IEEE CIS

AMD Newsletter

Robotics
Psychology
Neuroscience
Machine Intelligence

The Newsletter of the Autonomous Mental Development Technical Committee

VOLUME 6, NUMBER 1 ISSN 1550-1914 April 2009

Editorial

This issue of the newsletter presents a major milestone for the AMD community: the first issue of the IEEE Transactions on Autonomous Mental Development is ready to be published, and as a sneak-preview we present the table of contents and abstracts. A particularly stimulating feature of IEEE TAMD is the possibility to publish short "Commentary papers", that may consist in well-argumented discussions, concise technical extensions, or potential invalidations of results presented in papers published in IEEE TAMD. I strongly encourage you to take this opportunity to increase the interactions among different theories and experimental methodologies, which is essential for cumulative progress in our field. As a testimony of the interest of such debates, this issue's dialog column, initiated by Kerstin Dautenhahn, goes straight to the core challenges related to the use of robots for research and therapy of children with developmental disabilities, with a focus on autism.

Then, a novel Call for Dialog proposed by Max Lungarella, entitled "Developmental robotics: From black-art to discipline guided by principles?", asks fundamental questions about whether we should search for general principles that uniquely characterize natural and artificial developmental processes. Researchers interested in this topic are welcome to submit a response (contact lunga@ifi.uzh.ch or pierre-yves.oudeyer@inria.fr) by September 1st, 2009. The length of each response must be between 300 and 500 words (including references).

-Pierre-Yves Oudeyer, INRIA, Editor

AMD TC Chairman's Message

The past six months have been marked by the intensive work needed to prepare for the launch of the IEEE TAMD inaugural issue and to prepare and review papers for ICDL 2009.

I am happy to report that all the materials for the TAMD inaugural issue are ready, and the IEEE production department will very soon post them online and print them in paper after copyediting. To give you a first glance, we are publishing the table of contents, together with the abstracts, in this newsletter. I want to thank all the authors who have submitted papers, all the Associate Editors for managing the review process, and all the reviewers for volunteering their precious time. The materials for the second issue are lining up, and we look forward to receiving more submissions for the forthcoming issues.

The ICDL 2009 organization is progressing smoothly as planned. Due to the current economic conjuncture, the number of submissions is relatively low, as expected. The good news is that the quality of submissions is excellent. The review process is now complete, and the authors have been notified the accept/reject decision. Furthermore, ICDL 2009 is featuring 4 keynotes by Mitsuo KAWATO (ATR, Japan), Andrew PARKER (University of Oxford, UK), Mriganka SUR (MIT, USA), and Manabu TANIFUJI (RIKEN, Japan). It will also start with 2 tutorials on June 4, one by Tiande Shou (Fudan University, China) on Cortical Basis of Visual Information Processing and the other by Juyang Weng (Michigan State University, USA) on Brain-Inspired Mental Architectures.

Together with the social program sponsored by Fudan University, ICDL 2009 will be an intelligently stimulating and culturally rewarding experience. I encourage everyone to attend.

I have been thinking about ways to bring the AMD community to the next level. One idea is to create a wiki-like community website so an AMD member can post a link to a paper he/she likes, and other members can post comments. Such discussions may help improve the understanding of the topic and shape future research directions, and have the potential to evolve into a "Comment" paper in IEEE TAMD after consolidation.

Anyone who likes the idea and would like to volunteer to lead the project, please contact me at zhang@microsoft.com. I welcome other ideas and suggestions regarding the AMD TC activities. I am also planning the transition of my AMD TC Chair role to a next-generation volunteer leader from January 2010.

-Zhengyou Zhang, Current chair of the AMD TC

Committee News

- Jan. 9, 2009, David Fogel (IEEE CIS President) and Kay Wiese (IEEE CIS VP for Technical Activities) re-appointed Zhengyou Zhang as the Chair of the AMD TC and Minoru Asada and Giorgio Metta as the Vice-Chairs. Please visit http://research.microsoft.com/~zhang/amdtc/.
- March 19, 2009, IEEE TAMD online submission system went live. Please submit your papers at http://mc.manuscriptcentral.com/tamd-ieee. The information for authors is still available at http://ieee-cis.org/pubs/tamd/.
- March 27-28, 2009, Zhengyou Zhang attended the IEEE Panel of Editors, held in Atlanta, GA, USA. This annual event is a two-day session for Editors-in-Chief of IEEE journals, magazines and newsletters and other Volunteers that work in publication and information services areas. Information is available at http://www.ieee.org/web/services/mps/poe0309/index.html.
- The annual AMD TC meeting will be held at ICDL 2009, Shanghai, China, June 6 or 7. AMD TC members please plan to attend. Please visit http://www.icdl09.org for details.

Dialog Column

Are robots Beneficial to Children with Autism?

