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Editorial

Development happens through the dynamic interaction of biological and physical components at several scales of time and space. These interactions range from the dynamics of gene expression within cells to inter-organ chemical signalling during embryogenesis to the progressive shaping of brain structures through physical and social interaction. What are the adequate levels of abstraction for modelling and understanding such a complex system? This is the topic of the dialog column featured this months, where Linda Smith, Annette Karmiloff-Smith, Peter Dayan and Gert Westermann respond to the dialog initiated by Denis Mareschal. Opinions differ on what should or should not be abstracted. But all converge to a needed shift for 21st century developmental science: “innate” or “learned” are outdated concepts that are not suited for understanding human behaviour and cognition. There are no “start” or “end”, but only continuous processes of change that grow our bodies, our minds and our cultures.

After this dialog, a new dialog initiation by John Weng digs into the concept of autonomy for “skull-closed” learning robots, and its implications for socially assistive robotics, echoing the April 2012 dialog column on the interaction between HRI and developmental robotics scientific approaches. In particular he calls for a detailed argumentation of the pros and cons for using emergent representations and skull-closed developmental approaches for assistive robotics applications.

Those of you interested in reacting to this dialog initiation are welcome to submit a response (contact pierre-yves.oudeyer@inria.fr) by March 1st, 2013. The length of each response must be between 500 and 700 words (including references).

— Pierre-Yves Oudeyer, Inria, Editor

Message from the Chair of AMD Technical Committee

First let me celebrate the success of our IEEE Transactions in Autonomous Mental Development, with the announcement last Summer of its first impact factors: 2.31. This is a very high impact factor when compared with the other well established journals in related computational and robotics disciplines. We all know that impact factors are not the only research quality indicator, but a high impact value adds to the reputational value of our discipline and community. Well done to Zhengyou Zhang, the associate editors, the referees and, of course, the authors. Please keep sending your top quality papers in this top quality journal!

We are all geared up for the next IEEE ICDL-EpiRob Conference in San Diego (7-9 November 2012). Following the success in Frankfurt of the integration of the previous IEEE ICDL and the EpiRob conferences, we hope that the San Diego event will be again the main meeting opportunity for the extended developmental robotics community. And the plans for the 2013 Conference are already at full speed, with the IEEE’s approval of the sponsorship of the 2013 ICDL-EpiRob in Osaka, Japan (18-22 August 2013).

Our new website domain icdl-epirob.org will be used to find out about the latest conference, but also about the previous ones (e.g. icdl-epirob.org/2011 for the previous conference), and the AMDTC page (icdl-epirob.org/amdtc).

Amongst the forthcoming events of interest to our community, the IEEE SSCI 2013 in Singapore will include various Symposia of relevance to our research interests. So you are all encouraged to submit a paper (28 November 2012 paper submission deadline).

As for the AMDTC organization, work is on-going for the restructuring and revival of the Task Forces (TFs). From January 2013, we will have a group of community support task forces (TF Newsletter, TF Education, TF Web Presence), one for liaison with other communities (TF Developmental Psychology, TF Robotics, TF Human-Robot Interaction, TF Neuroscience) and a group of research theme task forces (TF Action and Perception, TF Language and Cognition, TF Social Learning). If you want to become an active member of these TFs, please email the TF chair or myself.

I look forward to meeting many of you in San Diego this November, and in Osaka in August 2013.

— Angelo Cangelosi, the new chair of AMD TC

Dialog Column

Children's Natural Learning: Why Development Really Does Matter!

Denis Mareschal
Centre for Brain and Cognitive Development
School of Psychology
Birkbeck College
University of London, London, UK

There have been many significant advances in the field of developmental cognitive neurosciences over the last few years. These have important implications for the way learning in developing systems is to be considered. To date these factors are rarely directly considered in the existing (virtual or robotic) models of development. I will list three of these and suggest that they pose significant challenges for current computational and robotic models of learning in developing systems.

Epigenetics: When genes are turned on and off

One simple view of development is that it is the outcome of genetic "innate" constraints and environmental "experiential" constraints. Indeed, the field of *Behavioural Genetics* is largely concerned with trying to partition any observed variation in behaviour into a "genetic component" and an "environmental component" [8]. A more complex view is that these processes interact. So, for example, a constant genetic predisposition may have a greater or lesser impact on development depending on the agent's environment [11]. *In fact, the situation is far more complex.* It is now clear that gene expression itself can be self-modulated depending on the environment ([4-5], [7]). For example, environmental changes such as an absence of food can lead to brain chemical imbalances in worker bees that alter the expression of genes, and consequently the physiological and functional roles of these bees in a hive. In other words… the effective genetic constraints are not constant and depend on environmental pressures. The extent to which genetic material is expressed depends on the environmental needs of the agent. This is not only true in bees, but may play an important role in the expression of complex cognitive behaviors [3].

