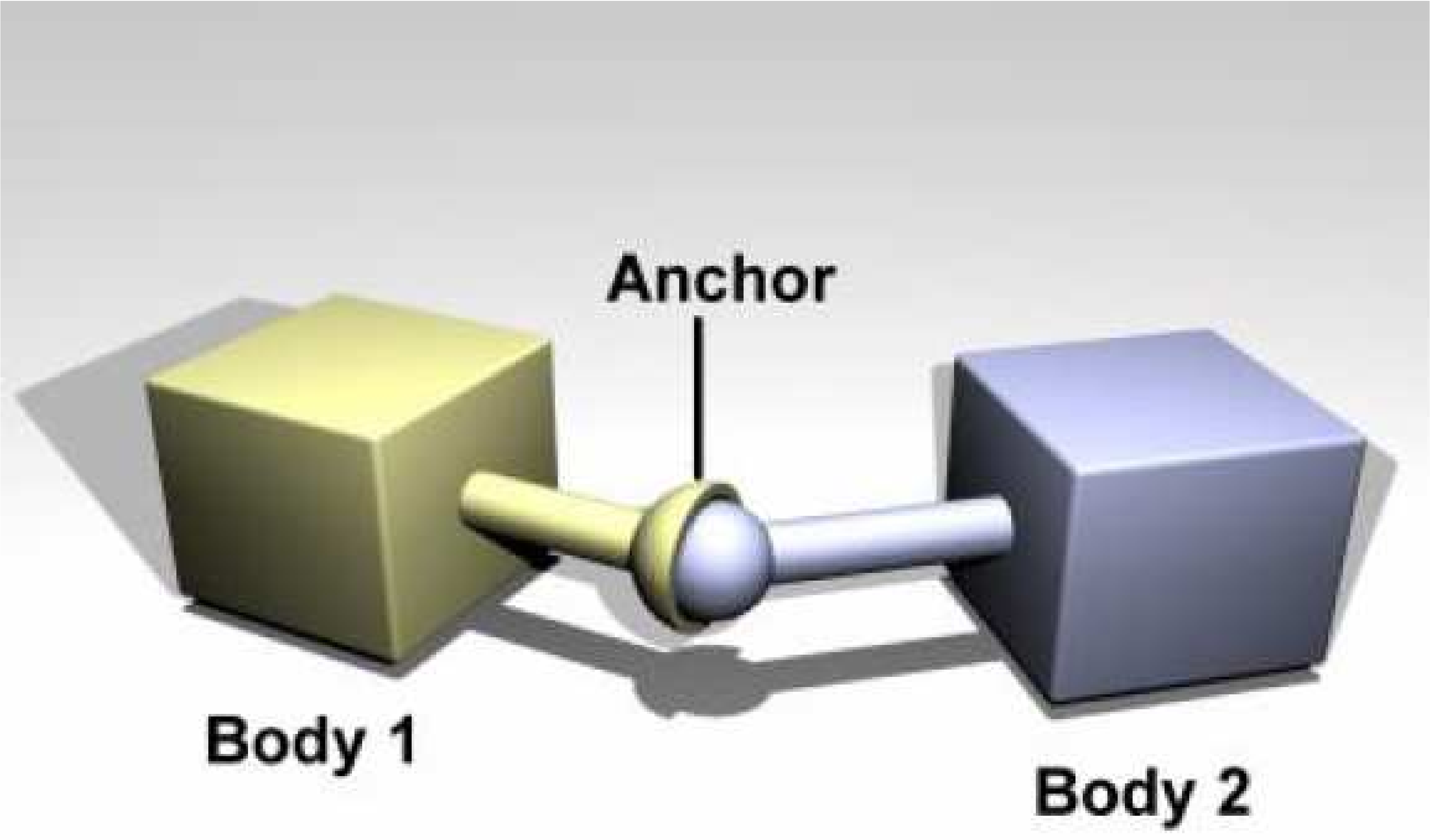
One object can be throw into an other: for an action we can obtain a reaction!



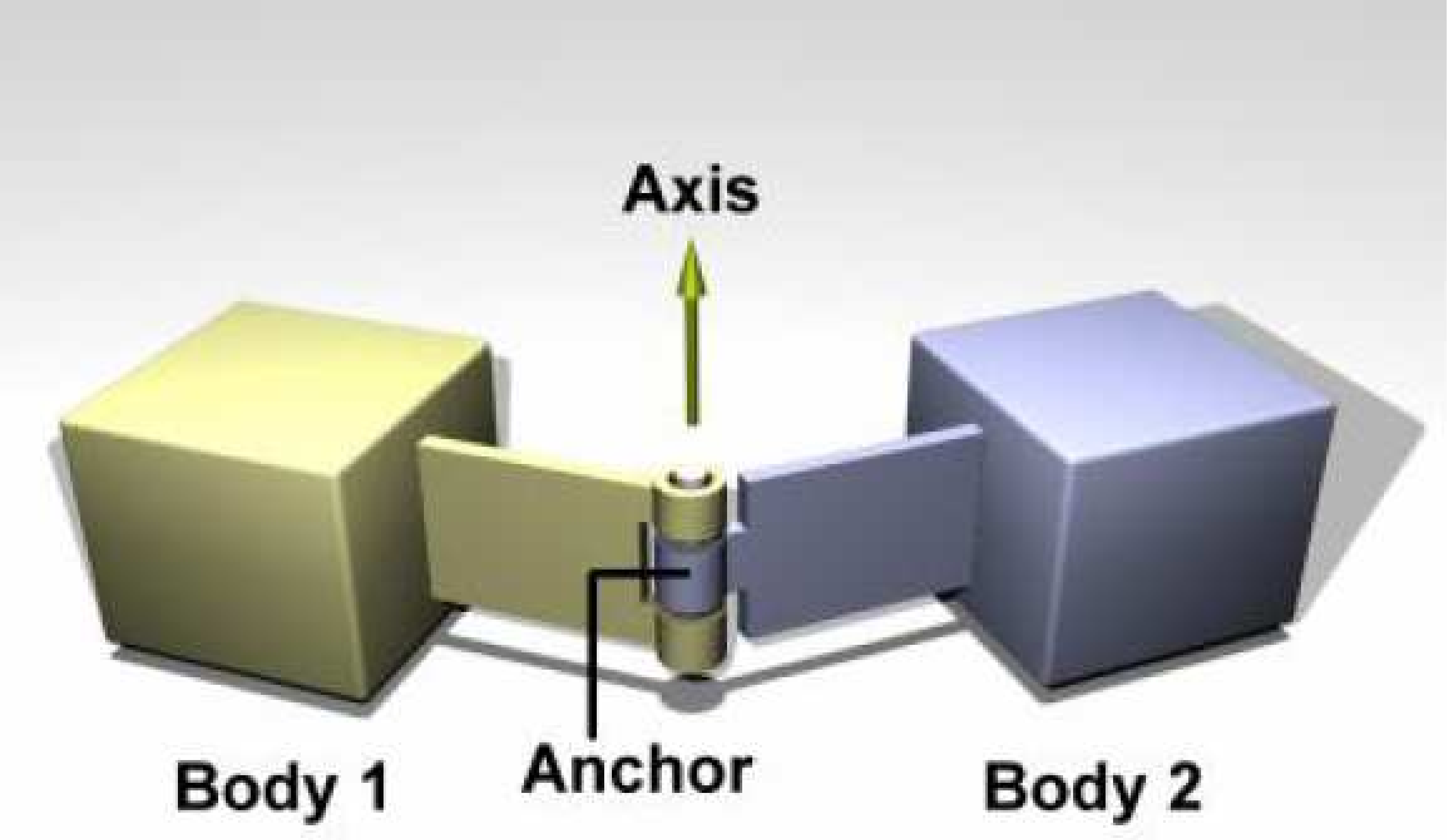
ODE Joints

- 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.

