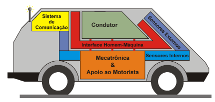
IEEE / DVP - Distinguished Visitors Program Latin America

Virtual Reality Applications based on Physical and Behavioral Simulation

Applied Computing Research Post-grad Program - PIPCA
UNISINOS University - Brazil

GRAPHIT - Computer Graphics and Vision Group (Unisinos/PUC-RS)
GPVA - Autonomous Vehicles Research Group (Unisinos)
GIA - Artificial Intelligence Research Group (Unisinos)
RBV - Rede Brasileira de Visualização [FINEP/Brazil]

Graphics, Vision and Image Processing
GRAPHIT



GPVA

GIA

RBV Rede Brasileira de Visualização

Prof. Dr. Fernando Osório - Applied Computing / Unisinos
Profa. Dra. Soraia Musse - Computing Science / PUC-RS
Prof. M.Sc. Farlei Heinen - Computing Eng. / Unisinos
M.Sc. Milton Roberto Heinen - Ph.D. Student at UFRGS
Prof. Dr. Christian Kelber - Electrical Eng. / Unisinos
Gustavo Pessin - M.Sc. Student at Unisinos

SEGURANÇA E DEFESA
RBV - FINEP

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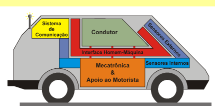

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SEGURANÇA E DEFESA
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Prof. *Fernando Santos Osório - IEEE Member*
Applied Computing Research Post-Graduation Program - PIPCA
UNISINOS University - Brazil (Porto Alegre - Southern Region)
IEEE DVP Program

UNISINOS

Created in 1969 by Jesuits
Now with:
- 30.000 Students
- 900 Professors
- 16 PPGs (post-grad programs)

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UNISINOS

IT Resources:
"Polo de Informática"
- Technological Park
- Hi-Tech Business Incubator

Undergraduate courses (4 years+):
- Computer Science (CS)
- Information Technology and Systems (IT)
- Computer Engineering (CE)
- Electrical Engineering (EE)

Technological courses (3 years):
- Digital Games and Entertainment
- IT Security
- Software Dev. and Quality Management

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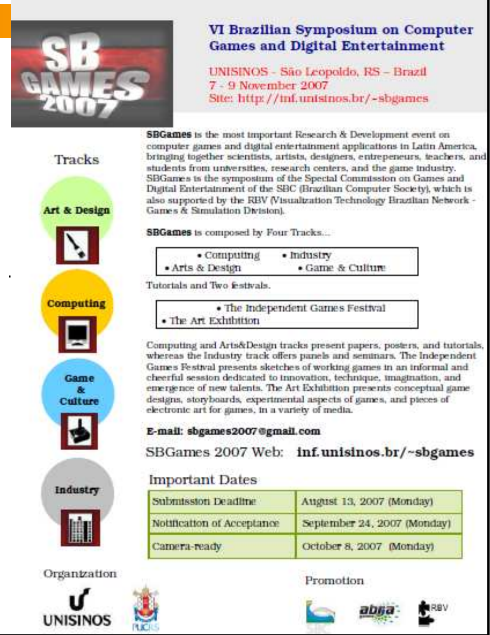
VI Brazilian Symposium on Computer Games and Digital Entertainment

Organized by
- Unisinos
- PUC-RS

Conference Chairs
- Soraia Musse
- Fernando Osório
- Christian Hofsetz
- João Ricardo Bittencourt
- Luiz Gonzaga Jr.



SB GAMES 2007

VI Brazilian Symposium on Computer Games and Digital Entertainment

UNISINOS - São Leopoldo, RS – Brazil
7 - 9 November 2007
Site: http://inf.unisinos.br/~sbgames

Tracks: Art & Design, Computing, Game & Culture, Industry

SBGames is the most important Research & Development event on computer games and digital entertainment applications in Latin America, bringing together scientists, artists, designers, entrepeneurs, teachers, and students from universities, research centers, and the game industry. SBGames is the symposium of the Special Commission on Games and Digital Entertainment of the SBC (Brazilian Computer Society), which is also supported by the RBV (Visualization Technology Brazilian Network - Games & Simulation Division).

SBGames is composed by Four Tracks...

- Computing
- Industry
- Arts & Design
- Game & Culture

Tutorials and Two festivals.

- The Independent Games Festival
- The Art Exhibition

Computing and Arts&Design tracks present papers, posters, and tutorials, whereas the Industry track offers panels and seminars. The Independent Games Festival presents sketches of working games in an informal and cheerful session dedicated to innovation, technique, imagination, and emergence of new talents. The Art Exhibition presents conceptual game designs, storyboards, experimental aspects of games, and pieces of electronic art for games, in a variety of media.

E-mail: sbgames2007@gmail.com

SBGames 2007 Web: **inf.unisinos.br/~sbgames**

Important Dates

Submission Deadline	August 13, 2007 (Monday)
Notification of Acceptance	September 24, 2007 (Monday)
Camera-ready	October 8, 2007 (Monday)

Organization: UNISINOS, PUCRS

Promotion: abeja, RBV

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Presentation Topics

Agenda:

1. **Introduction: VR - Hierarchy of Models**
2. **VR and Simulation**
   Geometry, Physics, Behaviour, Knowledge and Cognition
3. **Physics Simulation Tools**
   Opensteer, ODE, PhysX, Deformable/Dynamic
4. **Intelligent Behaviour**
   Agents: Perception, Action, Behaviour
   Autonomous Agents - Control
   Multi-Agents Systems - Knowledge
5. **Applications: VR Simulation Tools**
6. **Conclusions and New Trends**

Vídeo Demo Web/Java

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Introduction VR - Virtual Reality

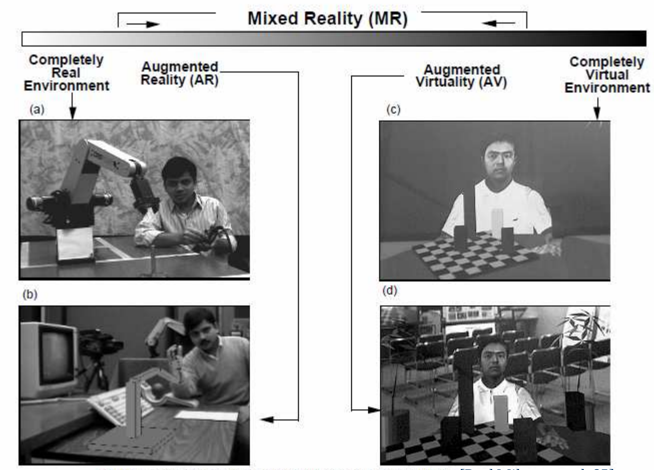

Figure 1: Schematic representation of Reality-Virtuality (RV) Continuum [Paul Milgram et al. 95]
AR and AV are special cases of MR, within the RV continuum, shown along the top

Introduction VR - Virtual Reality

From REAL to VIRTUAL
3D + Immersion + Interaction

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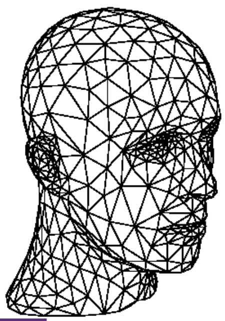
Virtual Reality

Introduction VR - Virtual Reality

3D Visualization

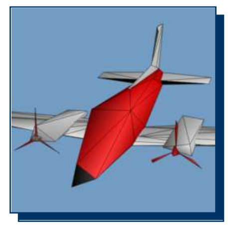
3D World Recreated:

3D Coordinate System - Axes X, Y, Z



- Create 3D objects
  - Position, Scale, Orientation
  - Color, Texture, Light
  - Mesh of polygons
    (faces = polygons)
- "Virtual camera"

\PPT-Demos\obj-3d



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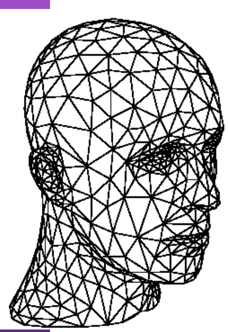
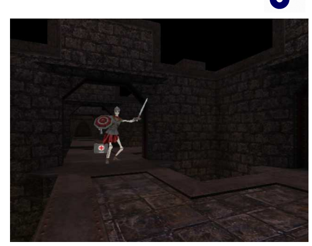


- Create 3D objects
  - Position, Scale, Orientation
  - Color, Texture, Light
  - Mesh of polygons
    (faces = polygons)
- "Virtual camera"

\PPT-Demos\Labirinto
\PPT-Demos\Castle



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Virtual Reality

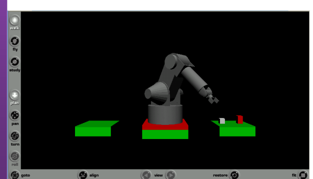
Introduction VR - Virtual Reality

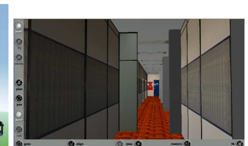
VISUALIZING 3D & VIRTUAL ENVIRONMENTS

Virtual Reality...

* **VRML** - 3D Worlds (Geometry)
* **QTVR** - Panorama 3D (Images)

\VRML





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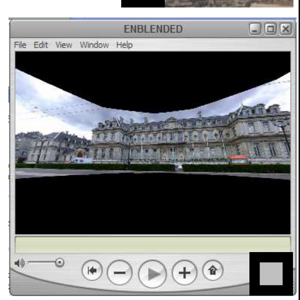
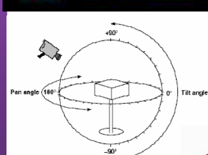
\QTVR





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Augmented Reality

Real World Integrated with Virtual Objects

ARTool Kit

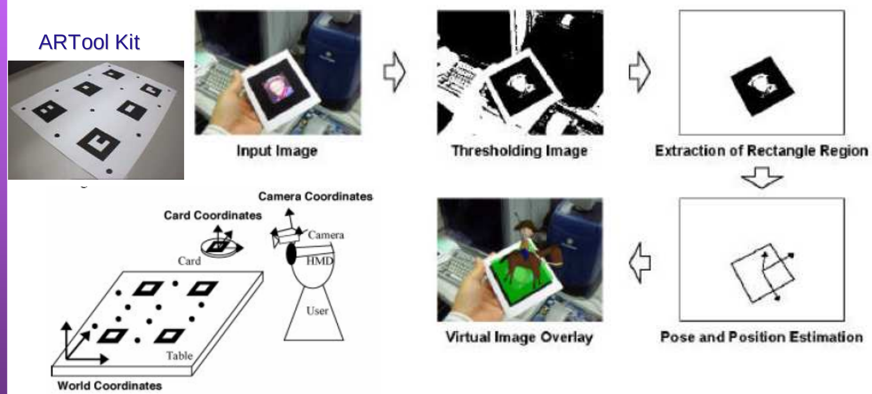

Figure 4: The Vision-Based AR Tracking Process
http://www.hitl.washington.edu/artoolkit/

Augmented Reality: ARToolkit - Positioning 3D Objects using references obtained with a camera (webcam)

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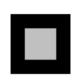
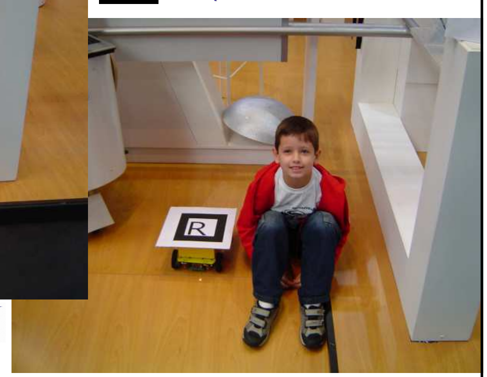
Augmented Reality

Real World Integrated with Virtual Objects



\ARToolKit2.65vrml\bin
simpleVRML.exe
simple.exe



ARTool Kit

Augmented Reality

Real World Integrated with Virtual Objects

IRISA / INRIA - France
http://www.irisa.fr/lagadic/demo/demo-ar3/demo-ar3-eng.html

Virtual Reality

VISUALIZING 3D & VIRTUAL ENVIRONMENTS

Virtual Reality...

- **3D Virtual Environment**
- **Interaction**
- **Immersion**
- **Realism**

Virtual Reality

VISUALIZING 3D & VIRTUAL ENVIRONMENTS

Virtual Reality...

*** 3D Virtual Environment**

*** Interaction => Virtual Reality Devices**

*** Immersion => Virtual Reality Devices**

*** Realism => Graphical Realism (photo-realism)**

Movements

Interaction Real x Virtual

"Physics Realism"

Virtual Reality

VISUALIZING 3D & VIRTUAL ENVIRONMENTS

Virtual Reality...

*** 3D Virtual Environment**

*** Interaction => Virtual Reality Devices**

*** Immersion => Virtual Reality Devices**

*** Realism => Graphical Realism (photo-realism)**

Movements

How to do it?