Kerstin Dautenhahn
Adaptive Systems Research Group, University of Hertfordshire, UK

Increasingly various types of robotic systems are being used in care or therapeutic contexts, involving elderly people in care homes or children with developmental disabilities. Over the past 12 years I have been involved specifically in research investigating the potential use of robots as therapeutic toys for children with autism, and we have used various mobile (e.g. Aibo, Labo-1) and humanoid robots (Kaspar, Robota) in this research. Autism is a spectrum disorder and life-long developmental disability that affects communication, social interaction, imagination and fantasy.

There are many potential roles that robots may play in therapy or education for children with autism: robots as interaction partners for children (with the purpose to teach about interaction and communication skills, e.g. imitation); robots as research tools e.g. for psychologists in order to investigate certain hypotheses regarding the nature of autism; robots as a diagnostic tool that may be used in the assessment of children with autism; robots as an educational 'tool' that may be used e.g. to teach about colours, shapes etc. similar to other interactive toys that are already being used in teaching; and robots as mediators where the robot mediates between the child and other children or adults.

While I am very enthusiastic about this topic from the point of view of a human-robot interaction researcher, a number of issues have emerged over the years, and I invite other researchers to comment on this:

1) Design space of robots: Given the variety of different robots used in the field, how can we arrive at a common understanding of the impact of robot behavior and appearance on the children's reactions?
2) Can robots (mechanical entities) really help children to better cope with the social world (beyond being an engaging toy)? Can they isolate children even more from the social environment rather than helping them to cope with it better?
3) How important is the autonomy of the robot's behaviour?
4) To what extent can robots help scientists understand better the developmental disorder of autistic children? How far can the use of robots as "research tools" be compatible with the use of robots as "educational tools"?
5) Ethical issues: How can we ensure that this type of work is benefiting the children?

Dialog Column

A Need for Flexible Robotic Devices

Tamie Salter
Universite de Sherbrooke, Sherbrooke, Quebec, Canada

It is clear that robots possess many qualities that make them beneficial for interaction with children diagnosed with autism. It is known that some people diagnosed with autism have shown a liking for mechanical objects. They also incline towards predictability and respond well to objects of a simple appearance. Therefore, robots have great potential, we can tailor every aspect about them and they are mechanical. However, it is doubtful that at this point in time they could be beneficial to children with autism as a broad group due to their lack of ability to effortlessly change. Currently robots are too rigid in the structure, behaviour and modalities. Children with autism vary dramatically in their persona, each with their own special needs; as such they have different needs when it comes to robots.

For example, our laboratory received a request from a school that had a large autism section to bring some robots for interaction with children diagnosed with varying levels of autism. This was the first completely unstructured trial our lab has been involved with, that is to say that we had no control over which room was used, how the room was arranged, also we had no say in picking which children that participated nor how the trial was conducted. We simply handed the robots over to the care workers. It was interesting to see how robots will ultimately be used in a real environment.

What came out of this trial is the need for robots that can *easily* adapt. It is known that those diagnosed with autism can have difficulties with fine motor skills. One of the robots (Potato) we took had a game that involved motor skills (the placing of magnetic objects on the robot). Despite the fact that we believed it only took a low level of motor skills, the majority of the children involved in the trial found this task difficult to the point of not being able to accomplish it. Another robot (Fishu) played music lively when it was initially started. This seemed to overwhelm one child who then no longer wanted to participate: the child seemed distressed and continuously signed "go" and so the trial was ended. This particular child did not appear comfortable at the next planned trial and so the care worker did *not* turn any of the robots on. The only robot that could be played with without being turned on was Potato. It was still possible to play by placing the objects without any power. Therefore, in this particular instance, Potato was the best robot for this particular child.

To be of benefit, robots need much more flexibility and simple control over their modalities such as: appearance (complexity), sound (volume control/mute), lights (on/off/dim/colour, control over flashing), movement (slow, fast) and behaviour (adapting to preferences and level). Once these issues are overcome I am sure robots will benefit children with autism. I have no doubt that these necessities will be addressed in the not to distant future.

Are Robots Beneficial to Children with Autism?

Sarah Parsons
School of Education, University of Birmingham, UK

I very much welcome Kerstin's critical reflection on the field of robotic interventions for children with autism. I am not an expert on the use of robotics for autism and nor am I familiar with all of the literature in this area, so what I offer here are some thoughts about the kind of evidence that might be needed to answer these questions. Those more familiar with this field of research may then reflect on whether the evidence exists or not.

Firstly, many of these questions could be usefully informed by *comparative studies*. There is often a tendency in any technology-driven research to over-engineer expensive solutions because there are good conceptual and financial reasons for doing so; not least because funders increasingly seek 'innovative solutions' and this usually means discarding the old and developing something new. The real challenge for researchers (and funders), then, is to value opportunities to step back and *consolidate* gains in research and understanding.

