XIA-MAN:
An Extensible, Integrative Architecture for Intelligent Humanoid Robotics

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SUPPLEMENTARY MATERIAL FOR THE PAPER,
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This supplementary material consists of one textual section, and a number of figures, that were omitted from the publication version of the paper for reasons of space.

Bringing Robot Simulators and Virtual Worlds Together

It is worth mentioning one point that has come to our attention in designing the XIA-MAN architecture, pertaining to the technical infrastructure available for teaching intelligent robots. At the present time, due to various difficulties involved in working with physical robots, a great deal of practical robotics work actually involved working with simulated rather than real robots. Robot simulators are fairly sophisticated these days, providing accurate simulations of physics as manifested in laboratory environments, if not real-world situations like forests, oceans and city streets. However, they lack one of the key strengths of virtual worlds such as Second Life and Multiverse (where the Novamente Pet Brain controlled animals have been prototyped): this is the capability for massive multiplayer interaction.

On the other hand, current game engines and entertainment virtual worlds have their own shortcomings. Figure 8 shows the simplified overall architecture via which one connects an AI engine to a contemporary virtual world or game. Note that the interaction occurs at a quite high level: the AI engine sees a very abstracted version of the visual scene, and it sends high-level motion commands rather than detailed actuator-control signals.

Robot simulators exceed virtual worlds and game engines in terms of allowing detailed control of simulated robot joints, and physically realistic interactions between objects (as needed for instance to enable tool use), but don't allow large numbers of individuals to log on and help teach robots. It seems that the integration of robot simulator and virtual world technology has a great potential to advance intelligent robotics, via supplying robots with a large number of teachers. We are exploring ways of bringing this integration about, such as modifying the OpenSim (opensimulator.org) virtual world to use the Gazebo (see playerstage.sourceforge.net) robot simulator in place of its current physics engine.

Figures

The figures given here are numbered separately from those in the main paper. Figure 1 here is identical to Figure 2 in the main paper, and is replicated here for reference, due to its direct relevance to the figures that follow it.