Morphogenesis: body growth does matter in early learning

The brain is particularly plastic during the early years [10]. This is not just so that children can acquire new knowledge easily, but is also true because there is a need to constantly re-calibrate sensory information in a sensory-motor system that is dramatically changing in size and sensory efficacy. Indeed, while adults are able to combine sensory cues optimally to improve sensory estimates, children do not appear to do so until 8-12 years of age (e.g., [6]). This is because child's changing physical dimensions (e.g., separation eye) continually distort the possible interpretation of sensory input. Body size also acts as an effective filter on the complexity of the environment children learn from. For example, arm length helps support what they are attending to because objects closer up will block larger portion of visual field [9].

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Affect and Trust: Not all teachers are equal

It is now well established that social interactions form an important part of how children learn [12]. In particular, children can only acquire some knowledge (such as the existence of germs) through the testimony of others and not through direct experience. However, children do not learn equally from all social interactions. In fact, from the earliest ages children identify those adults or peers in whose testimony they can trust [2]. This often leads to increased attachment and affect for that person. At the neural level, increased positive affect leads to the releases of dopamine throughout key parts of the brain that has the consequence of increasing plasticity in those parts of the brain [1]. Thus, positive affect plays a role in modulating learning both at the neural level and at the (macro) social level.

These three factors (among others) result in an effective learning environment that is highly adaptive to the current needs of the learner. Importantly, it is a very different environment for a developing agent than for the fully developed, adult agent. Traditionally, computational modelers have tended to characterize learning systems in terms of the mechanisms and processes present in the adult. My claim is that they also need to recognize the unique character of learning in a truly developmental system.

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Dialog Column

Development is a Path: Each Step Forward Depends on the Local Context and all the Previous Steps that Brought the Organism to this Point

Linda B. Smith
Department of Psychological and Brain Sciences
Indiana University, USA

All processes of biological change are local, in real time, and thus contingent on the local context. This is so for processes of gene expression, for the processes through which functional neural systems are built, and for the processes through which cognitive skills are acquired. The stabilities in developmental outcome across individuals –the fact that livers quite regularly get made and function, that visual and motor cortical regions manage to be connected and coordinated, that children learn language – can be mapped to stabilities in specific processes *and* to the stabilities that emerge *across processes* because of the many interdependencies that shape the context for change. Within the fields of neural development, evolutionary biology, and psychobiology, there are many examples as well as illuminating discussions of the intrinsic connection between developmental process and evolutionary process. I list below some excellent reads in these domains [1-4].

Here I illustrate one fundamentally important consequence: *the local context is itself a product of development, and dependent on the history of the individual*. Consider, for example, the development of visual object recognition in human infants. There are multiple overlapping processes – bag of feature systems, category specific and configural features systems, and representations of the 3-dimensional structure of object shape [5]. All these overlapping systems develop and are highly dependent on specific visual experiences. However, what babies see depends critically on where their heads are and where their heads are depends critically on how they move, and how they move changes dramatically in the first year and half of life. Infants spend their first 5 months mostly sitting and see what people show them or what happens to be around where they are sitting. However, once infants can reach and grasp objects, they can bring those objects close, selecting the objects to be visually explored and selecting the views they show themselves. Recent research shows these self-generated views, particularly those that result from manual and visual exploration while holding an object, play a critical role in developing in representations of 3-dimensional whole object shape [6,7]. Sustained manual and visual exploration requires and infant that sit steadily, and research shows that sitting steadily is a prerequisite to these advances in visual object recognition [6]. The ability to sit without falling over is part of the causal context, part of the pathway that leads to 3-dimensional whole object representations in human infants.

Holding objects and the visual consequences of that holding also play a causal role in early object name learning [8]. When infants *jointly* hold and look at objects, they look longer, stabilizing attention on the attended thing; moreover, because their arms are short, they bring the object close so that it dominates the first person view, is often the only thing in sight. This creates an optimal moment for learning an object name, and recent research shows that infants learn object names during these moments of visual clarity better than in other more cluttered visual moments. So sitting stably is connected to joint manual and visual object exploration which is connected to breaking into language by learning the names of objects.

Learning the names of objects also trains visual object recognition, enabling children to learn category-specific features and to build 3-dimensional models of the shapes of basic level categories [5].

