Development of Robot-enhanced Therapy for Children with Autism Spectrum Disorders

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DREAM

Development of Robot-enhanced Therapy for Children with Autism Spectrum Disorders

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D1.2 Robot Behaviour Specification

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Dissemination Level		
PU	Public	**PU**
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	

Contents

I Executive Summary

Deliverable D1.2 is concerned with the identification of the robot's behaviour in robot-enhanced therapies. It forms a part of the Reference Manual of Clinical Requirements and describes in detail the robot actions that are required for the targeted interventions. The general working framework undertaken by this project for using the robot in diagnostic and therapeutic activities is that of the robo-mediator approach. This means that the robot is used as a facilitator for delivering the same psychological treatment as in classical approaches, but its presence might have positive effect on the efficacy and/or the speed of gains.

D1.2 is based directly on Deliverable D1.1: Intervention Definition. Section 3 of D1.1 defines the robot actions specified in the intervention and diagnosis tasks. The purpose of this deliverable is to abstract these actions and present them in a parameterized manner; e.g. moveHead (x, y, z) to move the head to gaze at a location given by the coordinates x, y, and z, or moveHand(x, y, z, roll) to move the hand to a location given by the coordinates x, y, and z and orient the hand at that point to align it with the roll angle.

Note that D1.2 also includes vocal expressions, parameterized both by spoken message and tonal quality (e.g. happy, sad, excited, fearful).

D1.2 provides the requirements for work package WP6 on robot behaviour. Specifically, it provide the basis for behaviour synthesis in WP6 and, in particular, this deliverable, along with deliverable D1.3 Child Behaviour Specification, provides the training set for the learning process that maps child behaviours to robot behaviours. This training set is used in WP6, task T6.3: Deliberative Subsystem.

II Principal Contributors

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III Revision History

Version 1.0 (DV 23-06-2014)
First draft.

Version 2.0 (SM 23-06-2014)
Extended the Executive Summary.
Extended Section 1: The Basis for Behaviour Definition.
Added references.

IV Robot Behaviour Definition

1 The Basis for Behaviour Definition

The robot's behaviour in therapeutic activities, as it is described in this deliverable and elsewhere in the DREAM project, is conceptualized in a robo-mediator paradigm (David, Matu & David, 20014). That is, the robot acts a facilitator in the interaction between the child and the therapist for delivering the same psychological treatment as in the classical condition (unmediated by the robot). The choice for this approach is justified by previous research showing that that children with autism spectrum disorders (ASD) have better performances in some basic interaction and social skills (such as joint attention, sharing objects, etc.) when these desired behaviours are trained in robotic-mediated interventions (Vanderborght et al., 2012; Wainer, Dautenhahn, Robins, & Amirabdollahian, 2010). Is important to note here that in the mediator stance the robot does not act as a psychotherapist by itself (as in a robo-psychotherapist approach), nor as an optional adjuvant that could be replaced by other tools (as in a robo-assistant approach; see for detail David et al, 2014). Instead, the robot acts as a specific and necessary "catalyst" for this population by increasing the efficacy of the treatment and/or speeding up its effects. The therapists is still present but instead of directly teaching the child the skills targeted in the treatment plan, he uses the robot as a mediator for doing so, making use of this technological tool to attract the interest and the attention of the child (Michaud & Theberge-Turmel, 2002). Yet, the therapist monitors the interaction and can always intervene if required.

After the presentation of this general working framework, we will now operationalize the robot's behaviour (in an abstract and parameterized manner) as it will be used in the diagnostic and intervention tasks. We start from Deliverable D1.1 Intervention Definition that identified the set of baseline robot actions that are invoked during the interventions and diagnosis tasks. These are summarized in Table 1 below.

Table 2 defines an abstract set of action primitives, each of which encapsulates a subset of one or more of these baseline robot actions. Each action primitive has a set of parameters that, suitably chosen, allows it to produce one or more required robot actions.

Table 3 maps the baseline robot actions to the corresponding abstract parameterized action primitives.

One of the robot's actions is a vocalization of some linguistic message. Table 4 lists the words, phrases, and sentences that the robot has to say.

Section 2 provides a more detailed explanation of each action primitive and describes the parameters in each case.

Before continuing, we need to mention an important point: all actions (and all sensory information in Deliverable D1.3) are specified in a Cartesian world frame of reference. We have chosen to adopt this approach because sensory information is provided by several sensors that are distributed in the environment, specifically around the therapy workbench but also on the robot itself. All this information has to be integrated in a common frame of reference and for convenience we choose to use a world-centred frame of reference in Cartesian coordinates. As a consequence, a number of utility functions are required to calibrate the sensors with respect to this world frame of reference and to identify the position and orientation of the robot in this

frame of reference. These allow the robot's movements (specified in its own frame of reference) to be related the location of objects in the robot's environment (specified in the world frame of reference).