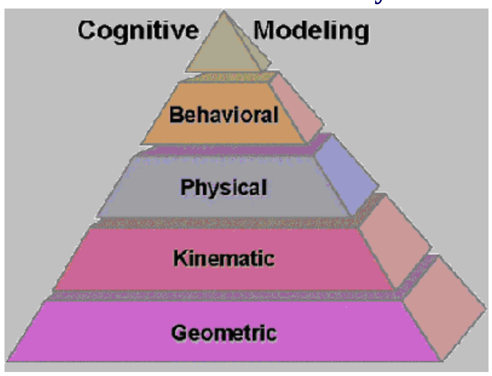
Interaction Real x Virtual

"Physics Realism"

1. Introduction

Sources of Inspiration:

3D Virtual Worlds - Hierarchy of Models



[Funge 1999]

1. Introduction

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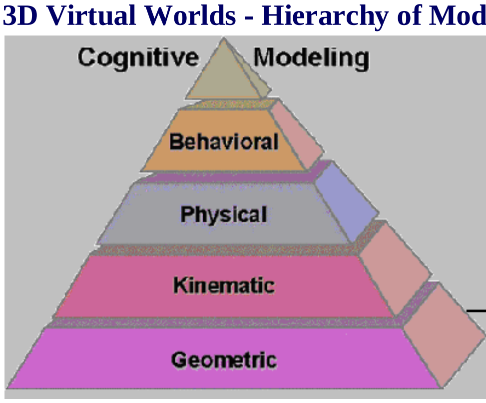
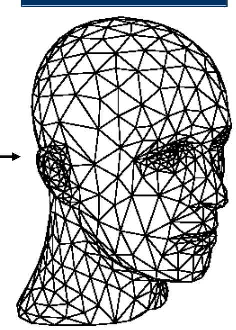
3D Virtual Worlds - Hierarchy of Models





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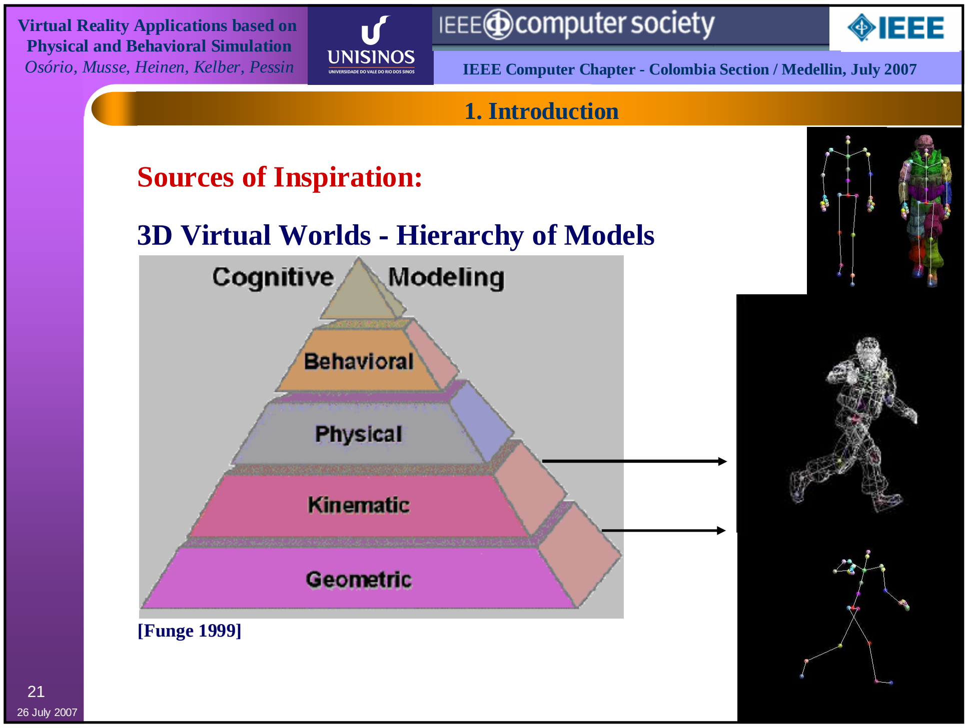
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1. Introduction
Sources of Inspiration:
3D Virtual Worlds - Hierarchy of Models
Cognitive Modeling
Behavioral
Physical
Kinematic
Geometric
[Funge 1999]
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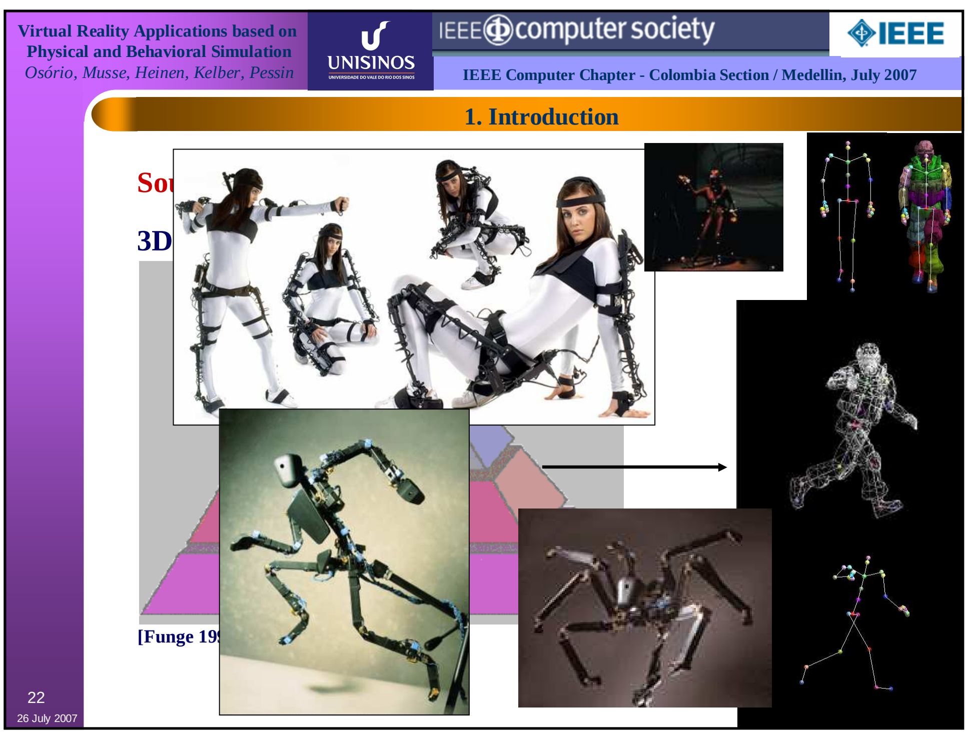
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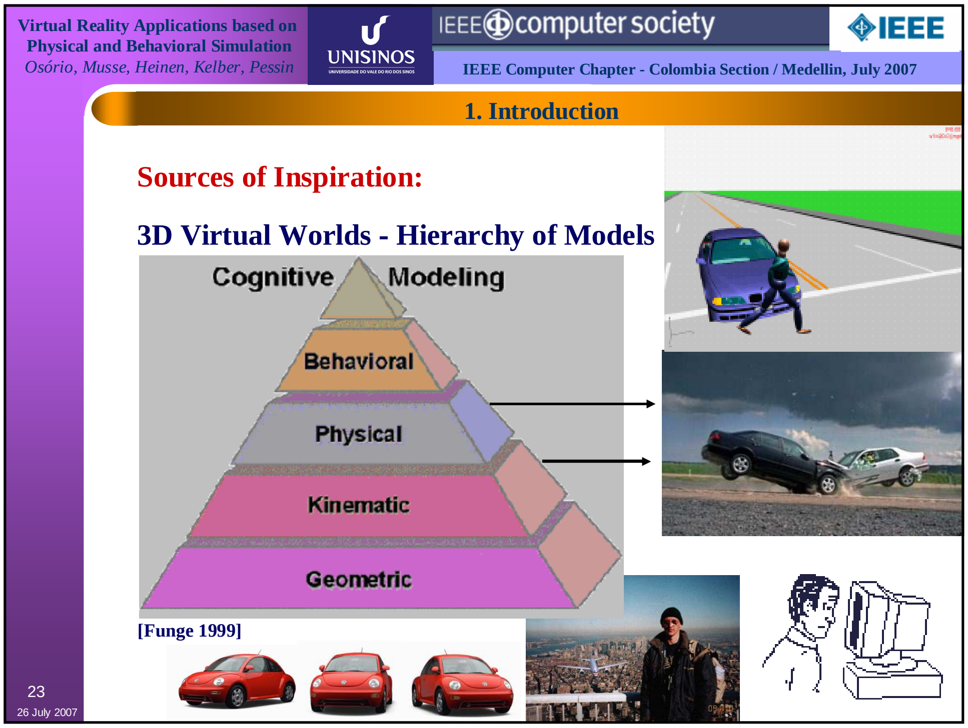
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[Funge 1999]
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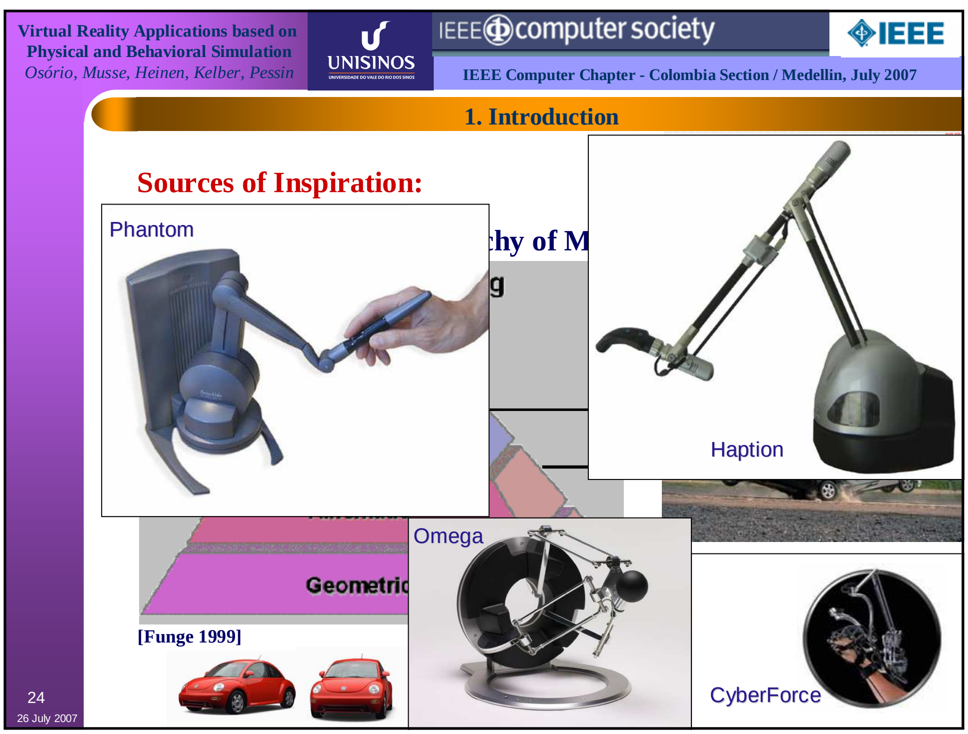
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Sources of Inspiration:
Phantom
Haption
Omega
CyberForce
[Funge 1999]
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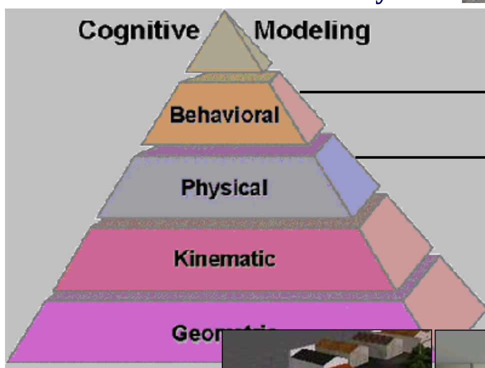
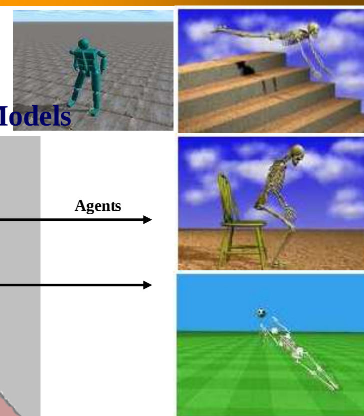
1. Introduction

Sources of Inspiration:

3D Virtual Worlds - Hierarchy of Models

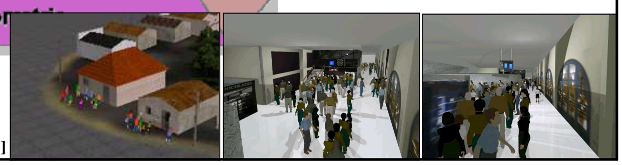


Agents



[Ari Chapiro - Dance]

[Funge 1999]



[CromosLab]

