Investigating a Robot as a Therapy Partner for Children with Autism

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Abstract:

The aurora project is investigating the possibility of using a robotic platform as a therapy aid for children with autism. Because of the nature of this disability, the robot could be beneficial in its ability to present the children with a safe and comfortable environment and allow them to explore and learn about the interaction space involved in social situations. The robotic platform is able to present information along a limited number of channels and in a manner which the children are familiar with from television and cartoons. Also, the robot is potentially able to adapt its behaviour and to allow the children to develop at their own rates. Initial trial results are presented and discussed, along with the rationale behind the project and its goals and motivations. The trial procedure and methodology are explained and future work is highlighted.

Introduction:

The term autism encompasses a range of disabilities on the Autism Spectrum, including Aspergers Syndrome (sometimes referred to as high functioning autism), Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS) and autism. The spectrum is defined by its effects on the individual, and although these can be wide ranging and diverse between people, a few common features exist. The most prominent of these are categorised as the Triad of Impairments by the National Autistic Society (NAS). They are:

- Deficits in social interaction
- Deficits with social communication
- Deficits and limitations in the areas of imagination and generalisation

Autism is a disability which affects between five and fifteen people in every ten thousand and there is currently little evidence of the reasons behind the disability or who is most at risk from it. Autism is a present from the very first moments of a child's life and there is currently no cure for it, but if it is diagnosed early in the child's development then certain therapy techniques can help the child to compensate and to learn to cope with the disability in the real world more effectively.

One of the more popular therapy techniques is that of TEACCH (Treatment and Education of Autism and Related Communication Handicapped Children) (Watson et al, 1989). This approach centres on the child being presented with a range of situations which he should respond to. Appropriate responses are rewarded and reinforced. The child's lack of ability to generalise can make this process lengthy, but the situations are controlled in order to give the child a range of similar experiences to learn from.

The Aurora Project:

The prospect of using technology to enhance our understanding of autism and to help those who suffer from it was investigated in 1976 (Weir & Emanuel, 1976). An autistic boy was introduced to a logo turtle, operated via a set of buttons, however this case study gives little details of the boys background and functioning ability. Other researchers have also realised the potential of computers for enhancing the autistic child's interaction capabilities, for example see Murray & Lesser's Autism and Computing web site and Michaud et al, 2000, who developed interesting robotic designs for children with autism.

The Aurora Project (Werry & Dautenhahn, 1999; Dautenhahn & Werry, 2000) was started in 1998 to investigate the use of a robotic platform as a therapy aid for children with autism. It was thought that a robot as a teaching aid for therapists holds a number of advantages over the use of only a human therapist. While autistic children focus on individual details of a scene, they may miss the more general picture of events due to the number of features and articles which require their attention. A robot is able to function and communicate in a limited number of ways, allowing the child to focus on a few communication channels and not miss any of the details. Additionally, while the stress of interaction and learning with a human teacher may place extra pressure on the child, interaction with a robot – which is often a familiar and safe environment due to exposure from television and similarities with the child's toys – reduces this pressure and allows the child to relax and enjoy the interaction, leading to a stronger learning environment.

Long term goals of the project include the development of a robotic platform which can be used in schools by teachers and therapists to allow autistic children to practise their social development and interaction skills learned in other classes. In the short term, the robots effectiveness must be evaluated so that we are able to determine better the strengths and weaknesses of this approach. The level of interaction with the robot by the children is an important factor in its success and so the children should enjoy the robotic platform. A particular challenge in this aspect is the evaluation methodology, since the children are able to move around the room and to interact with the robot in any way that they feel comfortable, for example by their relative position to the robot and their level of interaction and involvement. This leads to the difficulty of getting quantitative results from an unrestrained process which could result in the child performing almost any gesture or action.

Testing Methodology:

In order to gauge the effectiveness of the robot, it is tested with a number of autistic children in a special school. These trials take place in the children's school, providing a familiar surrounding for them, and are video recorded for evaluation at a later time. Trials occur in a room approximately 2 metres by 3 metres which has only enough chairs for two experimenters and a teacher from the child's school, on hand to provide guidance and to ensure that the child does not become agitated or bored. Trials typically last for ten minutes, with the first four minutes taken with either the robotic platform or a toy truck of approximately the same size and shape. The next two minutes involve both the toy and the robot, although the robot is now turned off and inactive, and the last four minutes then involve the toy or the robot, which ever was not present initially. However, this schedule is occasionally altered by the teacher if it becomes apparent that the child is bored, irritated or is not enjoying the interaction.

The video record of the trial is evaluated according to a set of criteria. The trial is broken into one second intervals, and each second is evaluated for micro-behaviours, following from Tardif et al, 1995. The behaviour parameters consist of two categories, those which depend on the focus of the behaviour, for example the distinction between the child looking at the robot and looking at an environmental feature is important, and those parameters which are relatively independent of focus, there may be instances where the child produces speech and that it is impossible to determine the focus of this speech, although the occurrence is an important event. The behaviour parameters are:

Focus Specific: *eye gaze, eye contact, operate, handling, touch, approach, move away, attention.*

Focus Independent: *vocalisation, speech, verbal stereotype, repetition, blank*

Eye Gaze measures the amount of time that the child spends looking at the robot or toy, while Eye Contact is an indication of how much the child looks at the face or eye area of the robot or toy. Autistic children show an avoidance of eye contact, and the children in trials identify the heat sensor of the robot as its head. In this way, we are able to gauge how willing the children are to make ‘eye contact’ with the robot – or toy in terms of the front windscreen. The parameters ‘operate’, ‘handling’ and ‘touch’ can be grouped together to give the total contact time, where ‘operate’ is interacting with the robot through its sensors and so is impossible for the toy. However, we expected that the inability to ‘operate’ the toy would be balanced by an increased ‘handling’ factor, such as pushing it around the room. ‘Verbal stereotype’ includes echolalia, while repetition focuses on, but is not limited to, autistic behaviours such as spinning wheels. ‘Blank’ is the amount of time that the child sits idle, seeming not to interact or notice the external world in any way. Additionally, notes are kept to document any behaviours which do not fall into existing categories.