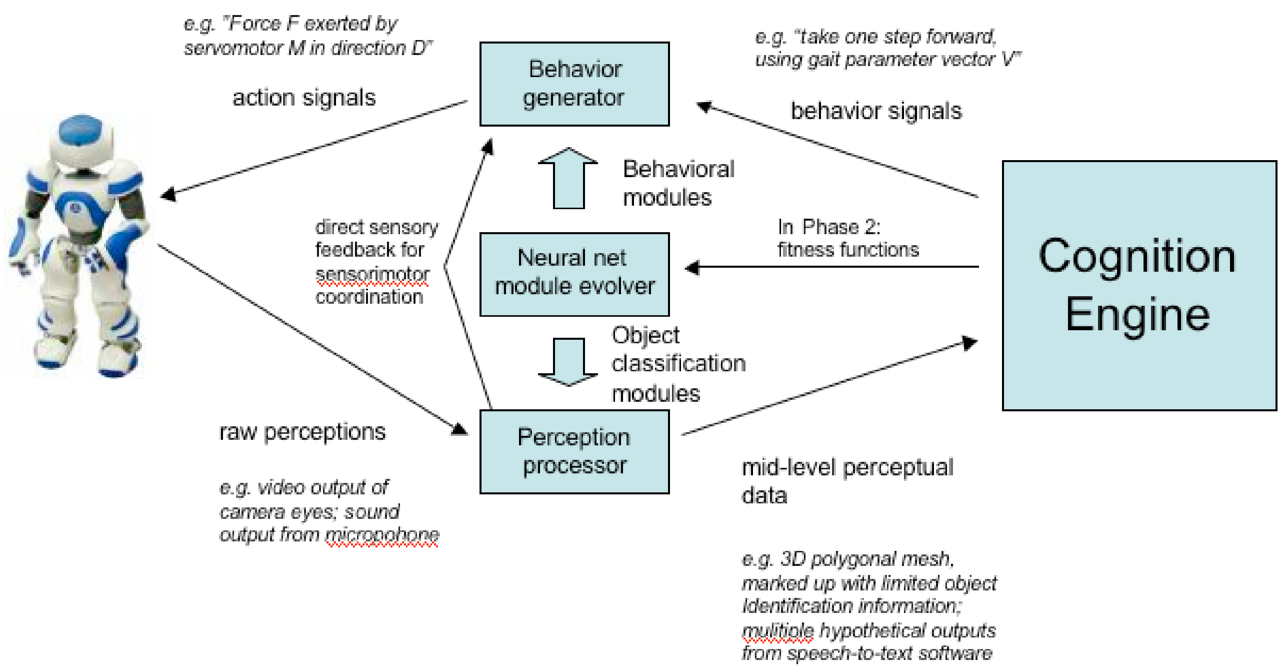

Figure 1. High-level diagram depicting key elements of the proposed integrative architecture for humanoid robotics.