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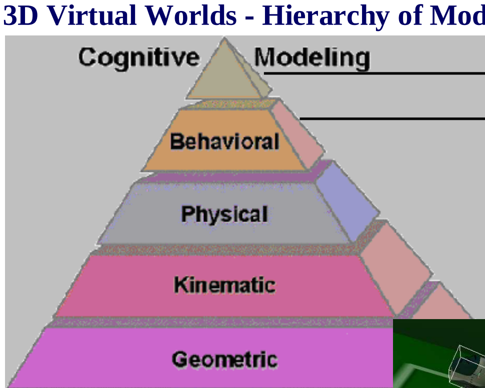
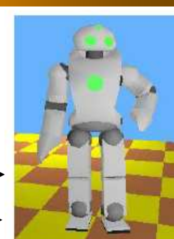
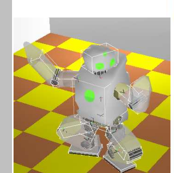
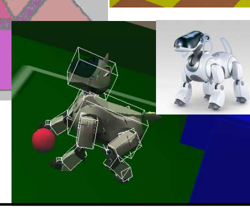




The Sony Dream Robot simulated into Webots

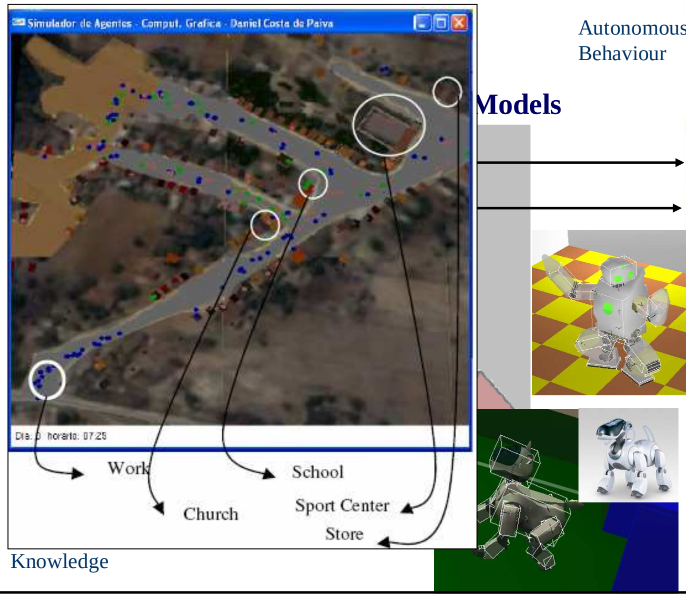




The Sony Dream Robot in the real world

[Funge 1999]

1. Introduction



The Sony Dream Robot simulated into Webots

The Sony Dream Robot in the real world

2. VR and Simulation

Sources of Inspiration:

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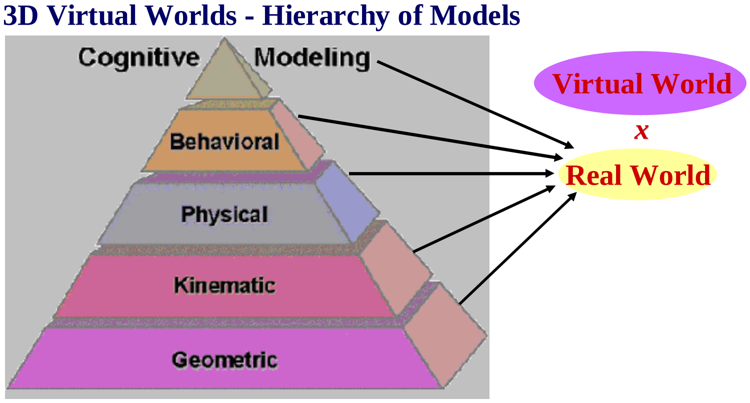

[Funge 1999]

Presentation Topics

Agenda:

Vídeo Demo Web/Java

Virtual Reality Applications based on Physical and Behavioral Simulation
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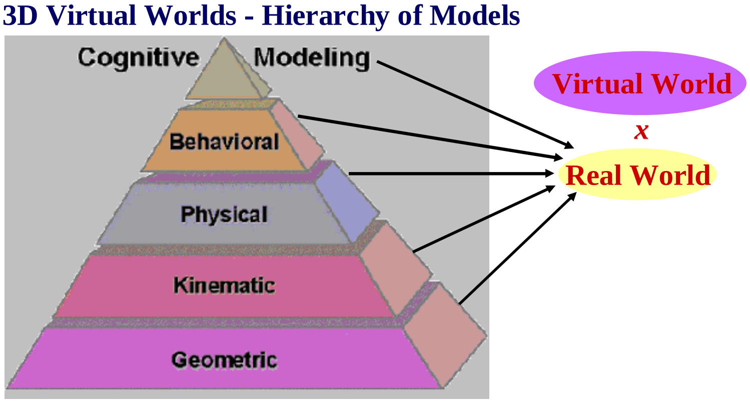

[Funge 1999]

Increasing Reality in VR Applications: Physical and Behavioral Simulation

Virtual Reality Applications based on Physical and Behavioral Simulation
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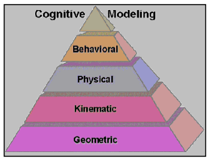
Realistic VR



Virtual World
x
Real World

From Simple VR Visualization Tools to Realistic VR Simulation Tools

Visualization	**Geometry** [3D Meshes]	Static Objects Animated Objects (Key-Frame)
Simulation of Motion	**Physics** [3D Objects]	Rigid Body (Physically based) Kinematics (Movement) Collision (Solid Objects) Collision Response Articulations Particles (Fire, Smoke, Water) Springs (Mass-spring Systems) Deformable Objects (Cloths, Elastic, Fluids) External Forces: Interaction Interaction Object x Object Interaction Camera x Object Interaction User x Object Interactive Control
Simulation of Behavior	Artificial Intelligence **"Simple A.I."** **Behavior** [Agents] [Characters]	Agents Control Scripts Finite State Automata (FSA) Perception (Sensorial) Action (Motor) Control: Reactive Control: Deliberative Control: Modular / Hybrid Memory, Beliefs, Intentions,... Biomechanics Simple Autonomous Agents
Simulation of Intelligent Behavior	Artificial Intelligence **"Advanced A.I."** **Cognitive** [Autonomous Agents] [Multi-Agents]	Knowledge Reasoning Cognition Communication Cooperation Coordination Adaptation: Learning, Optimization, Evolution Robust Autonomous Agents

: **Models and Components of a Virtual Reality Environment applied into Realistic Simulations**

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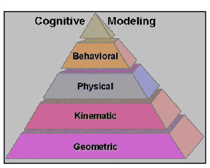
Realistic VR



Virtual World
x
Real World

Real World Simulation

From Simple VR Visualization Tools to Realistic VR Simulation Tools

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: **Models and Components of a Virtual Reality Environment applied into Realistic Simulations**

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3. Physics Simulation Tools

Simulation Tools:

1. OpenSteer

2. ODE - Open Dynamics Engine

3. PhysX AGEIA

4. Deformable Objects and Fluids:
- **Finite Elements Methods**
- **Spring-Mass Systems**
- **CFD (Computational Fluid Dynamics)**
- **Level Set Methods**

VR Simulation: Some important questions...

3. Physics Simulation Tools

Simulation Tools:

1. OpenSteer

2. ODE - Open Dyna

3. PhysX AGEIA

4. Deformable Objet
- **Finite Elements I**
- **Spring-Mass Sys**
- **CFD (Computati**
- **Level Set Methods**

Physics:

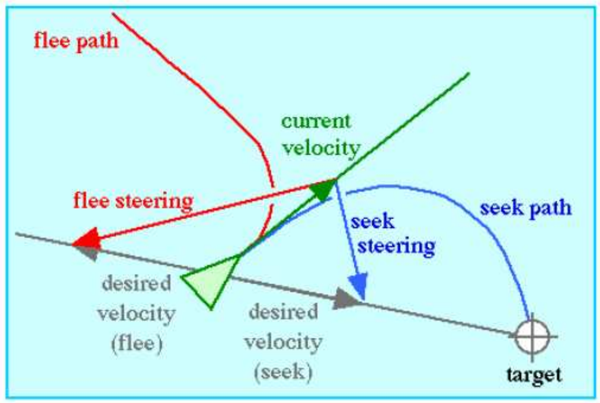
Physical structure: resistance, mass, density, elasticity;
Position and orientation in the 3D space;
Kinematics and Dynamics;
Linear and angular velocities;
Motion (w/ forces and torques), trajectories;
Acceleration, deceleration;
Attraction and repulsion;
Gravity, friction, inertia;
Kinetic and potential energy;
Laws of energy conservation, linear and angular momentum;
Collisions and reaction to collisions;
Steering models (wheeled cars, aircrafts, projectiles, boats and ships);
Articulated Rigid Bodies Simulation (skeleton, robotic arm);
Dynamic Simulation of Deformable Objects: elastic objects;
Fluid simulation and Particle Systems (fire, smoke, clouds and liquids).

VR Simulation: Some important questions...

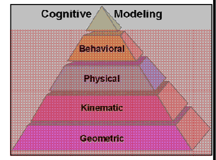
3. Physics Simulation Tools

1. OpenSteer [Reynolds]

Simple steering behaviours



Seek and Flee Behaviour in OpenSteer [Reynolds 1999]



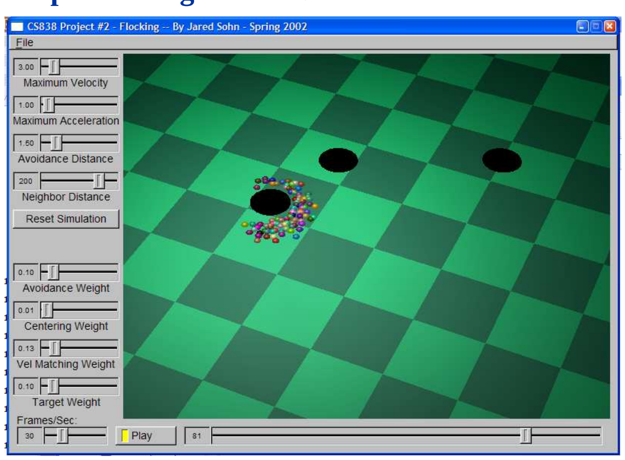
Geometric: Simple
Kinematic: Simple
Physical: Simple
Behavioural: Simple

Steering Behaviour
Group Behaviour

3. Physics Simulation Tools

1. OpenSteer / Boids

Simple steering behaviours



3. Physics Simulation Tools

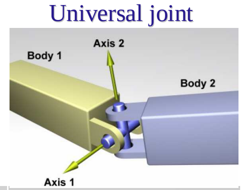
2. ODE - Open Dynamics Engine

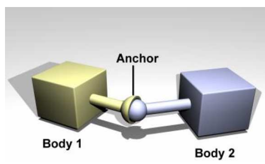
Simulation of Articulated Rigid Body Dynamics

Open Source Library (C/C++ API)

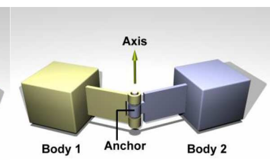
Used with OSG, Ogre3D, CrystalSpace, ...

Universal joint

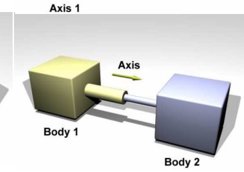




Ball and socket joint



Hinge joint



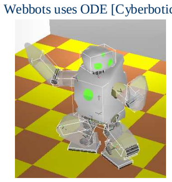
Slider joint

3. Physics Simulation Tools

2. ODE - Open Dynamics Engine

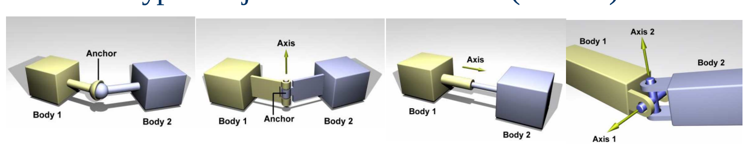
Simulation of Articulated Rigid Body Dynamics

Webbots uses ODE [Cyberbotics]



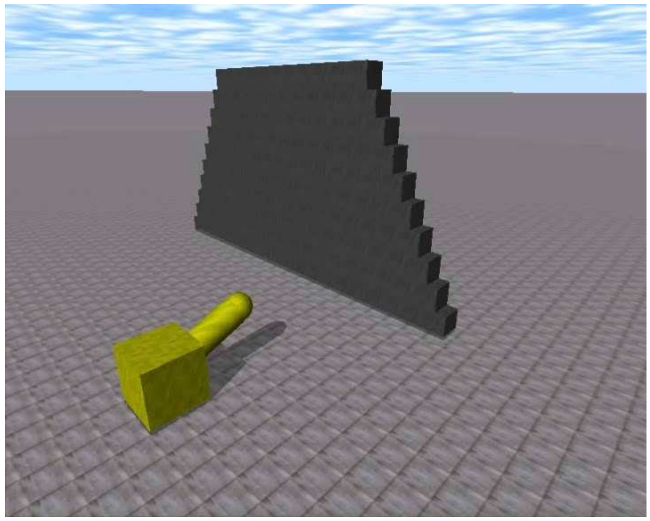
Physics Simulation:

- Gravity, friction, acceleration, deceleration;
- Generation of motion: applying forces and torques (motors);
- Collision avoidance and treatment (reaction, object bounce);
- Kinematics models and rigid body dynamics simulation;
- Different types of joints with actuators (motors)



3. Physics Simulation Tools

2. ODE - Open Dynamics Engine



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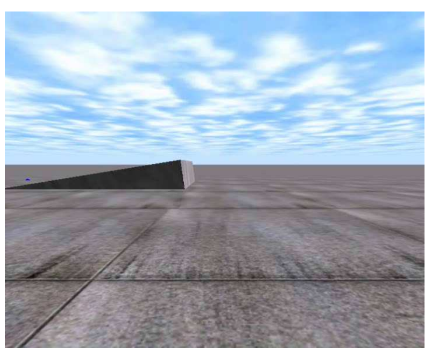
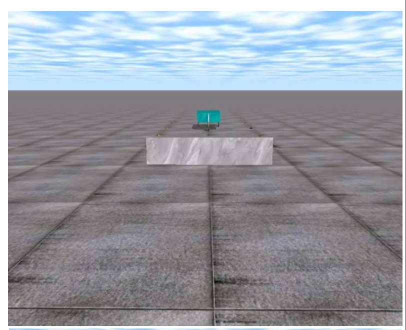
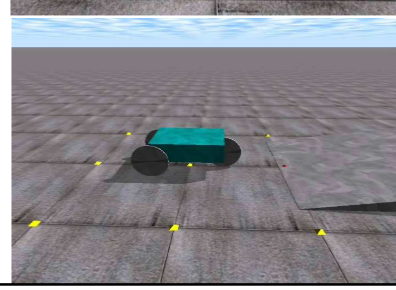
3. Physics Simulation Tools

2. ODE - Open Dynamics Engine

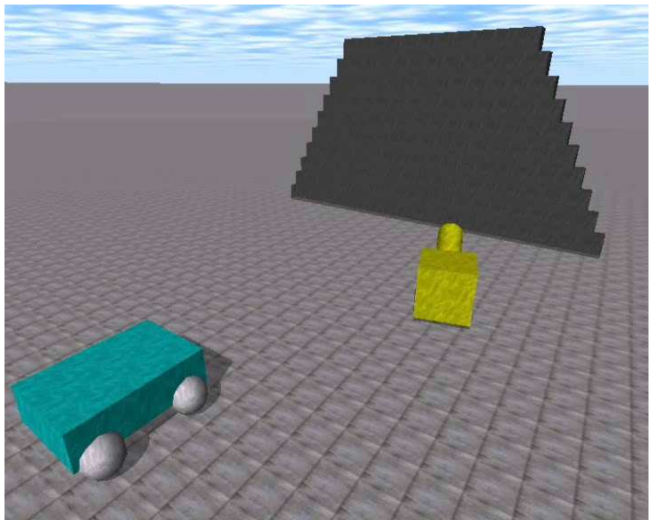






3. Physics Simulation Tools

2. ODE - Open Dynamics Engine



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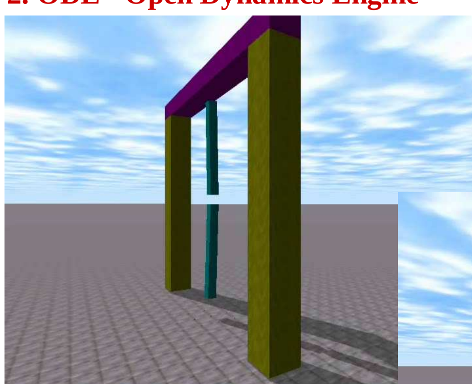
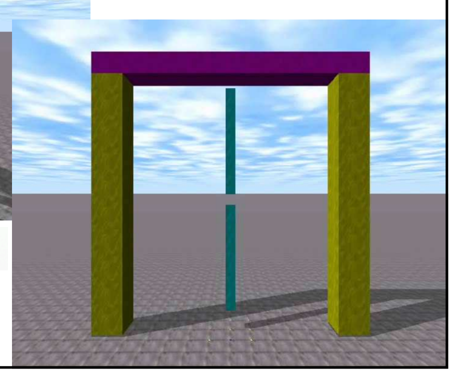
3. Physics Simulation Tools

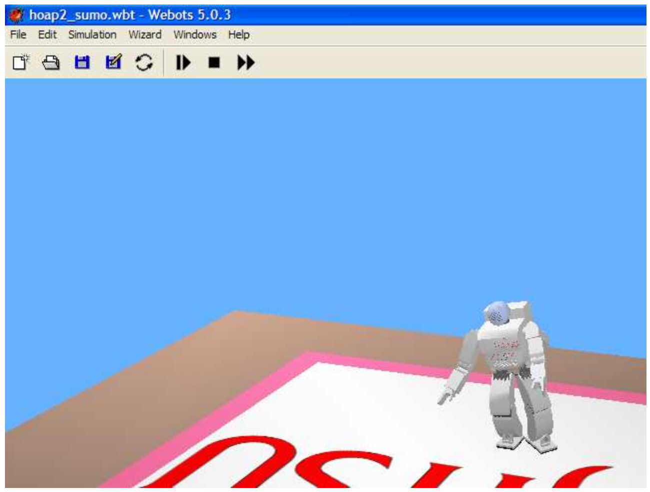
2. ODE - Open Dynamics Engine





3. Physics Simulation Tools

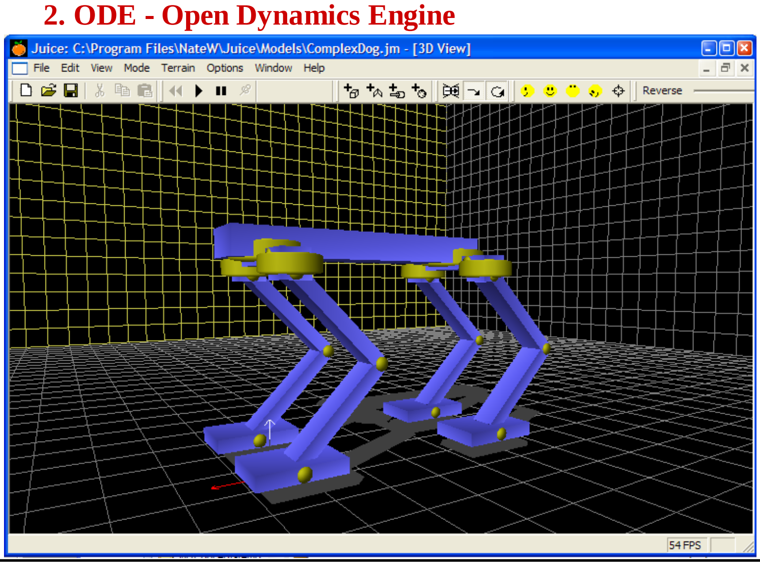
2. ODE - Open Dynamics Engine



Webots
Cyberbotics

3. Physics Simulation Tools

2. ODE - Open Dynamics Engine



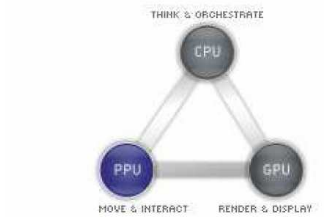
Juice
[Nate W.]

3. Physics Simulation Tools

3. PhysX AGEIA

Hardware Accelerated Physics Simulation

PPU - Physics Processing Unit / GPU - Graphics Proc. Unit



Computer Graphics and Virtual Reality Triangle [AGEIA 2006]

- Complex rigid body object physics system: dynamics and collision detection
- Joints and springs. Characters with complex, jointed geometries for more lifelike motion and interaction
- Volumetric fluid creation and simulation
- Cloth that drapes and tears the way you would expect it to
- Smart particles. Dense smoke and fog that billow around objects in motion.
- Explosions that cause dust and collateral debris

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3. Physics Simulation Tools

3. PhysX AGEIA - PPU


Screenshots of the AGEIA PhysX effects [AGEIA 2006]

AGEIA PhysX - http://www.ageia.com/physx/

Simulation Tools:

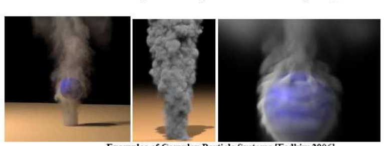
1. OpenSteer
2. ODE - Open Dynamics Engine
3. PhysX AGEIA
4. **Deformable Objects and Fluids:**
   - Finite Elements Methods
   - Spring-Mass Systems
   - CFD (Computational Fluid Dynamics)
   - Level Set Methods

VR Simulation: Some important questions...

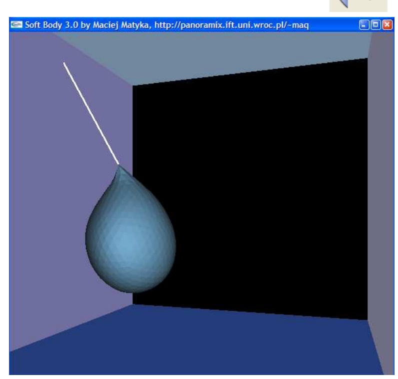
4. Deformable Objects and Fluids

- Finite Elements Methods
- Spring-Mass Systems
- CFD (Computational Fluid Dynamics)
- Level Set Methods

Examples of Complex Deformable Objects [Fedkiw 2006]



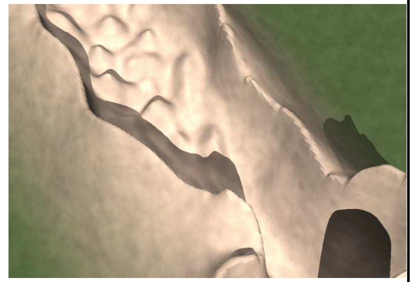
Examples of Complex Particle Systems [Fedkiw 2006]

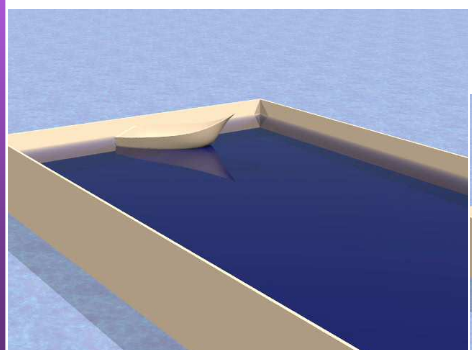


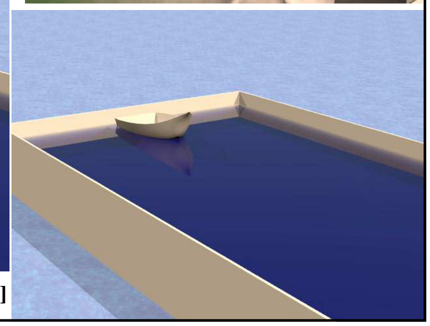
3. Physics Simulation Tools

4. Deformable Objects and Fluids

- **CFD**
  Computational Fluid Dynamics
- **Level Set Methods**







[Fedkiw 2006]

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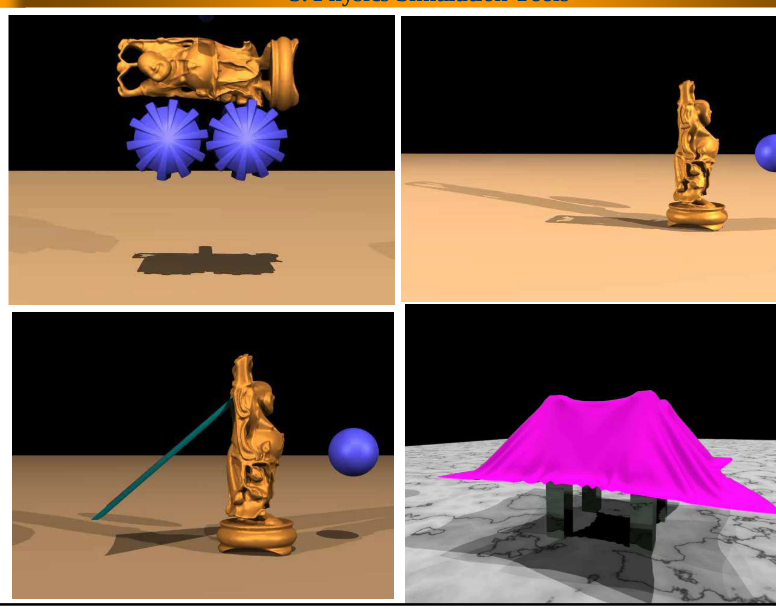
3. Physics Simulation Tools



[Fedkiw]

3. Physics Simulation Tools

Simulation Tools:

1. OpenSteer

2. ODE - Open Dynamics Engine

3. PhysX AGEIA

4. Deformable Objects and Fluids:
- **Finite Elements Methods**
- **Spring-Mass Systems**
- **CFD (Computational Fluid Dynamics)**
- **Level Set Methods**

VR Simulation: Some important questions...
REAL TIME SIMULATION !

