
RoboSkin
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ROBOSKIN

Skin-Based Technologies and Capabilities for Safe, Autonomous and Interactive Robots

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Istituto Italiano di Tecnologia (I)	University of Wales, Newport (UK)	Universita' degli Studi di Cagliari (I)

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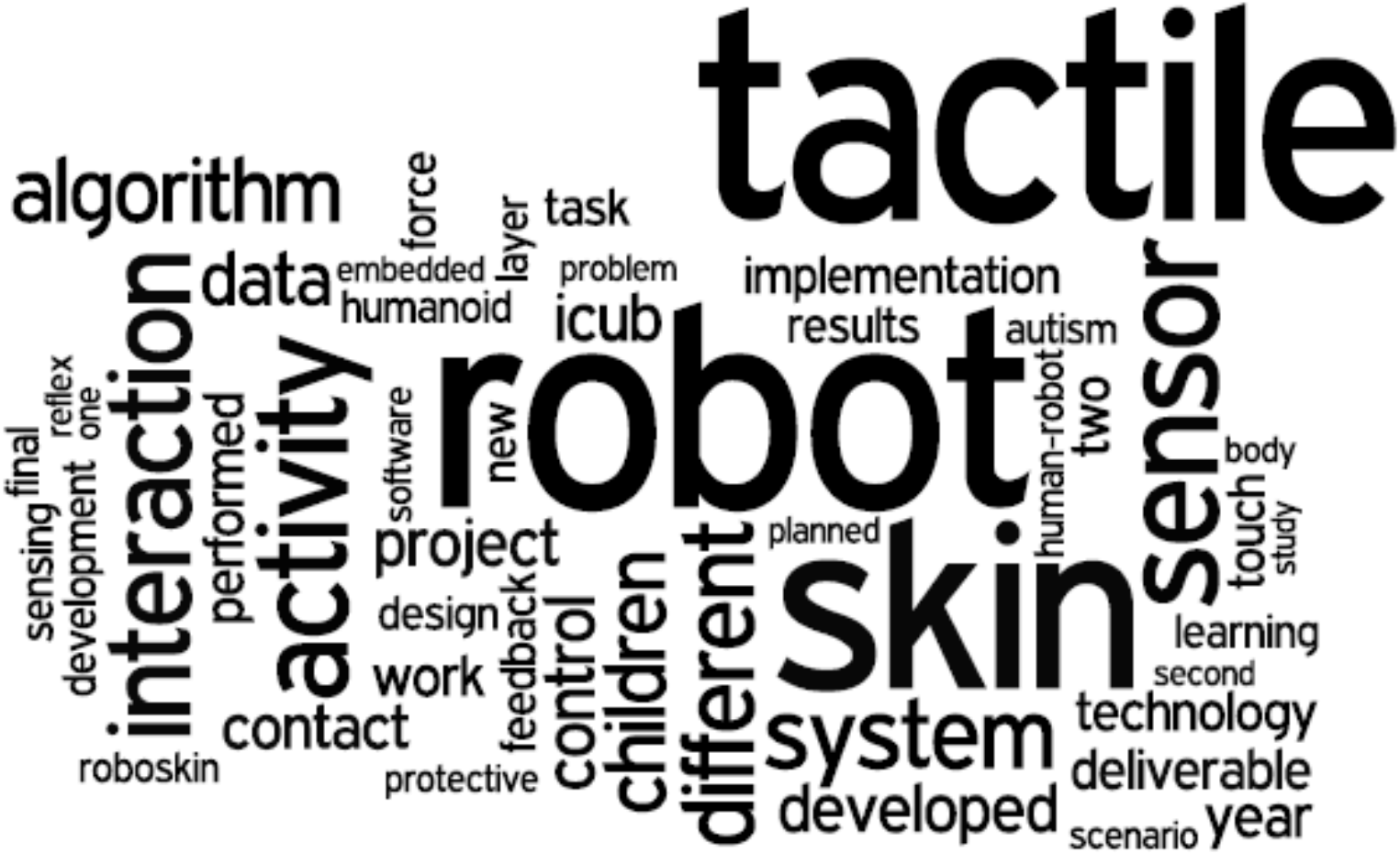
Part 1