So, for example, with regard to whether autonomy matters: is there any evidence that the autonomy offered through robots is more effective or desirable than other toys (that may be significantly cheaper to produce and available off-the-shelf)? Do different groups of children respond in different ways to different kinds of autonomy?

Dialog Column

Simple puppets could have much to offer in answering these questions. Puppets differ in terms of their ostensible autonomy; they can be operated via a hand or strings, and the puppeteer can be visible or not depending on the set-up. Comparing responses of children, with and without autism, across different conditions where level of apparent autonomy is systematically varied, would provide some very interesting insights into whether, and how, autonomy 'matters'.

Of course, one of the other main issues raised by Kerstin's questions is '*matters to whom*?' There is always a careful balance that needs to be struck between the needs of participants and the needs of research (whilst not necessarily mutually exclusive, the immediate benefits to participants may not always be obvious). It is important not to lose sight of the essentially *applied* nature and intent of this area of study; ultimately, we do want to develop applications that *really help* children with autism.

Researchers must continue to explore specific and detailed, conceptually driven, research questions; but, equally, the question of 'what's in it for the participants?' should also be at the forefront of researchers' minds. Often, research becomes attenuated away from our key stakeholders – the participants and their families – as we move onto the next project. In terms of our ethical responsibilities, we should therefore consider whether we:

- Involve stakeholders as much as we should ;
- Communicate our results to them often enough and in accessible and meaningful ways ;
- Properly seek and include their views and use them as a basis to challenge our own ;
- Regularly evaluate our technological 'tools' in the contexts for which they are intended ;

Our research 'journeys' may be long, and unlikely to yield immediate benefits, but we must not forget to communicate clearly along the way with all of those involved in our work.

Modeling Development is Crucial for Building Really Adaptive Companions

Philippe Gaussier and Pierre Andry,*
*Information Processing ans Systems Lab, ETIS, ENSEA, CNRS, Univ Cergy Pontoise, IUF**

Our team is working on modeling development in a cognitive science perspective. We use various robotic systems to test the behavioral consequences of our Neural Network models. At the end of the 90s, after several works on autonomous learning, we ended understanding that individual development could not be considered apart from social development. In robotics, imitation was often considered only as a useful "tool" allowing to speed-up learning. We showed that low-level imitation could be an emergent behavior resulting from the coupling of an homeostatic system and perception ambiguity. Discussions with J. Nadel, specialist in developmental psychology and children with autism (CNRS UMR 7593) have shown us that imitation has also (and mainly ?) a communication function. It appeared that our Neural Network for low-level imitation could be used as a model of one of the first stages of infant development.

From this starting point, we have used robots as an experimental platform allowing us to test hypotheses about the development of an autonomous control architecture: what are the minimal low-level mechanisms allowing a robot to imitate, to resonate emotionally, or to understand the intentions of others? In parallel, we have used with our psychologists colleagues the same robotic platform as a central setup for psychological experiments involving human-robot interactions: adult-robot, baby-robot, child-robot and CWA-robot experiments. For example, we have designed with Nadel's team a robotic head, duplicated in two exemplars in order to test the essential properties of early communication : The first exemplar was devoted to study human responses to an expressive robot (psychological experiments), while the second one was used to test the robotic responses to human expressions (how a robot can learn autonomously to recognize and imitate facial expressions).

Here, the robot is obviously a research tool, allowing us to refine a developmental model with feedbacks on:

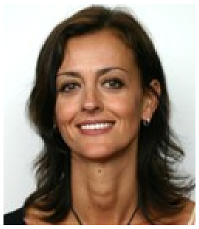
- The failures of the model in robotic experiments,
- The results of the agent responses in psychological experiments,
- The relative and estimated developmental age of the model when compared to children and CWA.

In turn, advances with such a developmental model allow for a better understanding of the key properties underlying learning and communication. These works allow us to formulate new hypotheses on the role of mechanisms that we initially did not think as "central" in our models : synchrony, rhythms and the overall dynamics of the interactions composed of two agents (robot, adult or child) . It also brings us to study more the role of emotions in development.

Dialog Column

In our Lab, we are far away from using robots for therapeutic applications. Recently, a lot of roboticists have started to develop robots intended to help CWA and other disorders. Yet, as stated by Kerstin Dautenhahn, we should be very careful not to try to sell a tool before understanding what could be its real effect on children. Robotic toys can be very useful for psychologists (to facilitate the interaction), but if the robot is unable to adapt and progress with the child it will tend to result in isolating more the child in a new routine (after the first positive interactions). Hence, pluri-disciplinary researches are crucial both for a better understanding of the processes involved in the child development and the design of new robotic architectures allowing us to take into account the social environment.

