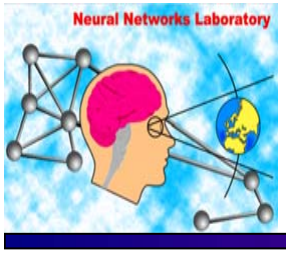


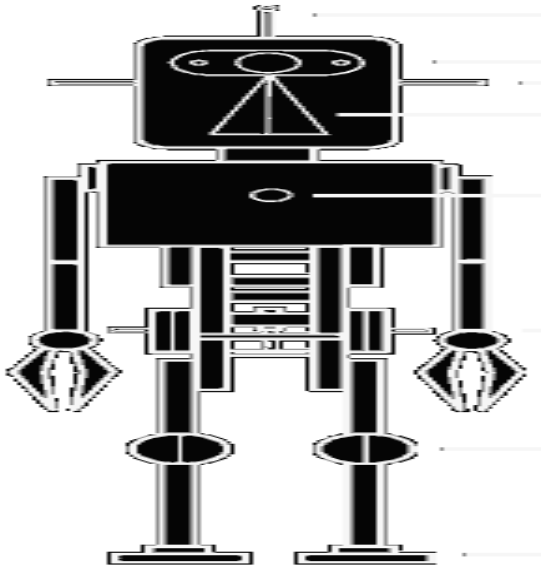
Technological Educational Institute Of Crete

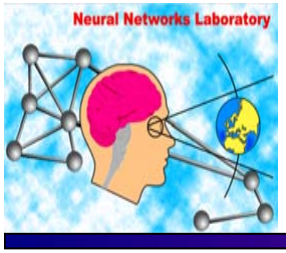
Department Of Applied Informatics and Multimedia

Intelligent Systems Laboratory

Monocular Omnidirectional Vision Simulator for Robot Navigation

Panagiotis Palantas, George Palamas, Manolis Kavoussanos, George Papadourakis





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Why a 3D Robot Simulator ?

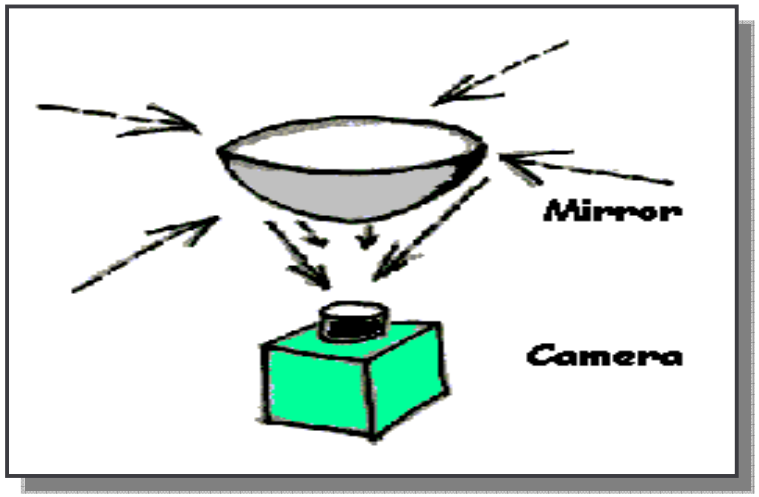
- Rapid prototyping of algorithms
- Simple basis for studying Situated Artificial Intelligence for autonomous agents
- Inexpensive, especially in multi-agent applications
- Adjustable environmental conditions
  - Lighting
  - Sensorial noise
- Faster and safer than a real robot