CONTRIBUTION OF ROBOSKIN

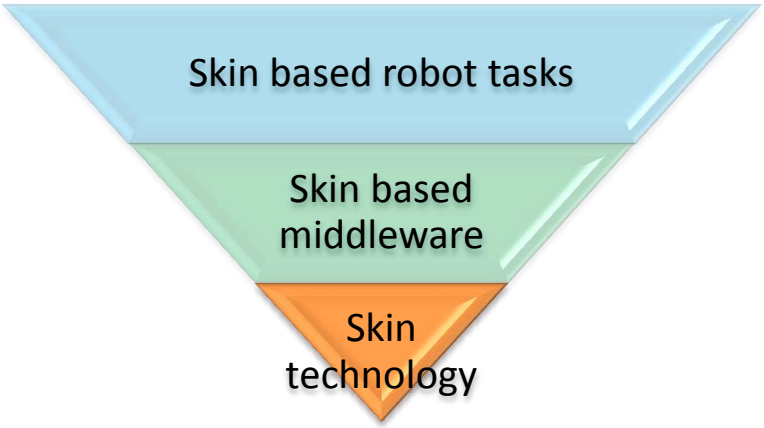
What's inside ROBOSKIN



ROBOSKIN: STEP changes

A. Methods and technologies for the development of multimodal modular *robot skin*
B. Control and perceptive methods for efficient and safe utilization of tactile data at motor and cognitive level.
C. To develop cognitive mechanisms based on the use of tactile feedback to improve human-robot interaction capabilities.

Robot skin hardware

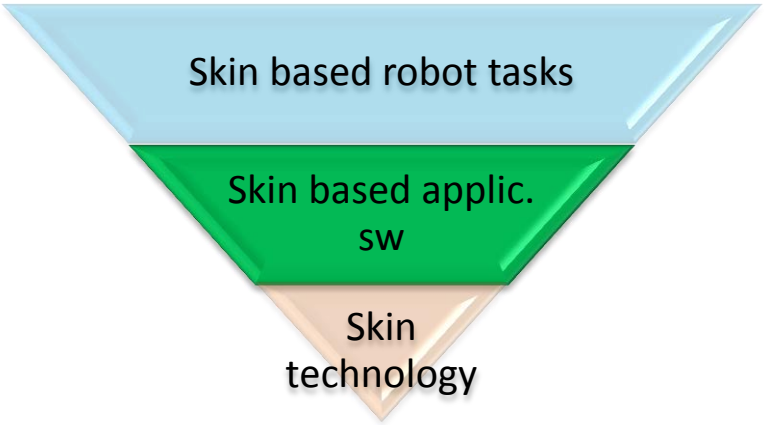


- Procedures, methods and technologies, for the development of large scale robot skin systems, which can be tailored for different robotic platforms.

ROBOSKIN achievements

- *robot skin design methodologies*
- *robot skin embedded hw and distributed sw for early skin data processing*
- *development of robot skin for different types of robots*

Robot skin based application sw

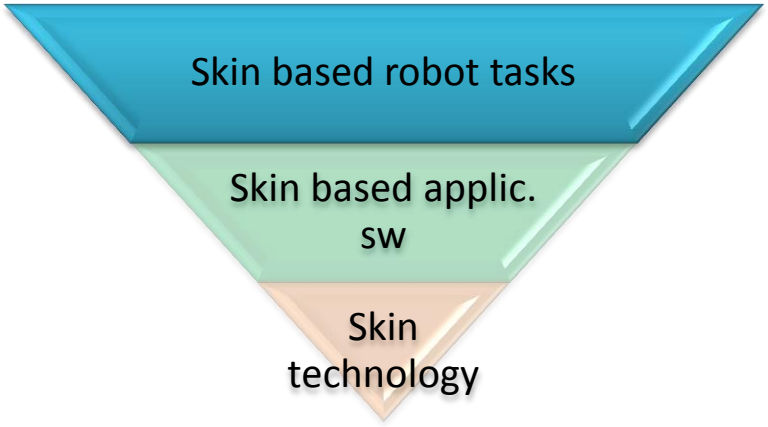


- Application software layer bridging **tactile hardware** with **perceptive and the control modules**, to support the implementation of high level skin based cognitive and interaction tasks.