Spaces and Design Niches



Patrizia Marti
Communication Science Dept, Interaction Design Area, University of Siena, Italy

As interaction designer I would like to comment the first issue proposed by Kerstin Dauthenhan: what is the design space of social robots, and how we can arrive at a common understanding of the impact of robot behavior and appearance on the children's reactions.
From my experience the physical, perceptual and behavioral characteristics of social robots can help sustain the interaction but in various ways and from different viewpoints. For example some researchers believe that a very simplified cartoon-like "mechanical" face without too many details is more suited to autistic children. Other researchers like Justine Cassell believe that virtual characters and virtual reality are more predictable than real children and real places, and so autistic children may find it easier to engage in interactions. Little consensus has been reached so far in this respect.

Furthermore, robots with social behavior are often designed to resemble humans and animals (*lifelike robots)* in their physical, behavioral, cognitive and emotional characteristics. However the resemblance between robots and humans or animals inevitably creates great expectations in the human interlocutor (or great embarrassment in the autistic child) which are often let down during interaction. For example Robins et al. (2004) demonstrated a preference of autistic children for interaction with a plain, featureless masked face robot over interaction with a human like robot. Researchers who have tested Sony Aibo with a group of elderly patients (Tamura et al. 2004) had to "dress" the robot in order to ease interaction that, from the beginning, proved very difficult.

The unfortunate case of Sony Aibo which had to be dressed with a fur to look like a dog, or Robota which had to dress a mask to be accepted by autistic children are not a unique anecdote for social robots. We can orientate social robots design from extreme realism (humanoid robots or life-like robots) to more abstract and iconic solutions (Sony Aibo). However whatever the representation we choose (a simple iconic design, or a realistic, anthropomorphic or zoomorphic design) the robot's visual appearance in itself is not a key to the success of social interaction if not integrated by other perceptive characteristics, like those conveyed by the tactile experience for example.
Kerstin Dautenhahn (2002) states that a simple design, one therefore more essential and closer to iconic traits, should be preferred to a realistic, anthropomorphic or zoomorphic design. In particular a "new" design, inspired by fantasy, and not by any living organism, could better support human users in shaping a correct mental idea of how the robot works and behaves. Although one could share this idea, the motivations for adopting a design style may be far more complex. We believe that a minimalist and iconic design should be preferred in those cases in which the morphological characteristics are not integrated with other perceptual characteristics, like those conveyed by tactile experience for example. This way, users' expectations will not be let down by a realistic resemblance of the robot not matched by as much resemblance from the point of view of perception and touch. However, should morphology be strictly connected to the robot's perceptual and tactile characteristic, this connection would strengthen the role of significance, characterizing the robot as an experience mediator.

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Dialog Column

Design Challenges when Developing Robotic Systems for Children with Autism

Henrik Hautop Lund
professor, Center for Playware, Technical University of Denmark

The question of "whether robots are beneficial to children with autism" probably arises from a technical robotics community, as does the robots utilized for investigating the question. Hence, the robotic systems proposed for autistic children to a large extend follow the trends in the robotic research and development community, e.g. with a high focus of mobile robots, humanoid robots and robotic manipulators.
It is my belief that the good intentions and skills provided by the robotics community cannot stand alone and need the collaboration with skills from other fields in order to give positive answers to the question. The medical and therapeutic fields as well as culture, interaction design, and design fields seem crucial to not only contribute to this development, but they should even be the starting point for making cultural analyses, activity analyses and interaction studies in order to make a common process of development through synthesis with the robotics researchers.

It is therefore an important question that Kerstin poses, and I believe that there is a danger in simply transforming the traditional robotics (e.g. mobile robots and humanoid robots) into objects that we may think of as beneficial to children with autism without thinking and investigating carefully about why such designs necessarily should be the best for this user group and their carers. Cultural analyses and synthetic participatory design of robotic systems together with researchers and practitioners of the above-mentioned fields may yield radically different robot system designs (than aluminum mobile and humanoid robots) that are more appropriate for children with autism and the activities that they engage in. Or it may result in similar robotic systems, but then with our reassurance that these systems are appropriate for the autistic children, their activities and environments.

As an example, based upon interaction analyses, Kozima's keepon was provided with a fairly different, simplified robotic expression and material with regard to many traditional robotics systems, and it appears under some circumstances to allow for a better interaction for some autistic children. If we follow such design and development principles in this field, I believe that there exists a good potential for developing robotic systems that meet some of the challenges that autistic children and their carers face in their daily life. Especially, robotic systems are interesting as they may provide important possibilities for design of interactive physical systems that can provide explicit immediate feedback to the autistic children's action.
By understanding how to best create such physical feedback (sound, light, movement, smell, tactile response, …), we may be able to develop systems that motivate to engage and interact, for instance with the robotic system as a mediator for playful social interaction. In my point of view, it is important to view the robotic technology as a mediator e.g. for social interaction and not as the actual focus point for social interaction. I would actually hypothesize that playful interactions may provide motivation and engagement with robotic systems also for autistic children, so it becomes important to investigate and understand the *play dynamics* and underlying *play forces* for autistic children. But the knowledge of play dynamics and play forces (of autistic children) has to be profound and well documented in order to allow for the creation of better human-robot interaction design in this field, and therefore this seems to be the most immediate research challenge, in my point of view.