This is what developmental process is: interleaving loops of cause and effect, of partial and overlapping dependencies, a complex dynamic system in which change depends on the local context, which depends on the past. In the example described here, we see how motor development drives changes in the visual system, but how this also sets the stage for language learning, and feeds back into change in visual representation.

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This is what developmental process is at every level of analysis and this is the deep importance of Professor Mareschal's opening question. If this is the 21st century understanding of developmental change, why on earth is anyone still formulating questions in terms of 18th century constructs such as "innate" and "learned?"

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Before, During and After

Peter Dayan
Gatsby Computational Neuroscience Unit,
UCL, London, UK

It is the seduction of developmental cognitive neuroscience to be the 'during' that links the 'before' of developmental neuroscience to the 'after' of the adult state. Neurobiological and psychological path dependencies that arise over this elongated period trammel and sculpt the future characteristics and likely success of the organism; the period itself is a time of rapid change. Mareschal's thought-provoking target article correctly invites us to expand the range of computational thinking to address three challenges posed in this period. Two concern path dependencies: epigenetics and trust; the third is more about coping with change. Mareschal is surely correct that the computational community could have paid more attention to these issues. However, existing work does provide some relevant foundations. For the cases of path dependency, the issue comes down to what aspects of the environment might be crystallized in structure and/or function; such crystallization makes sense if the relevant aspects of the world can be expected to persist after the initiating episode. The dramatic effect of tiny amounts of experience at crucial times speaks to the power of the effect [1]. One way to formalize it is via techniques of Bayesian inference – and indeed there are models of the adult phenomenon of learned helplessness [2] which work in just this way, enshrining experience in one environment as a prior over future environments [3]. Mind you, the target article's suggestion that positive affect has a particular role to play in path dependencies in trust is a little worrisome - to be flippant, aren't we all taught the perils of accepting sweets from strangers?

The issue posed by the effects of change during development are almost exactly the opposite of path dependence – how can the brain cope with evanescence rather than permanence. Of course, Bayesian models of development can cope with this just as easily – the fact of change is something that is of easy expectation, and indeed notice, for instance via a constant stream of prediction errors. Evidence of optimal treatments of related sub-optimalities [4] is most appealing in this direction, although, as ever for the dangerously dexterous Bayesian, the devil lies in the details of each particular case.

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Mareschal must have had a very wide range of choices from which to select his three examples, and it is interesting to speculate about the thread running through these particular choices. What is clear, though, is that the appeal and interest of the ’during’ is most certainly enduring.

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It’s New, but do We Need to Model it?

Gert Westermann
Department of Psychology
Lancaster University, UK

Mareschal rightly points out that our knowledge of the mechanisms of development has increased dramatically over recent years, and we now conceptualize development as a trajectory shaped by multiple interacting constraints involving genetic and environmental influences [3,7].

An important question is in how far this new knowledge poses challenges to computational and robotic models of development. To answer this question it is useful to remind ourselves of the purpose of modeling. By developing models of development we seek to provide explanations of developmental change and a characterization of the mechanisms underlying this change. In doing so, models must abstract away detail of the original process so that explanations are simplified and focus on the relevant aspects of the system. Model building is therefore a process of progressive abstraction and simplification with the expectation (or hope) that only irrelevant aspects of the original systems are removed.

The critical question is, of course, how much the abstracting away of the aspects of development discussed by Mareschal restricts the explanatory power of current models. I believe that whereas epigenetic processes can, for the time being, be safely ignored, Morphogenesis and Affect/Trust pose more real challenges to current models.

The reason why I believe that epigenetics is the least important of the three points is that only very few current models seek to provide explanations of development on the basis of the system’s genetic make-up. Genetic structure and epigenetic change operate on a level of description that is far below that of current models, and we don’t have good theories of how genes map onto learning structures in the first place. Introducing epigenetic plasticity therefore does not enrich or constrain current models of development.

Mareschal’s second and third point, Morphogenesis and Affect/Trust, are probably more constraining of developmental explanations. On a more abstract level they highlight the same point: information is not uniform and constant across development but possible inputs to the system vary across development as a function of physical change of the learner and characteristics of the environment. Non-constant information intake and processing have been explored within ‘starting small’ paradigms [1] in which

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either the complexity of the environment or the processing capacity of the learner are gradually increased. Based on this earlier work others have argued that experience-dependent brain development acts as an important filter for complex information and, in interaction with statistical learning, enables the gradual build-up of effective adult processing structures [5,6,8]. These approaches have usually compared a static learner in a static environment with the more dynamic learning in these systems and have found the explanatory power of the dynamic systems to be greater. Recent advances in this field have been formal characterizations of intrinsic motivation [4] as well as empirical exploration of how previous experience guides looking to new information [2]. It will be important to compare developmental models that have access to all information all the time with those in which information is filtered and selected on the basis of these principles. In the simplest case this can be achieved by the modeler providing inputs to a 'traditional' model according to a specific schedule, but more complex models would have to implement selection mechanisms within the learning system itself.