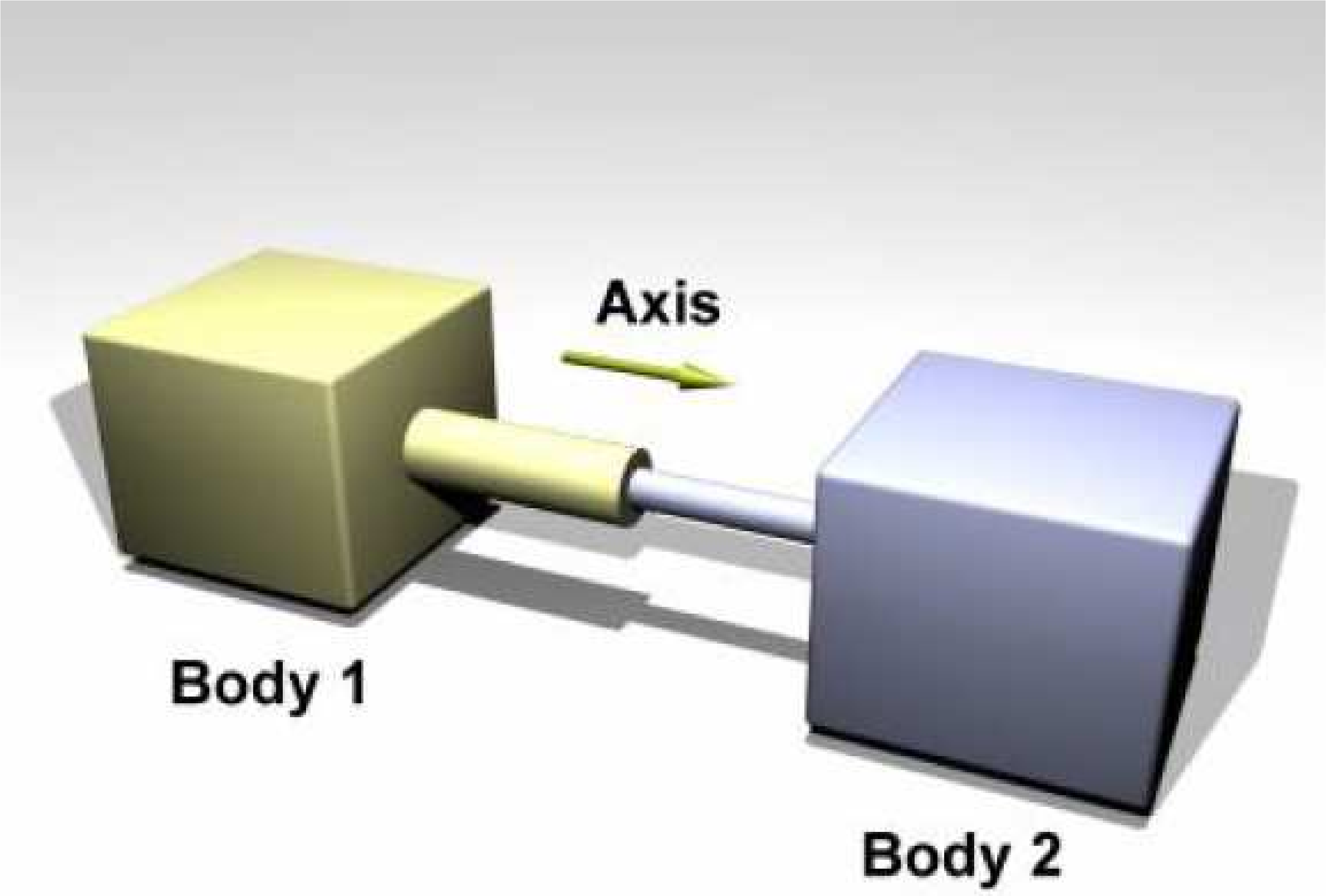
ODE: Ball and socket joint



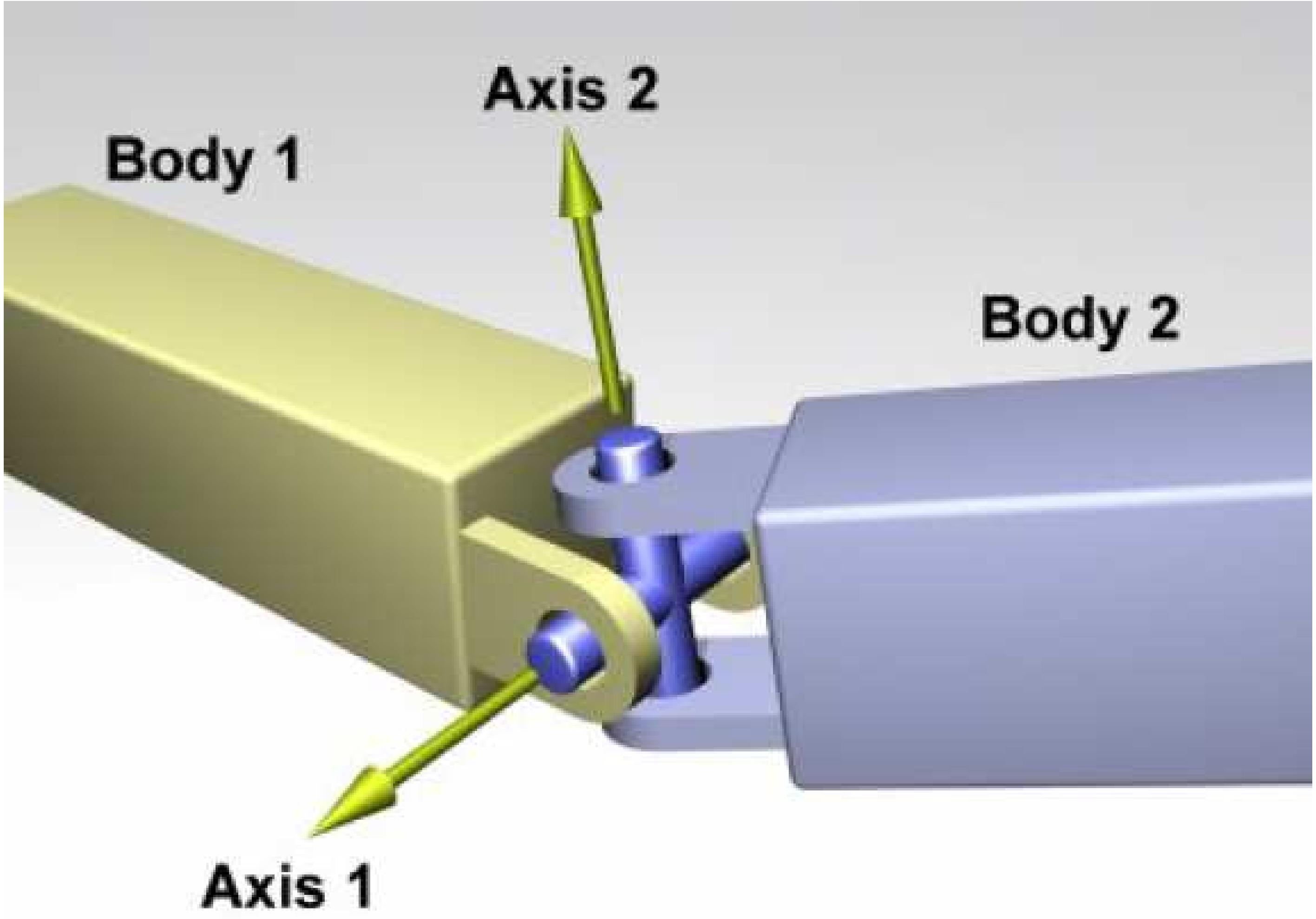
ODE: Hinge joint



ODE: Slider joint



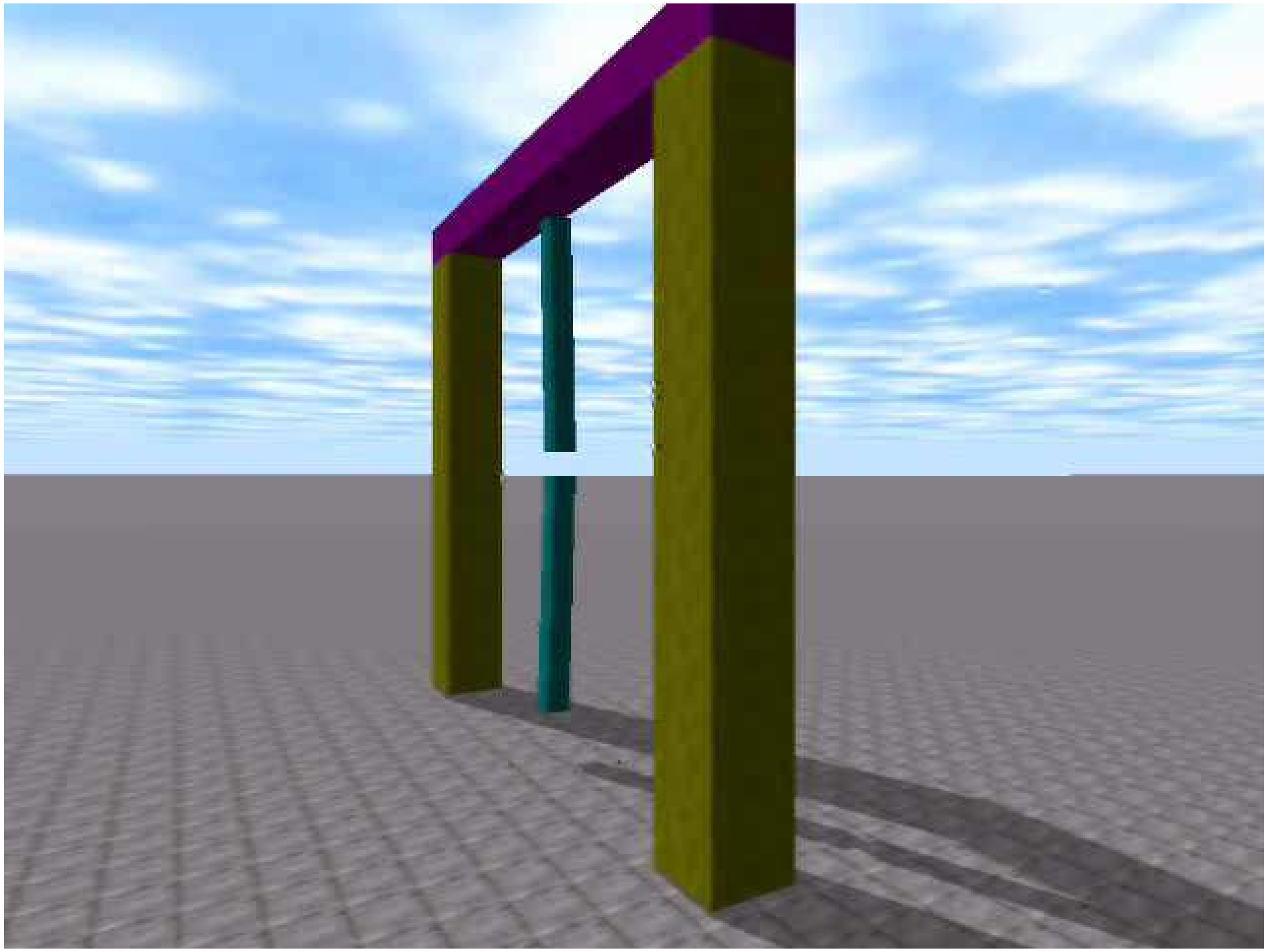
ODE: Universal joint



Open Dynamics Engine - ODE

Joints can connect and link together the objects.

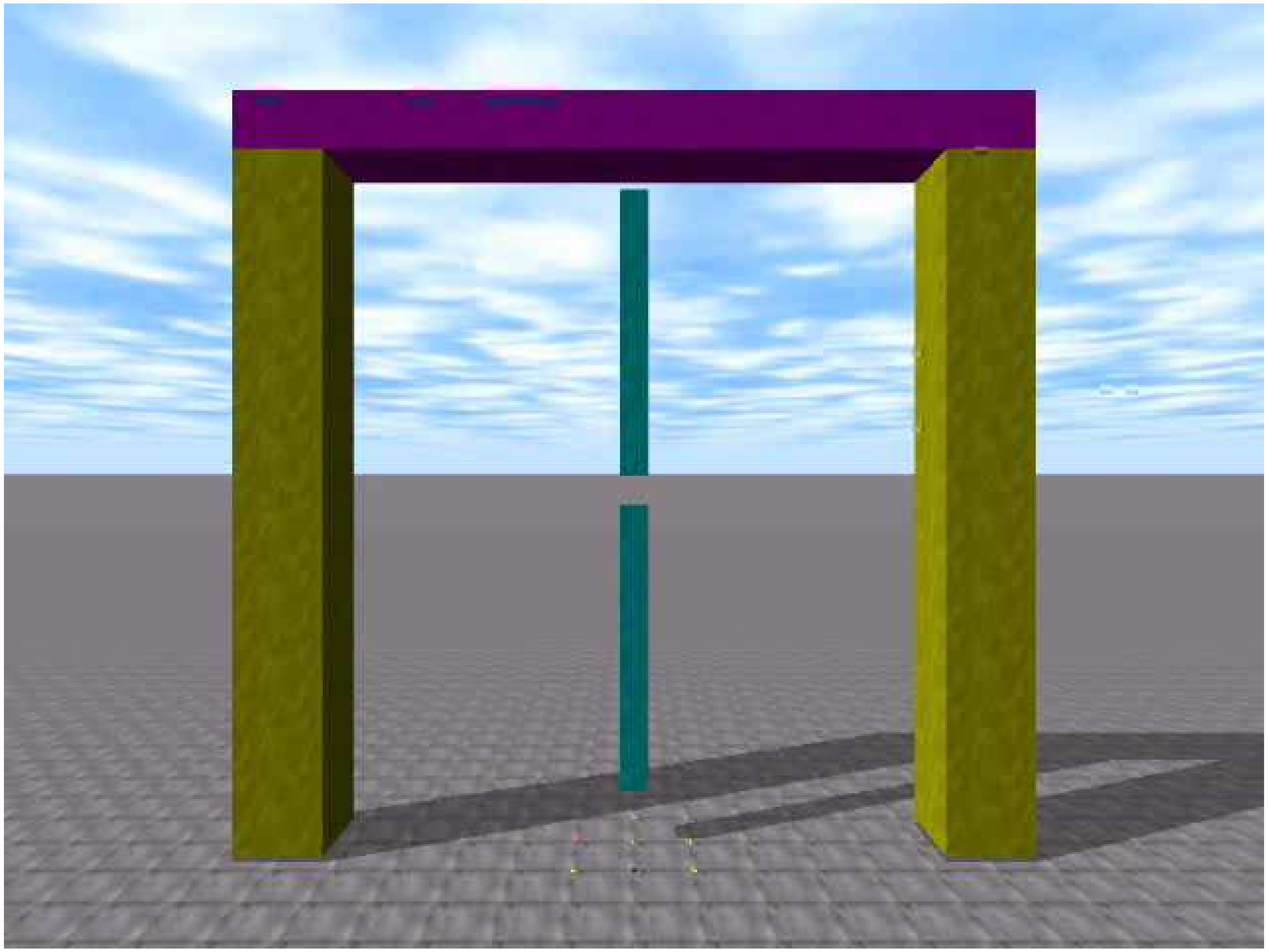
Joints have a connection point, freedom degrees (axes), and limits (min-max range values).



Open Dynamics Engine - ODE

Forces can be applied to joint objects...