Main Features

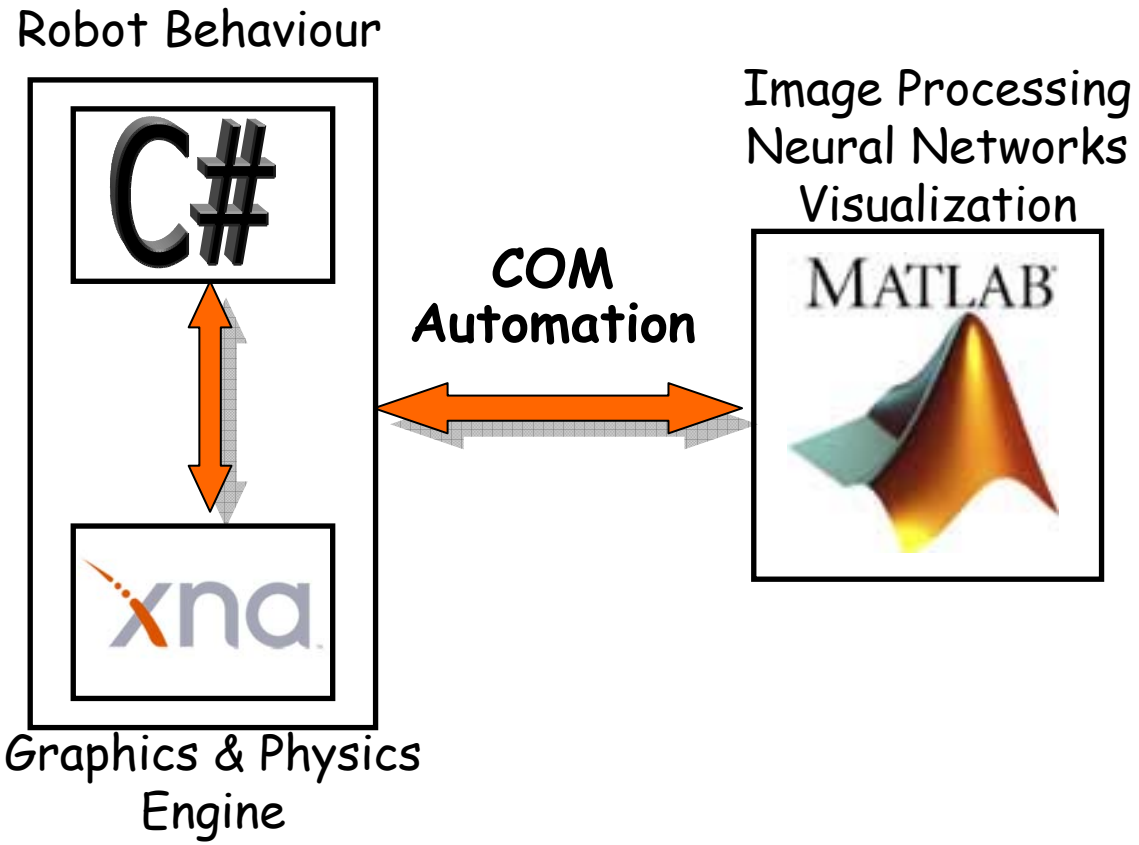
- **Single or Multi-robot simulation**
- **3D visualisation and sensing:**
  - Vision Sensors : Colour catadioptric camera
  - Contact Sensors : bumpers
  - Compass
- **Extensions in Matlab:**
  - Visualization toolbox
  - Image processing toolbox
  - Neural Network toolbox

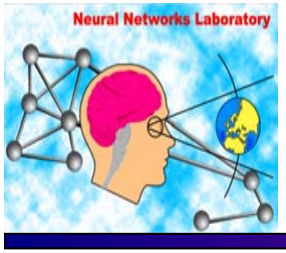
Omnidirectional Camera

- **Largest Field of View**
  - Landmarks always in the FOV except occasional occlusions
- **Orientation Independency using statistical methods**
  - Histograms
  - Distribution functions
- **Increased reliability due to no rotation mechanism**



System Architecture



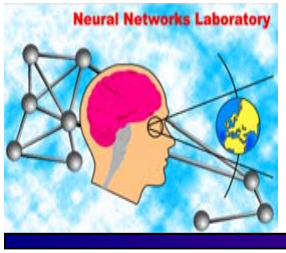


XNA Game Studio

- A set of tools with a managed runtime environment
- Facilitates computer game development and management
- Provides support for both 2D and 3D application creation
- Supports all versions of Visual Studio 2005 or Visual C# 2005 Express
- Includes
  - XNA Framework
  - XNA Content Pipeline

What is XNA Framework

- **Based on the .NET Framework 2.0**
- **Includes**
  - A rich set of class libraries for game development
  - A content pipeline for importing content such as
    - 3D models
    - Textures
    - Sprites
  - Build-in support for keyboard and mouse input
  - Classes for audio and storage
- ***But, no physics engine yet!***