Results:

Four children participated in the trials, with the trial for Child C cut short with the toy as the child was obviously bored and showed no interest in it. Figure 1 shows the percentage of trial time which was spent by the child touching, handling and operating both the robot and the toy. It also shows the contact time and the time spent looking at the robot and toy as a percentage of the total trial time.

		Touch	Handle	Operate	Seconds	Contact	Gaze
Child A	Robot	26.33%	42.70%	0.00%	452	69.03%	81.64%
	Toy	11.79%	45.12%	-	246	56.91%	40.24%
Child B	Robot	18.61%	5.28%	18.06%	360	41.95%	60.56%
	Toy	3.33%	57.22%	-	360	60.55%	71.67%
Child C	Robot	11.26%	72.64%	0.00%	435	83.90%	93.33%
	Toy	0.00%	2.99%	-	134	02.99%	14.18%
Child D	Robot	1.93%	0.23%	17.08%	363	19.24%	53.99%
	Toy	19.33%	37.67%	-	300	57.00%	60.33%

Figure 1: The percentage of time for behaviour parameters. Contact time is the total of touch, handle and operate.

Trial times here are generally greater for the robot, showing that the children seem able to interact and play with it for a substantial time comparative to ‘normal’ toys and that they are not afraid of it. Also, the robot is able to engage them for this amount of time and is sufficiently interesting for them.

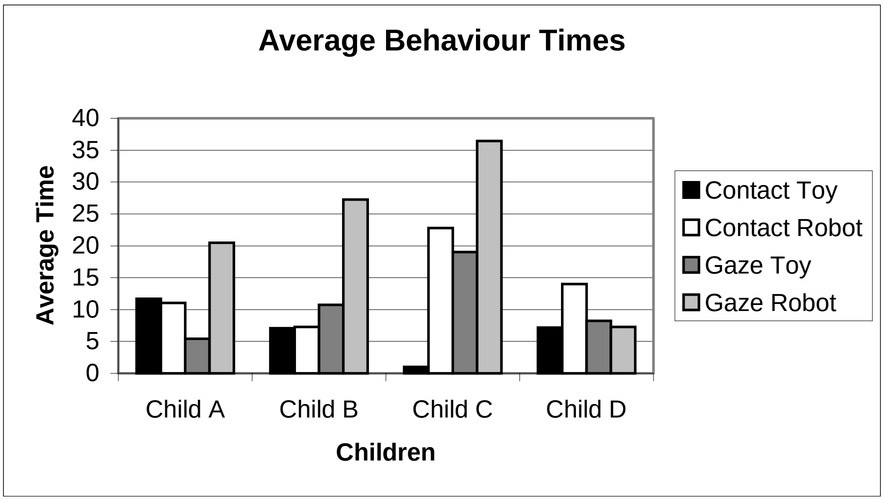

Figure 2: The average time of behaviours for toy and robot.

Figure 2 shows the average behaviour times for each of the four behaviours (contact time with the toy, eye gaze at the toy, contact time with the robot and eye gaze with the robot) for each of the four children. It can be seen that when comparing the average behaviour times for robot and toy, the times are similar, except for cases where the average time for the robot are markedly greater, in particular for eye gaze, for example Child B.

The evaluation data for the trials also need to examine the combination of behaviours, since isolated incidences may not give accurate results. For example, Child 4 interacted with the robot by allowing it to approach him. When the robot was very close, the child took several steps backwards and again waited for the robot to follow him. Then, when the child could not go back any further due the room's walls, he took several small steps into the robots space, and waited for the robot to reverse away from him before repeating this. In one instance, when the robot turned too far and so the child was no longer in its sensor arc, the child stepped sideways to continue the interaction. Also, when this child was given the toy truck, he spent most of the interaction time simply lifting it, and the rest of the trial time ignoring it.

Discussion:

The results thus far are encouraging in that they indicate that the children not only enjoy interacting and playing with the robot at various levels, but that they focus attention on the robot for longer than the toy truck. The children seem able to form very simple bonds with the robot and even to understand the basic interactions involved. The children spend time actively touching and making contact with the robot and they are not afraid or wary of it at all.

These factors are important for future work, since if the child does not feel comfortable interacting with the robot and if he is not happy to focus attention on it, then any amount of development would be wasted. Future work will concentrate on improving the complexity of the robot, while bearing in mind that some children will require more complex interaction than others. The evaluation methodology and behaviour parameters are in a constant evolutionary development and so we expect these to adapt and change as a result of further work. The ability of the robot to adapt to the interaction and to the individual needs of the child is obviously desirable as it would allow the robot to be used with a variety of children of different abilities, and additional features for the robot enhance the children's enjoyment are also under development. It is envisioned that the robot will be able to develop a storyline in order to guide the children through situations in a linear way, with the child able to control the speed of this progression.

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