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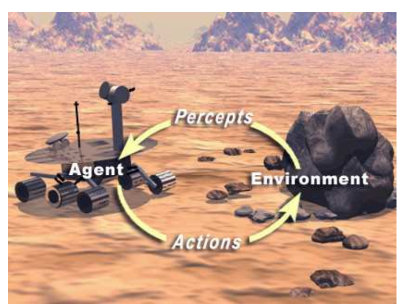
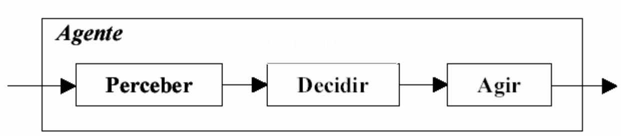
4. Intelligent Behaviour

Intelligent Agents:

Agents: Perception, Action
Agent Behaviours
Control Architectures
Autonomous Agents
Multi-Agents Systems
Knowledge / Reasoning



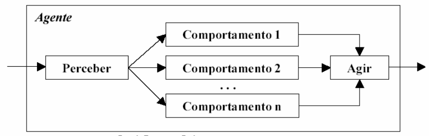


Arquitetura puramente reativa

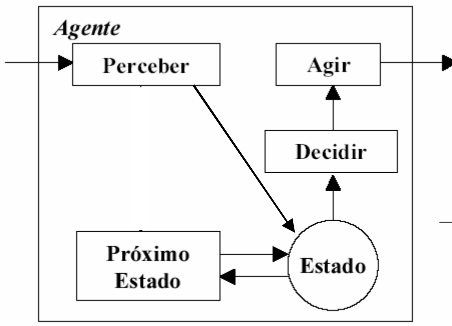
4. Intelligent Behaviour

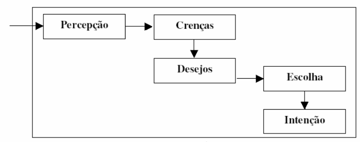
Intelligent Agents:

Agents: Perception, Action
Agent Behaviours

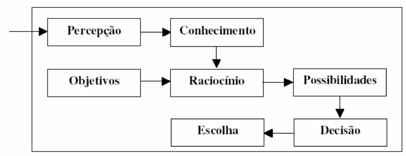


Hybrid Architecture





Architecture BDI (Beliefs-Desires-Intentions)



Arquitetura com Estado Interno

Reactive-Deliberative Architecture

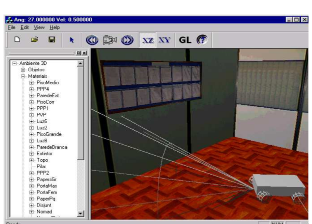
Control Architectures: Reactive, Deliberative, Hierarchical, Hybrid

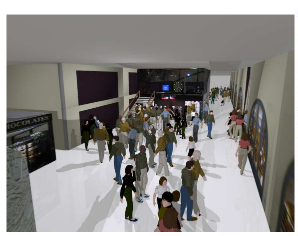
F. Osório et al.
[Virtual Concept 2005]

4. Intelligent Behaviour

Intelligent Agents:

Agents: Perception, Action
Agent Behaviours
  Control Architectures
Autonomous Agents → **Robotic [GPVA]**
Multi-Agents Systems → **Crowds [CromosLab]**
Knowledge / Reasoning → **Ontology [GIA]**





Presentation Topics

Agenda:

1. Introduction: VR - Hierarchy of Models
2. VR and Simulation
   Geometry, Physics, Behaviour, Knowledge and Cognition
3. Physics Simulation Tools
   Opensteer, ODE, PhysX, Deformable/Dynamic
4. Intelligent Behaviour
   Agents: Perception, Action, Behaviour
   Autonomous Agents - Control
   Multi-Agents Systems - Knowledge
5. Applications: VR Simulation Tools
6. Conclusions and New Trends

5. Applications: VR Simulation Tools

Applications @ Unisinos

1. Autonomous Robots in VR Environments
   SimRob3D - Mobile Robots Simulator
   SEVA 3D - Autonomous Vehicle Parking
   LEGGEN - Legged (articulated) Robots Simulator
2. Knowledge and Reasoning in VR Environments
   UEM - Urban Environment Model
   Crowds Simulation in Normal Life Situations

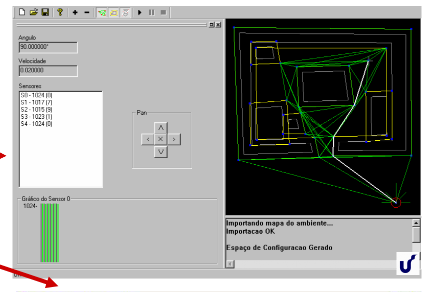
   Robombeiros - Fire Fighting

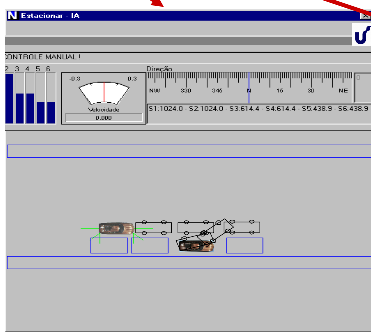
5. Applications: VR Simulation Tools

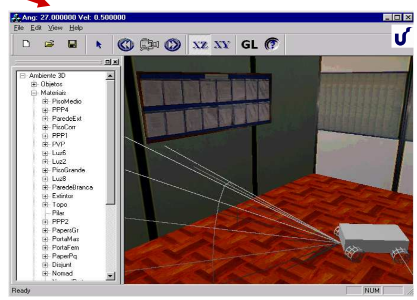
Autonomous Robots in VR Environments

SimRob3D

- Our Simulation Tools:
SimRob2D (Khepera)
SimRob3D
Seva2D







5. Applications: VR Simulation Tools

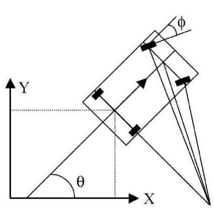
Autonomous Robots in VR Environments

SimRob3D Simulator

> Sensors: Infrared, Sonar, Bumper

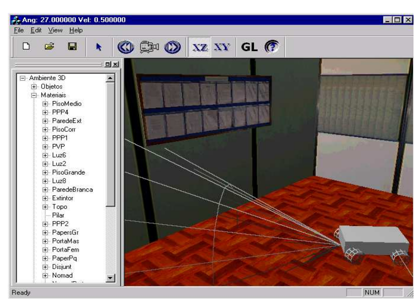
> Actuators / Kinematics: Differential, Ackerman

> Realistic Simulation Model:
3D World + noise / error (imprecise sensors and actuators)



$$\begin{cases} \dot{x} = v \cos\phi \cos\theta \\ \dot{y} = v \cos\phi \sin\theta \\ \dot{\theta} = \frac{v}{L} \sin\phi \end{cases}$$

Kinematics model

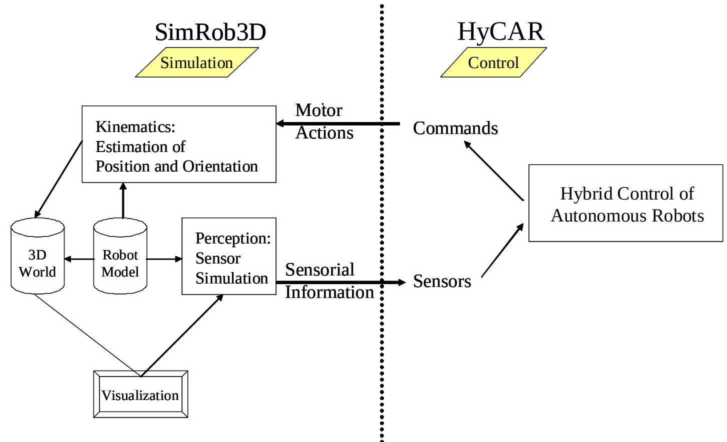


5. Applications: VR Simulation Tools

Autonomous Robots in VR Environments

SimRob3D Simulator

> Vehicle Simulation *x* Vehicle Control



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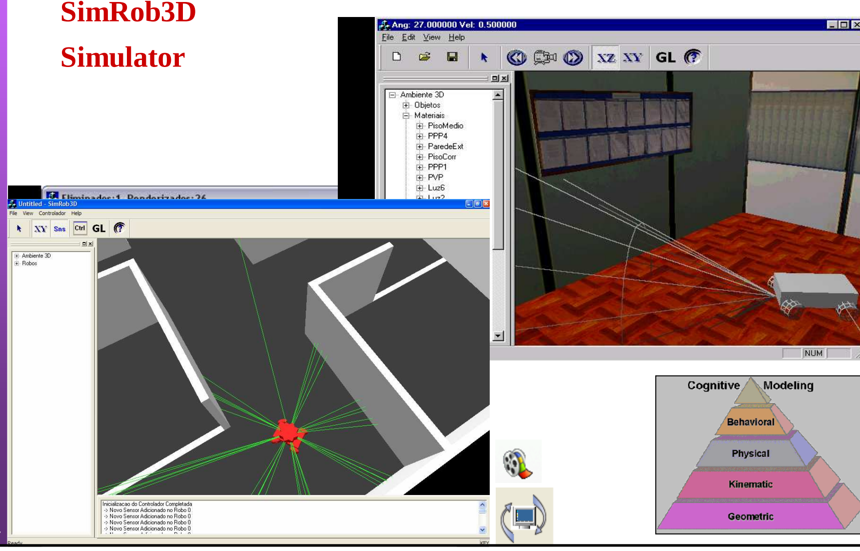
5. Applications: VR Simulation Tools

Autonomous Robots in VR Environments

SimRob3D

Simulator



5. Applications: VR Simulation Tools

Autonomous Robots in VR Environments

SEVA 3D - "Sistema de Estacionamento de Veículos Autônomos"

Sources of Inspiration:

**- Baja Buggy remotely controlled by a cell phone
C. Kelber - UNISINOS, Brazil**

**Published at:
IEEE WCCI
IJCNN 2006**

SEVA3D: Using Artificial Neural Networks to Autonomous Vehicle Parking Control

Applied Computing Research Post-grad Program - PIPCA
Autonomous Vehicles Research Group
[Grupo de Pesquisas em Veículos Autônomos - GPVA]
UNISINOS University - Brazil

Web: http://inf.unisinos.br/~osorio/seva3d
or Google: veiculos autonomos

IEEE WCCI - IJCNN 2006
Vancouver, July 2006

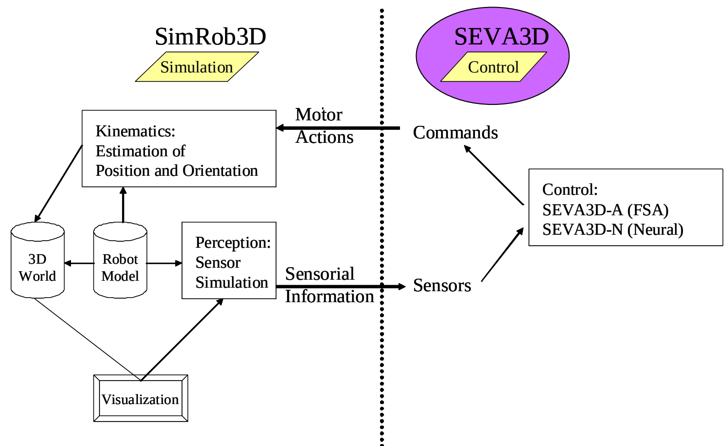
Milton Roberto Heinen - Applied Computing / Unisinos
Prof. Dr. Fernando S. Osório - Applied Computing / Unisinos
Prof. M.Sc. Farlei José Heinen - Computer Engineering / Unisinos
Prof. Dr. Christian Kelber - Electrical Engineering / Unisinos

5. Applications: SEVA 3D

Autonomous Robots in VR Environments

SEVA 3D Simulator

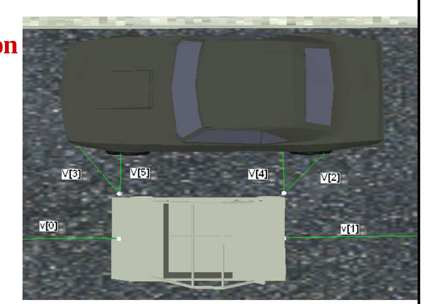
> Vehicle Simulation *x* Vehicle Control



5. Applications: SEVA 3D

Autonomous Robots in VR Environments

SEVA: FSA - Finite State Automaton



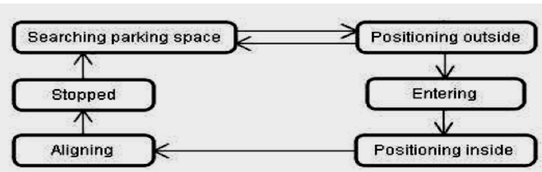
Inputs:

- Sonar Sensors:
Stochastic ray-casting / 3D cone)

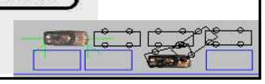
Outputs:

- Steering Wheel Angle
- Gas pedal (car speed + direction: fwd, back)

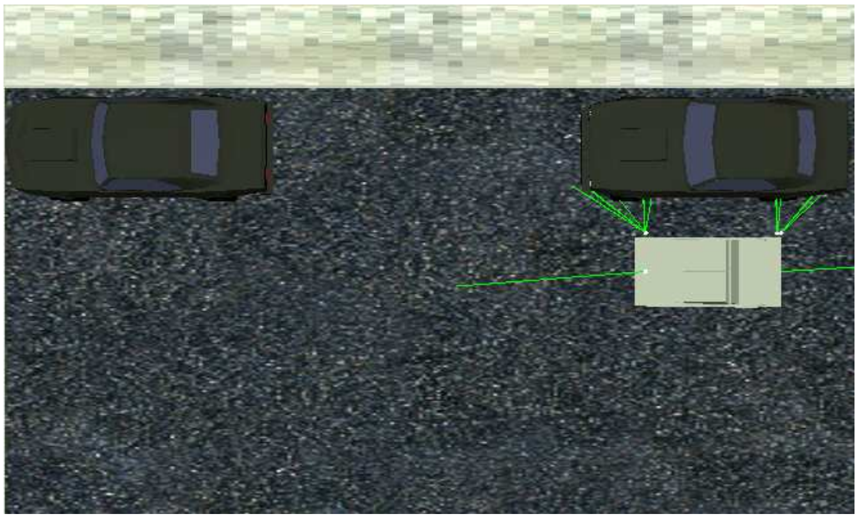
States:



Automaton states



SEVA: Searching Parking Space



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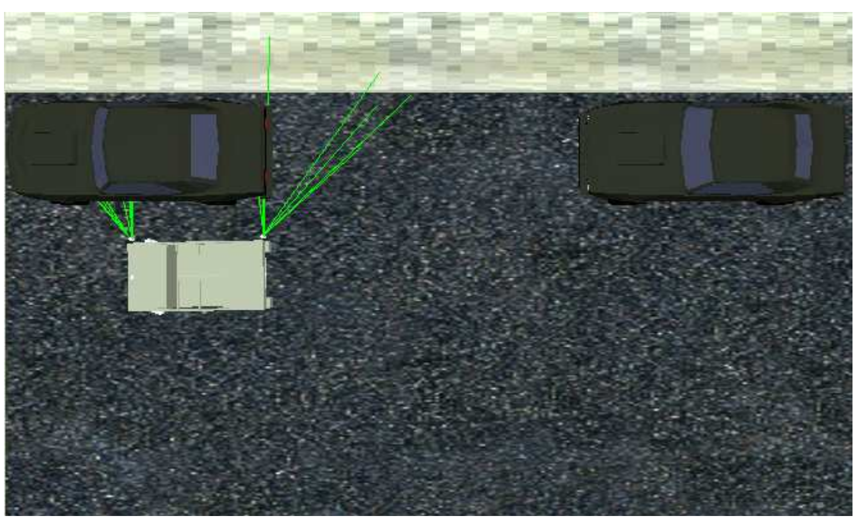
5. Applications: SEVA 3D

SEVA: Entering



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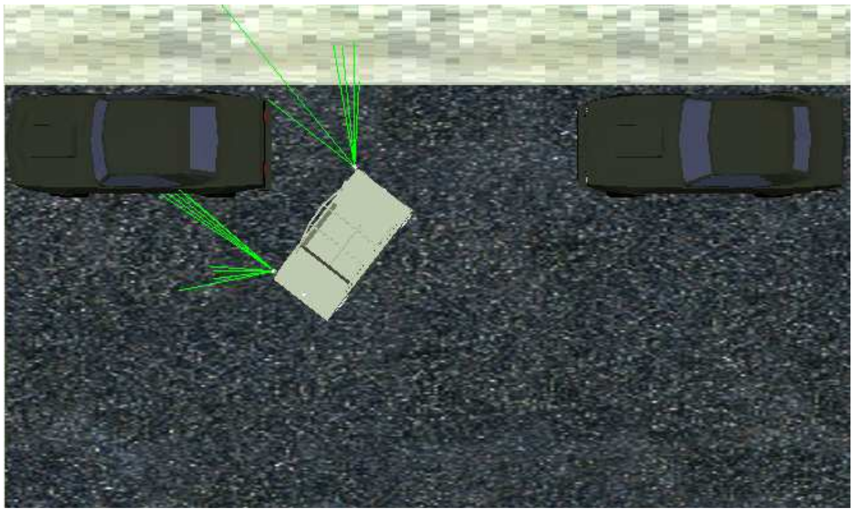
SEVA: Positioning Inside



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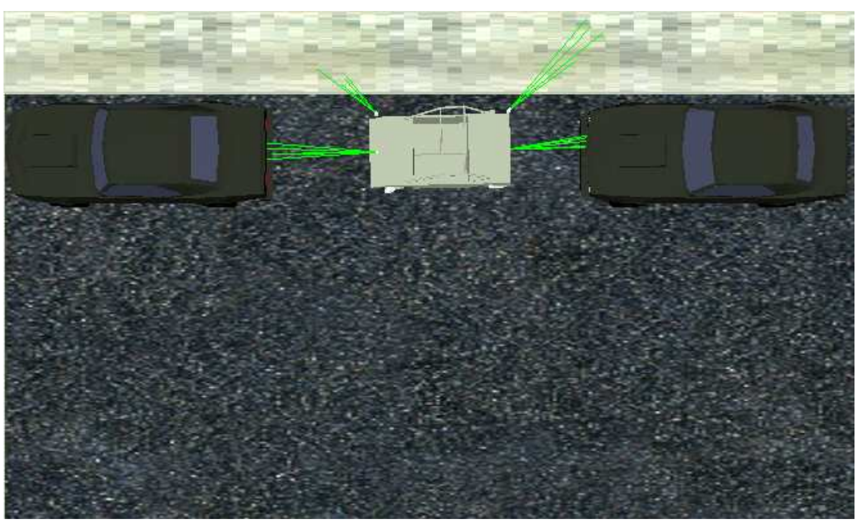
5. Applications: SEVA 3D

SEVA: Aligning



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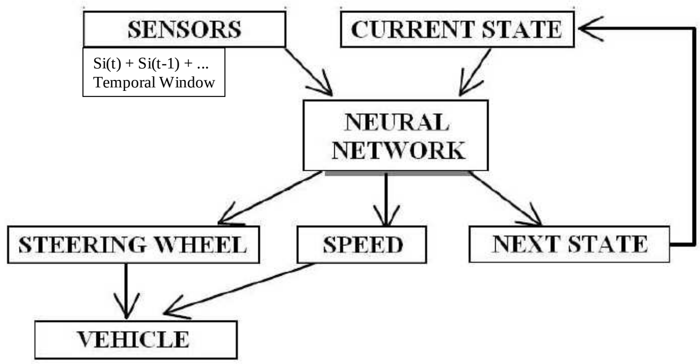
5. Applications: SEVA 3D

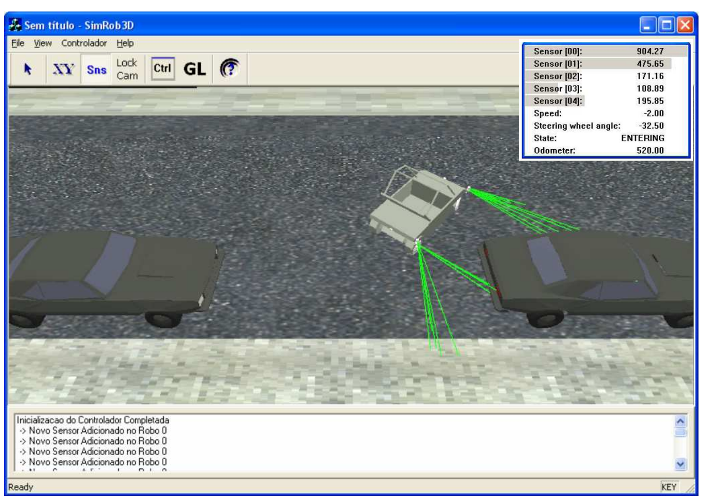
SEVA: NEURAL FSA - Learning the FSA...



Artificial neural network model scheme
Adapted Jordan-Net using RProp Learning

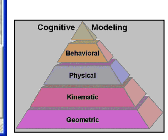
5. Applications: SEVA 3D

SEVA3D - Autonomous Vehicle Parking Simulator



3D

Sensors
Actuators
Kinematics
FSA Ctrl
ANN Ctrl



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5. Applications: VR Simulation Tools

Applications @ Unisinos

1. **Autonomous Robots in VR Environments**

   SimRob3D - Mobile Robots Simulator
   SEVA 3D - Autonomous Vehicle Parking
   ➔ <u>LEGGEN</u> - Legged (articulated) Robots Simulator

2. **Knowledge and Reasoning in VR Environments**

   UEM - Urban Environment Model
   Crowds Simulation in Normal Life Situations

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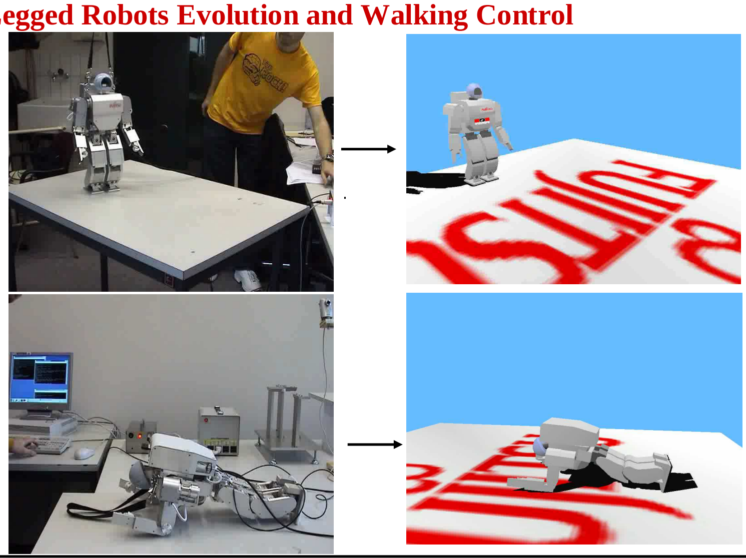
5. Applications: VR Simulation Tools

Autonomous Robots in VR Environments

Legged Robots Evolution and Walking Control



[EPFL]

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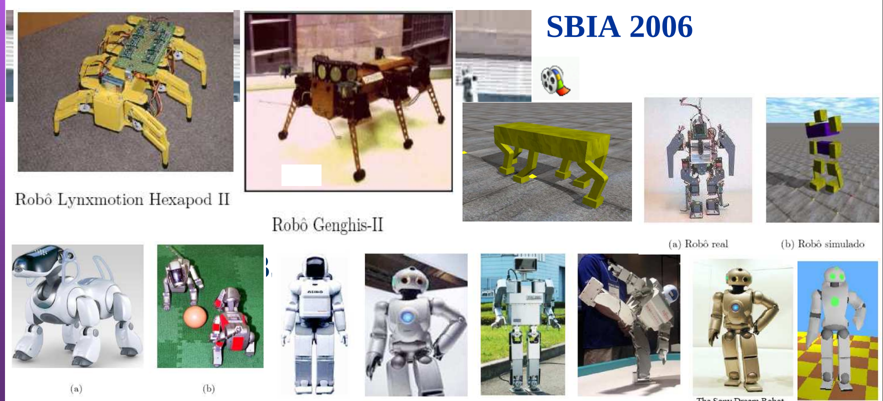
5. Applications: VR Simulation Tools

Autonomous Robots in VR Environments

Legged Robots Evolution and Walking Control

Sources of Inspiration:

LEGGEN - Published at:
IEEE WCCI CEC 2006
SBIA 2006



Robô Lynxmotion Hexapod II

Robô Genghis-II

(a) Robô real (b) Robô simulado

(a) (b) Asimo (b) Sony SDR-4X (c) Kawada H6 (d) Fujitsu HOAP-2 The Sony Dream Robot in the real world The Sony Dream Robot simulated into Webots

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Gait Control Generation for Physically Based Simulated Robots using Genetic Algorithms

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iberamia SBIA SBRN International JOINT Conference 2006

IBERAMIA / SBIA - 18th Brazilian AI Symposium

Pós-Graduação em Computação Aplicada - PIPCA
Grupo de Pesquisas em Veículos Autônomos - GPVA
>> Autonomous Vehicles Research Group <<
UNISINOS University - Brazil

Web: http://inf.unisinos.br/~osorio/leggen
or Google: veiculos autonomos

Gait Control Generation for Physically based Simulated Robots using Genetic Algorithms

IBERAMIA / SBIA / SBRN International Joint Conferences
SBIA - Brazilian Artificial Intelligence Symposium
Ribeirão Preto, October 2006

Prof. Dr. Fernando S. Osório - Applied Computing / Unisinos
Milton Roberto Heinen - Applied Computing / Unisinos