ROBOSKIN achievements

- *Low level interaction control*
- *Sensor-motor strategies for reactive protective reflexes*
- *Methods for touch gesture recognition*
- *Middleware for tactile data utilization at task level (e.g. reactive control), and application level.*

Skin based robot tasks



- There exist specific application domains based on direct human-robot interaction, requiring tactile sensing and perception, that motivate the development of large scale robot skin systems.

ROBOSKIN achievements

- *Programming by demonstration*
- *Skin based social cognition problems (application domain of autism therapy)*

STEP changes

30+ years of research in tactile sensing

- M. H. Lee and H. R. Nicholls (first survey late '80s)

Mostly demonstrators (proof of concept).

Few integrated solutions.

Very few portable solutions.

...

Think of a transduction principle and you get tons of papers

- Piezo-resistive
- Piezo-electric
- Capacitive
- Optical (diode/photodiode)
- Optical (wave guide + camera)
- Optical (fiber optic)
- ...

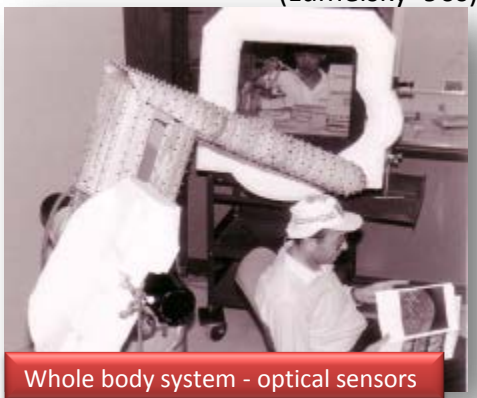
... biochemistry ...

Integration at system level is a key issue ... (the missing link!)

... evolution ...

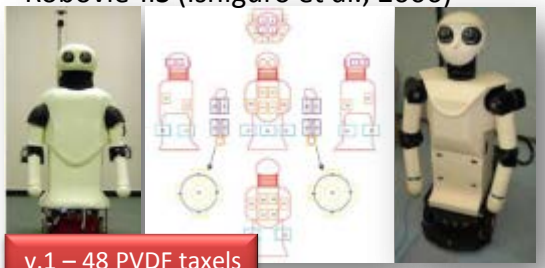
The Evolution

(Lumelsky '90s)



Whole body system - optical sensors

Robovie-IIS (Ishiguro et al., 2006)



v.1 – 48 PVDF taxels
v.2 – 284 PVDF taxels

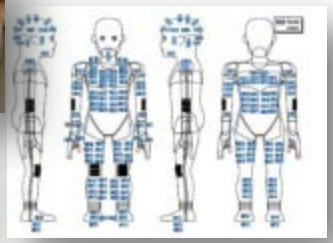
Kotaro (Mizuuchi et many al., 2006)

Pressure Conductive Rubber
64 taxels/bandage

((Kuniyoshi et al., 2007)

1864 optical tactile sensors
Embedded networking support

PVDF patches

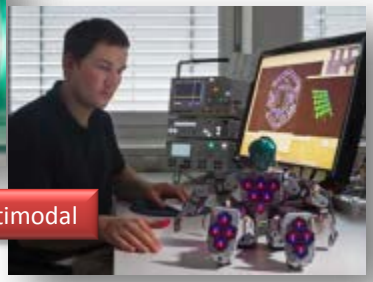


CB² (Minato et al., 2007).

Contact and collision detection

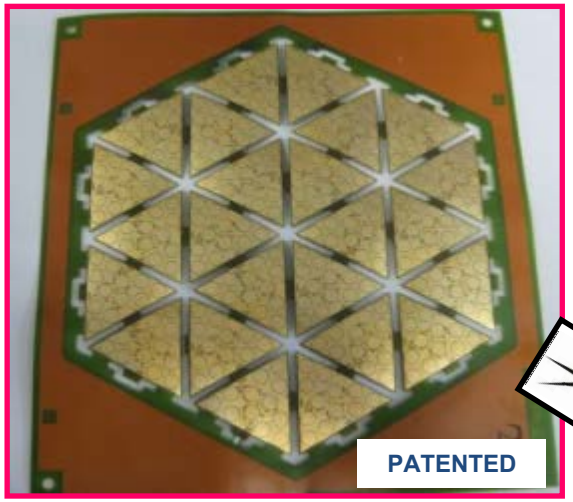
(M. Fritsche et al, 2010)