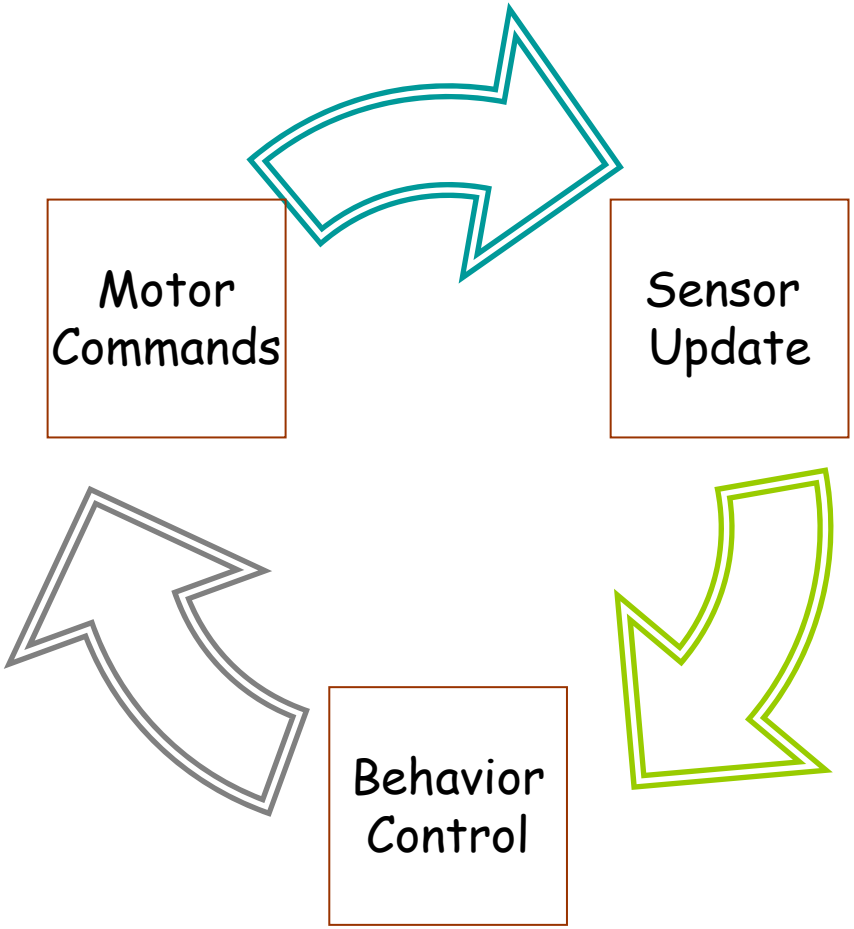
Basic Scene Generation

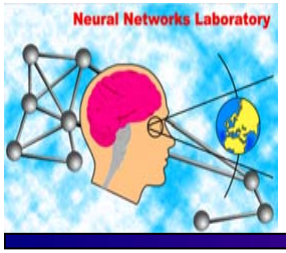
- Load Models
- Apply Textures
- Position Robot at startup point
- Random or user specified positioning of obstacles inside the world
- Collision Detection for the correct placement of the obstacles

Collision Detection

- **Use of boundary volumes**
  - Bounding Box
    - Room and obstacles
  - Bounding Sphere
    - Robot
- **Before each scene draw, checks for:**
  - Objects overlapping (Collision to obstacle)
  - Objects containing (Collision to room)

Sensori-Motor Coordination





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Environment Mapping

- **Most used methods are:**
  - Sphere mapping
  - Cube mapping
- **We choose Cube Mapping**
  - Hardware supported by major graphic cards
  - Create near realistic reflections
  - Real-time creation of textures
  - Viewpoint independency

Environment Cube Mapping (1/2)

- **Reflection Procedure**
  - Create the scene without the sphere
  - Change the projection matrix to 90 degrees FOV
  - Place the camera at the center of the sphere position
  - Acquire six textures from top, bottom, left, right, front and behind

Environment Cube Mapping (2/2)