Face tracking
Grip object (activate electromagnet)
Hand tracking
Head and hand tracking
Make a sound (angry, happy, sad, fearful)
Move arm to point at the picture
Move hand above grip location
Move hand above original grip location
Move hand down
Move hand left
Move hand right
Move hand right of grip location
Move hand to touch at the object (picture)
Move hand to touch position
Move hand up
Move head to centre gaze on the child
Move head to centre gaze on the hand
Move head to centre gaze on the object
Move head to centre gaze on the picture
Move head to centre gaze on the sand-tray
Move head to centre gaze on the sound
Move head to centre gaze on the table
Move head to centre gaze on this area
Move to a pre-determined pose:
angry, happy, sad, fearful, cover eyes, touch head with both hands, stretch out arms
Move torso to face child and adjust gaze
Move torso to face therapist and adjust gaze
Move hand up to face
Perform a dance routine
Release object (deactivate electromagnet)
Say “<word, phrase, sentence>” (see Table 4)
Wave with one hand

Table 1: The robot actions listed in Section 3 of Deliverable 1.1.

grip()
moveHand(handDescriptor, x, y, z, roll)
moveHead (x, y, z)
moveSequence(sequenceDescriptor)
moveTorso (x, y, z)
release()
say(text, tone)

Table 2: Action primitives

Face tracking	moveHead (x, y, z)
Grip object (activate electromagnet)	grip()
Hand tracking	moveHead (x, y, z)
Head and hand tracking	moveHead (x, y, z)
Make a sound (angry, happy, sad, fearful)	say(text, tone)
Move arm to point at the picture	moveHand(handDescriptor, x, y, z, roll)
Move hand above grip location	moveHand(handDescriptor, x, y, z, roll)
Move hand above original grip location	moveHand(handDescriptor, x, y, z, roll)
Move hand down	moveHand(handDescriptor, x, y, z, roll)
Move hand left	moveHand(handDescriptor, x, y, z, roll)
Move hand right	moveHand(handDescriptor, x, y, z, roll)
Move hand right of grip location	moveHand(handDescriptor, x, y, z, roll)
Move hand to touch at the object (picture)	moveHand(handDescriptor, x, y, z, roll)
Move hand to touch position	moveHand(handDescriptor, x, y, z, roll)
Move hand up	moveHand(handDescriptor, x, y, z, roll)
Move hand up to face	moveHand(handDescriptor, x, y, z, roll)
Move head to centre gaze on the child	moveHead (x, y, z)
Move head to centre gaze on the hand	moveHead (x, y, z)
Move head to centre gaze on the object	moveHead (x, y, z)
Move head to centre gaze on the picture	moveHead (x, y, z)
Move head to centre gaze on the sand-tray	moveHead (x, y, z)
Move head to centre gaze on the sound	moveHead (x, y, z)
Move head to centre gaze on the table	moveHead (x, y, z)
Move head to centre gaze on this area	moveHead (x, y, z)
Move to a pre-determined pose	moveSequence(sequenceDescriptor)
Move torso to face child and adjust gaze	moveTorso (x, y, z)
Move torso to face therapist and adjust gaze	moveTorso (x, y, z)
Perform a dance routine	moveSequence(sequenceDescriptor)
Release object (deactivate electromagnet)	release()
Say “<word, phrase, sentence>”	say(text, tone)
Wave with one hand	moveSequence(sequenceDescriptor)

Table 3: Correspondence between baseline robot actions and action primitives.

Broomm!
But let's dance first!
Good try!
Great job. Well done!
Hello! I am glad you are here to play with me
How about playing the next game
I like to play with children
It's okay if you don't want to do this now
It's still your turn … have a go
It's your turn: what do you like to do?
Look; now it's your turn
Not bad! Let's try again!
Sorry, that's not right. Let's try again!
That's angry
That's happy
That's right. Well done!
That's sad
That's scary
Today, we will play together
When you feel angry you can breathe slowly while counting from 1 to 5
Zoomm!

Table 4: Words, phrases, and sentences that are to be spoken by the robot. Other messages will be added as required.

2 Action Primitive Descriptions

2.1 grip()

The grip() primitive causes the robot to grip an object by activating an electomagnet on the hand. This assumes that a magnet is embedded in an appropriate specified location in every object that has to picked up. Provided the hand is placed close to this location, the object will be attached to the hand when the robot electromagnet is activated.

2.2 moveHand(handDescriptor, x, y, z, roll)

The moveHand() primitive causes the robot to move its hand to a location given by the coordinates x, y, and z (defined in a world frame of reference) and orient the hand at that point to align it with the roll angle (again, defined in a world frame of reference). The hand to be moved is specified by the handDescriptor argument (either left or right).

2.3 moveHead (x, y, z)

The moveHead() primitive causes the robot to move its head so that its gaze is directed at a location given by the coordinates x, y, and z (defined in a world frame of reference).

2.4 moveSequence(sequenceDescriptor)

The moveSequence() primitive causes the robot to replay a sequence of moves comprising a some physical animation, e.g. a dance or a wave or simply a pose that conveys some emotion. It takes one argument, sequenceDescriptor, which indicated what animation is to be enacted. The values of the sequenceDescriptor include the following: angry, happy, sad, fearful, cover_eyes, touch_head_with both_hands, stretch_out_arms, dance_A, dance_B, wave_A, wave_B, … Other sequence descriptors can be added as necessary. This primitive is more convenient than moveHand() when you need to position the hands with respect to the robot's body since moveHand() requires target location specified in world coordinates.

2.5 moveTorso (x, y, z)

The moveTorso() primitive causes the robot to adjust its body so that the normal vector from the centre of is torso is direct at a location given by the coordinates x, y, and z (defined in a world frame of reference). If the robot is sitting, then this primitive has no effect since there are no degrees of freedom in the robot's waist.

2.6 release()

The release() primitive causes the robot to release an object by deactivating an electomagnet on the hand (see grip() above).

2.7 say(text, tone)

The say() primitive causes the robot to speak the message contained in the text argument. The tone of voice is adjusted to reflect one of four emotions passed in the tone argument: happy, sad, fearful, angry.

V References

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