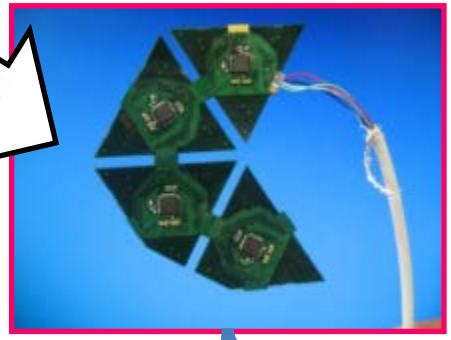
(Cheng and Mittendorfer, 2011)



Modular and Scalable Multimodal

ROBOSKIN

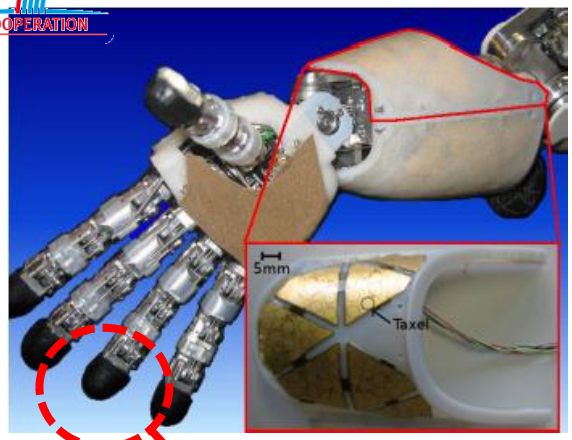


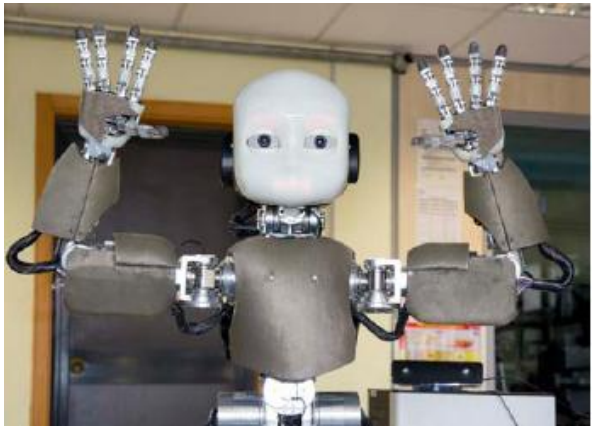


(ROBOSKIN 2009/12)

Modular and Scalable Multimodal

Portability (iCub)

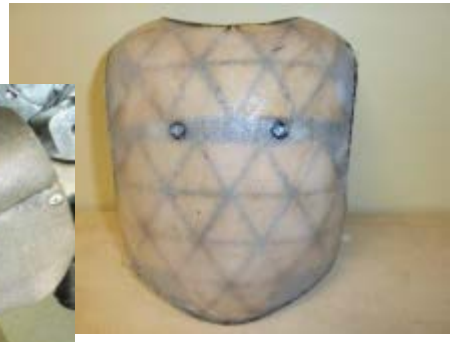




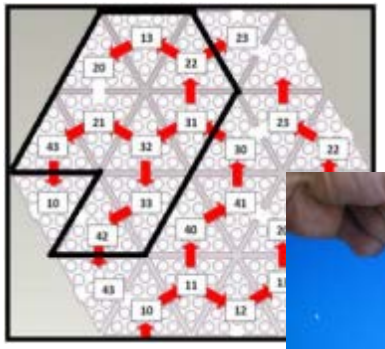
iCub

- 184 triangle modules
- 18 μControllers
- 2208 taxels

iCub skin: 0.7 m²



Portability (KASPAR/NAO)