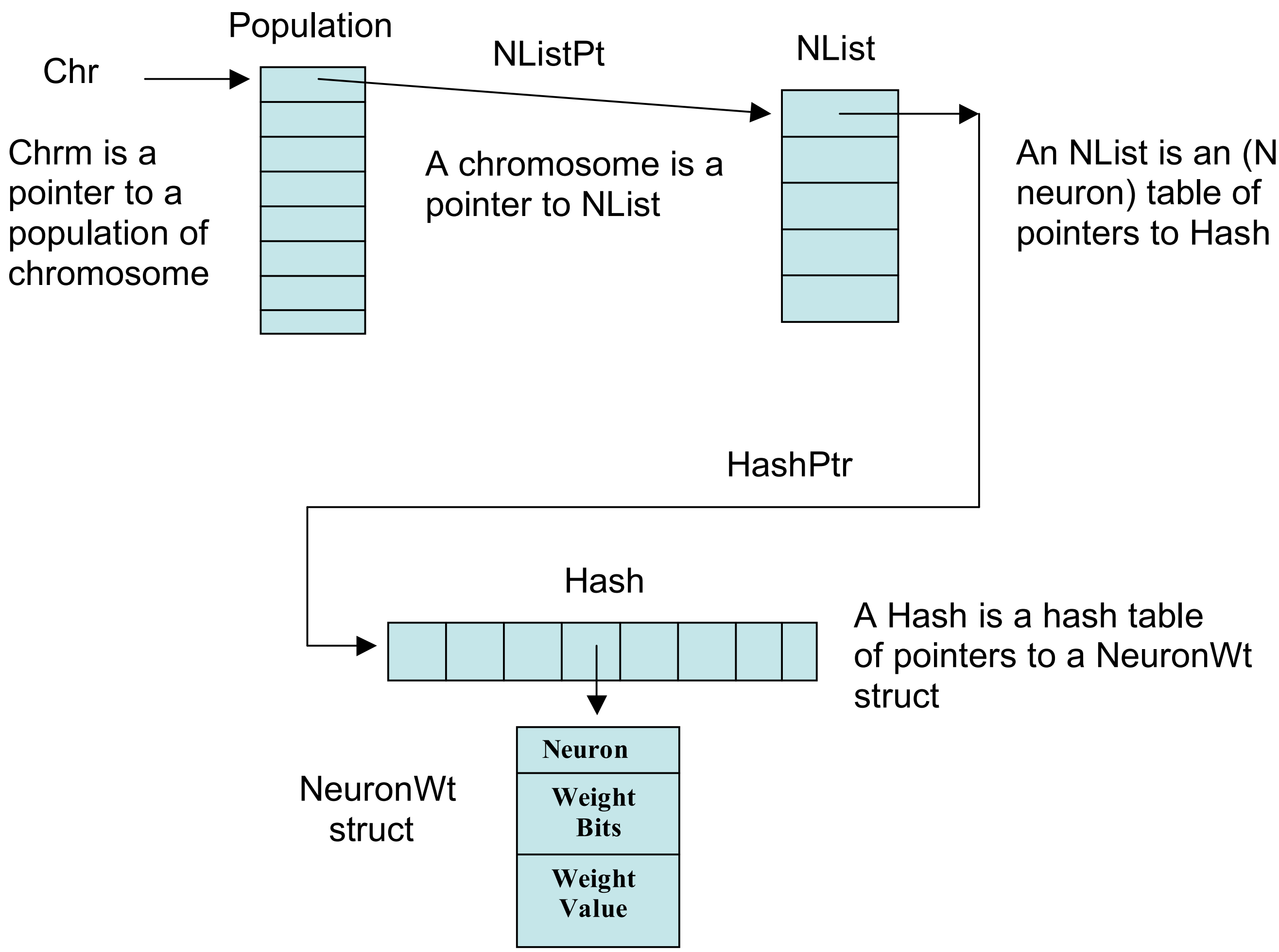

Fig. 2 Data Structures for the Parcone Model, which encodes flexible-topology neural nets in data structures that are well-optimized for evolution on FPGA's as well as via software.