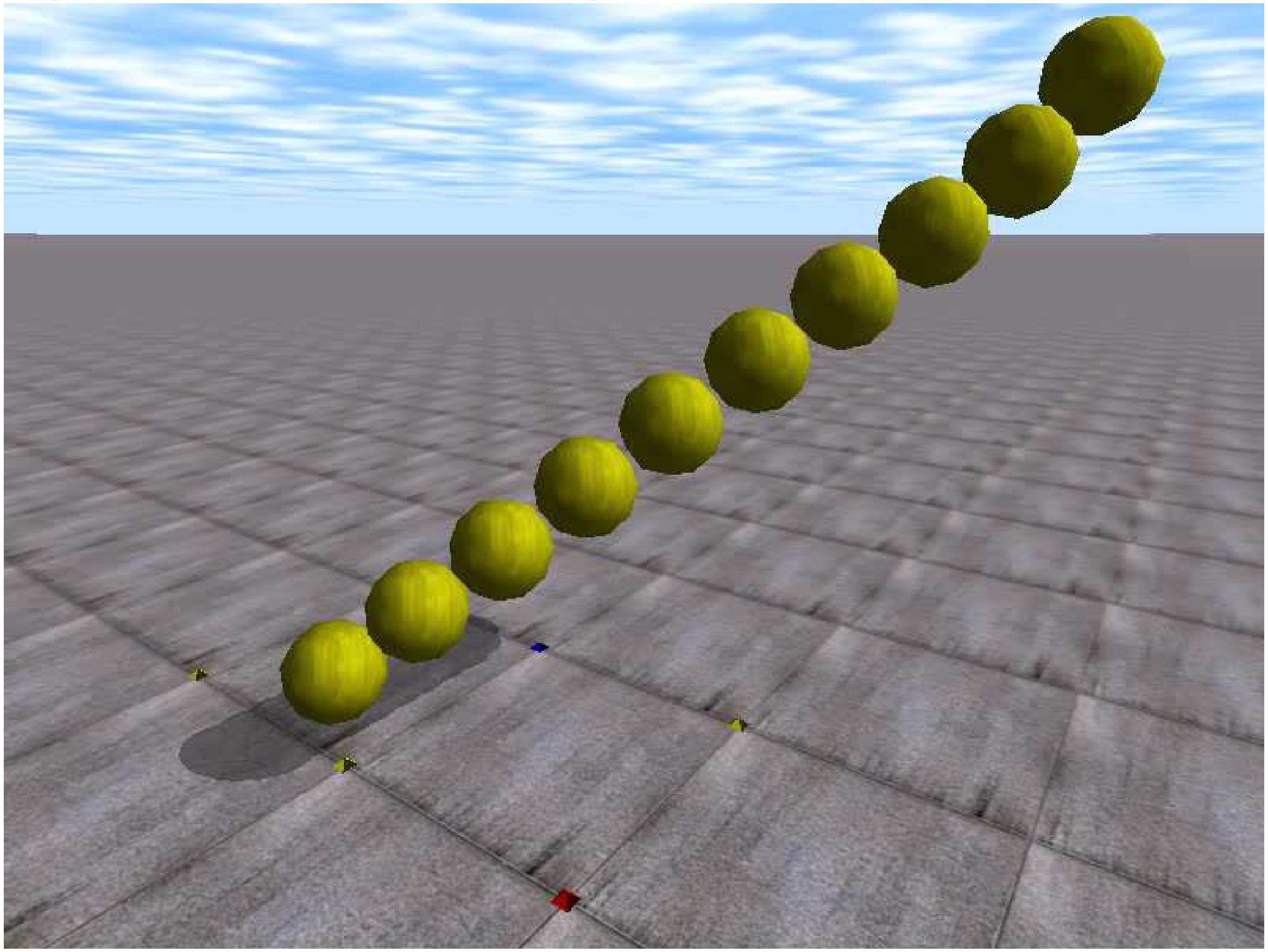
As they are linked, the force applied to one extremity will affect the other object which is connected to it.



Open Dynamics Engine - ODE

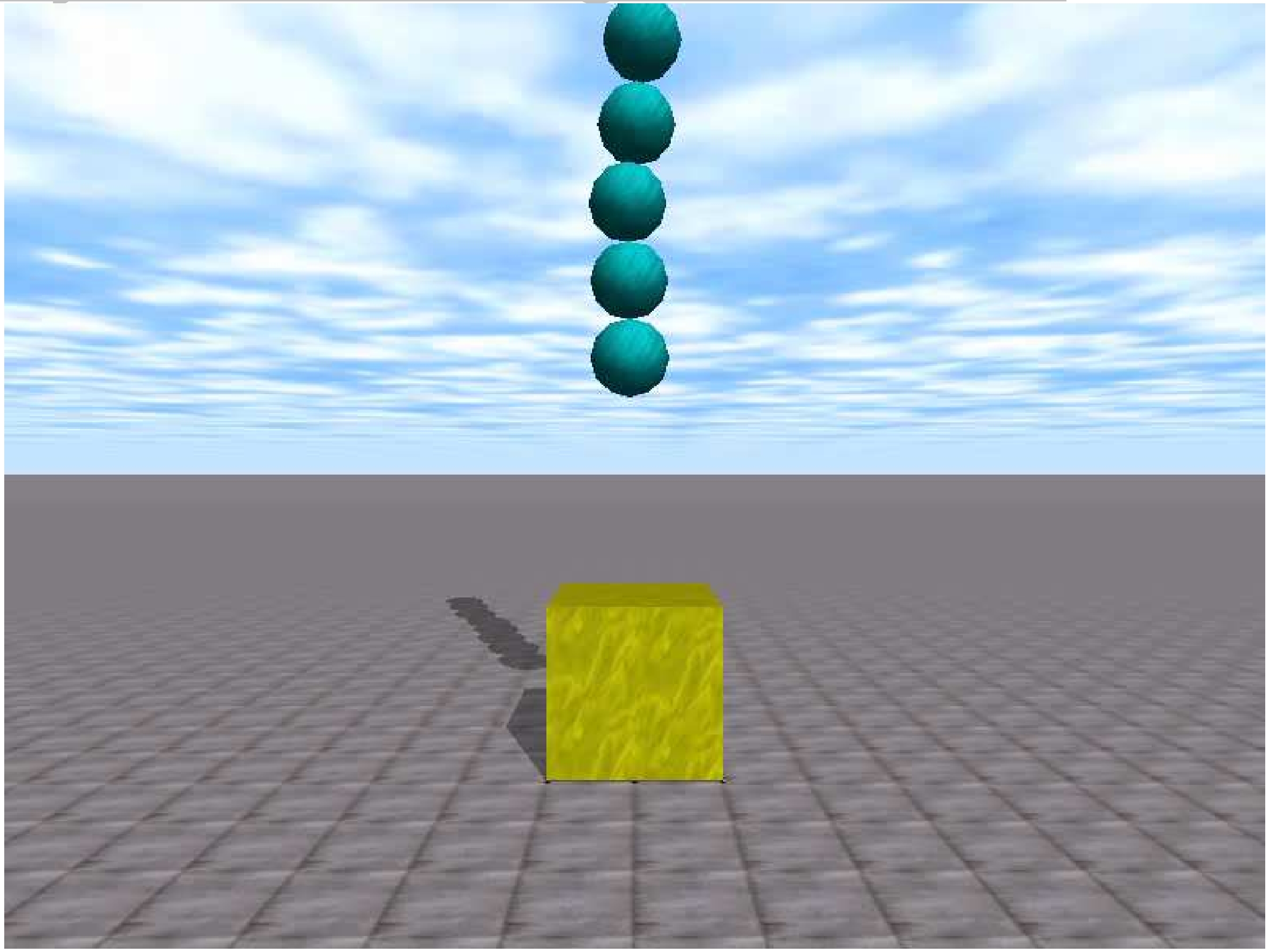
Several objects can be connected by an universal joint...

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



Open Dynamics Engine - ODE

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



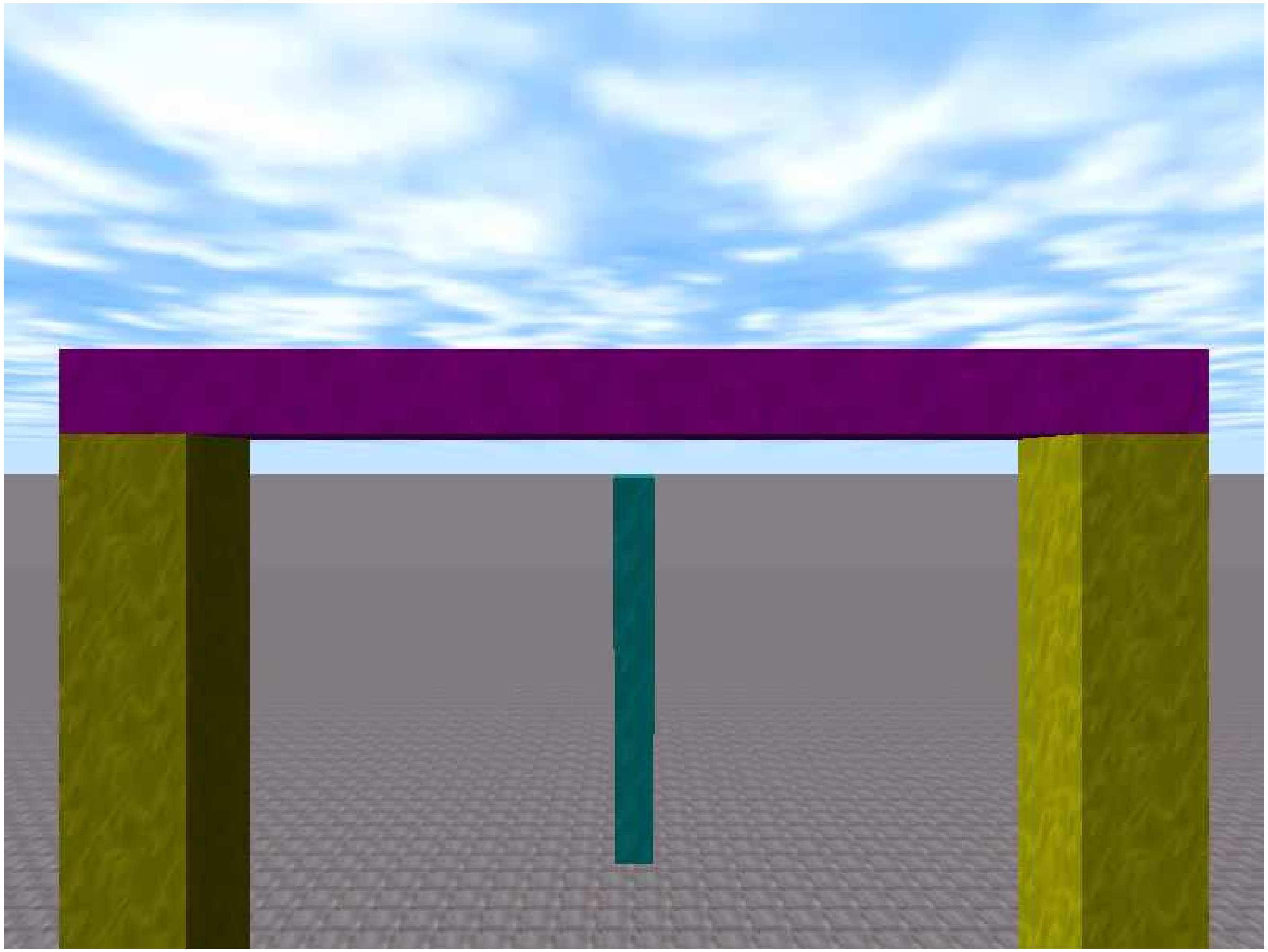
Open Dynamics Engine - ODE

Angular Motors and Joints:

Used to create

Vehicles and

Walking Robots



Open Dynamics Engine - ODE

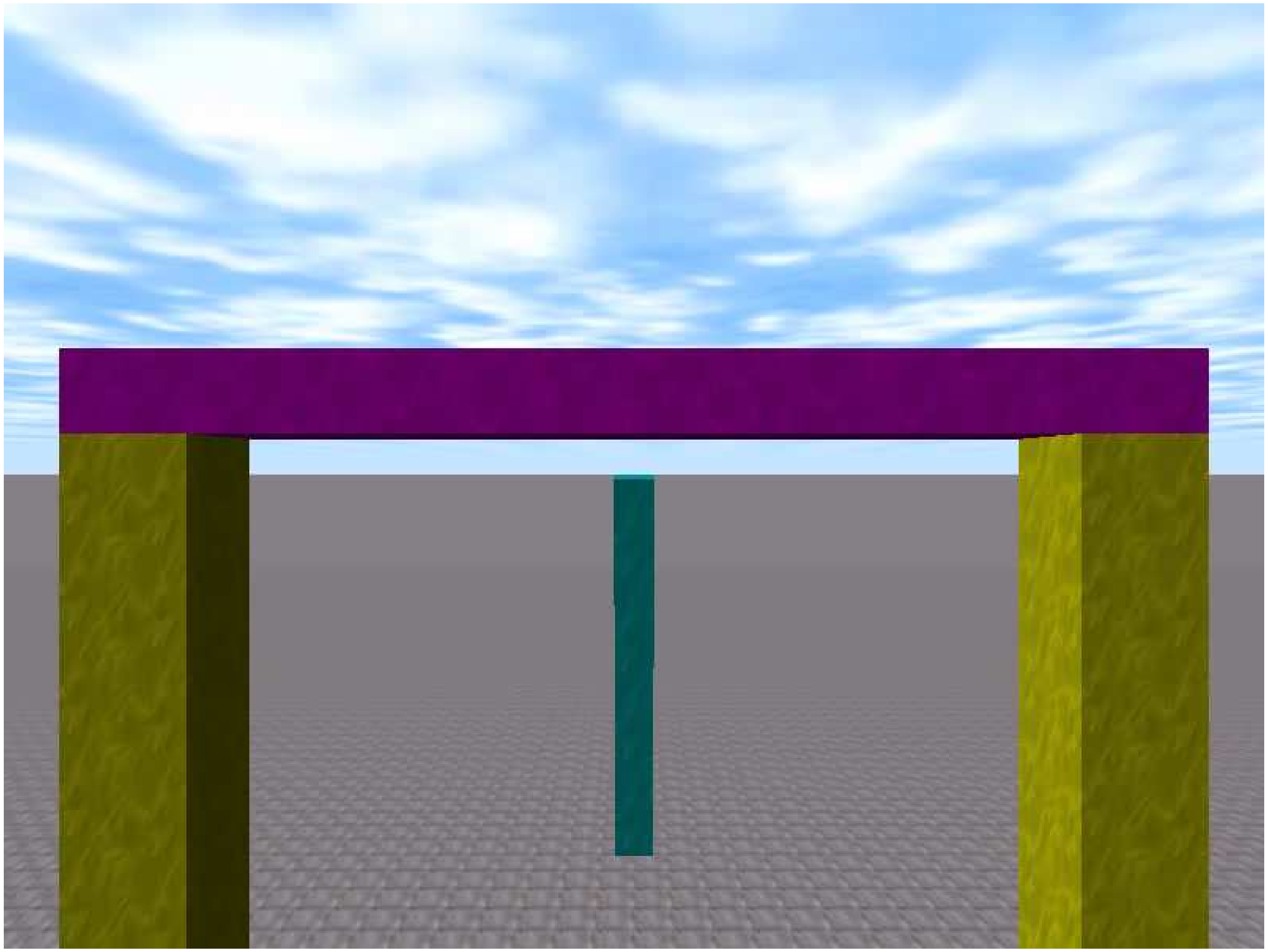
User controlled forces...