In sum, I do not think it is necessary to integrate every newly discovered developmental mechanism into computational models of development, but one should consider whether a new mechanism has the potential to improve explanations for developmental change. Whereas epigenetics currently doesn't fit this bill, information selection, either through physical change or intrinsic motivation to favour some bits of information over others, certainly does.

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Developmental Change Matters at Every Level of Analysis

Annette Karmiloff-Smith
Centre for Brain & Cognitive Development
Department of Psychological Sciences,
Birkbeck, University of London, UK

I agree with Mareschal that a developmental perspective is crucial for modelling, not only psychologically but also epistemologically [3-4]. Psychologically, because complex dynamics of developmental change operate at multiple levels - genetic, cellular, neural, cognitive and behavioural. Epistemologically, because the end-state of any system can only be understood by elucidating the developmental trajectory that lead to it. Modelling full developmental trajectories [8] is a crucial step towards capturing the mature outcome.

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Indeed, domain-specificity in the end state may only be possible through the process of development [2]. Even the so-called end state is not static. Research on healthy ageing reveals that while younger adults process syntax in the left hemisphere, older adults – achieving similar accuracy and reaction times - have switched to processing syntax bilaterally [10].

The modelling of neurogenetic disorders also demands a developmental approach [7-8], which adult neuropsychology has often ignored. For instance, Clahsen and Temple [1] claim that the neurodevelopmental syndrome, Williams syndrome, "…can be explained in terms of selective deficits to an otherwise normal modular system" (p.347). This static approach must be replaced by a truly developmental perspective. Indeed, tiny cross-domain asynchronies or basic-level impairments impact over developmental time on cognitive-level outcomes, so modellers cannot start with static notions of intact versus impaired modules, but must think in terms of an emergent process of progressive modularization [3].

In agreement with Mareschal, the environment plays a critical role in developmental trajectories. Infants as young as six months already display frontal cortical differences as a function of low or high SES (Tomalski et al., submitted). But why are the positive effects of high SES not greater in children with genetic disorders? Unlike those from low SES environments, many such children are well-nourished, raised in a caring environment, receive cognitive stimulation, and don't suffer the physical/mental abuses existing in some contexts of social adversity. So why don't such positive environments compensate for genetic vulnerabilities? Is it just the severity of the genetic mutations that constrains environmental effects? Or is it also because early environments differ in more subtle ways than is commonly realized? Having a neurodevelopmental disorder not only involves genetic mutations; it also modifies the environment in which the infant develops [5]. The moment parents are informed that their child has a genetic disorder, their expectations subtly change. The baby's responses within the dyadic interaction will then also be subtly modified. Observational data from families who visit our laboratory reveal that parents of infants/toddlers with genetic syndromes often find it difficult (compared with parents of typically developing infants) to allow their atypically developing offspring to freely mouth objects to explore their properties with the sensitive nerve endings in the mouth or crawl/walk uninhibited to fully discover their environment. This reticence is probably due to a natural fear of accidents in vulnerable infants, but it nonetheless results in a less richly explored environment. Thus, unconscious assumptions about what children can and cannot learn may unwittingly lead parents to provide a less varied environment to explore.

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Reply and Summary
Levels of Abstraction and Espistemological Perspective

Denis Mareschal
Centre for Brain and Cognitive Development
School of Psychology
Birkbeck College
University of London, London, UK

In my letter, I suggested three areas that current models of development had neglected and which would ultimately need to be addressed. These were (1) *epigenetics* … the fact that genes are not just on or off, but activated as a function of environmental needs, (2) *morphogenesis* … the idea that physical body changes with age and acts as an active filter of what the child can and will learn from, and (3) *trust*, the idea that even from a very young age, children select the social agents from which they learn non-empirically verifiable facts. This was not to say that existing models of development had no value (see [2] for an extensive review of models of cognitive development), but that these were factors that had real and measurable effects on the way human children grew and developed. Consequently, models that wished to refine their explanatory power needed to take these factors on board.