1
24 Oct. 2006

5. Applications: VR Simulation Tools

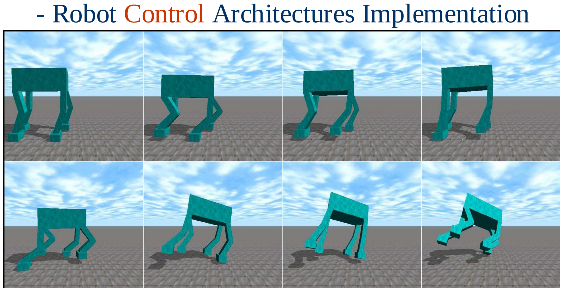
Autonomous Robots in VR Environments

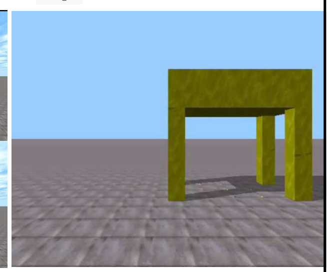
LEGGEN - Legged Robots Evolution and Walking Control

Simulation of Robots: 3D **Realistic** Virtual Environments
- Sensors: infrared, sonar, bumpers, gyro (accelerometers), GPS, compass, light and vision sensors, etc.
- Actuators: legs and arms with angular motors (joints)
- Physics: collision, kinematics, rigid body dynamics

Simulation of Legged Autonomous Robots:
- Robot Control Architectures Implementation

Genetic Evolved Control of Articulated Robots (w/legs)



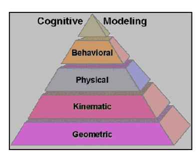


5. Applications: VR Simulation Tools

Autonomous Robots in VR Environments

LEGGEN - Legged Robots Evolution and Walking Control

Simulation of 3D Realistic Virtual Legged Robots
LEGGEN Simulator - Tools:



1. OSG - Open Scene Graph (OpenGL + Extensions)
[http://www.openscenegraph.org/]

2. ODE - Open Dynamics Engine
Rigid Body Physics Simulation
(gravity, inertia, friction, collision, joints, etc)
[http://www.ode.org/]

3. GALib - Genetic Algorithms Simulation
[http://www.lancet.mit.edu/ga/]

4. Robot Control FSM: Finite State Machine = Sense + Act

5. Applications: VR Simulation Tools

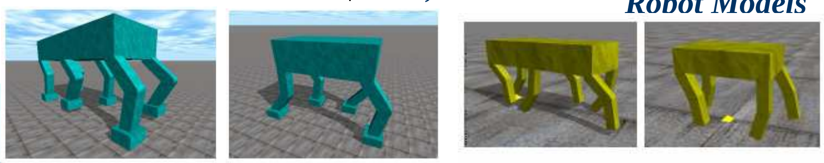
Autonomous Robots in VR Environments

LEGGEN - Legged Robots Evolution and Walking Control

Simulation main goals:

- **Evaluate different *Robot Models* (hardware configurations)**
  IEEE WCCI / CEC 2006 - Vancouver, Canadá
- **Evaluate different *Fitness Functions***
  IBERAMIA / SBIA - Ribeirão Preto, SP

Robot Models



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

Evaluate different robot models in order to select a better hardware configuration

Boston Dynamics

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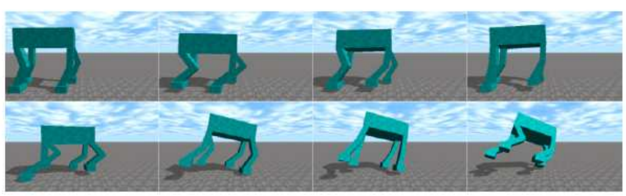
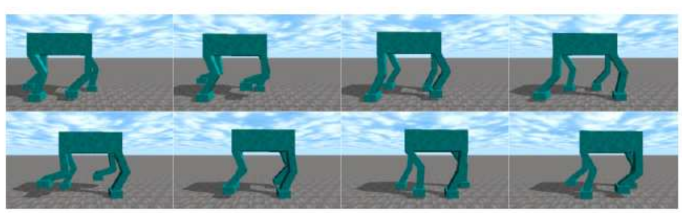
LEGGEN SIMULATOR

Simulation Results:



Example of a generated gait (experiment 01)

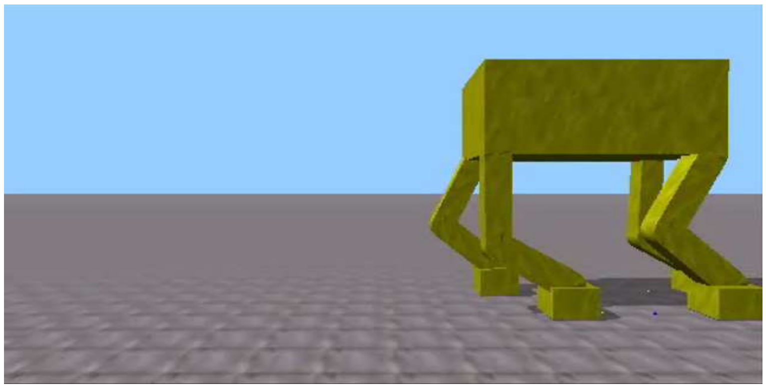


Example of a generated gait (experiment 04)

LEGGEN SIMULATOR

Simulation RESULTS:

Tetrapod Video - Distance, Gyro



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LEGGEN SIMULATOR

Simulation RESULTS:

Tetrapod Video - 2 a 2

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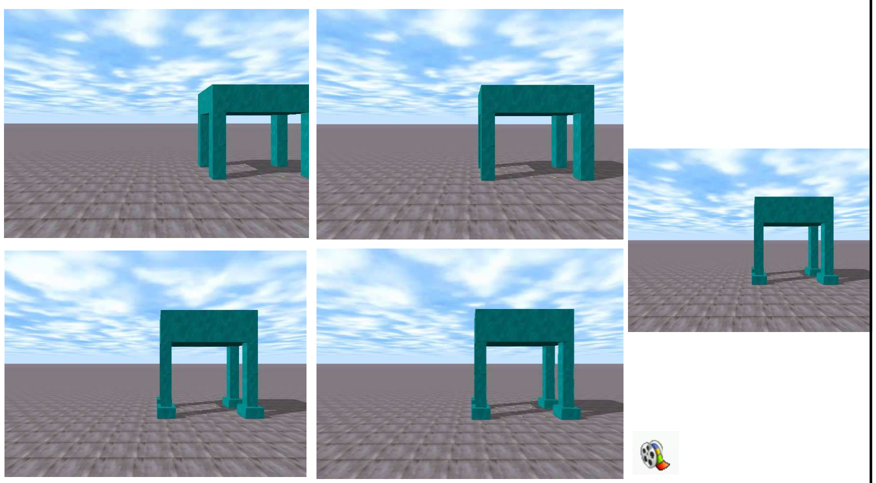
LEGGEN SIMULATOR

Simulation RESULTS: ***Tetrapod Video - "bloopers"***



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   ➜ **UEM - Urban Environment Model**
   Crowds Simulation in Normal Life Situations

   Robombeiros - Fire Fighting

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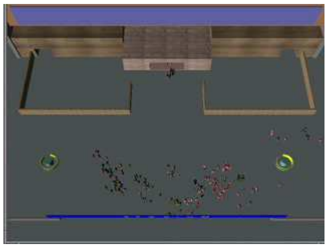
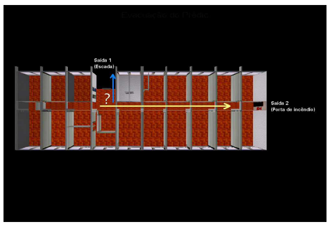
5. Applications: VR Simulation Tools

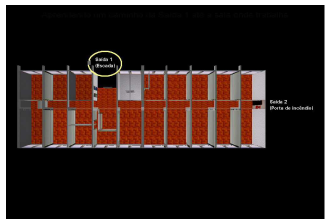
Knowledge and Reasoning in VR Environments

UEM - Urban Environment Model

Sources of Inspiration: CromosLab







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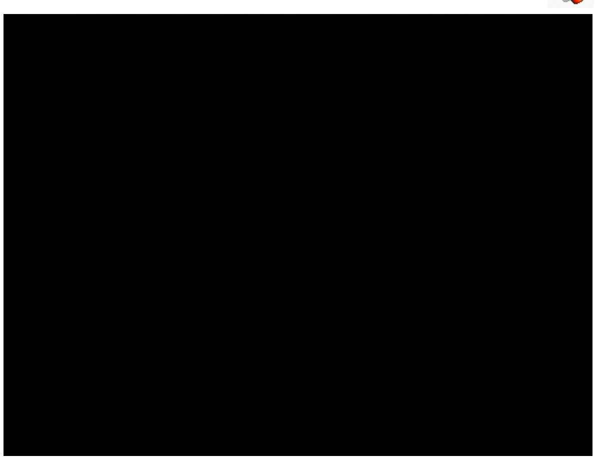
Knowledge and Reasoning in VR Environments

UEM - Urban Environment Model

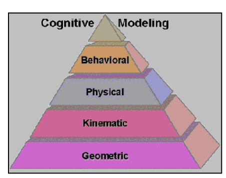
Sources of Inspiration: CromosLab



Normal Life - Agents:
Children going to the school
Adults going to work
at usual times...

Environment:
School, Stores, ...
Flammable Liquids...

Ontology!



5. Applications: VR Simulation Tools

Knowledge and Reasoning in VR Environments

UEM - Urban Environment Model

- Agents are created using an **ontology**;
- Ontology includes information of **population profiles**;
- Ontology includes information about the **urban environment**;
- People (virtual agents) created based on statistical data or fictitious information;
- Agents move and behave in the urban life according their usual activities (time), as described in the ontologies;
- People move during “normal life” in a more realistic way, without a “random aspect”, which is common in other (not so realistic) works;
- Able to manage crowds in a macrocospic point of view;
- Easy to define, easy to implement, easy to control!
- ***Knowledge about the general model of the VE can be used to the simulation***;

Structured and semantic environment

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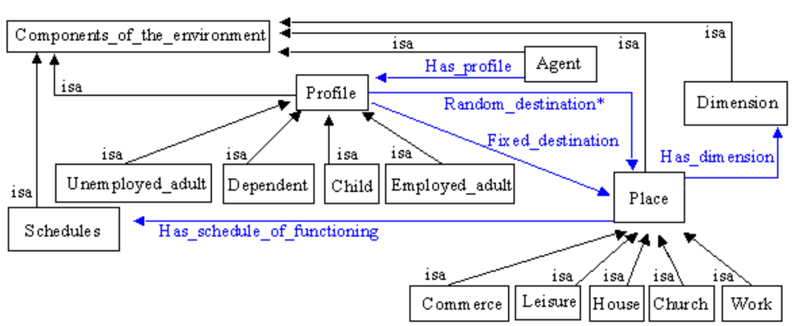
Knowledge and Reasoning in VR Environments

UEM - Urban Environment Model



UEM - Global Ontology

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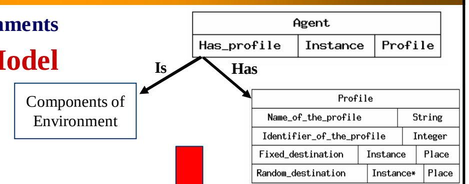
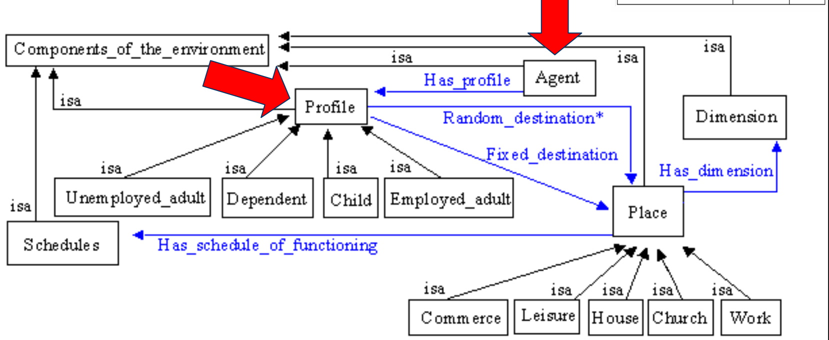
Knowledge and Reasoning in VR Environments

UEM - Urban Environment Model





UEM - Global Ontology

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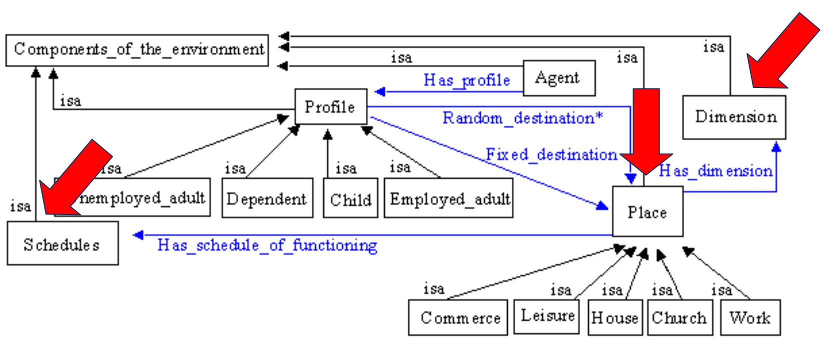
5. Applications: VR Simulation Tools

