# ADAPTING BODY AND BEHAVIOUR:
# - learning and playing with a modular robotic platform -

Patrizia Marti[1], Iolanda Iacono[2]

University of Siena
Social, Political and Cognitive Science Department
[1]marti@unisi.it, [2] iacono@media.unisi.it

**Abstract:** The paper illustrates the design of Iromec, a robotic platform developed to engage disabled children in exploring play scenarios and thereby in learning through play. Key features of the system are: *modularity*, provided both at physical and functional level; *configurability*, to allow the teacher to make the physical and functional rearrangement of the robot configuration, *construction* to modify, enrich and adapt play activities to different and evolving needs of the disabled children. Furthermore the platform offers the possibility for the teacher/therapist to design new play scenarios addressing different educational objectives**.** The paper shows how the adopted design enables multiple robot configurations and play scenarios, and exemplifies the use of the robot in the school context.

**Keywords:** modularity, play, learning, disability, game creation.

## 1 INTRODUCTION

In the last decade the technology evolution has produced a remarkable change in children's and adults' play offering new kinds of play experiences and equipments. From the humble beginnings of Pong, Pac-man, Tetris, and video pinball computer games, the game industry has moved to more realistic virtual worlds, more interactive environments and competitive play. A number of challenges guided this evolution: to increase the realism of virtual worlds, to turn "finger athletes" in sport and fitness people, to penetrate different areas of the industrial and public sector other than entertainment, like business (simulation games), education, professional training, health care. While some of these challenges have been successfully addressed by launching on the market physical and virtual games of increasing popularity, 3D representations used in courtrooms, interactive learning environments for the school and museum context, simulations for building designs and military systems, however a limited attention has been paid in making interactive games and equipments accessible for all, and in particular for disabled people to support them in improving their quality of life, their learning and development opportunities. Moving, exchanging, experimenting and learning through play are fundamental activities that should be exercised from childhood, according to the cognitive and physical abilities that an individual may have.

Unfortunately, disabled children are often prevented from playing due to their cognitive or physical impairment. Interactive games rarely adapt to the abilities of disabled children and therefore are far from being accessible for them.

Iromec (Interactive RObotic social MEdiators as Companions) is a robotic platform that addresses play as a medium for disabled children's learning, development and enjoyment. The platform is composed of passive and interactive hardware modules and configurable interfaces to enable the creation of play scenarios adapted to fit the needs of children with different kinds of disabilities [1].

Key features of the system are: *modularity* (passive and interactive modules can assembled to modify the robot appearance and its behaviour), *configurability* (the platform allows two main configurations, stationary and mobile), *construction* (the construction and deconstruction of modules allows to modify, enrich and adapt play activities to children with different abilities in different contexts). Furthermore the platform allows the creation of new games that can be implemented through "play script".

## 2 THE ROBOTIC PLATFORM

IROMEC is a modular mobile robotic platform developed to support children with cognitive and physical impairment to learn through play. The platform is conceived as a modular system equipped with different components: a mobile platform, an application module and some additional pluggable components used to modify the robot's appearance and behaviour [1].

The mobile platform developed by Robosoft (www.robosoft.fr) controls all the commands related to the movement, localization and navigation. It is equipped with

13 ultrasound and 18 infrared sensors and a laser scanner to allow obstacle detection, navigation in the space and reaction to external stimuli. Movement and speed are controlled through a motor/gearbox/encoder ensemble that makes the movement safe and suitable for the interaction with children. The platform contains also a video camera for colour tracking. It weights around 10 kgs.

The application module developed by Profactor (www.profactor.at) manages the user interaction through a set of digital components and interfaces. It can be plugged/-unplugged on/from the mobile platform through hooks that safely and invisibly fastener the two modules. The interaction module measures 35x55x17 cm and weights around 8 kgs. The module is composed of two parts: the body and the head. The body displays graphical interface elements related to different play scenarios on a 13 inch digital touch screen. For example, the body screen can represent the features of an imaginary cartoon-like character displaying a digital fur which moves according to the direction of the platform's movement. When the robot stops, fur clumps appear that extend when it moves again. The head is constituted of a 8 inch digital screen that displays the robot's facial expressions. The head rotates along a vertical axis from right to left (and vice versa) to simulate the robot's attention towards a specific direction. The head movements are controlled by an additional micro-controller that it also in charge for controlling the camera system.