How to control the system:

Intelligent

Control

Simulation

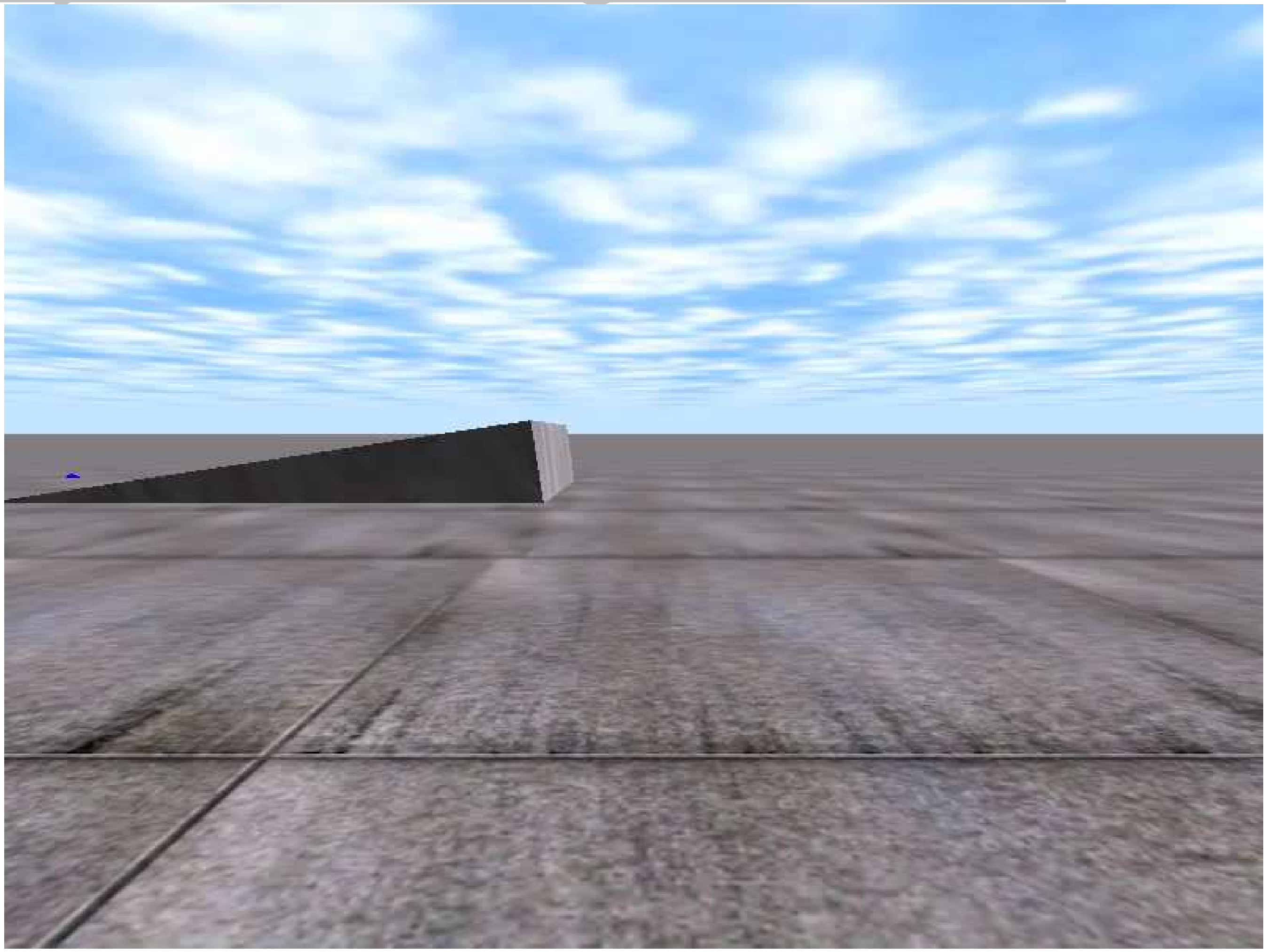


Open Dynamics Engine - ODE

Simulating
Realistic
Vehicles

Physics:
Kinematics +
Dynamics

Mobile Robots:
Sensors +
Actuators



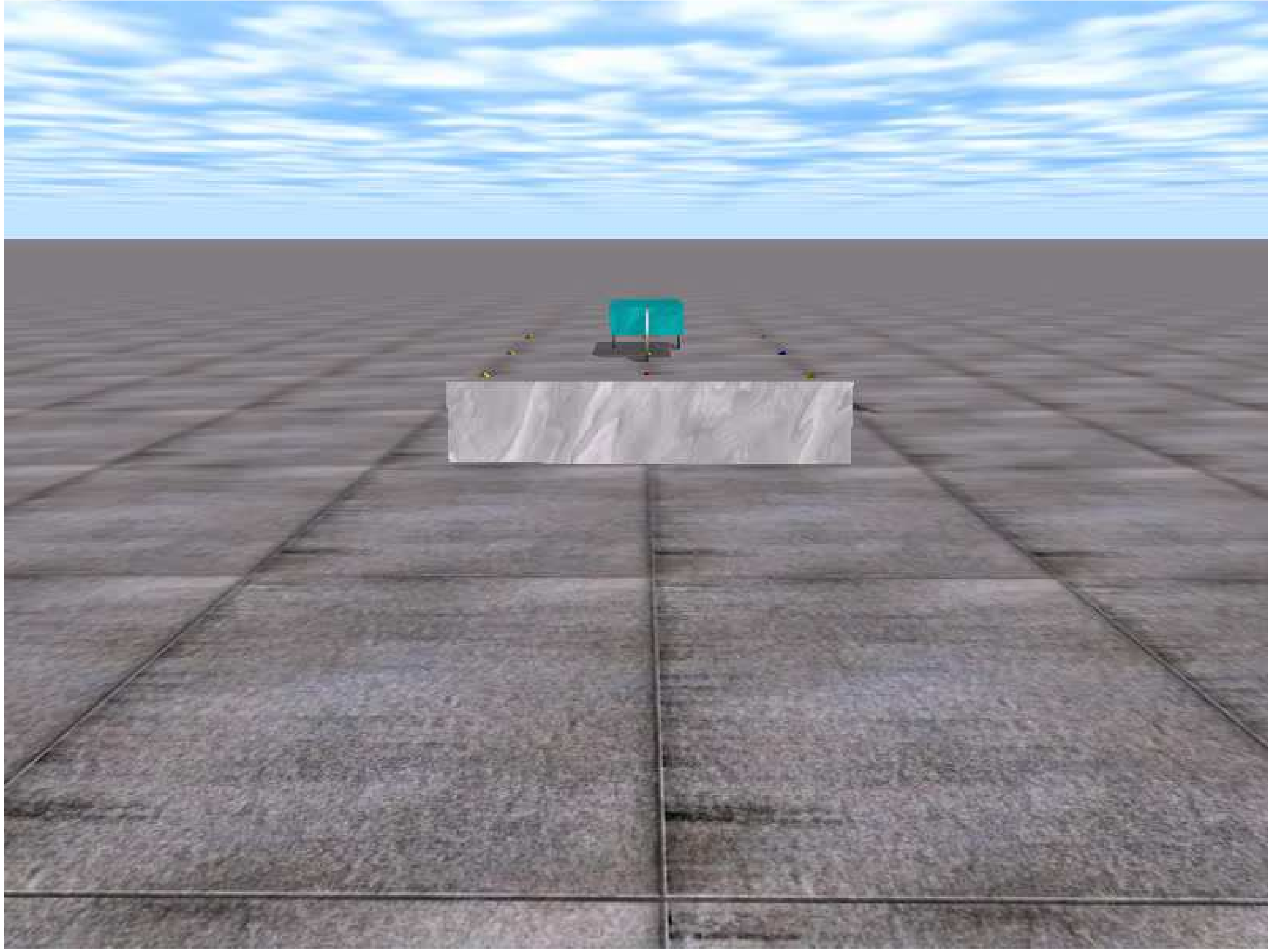
Open Dynamics Engine - ODE

Simulating
Realistic
Vehicles

Physics:
Kinematics +
Dynamics

Mobile Robots:
Sensors +
Actuators

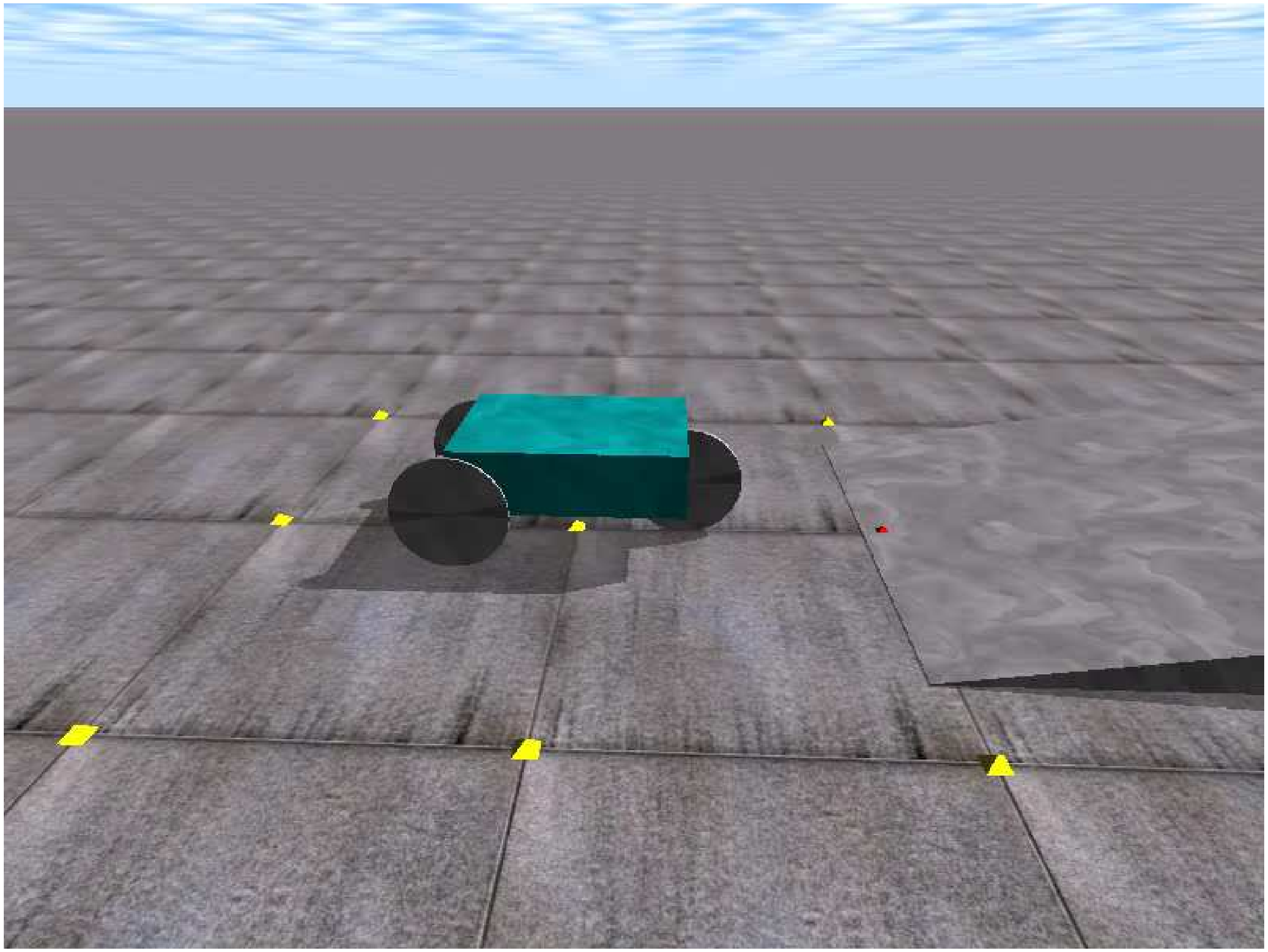
Other point of view



Open Dynamics Engine - ODE

Look the vehicle touching the ground...

