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MiRo: An Animal-like Companion Robot with a Biomimetic Brain-based Control System

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ABSTRACT

MiRo has six senses and eight degrees of freedom that are designed to promote human-robot interaction. A distinctive feature is the use of a biomimetic brain-based control system consisting of a layered control architecture alongside centralized mechanisms for integration and action selection. MiRo has been developed by Consequential Robotics, a spin-out of the University of Sheffield, and aims to provide the HRI community with a flexible platform for research and education.

Keywords

Developer platform; companion robot; robot-assisted therapy; brain-based control.

1. INTRODUCTION

There are relatively few robots available today that are (i) specifically-designed to promote human-robot interaction, (ii) based on the model of human-animal interaction, rather than human-human, and (ii) have sufficient sensory, motor, and computational capacity to provide an engaging long-term experience. The MiRo robot (Figure 1) is designed to be such a platform based on the view that animal-level social intelligence is within range of present-day robot technologies, and that social interaction with an animal-like robot can be enjoyable and could provide useful health or education benefits in environments such as homes, schools, hospitals and residential care facilities [1].

MiRo is designed as a fully programmable mobile developer platform for companion and social robotics that resembles domestic animals in some of their key features whilst being clearly a robot (in order to avoid deception). Key features include a friendly animal-like appearance, six senses, a nodding and rotating head, long moveable hearing-ears, large blinking seeing-eyes, a responsive wagging tail, life-like behaviour (see next).

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The MiRo robot is one of the few animal-like robot platforms that aims to be biomimetic in both aspects of its form and control. Moreover, MiRo is the first commercial robot to be controlled by hardware and software modelled on the layered architecture of the mammalian brain [2]. A brain-based biomimetic control system, *3B-CS*, based on twenty years of research in computational neuroscience and brain-based robotics at the University of Sheffield, allows MiRo to behave in a life-like way based on control system components that mimic, at an abstract level, some of the major sub-circuits of the mammalian brain. This architecture is easily extendable with new behaviors by specifying their trigger stimuli and by applying a brain-based action selection system that decides between competing behavioural alternatives in real-time.

Figure 1. The MiRo Robot

MiRo's layered control architecture is distributed across three embedded ARM processors that mimic aspects of spinal cord, brainstem, and forebrain functionality respectively, including their relative speed and computational power. One important feature is that the control latency of loops through the lowest reprogrammable processor, can be as low as a few milliseconds. This distribution of processing substrates from "fast and simple" through to "slow and sophisticated" is potentially a useful design element for robots. MiRo can also be controlled from a mobile, laptop or work-station, whilst streaming data and control signals over wifi or Bluetooth. Use of the 3B-CS control architecture is optional, the robot can also be easily configured as a ROS node or to operate with bespoke control systems.

MiRo's control systems currently support exploration and obstacle-detection and orienting towards directional sound or visual movement stimuli. This means that MiRo will generally approach and stop near to moving, sound-generating entities such as a people. The robot also responds to stroking touch on its body or head, using animal-like vocal utterances, movement, and patterns of colored LEDs in its torso, to express emotional signals of different valence [3]. Given its animal-like appearance and behavior, our experience is that many people, of all ages, spontaneously respond to MiRo as they might to a pet animal.

On-going research aims to add map-building and navigation, memory, learning from reward, person perception, and multi-modal social interaction capability. We also hope that a broader developer and research community will emerge to further extend the functionality of the platform.

2. APPLICATIONS—TOWARD NEXT GENERATION COMPANION ROBOTS

Like companion animals and pets, robots have the potential to sustain long-term social interactions, be engaging, and offer forms of verbal and physical comfort. Through their robotic functionality they can also support capabilities such as monitoring whilst requiring less care and support than pets. In addition to the domain of animal-like companion robots, MiRo is being developed to address the following application areas:

Human-robot Interaction (HRI). Within research on HRI thre is a need for programmable platforms with in-built capabilities that are engaging and easy to use. MiRo strengths are its attractive animal-like persona, robust build, long battery-life (6 hours+), and wide-range of sensor and actuator types. Unlike many other animal-like robots, MiRo is also an open development platform—the developer has full access to all of the sensor/actuator systems for on-board or off-board control.

Robot-assisted Therapy (RAT) Research with companion animals and pets show that these can provide many positive emotional outcomes for their owners including reduced risk of some diseases, decreased levels of pain in patients with chronic illness, and reduction in feelings of isolation and loneliness. Even a relatively short period of interaction with a companion animal can have positive and lasting impacts particularly in times of stress. Recent research has also demonstrated that some of these benefits can be obtained from interactions with animal-like robots (e.g. [4]). The appearance and behaviour of MiRo make it well-suited for investigating the potential use of robots in therapy for both children and adults. New interface software under development targets therapeutic interactions whilst a soft, washable and strokeable covering is being prototyped that we hope will encourage a still more rewarding tactile interaction.

Biomimetics and brain-based robotics. MiRo's animal-like design and control system will be of particular interest to researchers investigating models of animal brains and behaviour. Consequential's research partners at the University of Sheffield are currently using the MiRo robot to test brain models of animal-like spatial memory as part of the EU Human Brain Project, and would welcome further collaborations with researchers interested in brain-based robotics.

Public engagement. MiRo can demonstrate the potential of future companion robots to visitors to a laboratory, museum or visitor attraction. The platform is attractive to both adults and children and across genders. Unlike some larger robots, MiRo is unthreatening and can be used with children as young as two years old.

School and University Teaching. MiRo is versatile and flexible platform that could be used to teach everything from basic principles of programming through to computer vision, machine learning, robot control, psychology and biomimetic design. A screen-based simulation engine, MiRo-Sim (Figure 2), is provided free with the developer kit, and can be used by a classroom of students to develop and pre-test their software prior to live testing on-board the robot. This means that many students can be taught using a small number of robots.

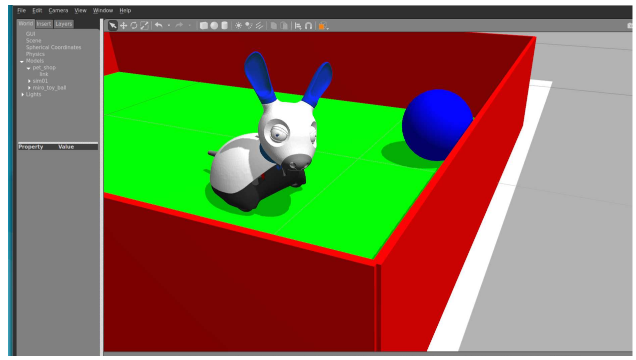

Figure 2. MiRo Robot Simulation Tool

A MiRo robot prototype was first exhibited at the Tokyo Robotics Show in 2015. At HRI2017 the first full production model MiRo will be demonstrated along with novel capabilities for spoken language recognition, and with a soft outer shell designed to encourage a rewarding haptic interaction.

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