Kaspar

- 92 triangle modules
- 12 μControllers
- 1104 taxels

NAO

- 54 triangle modules
- 6 μControllers
- 648 taxels

University of Hertfordshire

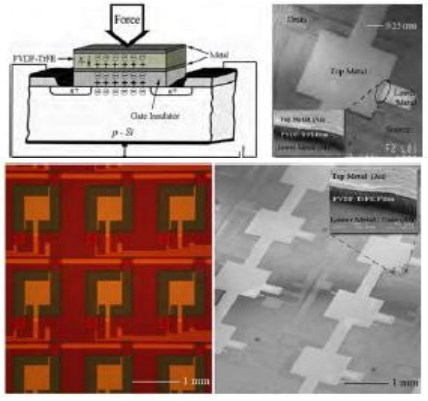
University of Wales, Newport | Prifysgol Cymru, Casnewydd

Portability (Schunk @ IPA)

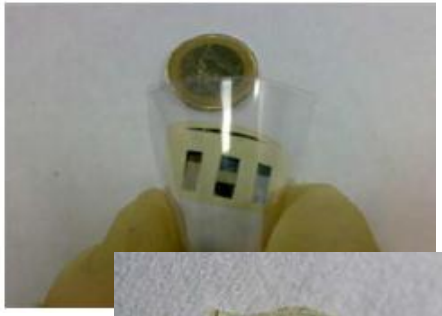
- 23 patches
  - 182 modules
  - 2184 taxels
- 16 µcontrollers
- 2 CAN backbones

(basic) STEP changes

- Different transduction tecnologies
  - **PVDF -> large BW, integrable at chip level (PosFET)**

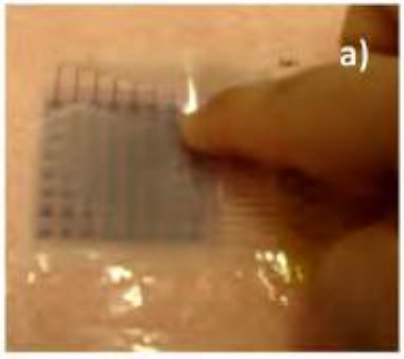


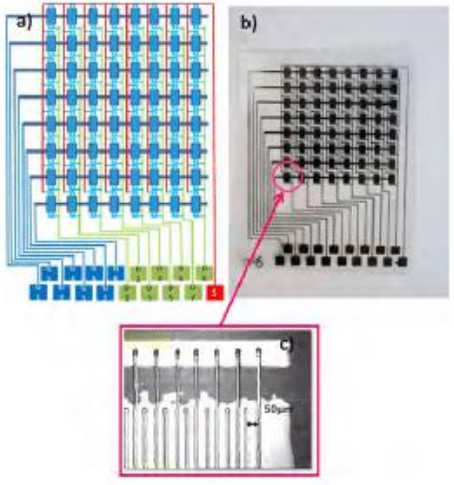
Silicon

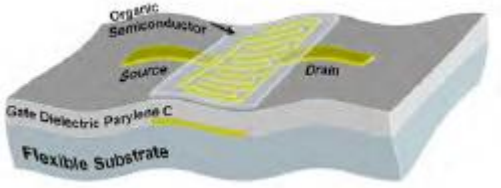


TFT

  - **Organic -> printable**





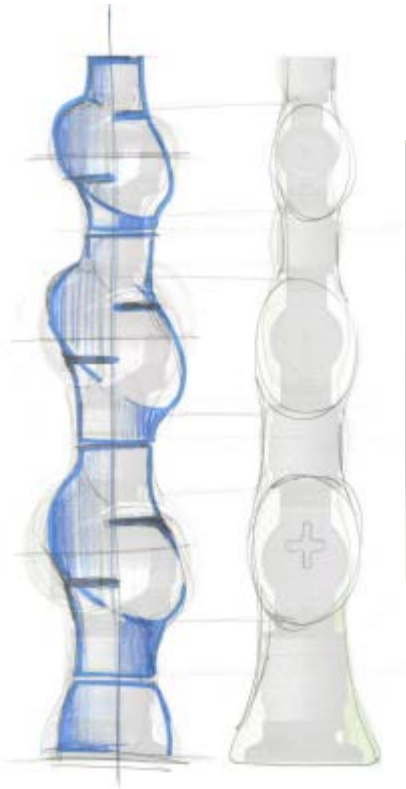


STEP changes

… *evolution* … has worked …

… and still needs to work …

Current evolution (Thales-Alenia)