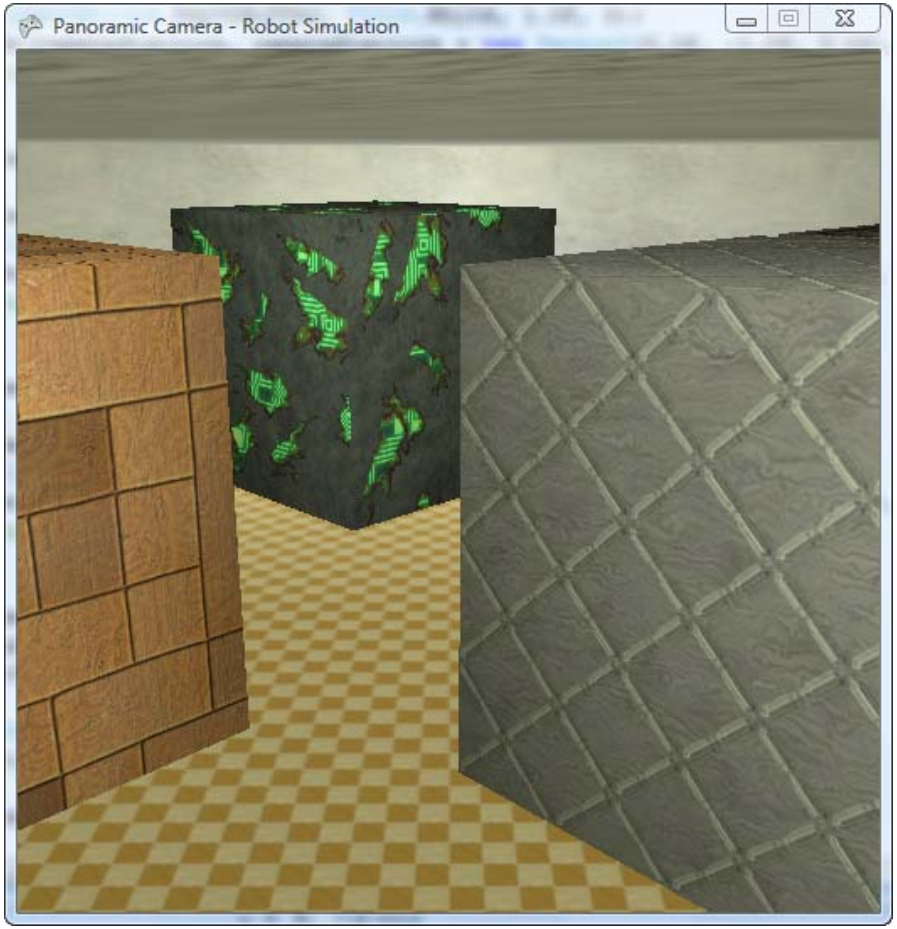
- Create the sphere
- Apply Cube Map to sphere
- Reposition our camera above the sphere

Cube Mapping

Cube map applied to sphere

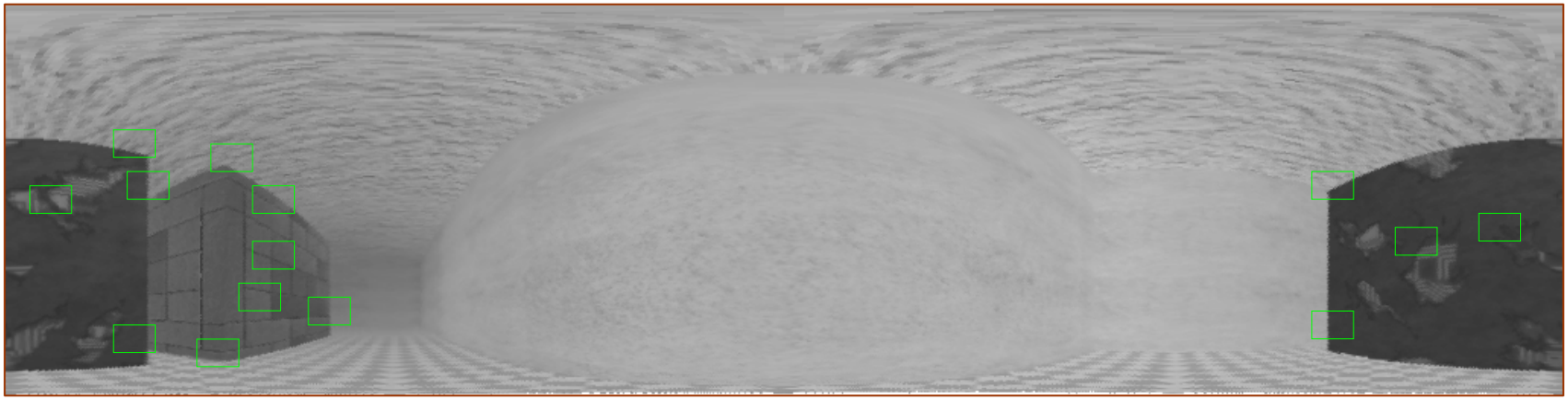
Artificial World

- **Custom made environment**
- **Simple 3D physics engine**
- **Selectable robot behavior**
  - Wall following
  - Obstacle avoidance
  - Random Walk



Application: Way Finding

- **An agent returns to a location that has visited before**
  - Agent tracks points of interest for every frame
  - Memorizes series of visual cues while exploration
  - Correlates current visual cues with previous memorized cues to aim homing



Unwarped Image

Future Work

- **Support for more sensor types**
  - Proximity
  - infrared sensors
- **Support for stereoscopic vision**
- **Different types of locomotion, like walking**
- **Evolutionary based optimization toolkit**
- **Reccurent Neural Networks toolkit**