Promote this New Field in order to Overcome the Difficult Issues

Kazuyoshi Wada
Graduate school of system design, Tokyo Metropolitan University, Japan

Prof. Dautenhahn's questions are important issues. I have studied the influence of interaction with seal robot on people, especially the elderly. Children and elderly people are different but some issues are common. So, I try to comment these questions from my own experiences.
As far as design is concerned, I think clarifying the target user and how to use robot in the therapy and education is important. Instruction of the robot, the number of participants, presence of the parents/therapist and etc. has much influence on the subjects. In addition, durability of the robot is very important to conduct experiment. Now, we can use several kinds of robots, but the effective methods to use robots are unclear. I hope the studies which investigate the methods for using robots will show some hints for designing the robots.

Dialog Column

As for the autonomy, I think it is the merit of robots. In the experiment, we compared the influences of the seal robot switched on and a stuffed toy (the robot switched off) on the hospitalized children (Shibata et al., 2001). The robot attracted the children, encouraged their communication and improved their feelings. On the other hand, the children didn't care about the robot switched off. In the case of elderly, we kept seal robot activating over 9 hours every day in a care house, and found psychological, physiological and social effects of the interaction (Wada and Shibata, 2007). In addition, long-term experiment has been conducted in an elderly facility since 2003 (Wada et al., 2005).

They still enjoy playing with the seal robots. Teleoperated robots can be used instead of autonomous robots, but a well trained operator is required. The seal robot is used in many countries including Japan, Denmark, Germany, Sweden, U.S. and etc. Especially, studies on autistic child are conducted in Italy (Marti et al., 2006) and Thailand.

Ethics is a very difficult issue, especially for studies on children. The influence of experiments remains longer in children than in elderly people. At least, the studies should be conducted under the ethical committee of the researchers' belonging institutions. In addition, mental therapy and education using robots is a new field. So, it is stared at with curiosity and oddity from the society. I think the effort to promote this field and make it widely used is important to avoid a biased view.

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Reply and Summary:

Facing the Challenges of Robots that Benefit Children with Autism

Kerstin Dautenhahn
Adaptive Systems Research Group, University of Hertfordshire, UK

I would like to thank my colleagues for their thoughtful reflections on the dialogue that I initiated previously. While it will be impossible to summarize and respond to all contributions in detail, I like to focus on a few issues that are emerging frequently in this research community.

The first response, by Tamie Salter, emphasizes the need of robots to adapt to children, not only in terms of their appearance, but also in terms of their behavior and modalities that are being used in the interaction with children with autism. On a related matter, Patrizia Marti highlights the need to link the design of robots in terms of physical appearance to other perceptual characteristics that facilitate experiences conveyed by the robot via e.g. tactile experience.
These are indeed important issues, in fact, recent research by François et al. has shown experimentally that children with autism engage more with an AIBO robot that adapts to the tactile interaction styles of the children than a non-adaptive robot in a different experimental condition (François et al., 2009). Here, strength and frequency of interaction were recognized with a novel computational algorithm (François et al, 2008) that allowed the robot to adapt in real-time to the children's interactions styles. The way how the robot adapted was based on a schema that, depending on the frequency and strengths of the children's tactile interactions with the robot, provided different "rewards" (in terms of robot behavior) – note that these rewards were chosen depending on the children's individual likes and dislikes (e.g. of sound and movement) as well as the overall therapeutic goal to discourage repetitive behavior and violent play. Thus, these findings support the views expressed by Salter and Marti. Given the need for robots to adapt and to provide tactile and other experience we, as a research community, thus cannot expect to develop "one robot that fits all children" with autism. I suspect we ultimately will arrive at common frameworks (e.g. for design, assessment and evaluation), a set of suitable computational algorithms (such as the one mentioned above), and a variety of designs proven experimentally to facilitate relevant sensory-motor interactions for specific groups of children with autism. For researchers, this is very good news since it provides a spectrum of research challenges that need to be addressed systematically and in depth.

Dialog Column

The role of robots as mediators was mentioned in several responses, by Patrizia Marti, who emphasized the role of the robot as a mediator of experience, and Henrik H. Lund who emphasized its role e.g. as a social mediator. This is indeed an important issue that has frequently come up in our research. In Robins et al. (2005, 2006, 2009) we presented case study evaluations of such mediation processes that can occur between children with autism and co-present adults and other children.
This direction has been strongly supported not only by therapists and teachers in schools we are working with, but also by parents. Anecdotal evidence indicated that this mediation may generalize to other situations outside the particular class, but firm experimental data is needed. However, even if generalization between very different situations cannot be shown, we should not underestimate the impact that a robot may have if it allows, in the presence of the robot, other people (peers, teachers, parents, siblings etc.) to interact socially with an autistic child. And from the child's perspective, being part of a 'social experience' may have general benefits in terms of quality of life and possibly others, benefits that we may not be able to assess as 'rigorously' as others, due to their subjective nature.