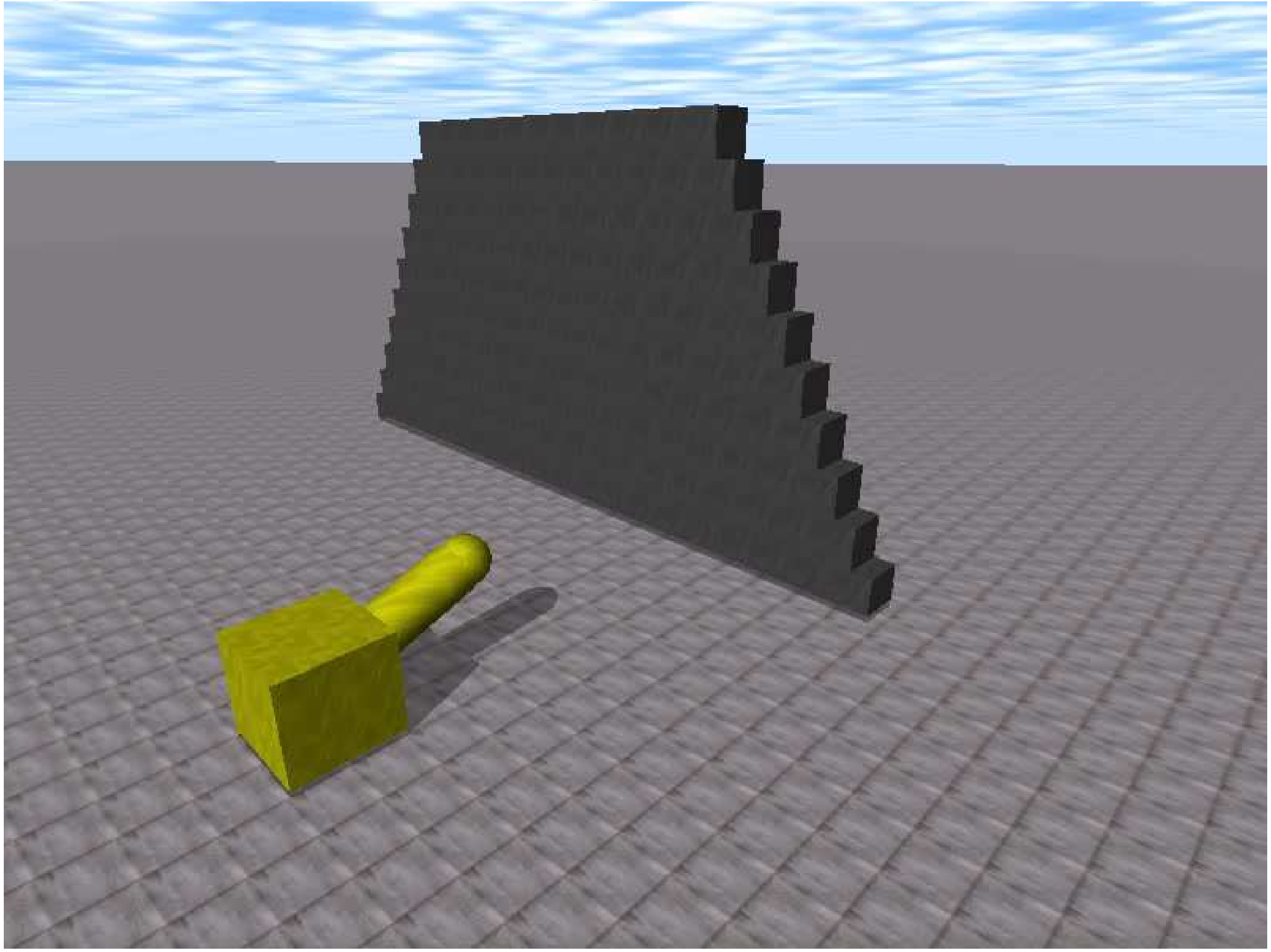
Seems realistic?



Open Dynamics Engine - ODE

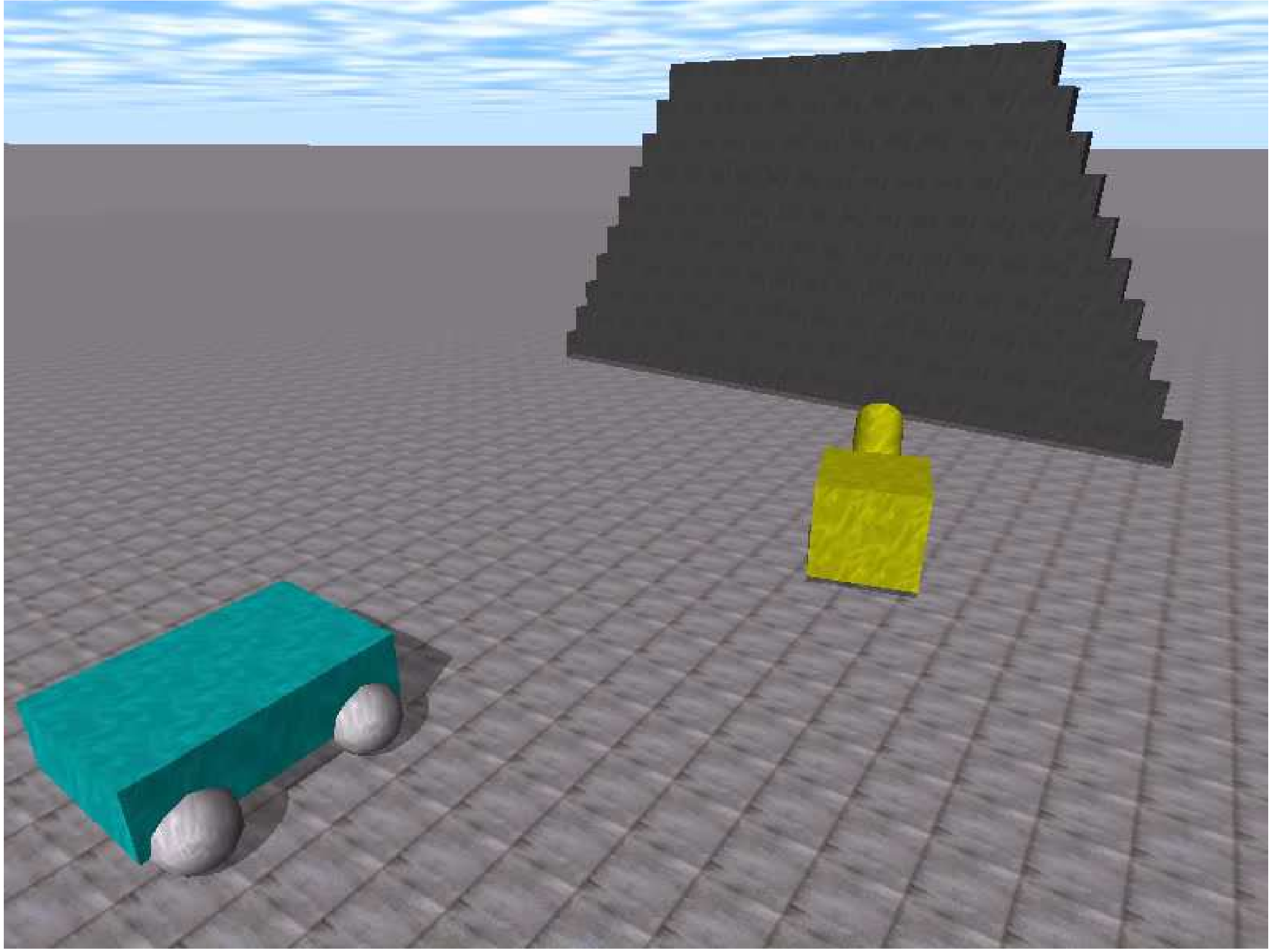
Virtual Simulation:

Collision with many objects



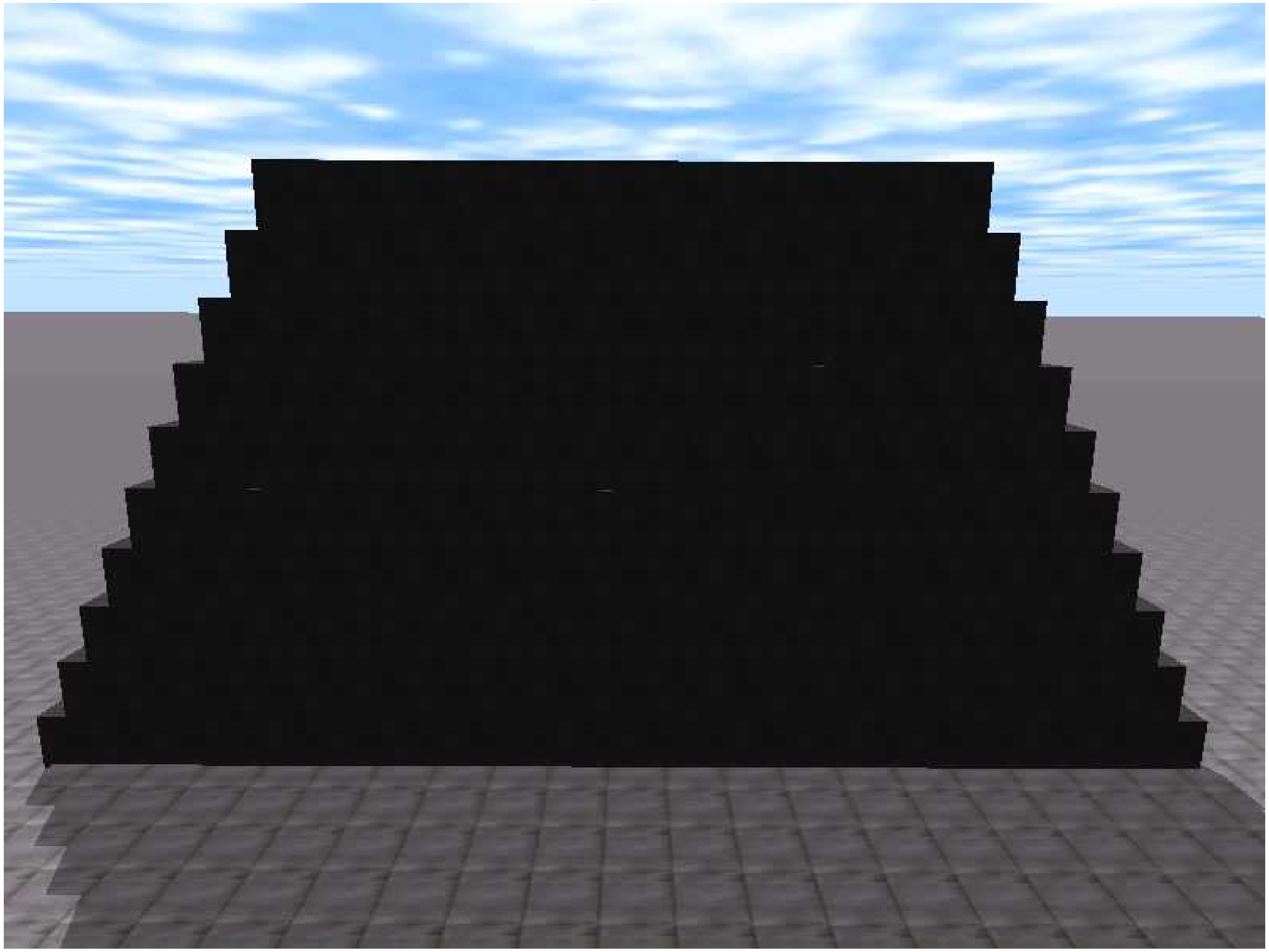
Open Dynamics Engine - ODE

Real-Time
Simulation
in a
Physically
Based
Virtual Reality
Environment



Open Dynamics Engine - ODE

From
an other
point of view...