Knowledge and Reasoning in VR Environments

UEM - Urban Environment Model

Place		
Name_of_the_place	String	
Capacity	Integer	
Identifier	Integer	
Has_dimension	Instance	Dimension
Has_schedule_of_functioning	Instance	Schedules



UEM - Global Ontology

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5. Applications: VR Simulation Tools

Knowledge and Reasoning in VR Environments

UEM - Urban Environment Model

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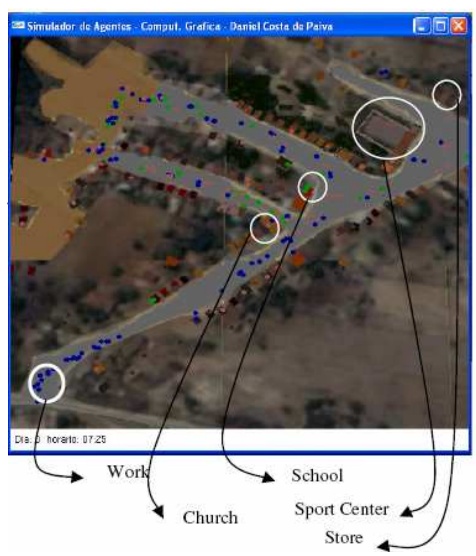
5. Applications: VR Simulation Tools

Knowledge and Reasoning in VR Environments

UEM
Urban Environment Model

At 7:00 AM people are at home



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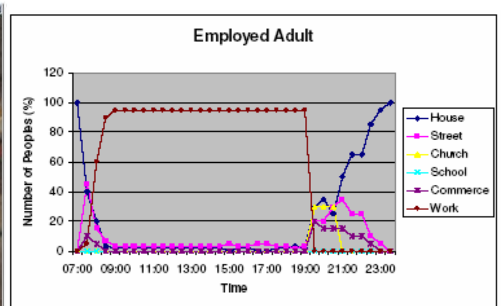
5. Applications: VR Simulation Tools

Knowledge and Reasoning in VR Environments

UEM

Urban Environment Model



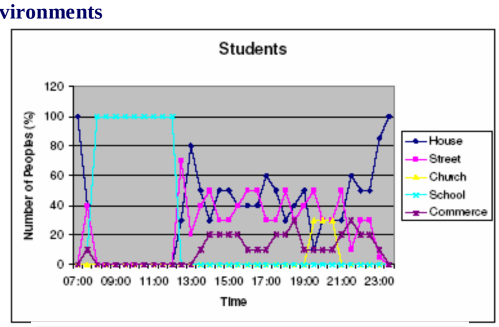
At 11:29 AM:
Students and employed adults are in school and work
We can observe some other people on the street

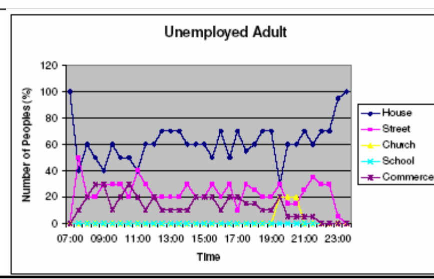
5. Applications: VR Simulation Tools

Knowledge and Reasoning in VR Environments

UEM

Urban Environment Model





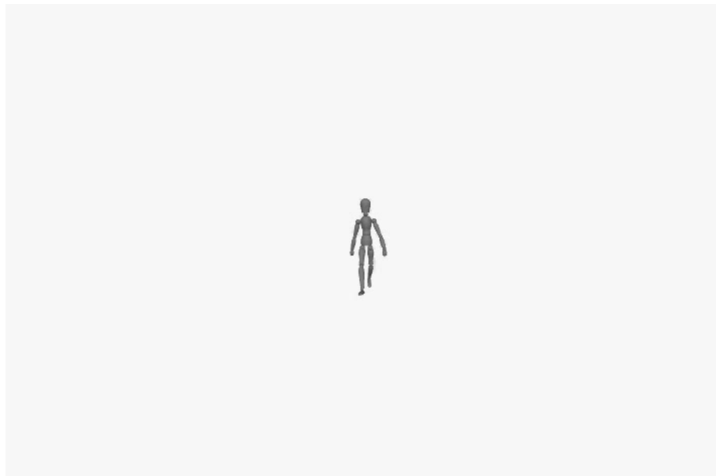
At 11:29 AM:
Students and employed adults are in school and work
We can observe some other people on the street
At 12:05 PM:
Students leave school

5. Applications: VR Simulation Tools

Knowledge and Reasoning in VR Environments

UEM

Urban Environment Model



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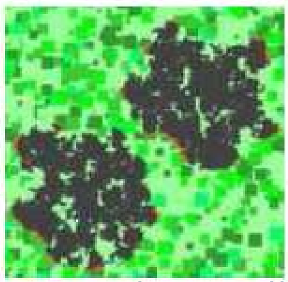
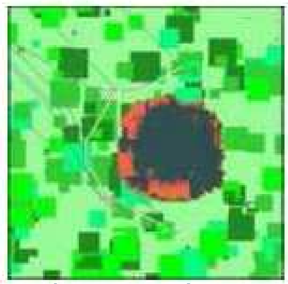
➔ **Robombeiros - Fire Fighting**

Robombeiros - Fire Fighting VR Simulation

Virtual Simulation Environment:

* 2D and 3D Simulation
* Simulation of fire propagation
* Autonomous fire-fighting team
* Define: Strategy, Mission, Execution





Fire Propagation Simulation:

- Direction and Speed of wind
- Vegetation type and coverture density (speed of propagation)
- Terrain

Figure: 2D Simulation using SDL library => http://pessin.googlepages.com/robombeiros

Published at SVR 2007 (Symposium on Virtual and Augmented Reality)
[G. Pessin, F. Osório, S. Musse, V. Nonnenmacher, S. Ferreira]

Robombeiros - Fire Fighting VR Simulation

Virtual Simulation Environment:

3D Visualization:
- Vegetation, Fire
- Autonomous mobile Robots
- Stereo 3D
- Tools: OSG, ODE, Demeter

Published at SVR 2007 (Symposium on Virtual and Augmented Reality)
[G. Pessin, F. Osório, S. Musse, V. Nonnenmacher, S. Ferreira] http://pessin.googlepages.com/robombeiros

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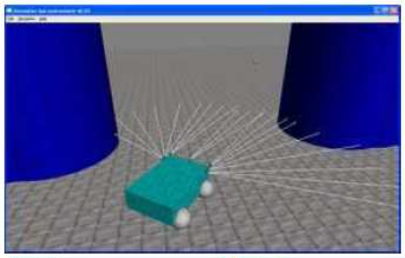

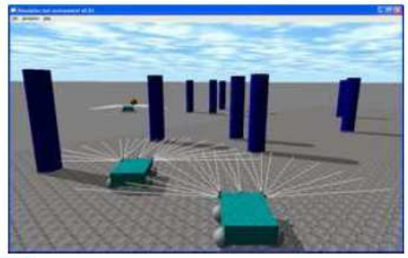

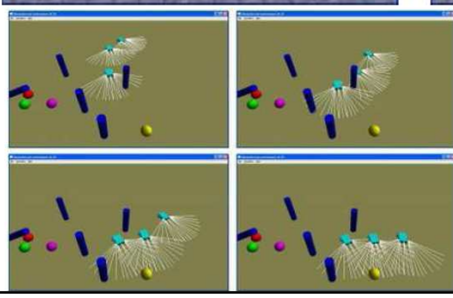

3D Simulation:
- Fire propagation
- Physics
- Robot Control

http://pessin.googlepages.com/robombeiros

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Presentation Topics

Agenda:

New Trends

A 3D Fax Machine based on Claytronics

Padmanabhan Pillai, Jason Campbell
Intel Research Pittsburgh
Pittsburgh, PA 15213

Gautam Kedia, Shishir Moudgal, Kaushik Sheth
Carnegie Mellon University
Pittsburgh, PA 15213

***Abstract*—This paper presents a novel application of modular robotic technology. Many researchers expect manufacturing technology will allow robot modules to be built at smaller and smaller scales, but movement and actuation are increasingly difficult as dimensions shrink. We describe an application — a 3D fax machine — which exploits inter-module communication and computation without requiring self-reconfiguration. As a result, this application may be feasible sooner than applications which depend upon modules being able to move themselves.**

In our new approach to 3D faxing, a large number of sub-millimeter robot modules form an intelligent "clay" which can be reshaped via the external application of mechanical forces. This clay can act as a novel input device, using intermodule localization techniques to acquire the shape of a 3D object by casting. We describe software for such digital clay. We also describe how, when equipped with simple inter-module latches, such clay can be used as a 3D output device. Finally, we evaluate results from simulations which test how well our approach can replicate particular objects.

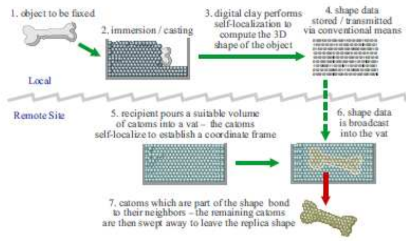

Fig. 1. An overview of the 3D fax scenario

Claytronics - Nanotech

[Published at IROS2006]

Conclusions => Review

VR... From Real to Virtual
Visualization (3D)
Interaction
Agents
Simulation

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Conclusions => Review

VR... From Real to Virtual

Visualization (3D) => OpenGL, DirectX, VRML, QTVR, OSG
Interaction => Augmented Reality, Haptic Devices, Sensors
Agents => Behaviour (Perceive, Act, Interact), Control
Simulation => Models, Physics, ODE

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*** Interaction based on Physics**

Perception — Physics => Rigid Body Dynamics
Action — Soft Body - Deformable, Particles
Kinematics — Steering models
Dynamics

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Conclusions => Review

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* Interaction based on Physics
  Perception — Physics => Rigid Body Dynamics
  Action — Soft Body - Deformable, Particles
  Kinematics — Steering models
  Dynamics

* **Behavioural Simulation and Virtual Autonomous Agents (AI)**
  Behavioural control (e.g. boids)
  Control Architectures: Deliberative, Reactive, Hierarchical, Hybrid
  Cognitive...

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* **Behavioural Simulation and Virtual Autonomous Agents (AI)**
  Behavioural control (e.g. boids)
  Control Architectures: Deliberative, Reactive, Hierarchical, Hybrid
  Cognitive:
  - Knowledge
  - Emotional states
  - Personality
  - Personal profile

  Agents

  - Special places
  - Functioning rules (ontology)
  - Place profile

  Environment

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- Personal profile

Agents

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- Functioning rules (ontology)
- Place profile

Environment

Autonomy
Reality ➡ IVRE
VR PBSim
VR++

Very interesting applications!

Virtual Reality Applications based on Physical and Behavioral Simulation
Osório, Musse, Heinen, Kelber, Pessin
UNISINOS
IEEE computer society · IEEE
IEEE Computer Chapter - Colombia Section / Medellin, July 2007

Conclusions and New Trends

Virtual Reality Environments:

Geometric + Kinematic + Physical + Behavioural + Cognitive

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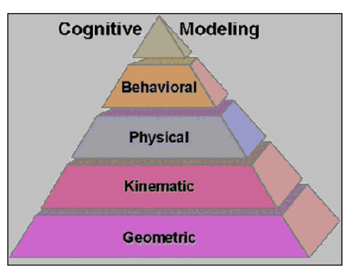
Realistic RV Environments

New Trends:

VR
Physics
Artificial Intelligence
AR - Augmented Reality
Haptic Interfaces



Conclusions and New Trends

Virtual Reality Environments:

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Realistic RV Environments

Full Immersion

New Trends:

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- **Physics**
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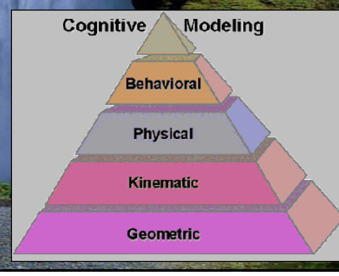

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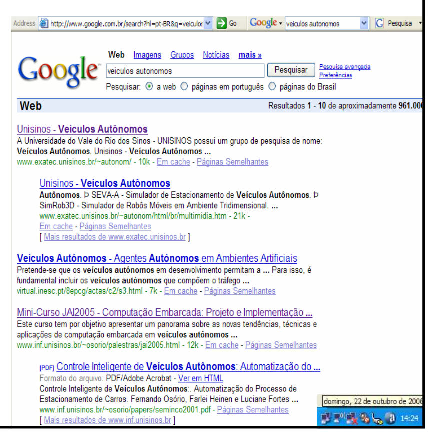

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