

## ***Interdepartmental Research Center "E. Piaggio"***

**Faculty of Engineering, University of Pisa,  
Via Diotallevi 2,  
56126 Pisa, Italy**

[www.piaggio.cci.unipi.it](http://www.piaggio.cci.unipi.it)

### ***Human-Robot Interaction in Autism***

*A. Fornai~ , G. Pioggia, S. Casalini, G. Della Mura, M. L. Sica, M. Ferro, A. Ahluwalia, R. Igliozzi\*, F. Muratori\*, D. De Rossi (Interdepartmental Research Center "E. Piaggio", Faculty of Engineering - University of Pisa; \*Scientific Institute "Stella Maris", Department of Developmental Neuroscience - University of Pisa; ~ Ph.D. Student in Cognitive Science - University of Siena)*

*F.A.C.E.T.* - One of the core features associated with autism is the impairment in reciprocal social interaction and in particular in processing emotional information. Children with autism, particularly those with high functioning autism, can learn to interpret meanings and intentions of people and to anticipate their emotional reactions if they are made to enact possible social scenarios. Recently, in order to stimulate the processing of emotional information, mobile robots are used to encourage children with autism to take initiative and to interact with the robotic tools. However these robots are incapable of any biomimetic or emotional representation and do not include any three dimensional facial display. Moreover, using such a kind of robots is difficult to enact social scenarios they may encounter during the course of their daily lives.

The android FACE (Facial Automaton for Conveying Emotions) used within the FACET (FACE as a Therapeutic Tool for autism) context represents an innovative android-based treatment for the social rehabilitation of people with autism. FACE is a social believable artefact able to interact with the external environment, interpreting and conveying emotions through a non verbal communication. FACE mimics the biological behaviour by means of dedicated smart soft materials and structures, likewise control strategy, algorithms and artificial neural networks. Focusing on core aspects of the autistic disorder, namely social attention and the recognition of emotional expressions, FACE can act as an interface between the patient and a trained therapist in a specially equipped room. On the basis of a dedicated therapeutic protocol it is able to engage in a social interaction by modifying its behaviour in response to the patient behaviour. FACE captures from the patient expressive and psychophysical correlates and actuates behaviours with kinesics, a non verbal communication conveyed by body part movements and facial expressions. FACE allows the real-time acquisition of both physiological and behavioural information by means of an unobtrusive sensorized wearable interface from a patient during the treatment. This

approach is close to an environment that people with autism could consider to be social, helping them to accept the human interlocutor and to learn through imitation. In fact, following an imitation-based learning strategy, the FACET project is searching to verify if such a system can help children with autism to learn, interpret and use emotional information. Moreover, if such learned skills may be extended to a social context.

*FACE AND ITS ENVIRONMENT* - The realisation of a social interactive machine entails critical requirements for the body, the sensory perception system, the mobility and the ability to perform tasks. The human mind responds and modifies itself in respect to the real world making the body to be able to perceive, to act and to survive; the human intelligence primarily rises from the interpretation of the body needs. For this reason it is preferred to follow a mind-body monism, i.e. an embodied mind able to perform the elaboration processes taking into account the domain of experiences where the machine is placed; such processes influence and are influenced by its own presence.

Dynamic interaction mechanisms are needed in order to place the robot inside its environment: FACE is then provided with extrinsic perception in order to interiorize the external world and to be able to suitably react. FACE possesses its own body structures, i.e. a support to the intrinsic perception (proprioception) and motor activity. The rising of a relationship domain close to a human context underlies the need of a high degree of believability in the FACE robot. FACE must possess a time-space capability for both egocentricity and allocentricity, taking into account the actuation of preprogrammed behaviours as well as an imitative learning strategy.

*FACE: IMITATION AND LEARNING* - The real environment is complex as well as the whole human cognitive processes. Obviously the internal representation of the external world rebuilt by a machine may result strongly incomplete. We should provide the robotic brain with the greatest possible external information and with the rules to correlate them, or we should allow the robot to learn. The former is unfeasible; the latter is difficult but possible through a process of imitation-based learning.

The process of imitation is innate to humans, and place a crucial role in distinguishing between actions arising from within or actions induced by others [4]. Imitation paves the way to the comprehension of the intentions of others establishing a reciprocal non verbal communication process in which the roles of the imitator and of the model are continuously exchanged. Moreover, in the early years of the life, imitation plays a fundamental role for the emerging of the proprioception, of the perception of the external world and of the ability to act our own actions.