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)
- Execute sequence of actions (act)
- Intelligent autonomous control techniques:
  - ⇨ Automata (FSA)
  - ⇨ Artificial Neural Networks
  - ⇨ Genetic Algorithms

Intelligent Control

VR Simulation - Practical Applications

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

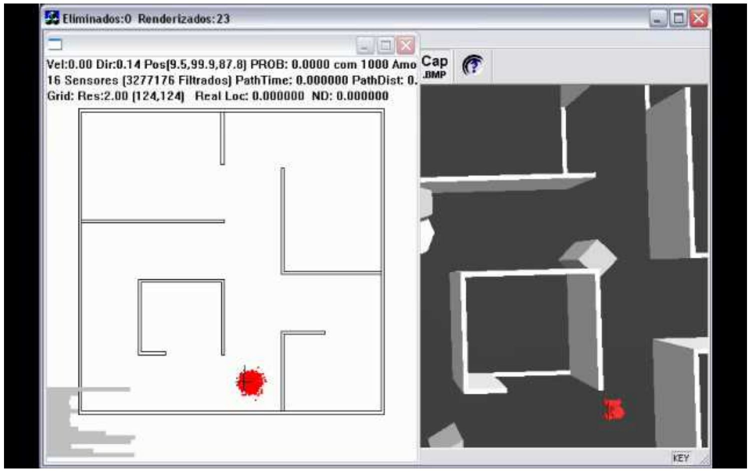
Intelligent VR Environment

3D SIMULATOR +
CONTROL ARCHITECTURES [Heinen 2002]

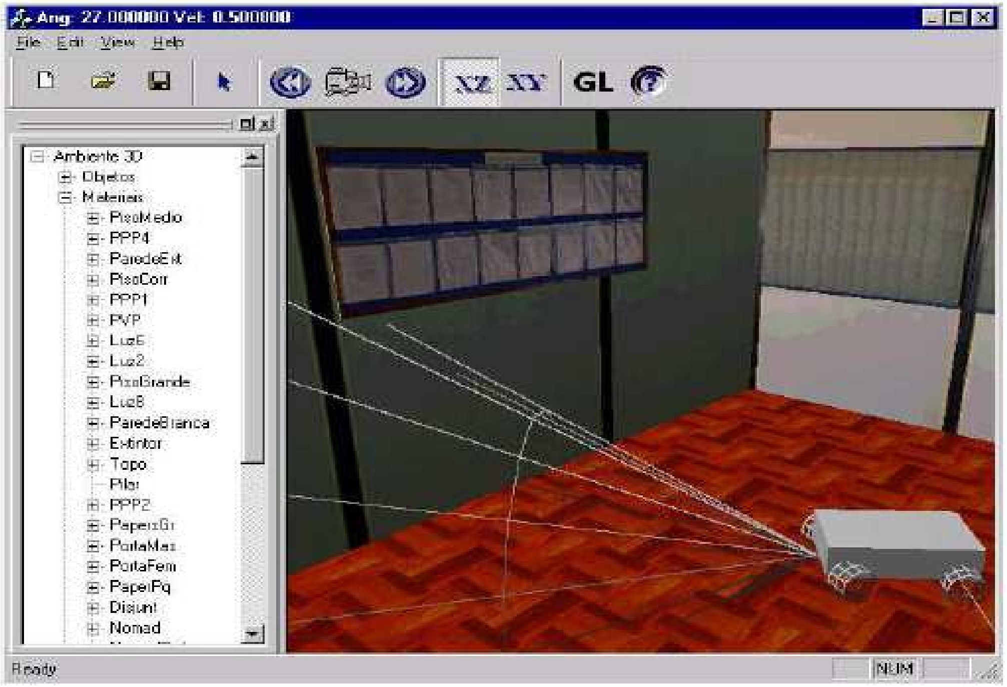
COHBRA: Integration of Perception, Action,

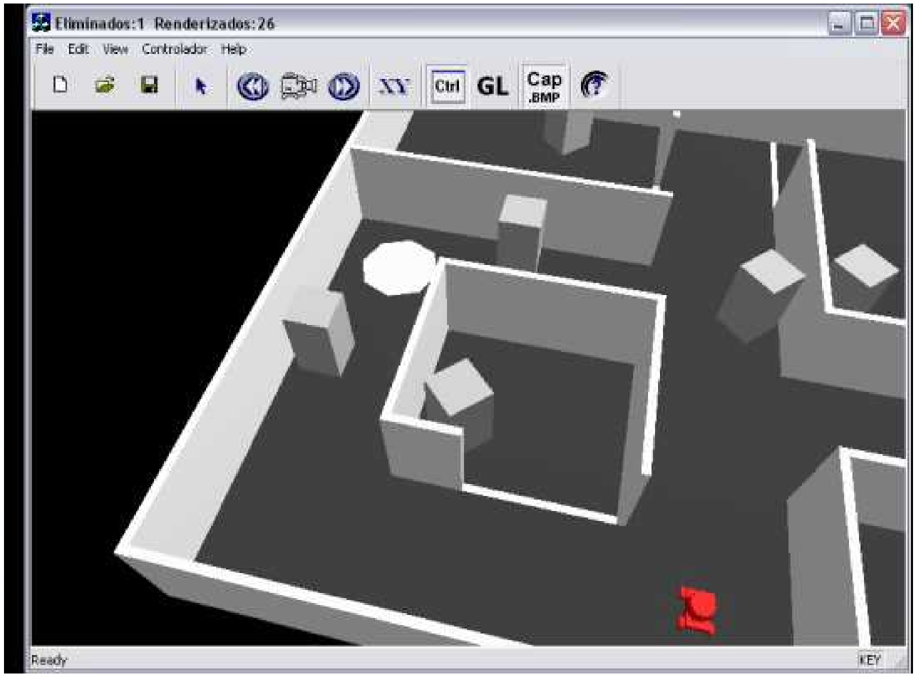
Sensor model, Kinematic Model, Maps and Planning

Hybrid Robotic Applications

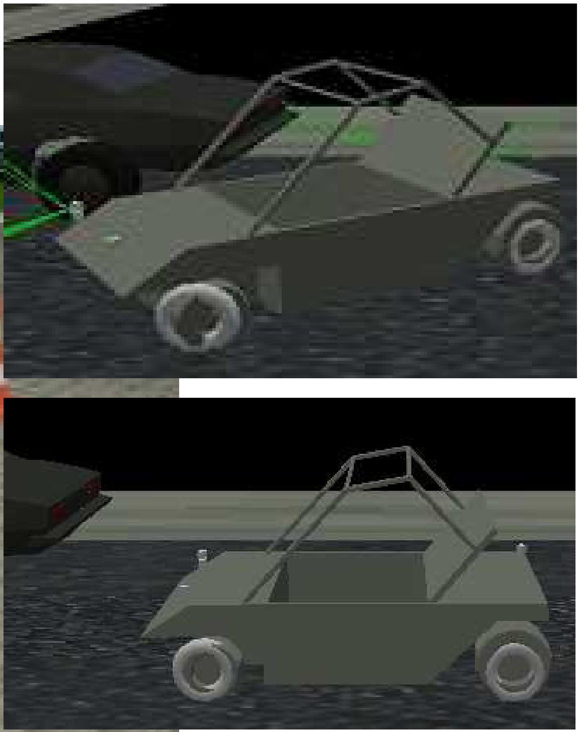


```
Vel:0.00 Dir:0.14 Pos(9.5,99.9,87.8) PROB: 0.0000 com 1000 Amo
16 Sensores (3277176 Filtrados) PathTime: 0.000000 PathDist: 0.
Grid: Res:2.00 (124,124)   Real Loc: 0.000000  ND: 0.000000
```

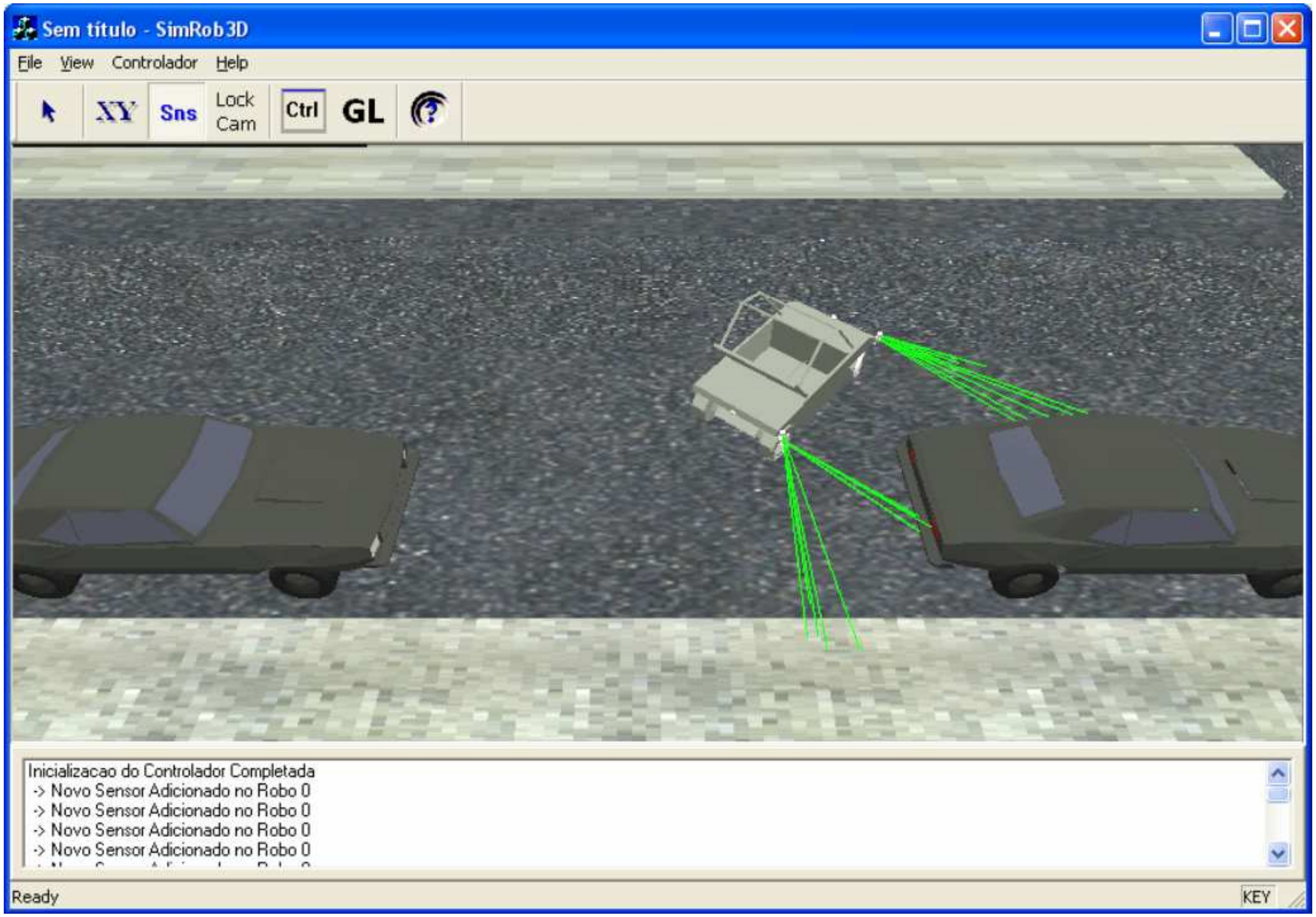




Modeled Vehicle



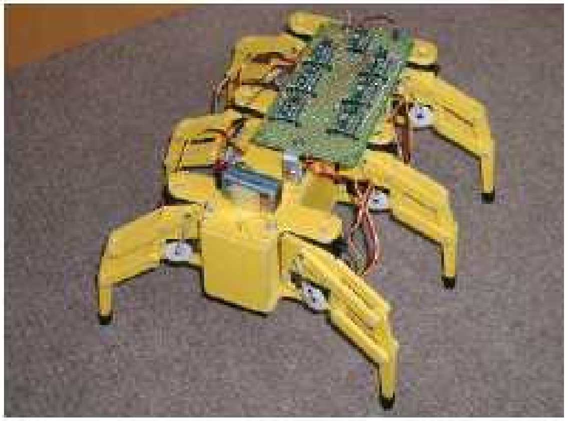
SEVA 3D Simulator



```
Inicializacao do Controlador Completeda
 -> Novo Sensor Adicionado no Robo 0
 -> Novo Sensor Adicionado no Robo 0
 -> Novo Sensor Adicionado no Robo 0
 -> Novo Sensor Adicionado no Robo 0
```