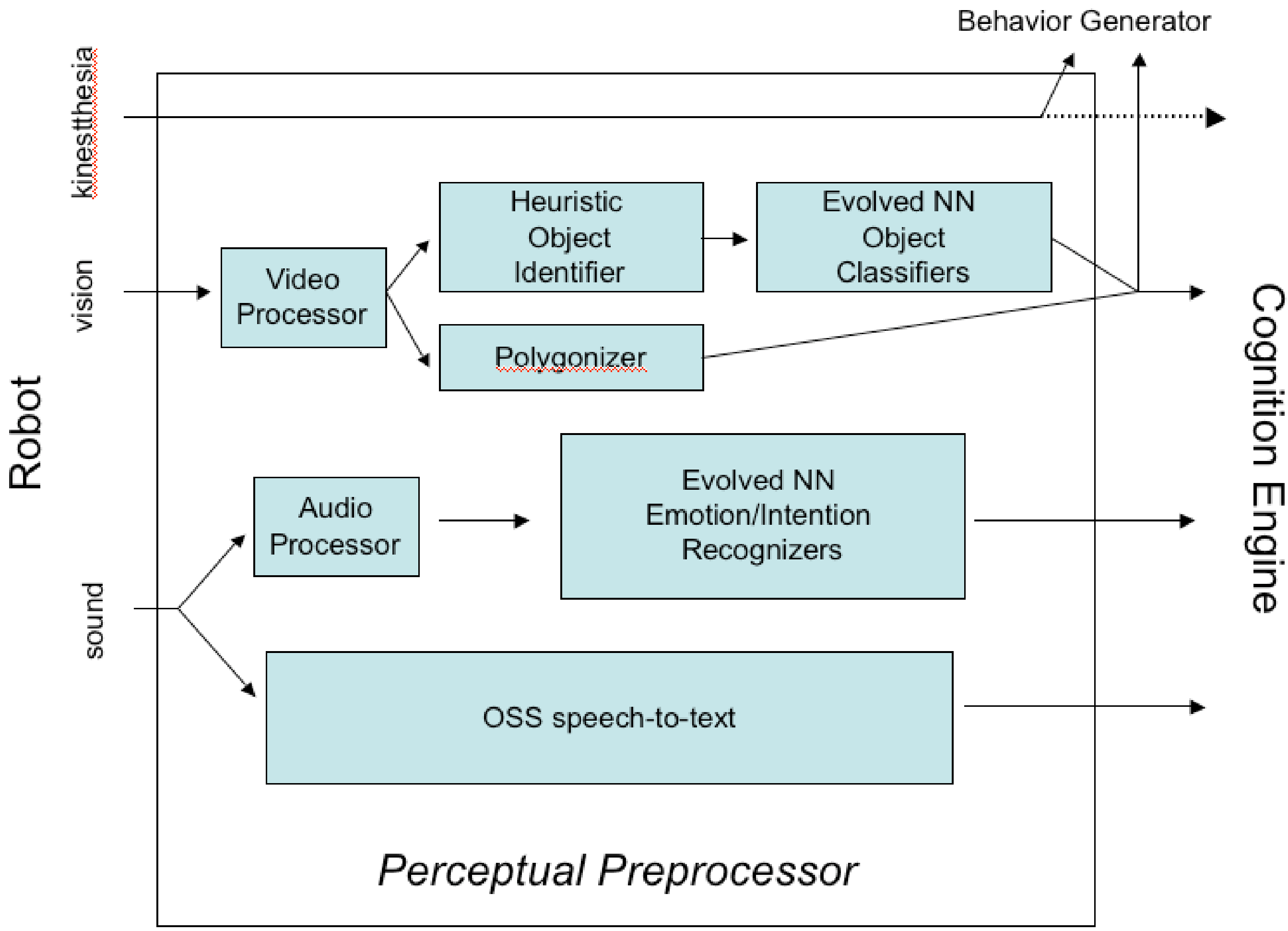

Figure 3. Internals of the Perception Processor

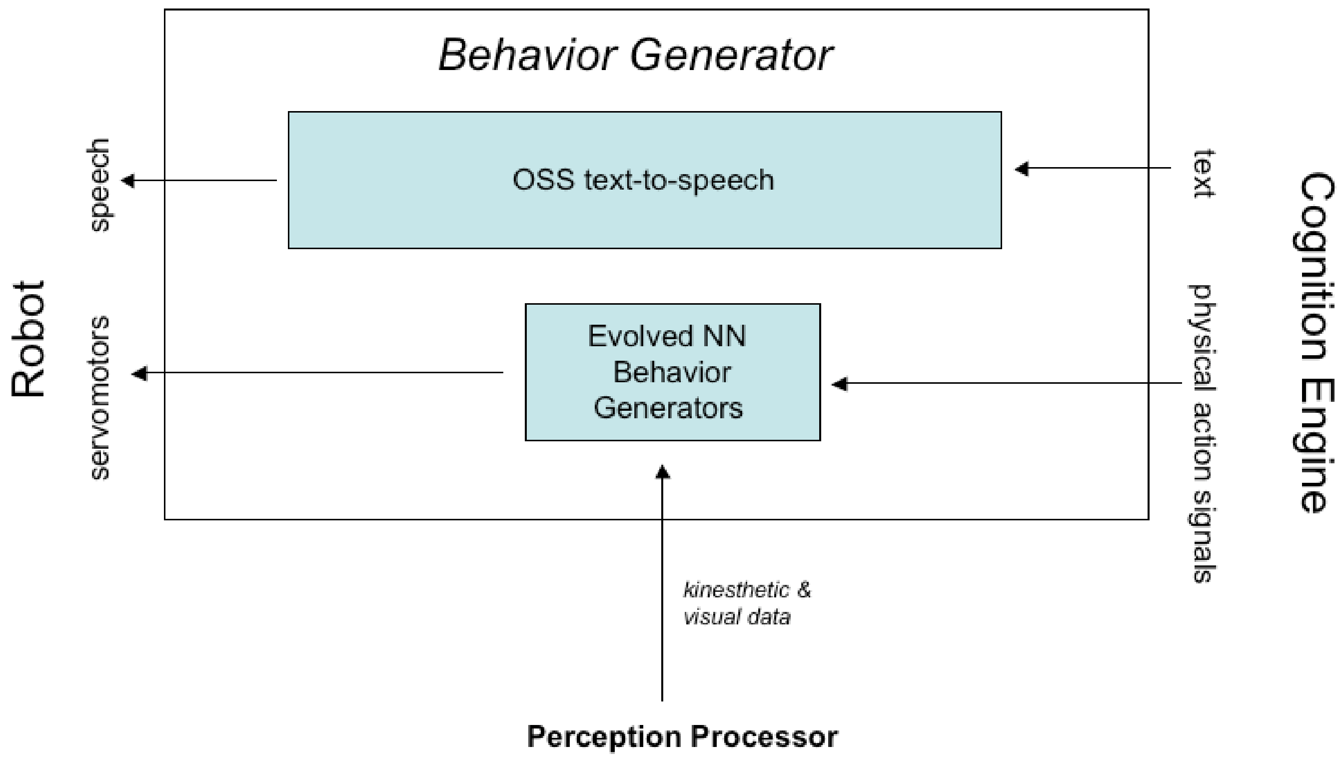

Figure 4. Internals of the Behavior Generator

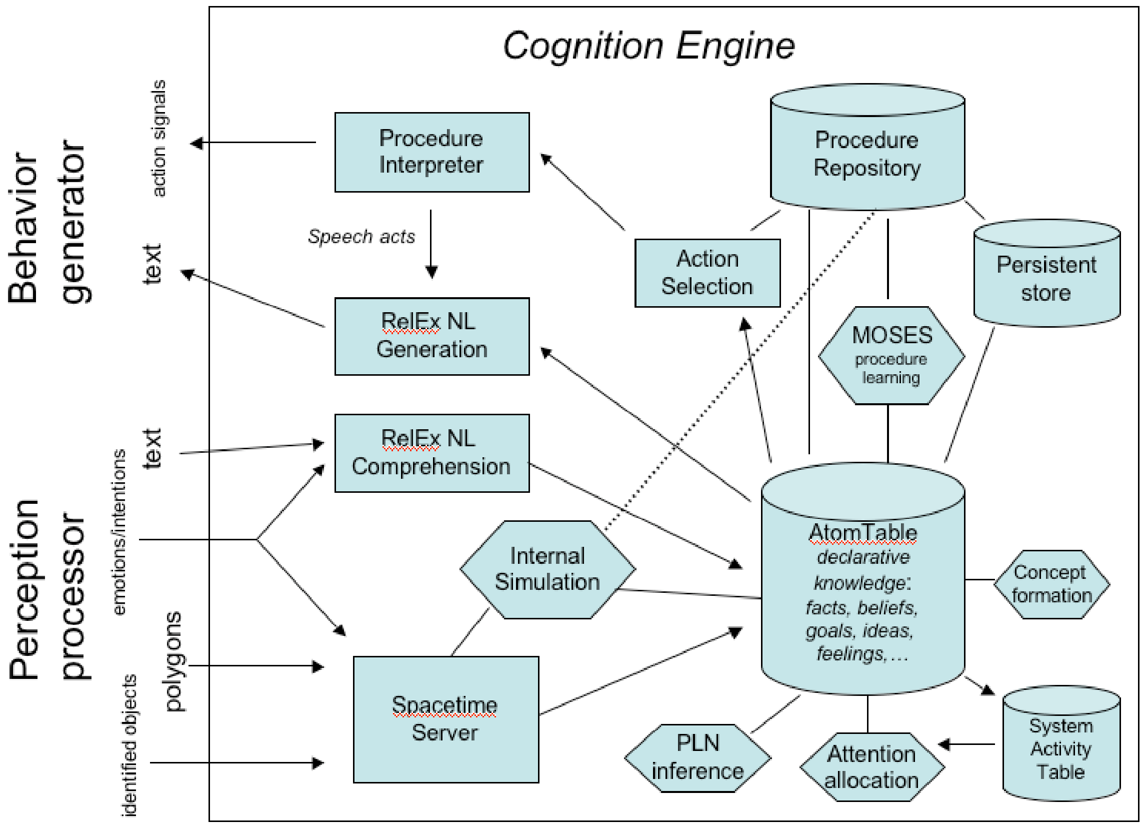

Figure 5. Internals of the Cognitive Engine, according to the Novamente / OpenCog Prime approach

Figure 6. Left: AI-controlled virtual dog in the Second Life, virtual world, learning the behavior “sit.” Right: Display of the current emotional and physiological status of an AI-controlled virtual dog in the Multiverse virtual world.