A number of additional components were designed to modify the appearance of the robot and its behaviours. Some of these modules are interactive and affect the robot's behaviour. For example luminescent fabric covers are plugged on the lateral sides of the robot and light up when the robot moves. They are fixed on the interaction module through magnets. Different groups of luminescent fibers are weaved into the fabric and can be managed independently being controlled by one inverter each. Different light patterns can be obtained are used to reinforce the feedback on the robot status during movements and coordination games. Another example of interactive module embedding smart textile is "interactive fur" is made of a soft woolen cover with static and moving hairs. This is a stand alone module which is plugged on top of the interaction module through an interlocking mechanism. The moving hairs are fixed to the copper fabric but their lower part is connected to a Nitinol spring.

Each Nitinol spring is connected in their central part to an electric wire wrapping the hairs. The Nitinol springs are fixed to the inner part of the dome shell by means of screws, and the electric wires are inserted through holes in the shell itself. When electricity passes from one extremity of the spring to the center, the other extremity contracts. The movement of the hair can be controlled in timing, intensity and form. This makes the effect of the moving hairs seem quite natural, similar to the fur of an animal [2].

Some other modules of the platform are passive and are used to modify the appearance of the robot. For example, a mask can be mounted on the robot's head to hide part of the digital face and reduce the robot's expressivity. The mask is composed of a fixed smiling mouth, nose and removable eyes.


**Fig. 1.** The robotic platform

The platform can be assembled in two main robot configurations, vertical (**Fig. 2.** left) and horizontal (**Fig. 2**. right). In the vertical configuration, the robot is stationary and the interaction module is mounted on a dedicated support that provides stability and maintains a fixed position. The mobile platform is not used in this configuration. The head is rotated on the vertical axe to fit the vertical position of the body and the head display automatically adapts the face with the correct orientation. In this configuration the robot has a human-like stance. A dedicated mask can be mounted on the head to hide part of the face if required. This configuration supports imitation scenarios that require the children to reproduce basic movements, like turning the head. The robot can also assume the horizontal configuration to support activities requiring wider mobility and dynamism. In the horizontal configuration the interaction module in plugged in the mobile platform and the head is rotated upside down. Also in this case the head display automatically adapts the face with the correct orientation.

**Fig. 2.** Vertical (left) and horizontal (right) configuration

The covering modules contribute to modify the appearance of the robot in both configurations (**Fig. 3.**).

**Fig. 3.** Interactive fur cover (left), mask (right)

### 2.2 Interfaces

The application module is featured with a high level control system (Game Control) that provides editing of "play scripts" through the GUI, by means of XML-description. The Game Control programming software is written in java programming language and it is easy to modify. An game editor is currently under development to allow the teachers to implement new scenarios autonomously. "Play script" allow to implement GUIs for different play scenarios, so that the robot can turn from an imaginary animal covered by a fur (**Fig. 4.**) into a creeping snake, or an agile tiger or a quite turtle (**Fig. 5.**). Currently the robot can show facial expressions that incorporate the mouth, nose, eyes and eyebrows, as well as different levels of expressiveness and emotional states. Smooth transitions are used to provide a life-like impression.

**Fig. 4.** Imaginary animal-like character

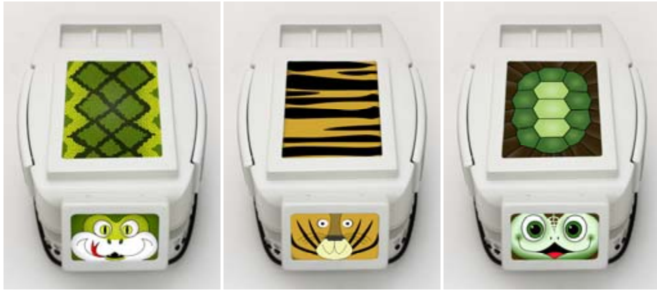

**Fig. 5.** Snake (left), Tiger (centre), Turtle (right)

The interfaces are enriched by original sounds to structure and articulate the play experience. They have been designed in collaboration with experts, therapists and teachers to give the impression of a living entity without any specific human or animal connotation. A library of sounds was created so that different sounds can be associated to various games through "play scripts".