Schunk LWA3

ThalesAlenia Space
A Thales / Finmeccanica Company

Position of ROBOSKIN w.r.t. SRA (2014-2020)

Domain	2020 Target	ROBOSKIN
System design	To develop robot specific design methodologies,…	Distributed large area tactile sensor design methods and techniques
System Architecture	To define interfaces and common architectures …	Development of tactile based middleware for tactile data abstraction.
Human Machine Interface	To develop instructable interfaces […] for collaborative working….	Tactile based teach by demonstration (key objective)
Sensors	To integrate robotic specific sensor processing at the sensor. …	PosFET transducer design.
Control	To devise safe control strategies allowing for physical interaction between human and robot …	Tactile based control and touch based calibration.
Human Robot Collaboration	To develop low cost safe dependable systems able to react and interact with people. …	Investigation on reactive behaviours (in humans and robot). Investigation in application domain of autism therapy.
Sensing	To increase the distribution of basic sensor processing closer to the sensors...	Distributed embedded sensor network w/ local processing
Interpretation	To be able to reliably recognise a wide range of known objects. …	Touch classification

Critical Feedback (1)

- Lessons learned
  - Tactile sensing is not easy …
  - New problems emerged (e.g. calibration, body modelling)
  - (maybe) ROBOSKIN really helped to move SoA

Combined tactile sensing built on flexible materials (e.g. capacitive and piezoelectric) is almost ready to be used at ***high TRL*** *levels for applications […] and to interact with people in R/T.*

(MAR page 156)

Critical Feedback (2)

- How to improve (Research)
  - Advanced design (e.g. organics, new transduction mechanisms, dedicated μ-electronics I/F (*) etc.)
  - Computational models (e.g. comp. contact mechanics, tactile data processing, tactile data interpretation etc.)
  - Cognitive models (e.g. multimodal data processing, recognition/classification, body modelling etc.)
  - …

- How to improve (Applied research and Tech-transfer)
  - Design and manufacturing processes (including CAD tools)
  - Improve performance (e.g. larger bw, multimodal sensing etc.)
  - Control and calibration (e.g. tactile based ctrl, self-calibration e.g.)
  - Safety standards compliance (e.g. self-diagnostics, etc.)
  - …

These topics are well addressed in the MAR

Critical Feedback (3)

- How to re-use existing resources
  - ROBOSKIN results are fully open for research
  - Key patents have been filed (hw design)
  - Some concepts have been re-used for different applications (e.g. networked control)
  - Results re-used in other projects (e.g. engineering specific solutions – e.g. CloPeMa project)

PART 2

USE OF RESULTS

The Implementation of the ROBOSKIN technology on the humanoid robot KASPAR and its possible use in the application domain of autism therapy

During the ROBOSKIN project, studies were conducted in three different special needs schools in the UK for children from different age groups and with different abilities (moderate and severe learning difficulties) as follows:

a- pre-school nursery for young children with autism, some of which with very limited abilities.
b- primary special school for children with moderate learning difficulties
c- secondary school for children with severe learning difficulties.

Case-study analysis of sessions were autistic children interacted with KASPAR (which was equipped with the ROBOSKIN patches) showed :

- children demonstrated an inclination for tactile contact with the robot.
- the children also have shown responsiveness to KASPAR's reactions to their touch
- initial evidence suggest that the children learnt across trials and may have even generalized some of what they learnt into other contexts outside the session with the robot.

The robot with tactile capabilities now could provide the facility for :

- ‘cause and effect’ games that allow low functioning children with autism to explore simple motor manipulation integrated with basic symbolic activity - an area of development known to be a difficulty for this population.

- possible embodiment and cognitive learning – through the evaluation and improvement of tactile social behaviour in Child Robot Interactions

- here the robot provides stimuli and reinforcement in a controlled manner helping the child’s exploration of social cognition and interaction skills

Teachers and therapists' observation and evaluation of the tactile play sessions of low functioning children with autism with the robot indicated that these sessions may:

- Help young children recognise their own feelings and those of people around them.
- Help to further develop body awareness and sense of self.
- Promote taking initiatives
- Promote the emerging of awareness of cause and effect

KASPAR helps to encourage or discourage certain tactile behaviours

To probe further

www.roboskin.eu

The Crew

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