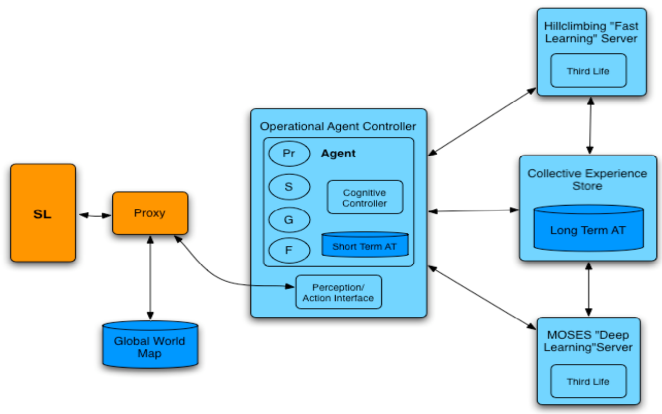

Figure 7. High-level architecture of Novamente Pet Brain, illustrating its connection to the Second Life (SL) virtual world. One aspect is included here that is not discussed in the main text: the use of a collective memory database to store the memories of a large population of virtual pets all together.

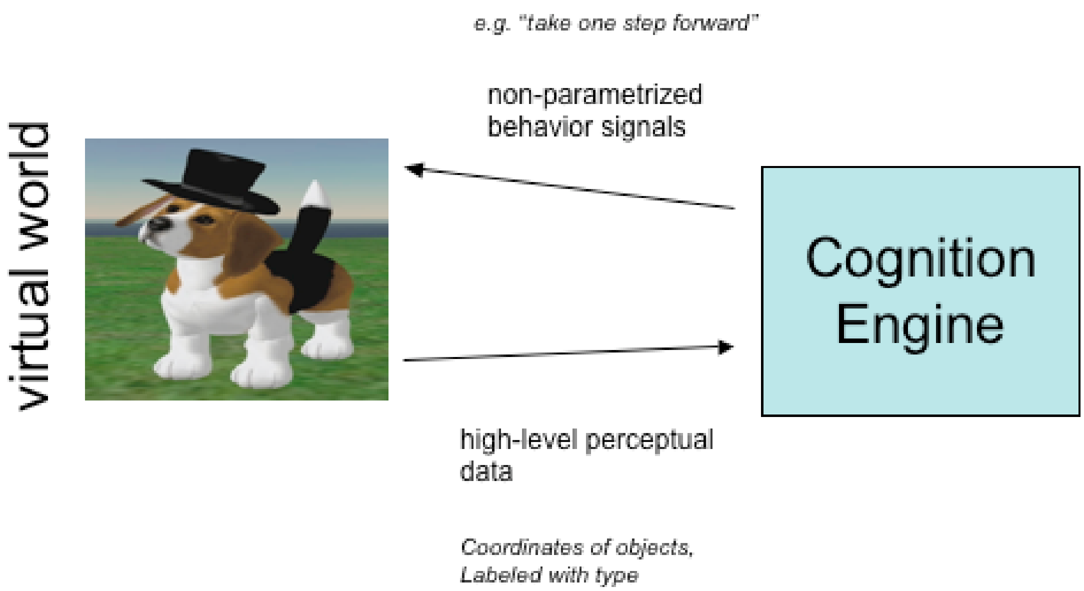

Figure 8. Simplified world-interaction scheme used with current virtual worlds and game engines