The learning process in FACE is based on imitating predefined stereotypical behaviours which can be represented in terms of FAPs (Fixed Action Patterns) followed by a continuous interaction with its environment, the epigenetic evolution of the machine. FAPs can be classified as belonging to action schemes, partly fixed on the basis of physical constraints and sensory-motor reflexes, partly subjected to a specialization

on the basis of the experience. FACE will therefore be able to continually learn, to adapt and evolve within a simplified behavioural space in function of the environment and to maintain spontaneous activity open to any innovative and intelligible behaviours arising which may then be interpreted.

**FACET'S TREATMENT** - Two distinct treatment modalities are employed: the first is based on a repertoire of pre-selected social situations and the second allows the therapist to realise new situations as a consequence of the real time interaction between FACE and the child. A series of initial sessions are devoted to the familiarisation of the child with the android, and to observe spontaneous reactions of the child when placed in front of FACE. During the familiarisation phase it will be possible to identify verbal and non verbal expressions of the child which can be used to ascertain the degree of social attention towards the robot.

The first element evaluated during the treatment is the ability of the child to imitate the movements of FACE. Factors such as spontaneous imitation, or imitation upon presses by the therapist will be considered, as well as the "goodness" of imitation. It is also possible to increase the degree of a given emotion on FACE to induce or potentiate imitation if necessary.

Results have shown that the android has a high visual impact and suggested that children with autism can be led to interact proactively in a positive manner with FACE [12]. In particular, the children's attention towards FACE was monitored and then if the android remains a restricted and repetitive interest or an object to share with the therapist were checked. It was observed that the children with autism focused their attention towards FACE's eyes movements as a result of verbal suggestions of the therapist. It was also observed that children with autism can sometimes show clear attempts to draw another person's attention to the android integrating eye contact with pointing and/or vocalization. They can sometimes also request different activities using more than one communicative strategy.

**FACET'S MORALITY: A RESULT OF INTERACTION** - From a bioethical point of view, the relation between FACE (as a therapist) and the autistic child (as a patient) is far from being a strictly paternalistic one. FACE employs a "specular" kind of therapy, FACET, whose purpose is to create an "intellective-emotional bridge" between a child and the robot.

By using a communication system focused on facial expressions, FACE is able to meet the child's affective needs, building an *ad personam* relationship aimed at every child. This link between the robot and a child doesn't rest on a set of rules establishing either a robot-centric or an anthropocentric moral. The bridge developed through a set of interactive child-robot steps is of an intellective-emotional type and its purpose consists in building the relationship itself: as soon as FACE can interact with the autistic child, FACET's goal is reached.

The only intervention tool is represented by the strategy FACE adopts to build the bridge. FACET depends in fact on the context; anyway, therapist play an essential role in every kind of robot-child interaction. This actor is able to help FACE in setting up

the intellectual-emotional bridge. It has to be regarded as the starting point of a future, structured relation between child and robot. This is an imitative relation that could be useful to help the child during future communicative social interaction with non-autistic people.

Then, if a reflection on FACET's morality is possible, it must start from the context from which the robot-child interaction arises. The question is: how much is therapist involved in the construction of this intellectual-emotional bridge?

We try to answer drawing the role at stake; FACET resorts to a imitative context-dependent construction strategy whose main feature is the absence of pre-determined constructive rules. In fact, the treatment start from a repertoire of pre-selected social situations but the therapist can realise new situations as a consequence of the real time examination of interaction between FACE and the child. Since an initial familiarisation sessions between the child and the android, the core of F.A.C.E.T. is the power of real time imitative interaction "child-robot". In this phase, Therapist has the responsibility to judge the ability of the child in the imitation of the FACE's movements. This examination and the following situations the therapist make up as a consequence of examination could help the child to improve his communicative strategy.

From a bioethical point of view, the morality of each robot-child interaction is an emergent property coming out from the connections between therapist, child and robot. In other words, it's all about a sort of "connectionist ethical stand point". As an emergent property, morality is not subdued to any component in the interaction: its source is the interaction itself. So our point of view on FACET's morality is based on the results of this complex interaction. In fact, our research model proceed at the same rate with a principle of precaution [11] as a set of action procedures able to estimate both risk and benefits.

We are therefore interested in the "historicity" of each robot-child interaction, since this approach allows us under treatment to take advantage of a pattern-free, ruleless construction model, being able to subsequently draw the main features of interaction even from a bioethical point of view.

To sum up, the morality of every interaction between FACE and the child with autism does not display any sort of fixed structure, rather it's similar to a real time ethically-responsible strategy of action in order to improve child communicative ability. So, FACET's morality results on interaction itself! The several construction steps involved resemble a "vortex" whose purpose is to let the autistic child gain access to the intellectual-emotional world of non-autistic people. FACET's therapeutic efficiency relies thus upon its capability to emancipate autistic children from their pathological isolation. And this is what is ethically relevant to our research project.

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