This line of argument leads directly to Sarah Parsons's important comments on the general research direction as such: firstly, beyond the enthusiasm of the robotics researchers involved, we need to constantly remind ourselves of the purpose of this research, namely not only to push forward the technological side, but try to contribute to a deeper understanding of the field. And secondly, she argues that we need to balance the needs of researchers with the needs of the participants and other secondary users who may be teachers/carers/family members etc. In this context I also like to raise an issue that regularly occurs in assistive technology: parents and schools usually will not have access to the robot anymore once a project has been completed, among other things due to the often prototype nature of the systems. We are usually not able to 'leave the robot behind', which is not a very satisfactory situation for everyone involved.

Including all relevant stakeholders, as Sarah Parsons suggests, is very challenging. One dedicated step towards involving stakeholders as much as we can has been made in the European IROMEC project (www.iromec.org) where requirements for robots as social mediators for children with autism and other children has been firmly based on feedback from teachers and other stakeholders, e.g. (Robins et al. 2007, 2008). In the case of IROMEC this required the collaborations among a European consortium of researchers, an effort that is difficult to achieve by single research groups alone.

Robots are certainly 'special', compared to non-robotic toys: they can be designed to be flexible and adaptive, both in behavior and (usually less so) appearance. And they can be operated in a variety of ways from full autonomy to remote control, as pointed out in Kazuyoshi Wada's response. He reports on encouraging results with the seal robot Paro that has been used for several years in care applications for children and elderly users.

And last but not least, robots can provide valuable insights on development and learning, as pointed out by Gaussier and Andry who provide an example of how robots can be used as an experimental platform for testing hypotheses for the development of autonomous control architectures – they describe how they as researchers benefitted from collaborations with developmental psychologists. Their example highlights the important need for interdisciplinary approaches which is characteristic of research in the field of AMD in general. The responses show the variety of different views and interests of research groups worldwide, but also demonstrate how researchers in the field are critically reflecting on the challenges ahead.

There is growing evidence that the benefit of robots for children with autism and their carers or family can potentially be huge – it is up to us, as researchers actively involved in the field to be persistent, to continue with a difficult endeavor against the odds of finding sufficient grant funding for long-term research, and facing the fact that research in this field often progresses not as fast as funding agencies on the one hand and PhD or tenure track assessment committees on the other hand wish for. But the opportunity is phenomenal – to demonstrate that interdisciplinary work on using robots for children with autism may have a real positive impact on the lives of children with autism. Many challenges are lying ahead and there is a lot of work that needs to be done, so let's get on with it.

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Dialog Initiation

Developmental Robotics: From Black Art to Discipline Guided by Principles?

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Developmental/epigenetic robotics differs from traditional robotics (and artificial intelligence) in at least three crucial aspects:

1. There is a strong emphasis on body structure and environment as causal elements in the emergence of organized behavior and cognition, requiring their explicit inclusion in models of emergence and development of cognition ;
2. Artificial cognitive systems are not simply programmed to solve a specific task, but rather a developmental process is initiated and maintained during which cognition emerges and develops through a process of self-organization and co-development (and interaction) between the artificial organism and its surrounding environment ;
3. In contrast to robotics as well as traditional disciplines such as physics, and mathematics which are described by basic axioms and fundamental laws, the basic principles governing the dynamics of artificial (and natural) developmental systems are still largely unknown ;

My question for the readership of this dialog column is: Are there any laws governing developmental systems or even a theory, and if so, how can such laws be turned into design principles for engineering robots which are more autonomous, adaptive, or resilient? Or, more fundamentally, is it plausible to assume that an approach to the construction of intelligent autonomous systems guided by principles is preferable to one which relies on ad hoc mechanisms?
On the one hand, it could be argued that such principles have essentially two advantages: 1) they allow capturing design ideas and heuristics in a concise and pertinent way, and 2) they reduce the amount of tinkering and blind trial-and-error. On the other hand, it could also be reasoned that biological evolution itself is based on tinkering and blind trial-and-error, and yet has produced extremely adaptive creatures – implying that ad hoc mechanisms might actually work after all, if given sufficient time and raw materials.