## 3 CREATION OF PLAY SCENARIOS

The robotic platform can be configured to engage in a number of play scenarios [3] [1] including turn taking and imitation games, cause and effect games, coordination games, sensory stimulation games. Each scenario is designed to address detailed educational and therapeutic objectives and can be adapted to the specific needs and ability of the child. For example, the *Tickle* scenario (**Fig. 6.**) consists of an exploration of the robot's body to discover where it is sensitive to being tickled. The game can be played in different configurations: either by tickling the robot in correspondence of "digital fur knots" appearing and disappearing on the touch screen display; or by stroking a pressure sensitive fabric cover mounted on the robot's body: whenever the child strokes a sensitive area the robot laughs emitting sounds. The tickling zones change dynamically and children have fun in trying to guess where the robot is more sensitive.

**Fig.6.** Two configurations for the Tickle scenario

The game is designed to improve the perceptual functions (auditory, visual, tactile and visuo-spatial perception) as a basic form of communication. This is important to the learner since the tactile sense can help to provide awareness of one's own self and each other, to build trust, and to give or receive support in order to develop social relationships during play.

The scenario was experimented in a primary school in Siena (Italy) with children with physical and cognitive impairments. As an example, we briefly present an excerpt of an experiment conducted with M., a 6 year old girl with Pierre Robin syndrome. Because of her disease, M. has a poor speech and difficulties in performing movements that require coordination of the upper and lower limbs, such as sitting down and getting up, and eye-hand coordination. She is emotionally fragile and needs to be constantly reassured during the execution of a task. She is in trouble in playing games that require the production of simultaneous mental schemes and the presence of co-occurrence of variables such as several moving objects at the same time. M. was involved in an experimental study conducted in a primary school in Siena (Italy) for 3 months with 3 sessions per week [4].

**Fig. 7.** shows the child playing the *Tickle* game. The child explores the robot's body (**Fig. 7**. up left), she observes the interface and the "fur knots" appearing on the digital screen (**Fig. 7.** up right), she executes the task (**Fig. 7.** bottom left) and at the same time monitors the robot's expressions in reaction to tickling (**Fig. 7.** bottom right). The sequence shows that M. is very engaged in playing with the robot. She carefully touches the fur knots showing a certain degree of eye-hand coordination and a correct understanding of the cause-effect relations of her actions. Furthermore, she attributes emotional states to the robot showing empathic engagement with the play companion. These behaviours are examples of social competence that the child can develop, exercise and reinforce in interaction with the robot.

**Fig. 7.** Experimenting the *Tickle* scenario

## 4 CONCLUSIONS

Iromec is a robotic platform that supports disabled children in exploring play styles. The platform has a number of key features that make the robot a suitable support in learning and therapeutic activities. The modularity is achieved both at hardware and software level: it allows to configure the robot by changing its appearance, and to create new games to address the specific needs of disabled children. Thereby, the platform can be used in a flexible manner by allowing the teacher/therapist to design educational activities. The design leads to solutions such as utilising the material properties of the platform to facilitate understanding of behavioural characteristics and to exercise creativity. These features further make it possible to create inclusive games which are adapted to children with different physical and cognitive abilities. Indeed, the platform has been used with autistic, motor impaired children, and children with mild cognitive impairment in the school context with the classmates with typical development [4].

### ACKNOWLEDGMENTS

The authors would like to thank the children and their families for their enthusiasm in experimenting with the robot. Thanks also to Sara Gioiosa for designing the tiger, turtle and snake games.

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