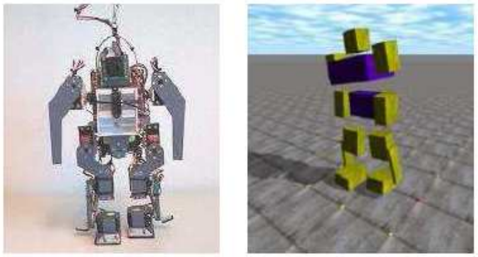
- 3DS modeled environment
- Sensorial Simulation Model
- Ackerman Kinematics
- Autonomous Control
- Automatic Parking

Autonomous Walking/Legged Robots

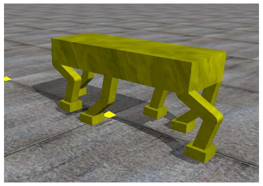


Robô Lynxmotion Hexapod II

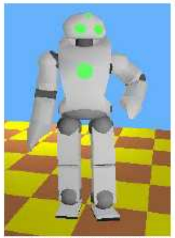
Robô Genghis-II



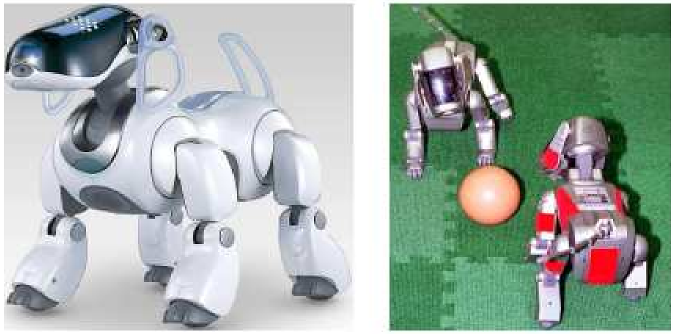
(a) Robô real (b) Robô simulado



The Sony Dream Robot in the real world

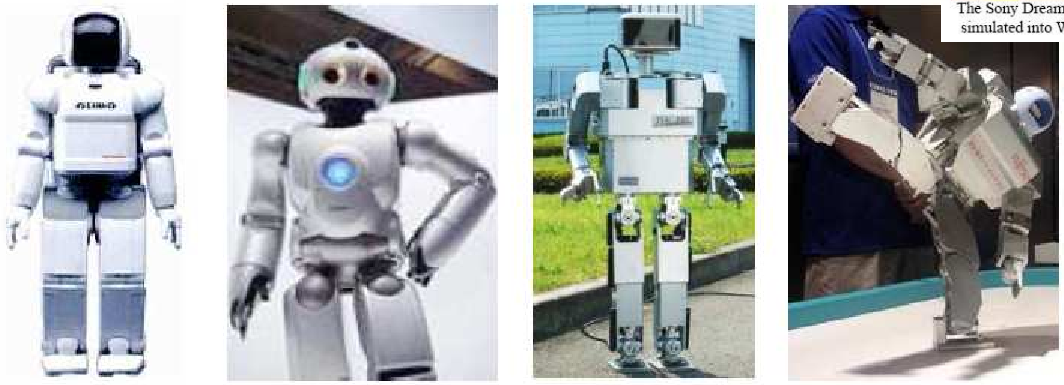


The Sony Dream Robot simulated into Webots



(a) (b)

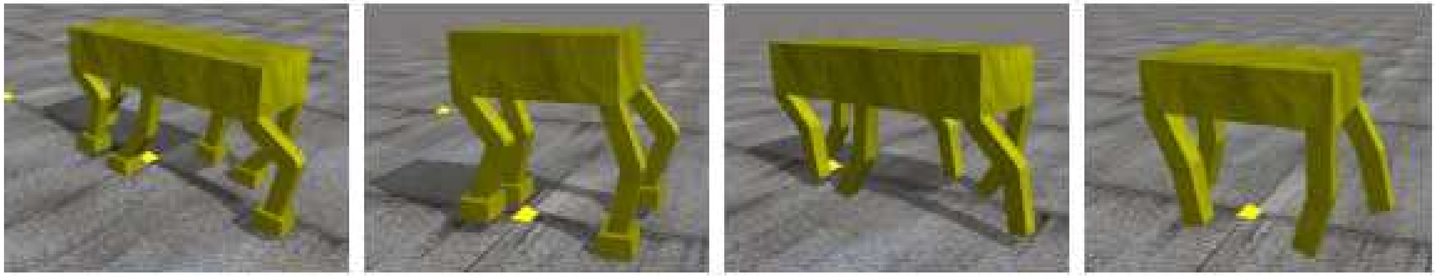
Figura 27: Modelos de Robôs Sony Aibo [95]



(a) Honda Asimo (b) Sony SDR-4X (c) Kawada H6 (d) Fujitsu HOAP-2

LegGen Simulator

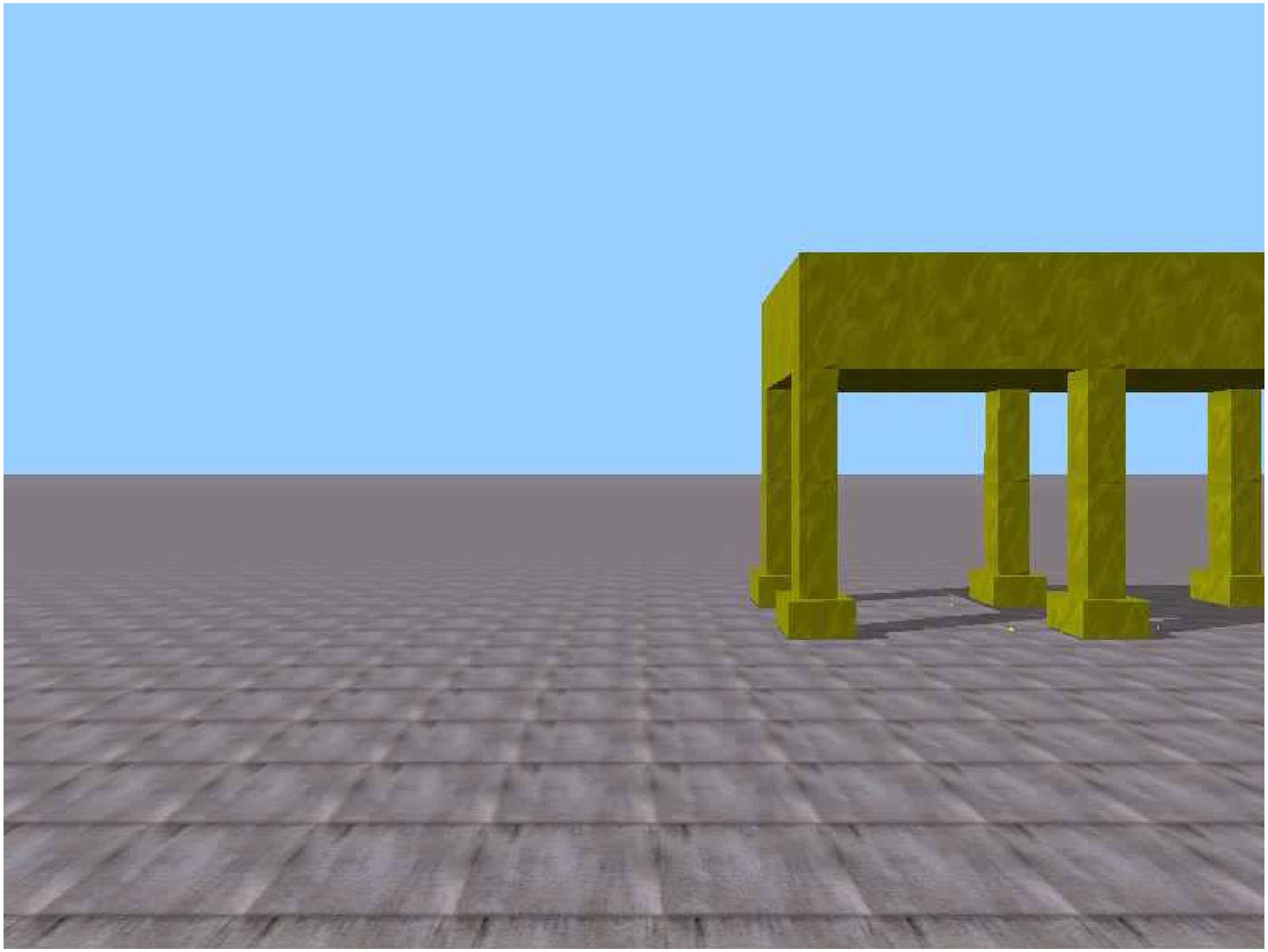
- Walking autonomous legged robots



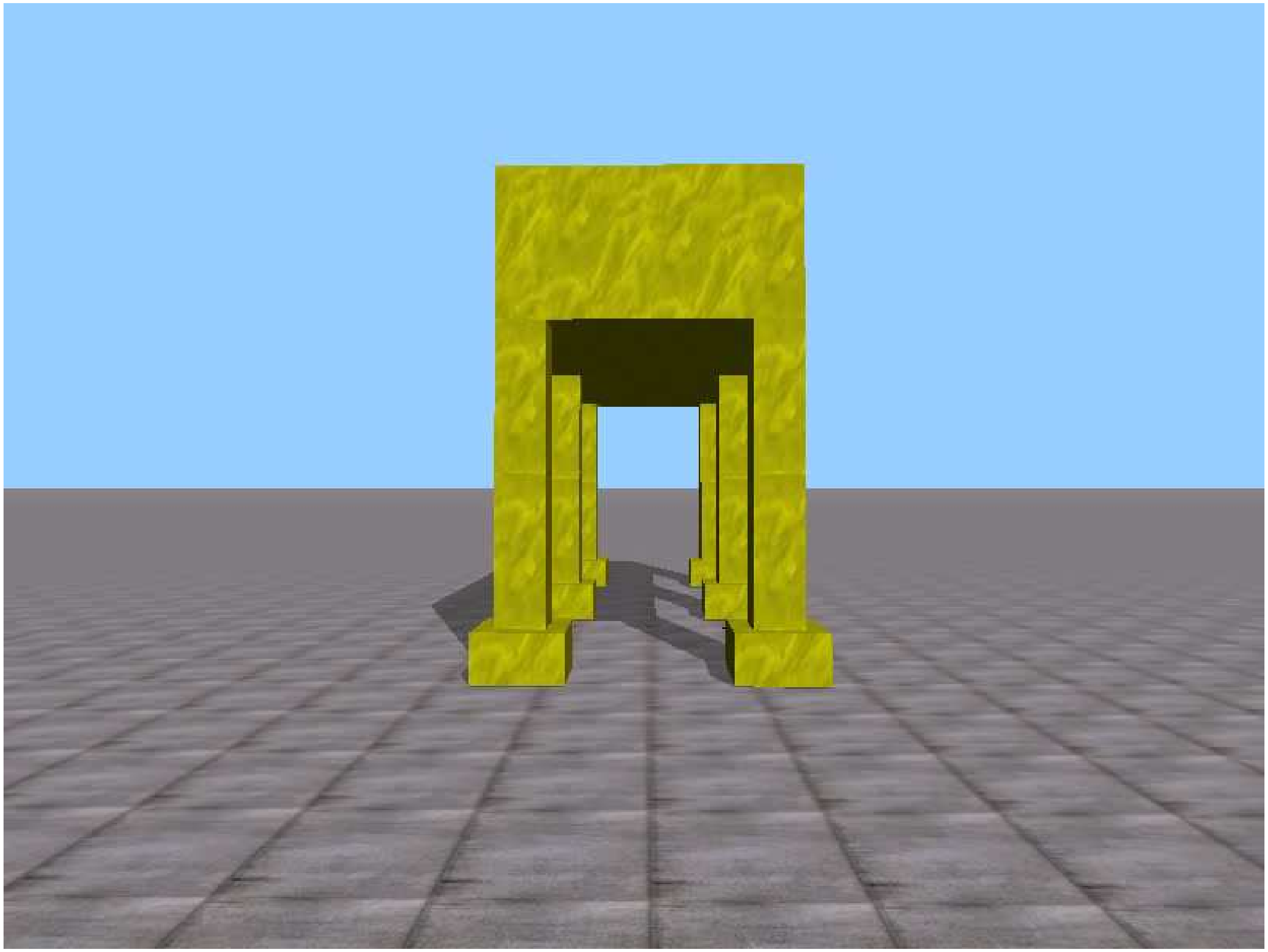
(a) HexaL3J (b) TetraL3J (c) HexaL2J (d) TetraL2J