To start the discussion, here I present three candidate design principles (see also [1–3]):

1. When designing a developmental agent it is important to see the behavior of the agent not merely as the outcome of an internal control structure (such as the central nervous system). A system's behavior is also affected by the ecological niche in which the system is physically embedded, by its morphology (the shape of its body and limbs, as well as the type and placement of sensors and effectors), and the material properties of the elements composing the morphology ;
2. An embodied agent does not passively absorb information from its surrounding environment: coupled sensory-motor activity and body morphology induce statistical regularities in the sensory input as well as in the control architecture and therefore enhance internal information processing and therefore learning. This property should thus be taken into account at design time ;

Dialog Initiation

3. Viewing an embodied agent as a complex dynamical system enables us to employ concepts such as self-organization and emergence rather than hierarchical top-down control. In other words, the agent should not be completely hardwired at the outset, but the agent needs to be endowed with the ability to self-direct the exploration of its own sensory-motor capabilities and with means to escape its limited built-in behavioral repertoire, and to acquire its own history ;

Clearly, a large number of such design principles can be abstracted from biological systems, and their inspiration can take place at several levels, ranging from a "faithful" replication of biological mechanisms to a rather generic implementation of biological principles leaving room for dynamics intrinsic to artifacts but not found in natural systems. But then, how does one choose their level of generality? Will it eventually be possible to turn developmental robotics from a black art into a principled discipline?

Researchers interested in this topic are welcome to submit a response (contact lunga@ifi.uzh.ch or pierre-yves.oudeyer@inria.fr) by September 1st, 2009. The length of each response must be between 300 and 500 words (including references).

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Call for Participation

8th IEEE International Conference on Development and Learning (ICDL 2009)
Shanghai, June 5 - 7, 2009, http://www.icdl09.org/

Invited Speakers: Mitsuo Kawato (ATR, Japan), Andrew Parker (University of Oxford, UK), Mriganka Sur (MIT, USA), Manabu Tanifuji (Riken, Japan).

The International Conference on Development and Learning is a multidisciplinary conference pertaining to all subjects related to the development and learning process of natural and artificial systems, including perceptual, cognitive, behavioral, emotional and all other mental capabilities that are exhibited by humans, higher animals, robots. Its visionary goal is to understand autonomous development in humans and higher animals in biological, functional, and computational terms, and to enable such development in artificial systems. ICDL strives to bring together researchers in neuroscience, psychology, artificial intelligence, robotics, and other related areas to encourage understanding and cross-fertilization of latest ideas and results from the different disciplines.

Call for Papers

Ninth International Conference on Epigenetic Robotics: Modeling Cognitive Development in Robotic Systems
http://www.epigenetic-robotics.org

The 9th edition of the International Conference on Epigenetic Robotics (EpiRob) will be held in Venice, Italy, on November 12-14, 2009.
Since 2001, the Epigenetic Robotics annual International Conference has established itself as a unique forum to present and discuss original interdisciplinary research from developmental sciences, neuroscience, biology, cognitive robotics, artificial intelligence, and other disciplines relevant to the study of cognitive development in natural and robotics systems.

Important dates:
June 8, 2009: Papers and abstracts submission deadline;
July 20, 2009: Acceptance notification;
September 8, 2009: Camera-ready versions of accepted papers and abstracts due in electronic format;
November 12-14, 2009: Conference dates

Publication

IEEE Transactions on Autonomous Mental Development

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Cognitive Developmental Robotics: A Survey, by Minoru Asada, Koh Hosoda, Yasuo Kuniyoshi, Hiroshi Ishiguro, Toshio Inui, Yuichiro Yoshikawa, Masaki Ogino, and Chisato Yoshida

Abstract—Cognitive Developmental Robotics (CDR) aims to provide a new understanding of how the human's higher cognitive functions develop by means of a synthetic approach that developmentally constructs cognitive functions. The core idea of CDR is "physical embodiment" that enables information structuring through interactions with the environment, including other agents. The idea is shaped based on the hypothesized development model of human cognitive functions from body representation to social behavior. Along with the model, studies of CDR and related works are introduced, and discussion on the model and future issues are argued.

Modeling Unsupervised Perceptual Category Learning,

by Brenden M. Lake, Gautam K. Vallabha, and James L. McClelland

Abstract—During the learning of speech sounds and other perceptual categories, category labels are not provided, the number of categories is unknown, and the stimuli are encountered sequentially. These constraints provide a challenge for models, but they have been recently addressed in the Online Mixture Estimation model of unsupervised vowel category learning [Vallabha et al., PNAS, 2007, 104:13273-13278]. The model treats categories as Gaussian distributions, proposing both the number and parameters of the categories. While the model has been shown to successfully learn vowel categories, it has not been evaluated as a model of the learning process. We account for several results: acquired distinctiveness between categories and acquired similarity within categories, a faster increase in discrimination for more acoustically dissimilar vowels, and gradual unsupervised learning of category structure in simple visual stimuli.

Computational Analysis of Motionese toward Scaffolding Robot Action Learning,

by Yukie Nagai and Katharina J. Rohlfing

Abstract—A difficulty in robot action learning is that robots do not know where to attend when observing action demonstration. Inspired by human parent-infant interaction, we suggest that parental action demonstration to infants, called motionese, can scaffold robot learning as well as infants'. Since infants' knowledge about the context is limited, which is comparable to robots, parents are supposed to properly guide their attention by emphasizing the important aspects of the action. Our analysis employing a bottom-up attention model revealed that motionese has the effects of highlighting the initial and final states of the action, indicating significant state changes in it, and underlining the properties of objects used in the action. Suppression and addition of parents' body movement and their frequent social signals to infants produced these effects. Our findings are discussed toward designing robots that can take advantage of parental teaching.

Attention via Synchrony: Making Use of Multimodal Cues in Social Learning,

by Matthias Rolf, Marc Hanheide and Katharina J. Rohlfing

Abstract—Infants learning about their environment are confronted with many stimuli of different modalities. Therefore, a crucial problem is how to discover which stimuli are related, for instance, in learning words. In making these multimodal "bindings", infants depend on social interaction with a caregiver to guide their attention towards relevant stimuli. The caregiver might, for example, visually highlight an object by shaking it while vocalizing the object's name. These cues are known to help structuring the continuous stream of stimuli. To detect and exploit them, we propose a model of bottom-up attention by multimodal signal-level synchrony. We focus on the guidance of visual attention from audio-visual synchrony informed by recent adult-infant interaction studies. Consequently, we demonstrate that our model is receptive to parental cues during child-directed tutoring. The findings discussed in this paper are consistent with recent results from developmental psychology but for the first time are obtained employing an objective, computational model. The presence of "multimodal motherese" is verified directly on the audio-visual signal. Finally, we hypothesize how our computational model facilitates tutoring interaction and discuss its application in interactive learning scenarios, enabling social robots to benefit from adult-like tutoring.

Dually Optimal Neuronal Layers: Lobe Component Analysis, **by Juyang Weng and Matthew Luciw**

Abstract—Development imposes great challenges. Internal ``cortical'' representations must be autonomously generated from interactive experiences. The eventual quality of these developed representations is of course important. Additionally, learning must be as fast as possible --- to quickly derive better representation from limited experiences. Those who achieve both of these will have competitive advantages. We present a cortex-inspired theory called Lobe Component Analysis (LCA), guided by the aforementioned dual criteria. A lobe component represents a high concentration of probability density of the neuronal input space. We explain how lobe components can achieve a dual --- spatiotemporal (``best'' and ``fastest'') --- optimality, through mathematical analysis, in which we describe how lobe components' plasticity can be temporally scheduled to take into account the history of observations in the best possible way. This contrasts to using only the last observation in gradient-based, adaptive learning algorithms. Since they are based on two cell-centered mechanisms --- Hebbian learning and lateral inhibition --- lobe components develop in-place, meaning every networked neuron is individually responsible for the learning of its signal processing characteristics within its connected network environment. There is no need for a separate learning network. We argue that in-place learning algorithms will be crucial for real-world, large-size, developmental applications due to their simplicity, low computational complexity and generality. Our experimental results show that the learning speed of the LCA algorithm is drastically faster than other Hebbian-based updating methods and ICA algorithms, thanks to its dual optimality, and it does not need to use any second or higher-order statistics. We also introduce the new principle of fast learning from stable representation.

Contingency Perception and Agency Measure in Visuo-Motor Spiking Neural Networks,

by Alexandre Pitti, Hiroki Mori, Shingo Kouzuma, and Yasuo Kuniyoshi

Abstract—Agency is the sense that I am the cause or author of the movement. Babies develop this feeling early on by perceiving the contingency between afferent (sensor) and efferent (motor) information. A comparator model is hypothesized to be associated with many brain regions to monitor and simulate the concordance between self-produced action and their consequences. In this paper, we propose that the biological mechanism of spike timing-dependent plasticity, that synchronizes the neural dynamics almost everywhere in the central nervous system, constitutes the perfect algorithm to detect contingency in sensorimotor networks. The coherence or the dissonance in the sensorimotor information flow imparts then the agency level. In a head-neck-eyes robot, we replicate three developmental experiments illustrating how particular perceptual experiences can modulate the overall level of agency inside the system: i.e., (1) by adding a delay between proprioceptive and visual feedback information, (2) by facing a mirror and (3) a person. We show that the system learns to discriminate animated objects (self-image and other persons) from other type of stimuli. This suggests a basic stage representing the self in relation to others from low-level sensorimotor processes. We discuss then the relevance of our findings with neurobiological evidences and development psychological observations, for developmental robots.

Editor : Pierre-Yves Oudeyer, INRIA Editorial Assistants : Adrien Baranès and Matthew D. Luciw
The AMD Newsletter is financially supported by the IEEE CIS and INRIA