- 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

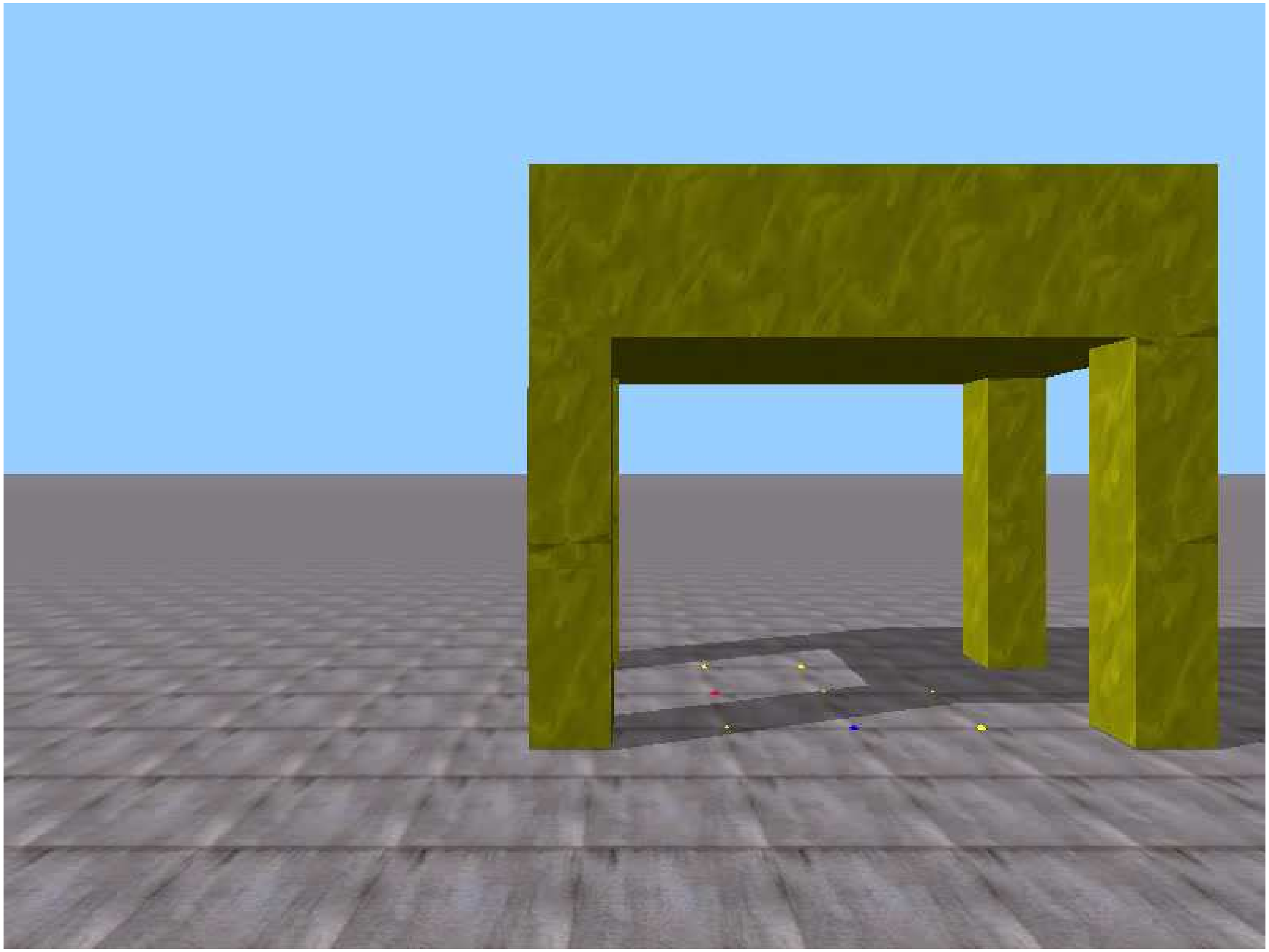
Obtained Results



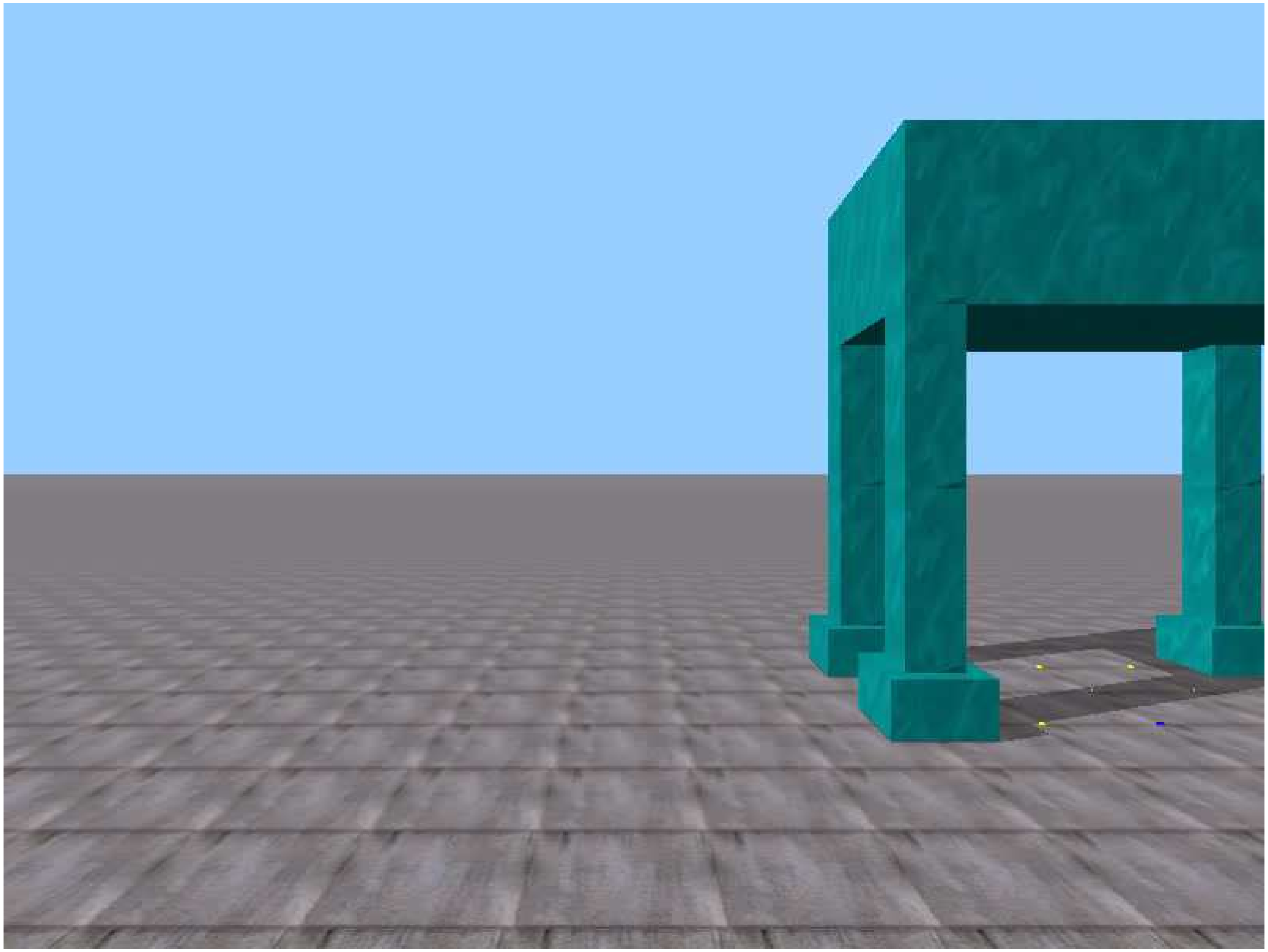
Obtained Results



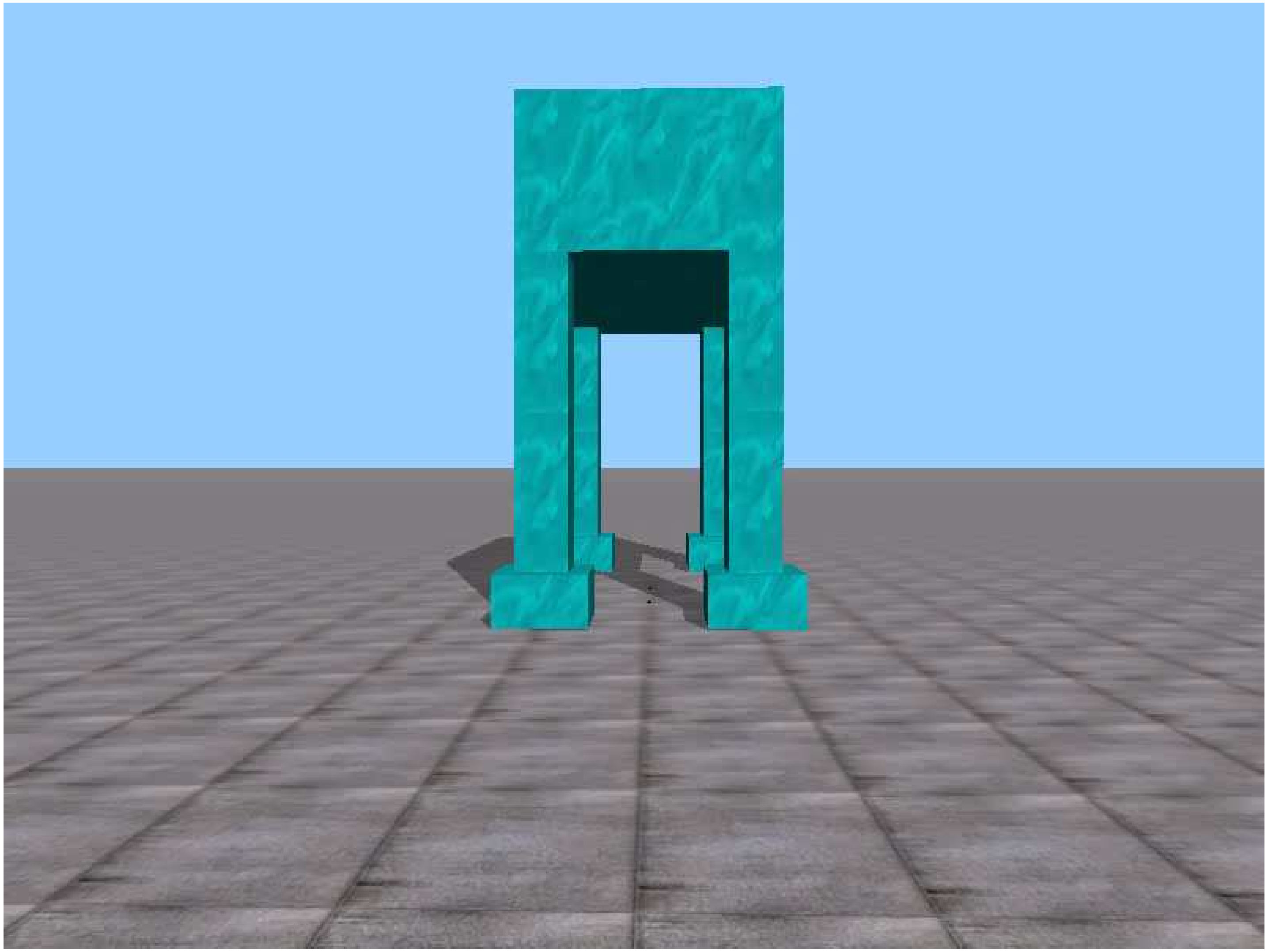
Obtained Results



Obtained Results



Obtained Results



Games

- Several games are being developed using the ODE library.
- One of them is the game FragFist
  - ⇨ Vídeo: ode-videos\fragfist_trailer_gc05.avi

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 (NVidea, 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

UNISINOS

UNIVERSIDADE DO VALE DO RIO DOS SINOS