In their own ways, the commentators accepted many of my points, but also underlined aspects that I had perhaps failed to emphasize sufficiently. Smith reiterates the fact that "All processes of biological change are local, in real time, and thus contingent on the local context." Moreover, she argues that the "developmental process is [one of] interleaving loops of cause and effect, of partial and overlapping dependencies, a complex dynamic system in which change depends on the local context, which depends on the past". This is entirely consistent with the idea of epigenesis and morphogenesis I raised in my initial letter. Similarly, Karmiloff-Smith writes that "the end-state of any system can only be understood by elucidating the developmental trajectory that lead to it". Indeed, "even the so-called end state is not static". In addition, she emphasizes one aspect that I had not highlighted; namely, that studying how developing systems can go wrong – such as in cases of developmental disorders – can illuminate just as much the processes of development as studying typical development.

Dayan suggests that Bayesian inference techniques could be used to accommodate my suggested changes in future models. While this is promising, it does raise the issues of levels of modeling. The models that I am describing are all situated at the algorithmic level, whereas most Bayesian accounts are simply proposed at a computational level (according to Marr's sense [3]) and would still need to be implemented in some kind of algorithm [1], facing similar issues to those raised in my dialog initiation. He makes the further point that too much *trust* may be misleading. While this is true, trust is nevertheless a fact about the way children select information in the world (not a suggestion – the suggestion is that modelers need to take this fact into consideration).

Finally, Westermann recognizes the challenges that I have posed as real elements of the developmental processes, but asks whether they are of sufficient generality to warrant being in a model. In particular, he suggests that it is not necessary to take epigenetics seriously (for the moment) because there are no models trying to bridge between genes and behavior. There are, in fact, a few models that do just that (e.g. [4]), but these models aside… the vast majority of models make assumptions about architectural stability across development and generally attribute this to "genetic" constant pre-existing effects. My point is that this is just not the case. I do, however, take Westermann's point that value (or Trust in a different guise) is being taken seriously by the robotic modeling community, and I see this as an invaluable step forward.

So, where does that leave us? Overall, my view is that the developmental modeling community is healthy, alive and kicking. The many strands are actively developing new and promising explanations of the continuous process of development that makes us who we are. Though what is not clear is whether they all have the same goal. Cognitive modelers (as described by Westermann) are attempting to formulate causal mechanistic theories of Human development as an end in and of itself. At times, it seems that roboticists are doings something slightly different… they are trying to understand human development so as to further the development of complex and intelligent robot agents. These are two slightly different ends, and while they can be mutually informative, their different goals may also explain why they emphasise to a greater or lesser extent the three points identified in my commentary.

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Dialog Initiation

Modeling AMD and Its Application to Assistive Robotics: Closed Skull or Not?

Juyang Weng
Dept. of Computer Science and Engineering
Michigan State University, East Lansing, USA

Task-nonspecific developmental programs for Autonomous Mental Development (AMD) have been raised for over a decade [1]. The term "autonomous" in AMD was insisted on by the late Developmental Psychologist Esther Thelen. She said to me that without autonomy the human development program (DP) could be mistreated as simply rolling out functions and behaviors. For example, autonomous actions play an important role in explaining the A-not-B error [2]. However, what the term "autonomy" means exactly still do not have a consensus so far.

What do we mean by autonomy in AMD? One may say that a developmental agent must be autonomous throughout development. However, this is not very clear. For example, suppose that a teacher supervises a child how to draw a house by holding and guiding the movement of his hand that holds a pen. In developmental psychology, it is called passive learning. Is this passive learning consistent with the term "autonomy" that Esther Thelen insisted on? Note that the effector is not autonomous in this case.

Therefore, I proposed that "autonomous development" implies "development with a closed skull": It is not allowed for a human teacher or programmer to open the learner's skull, e.g., supervise the connections and responses inside the "brain" while the agent is learning. This autonomy still allows and encourages human teachers to manually interact with the brain, but only through the brain's sensory port and the effector port [3].

Another deeper principle underlying autonomous development is the requirement for using fully emergent representations as a biological brain does --- inborn behaviors are allowed but not handcrafted symbolic concepts about the extra-body environment. There is a major reason --- symbolic representations are intrinsically brittle since they require an intractable exponential number of states in the number of involved concepts [3].

Mechanisms allowing an autonomous robot to adapt continuously to the dynamic social interaction with humans have been argued convincingly to be a key in establishing natural social interaction between humans and robots [4]. However, the representations in many such methods, including the basis of arguments in the AMD Newsletter dialog initiated by [4], are often symbolic in nature. For example, the human programmers programmed in concepts such as eye-gaze [4], face [6] and other parameters that depend on such handcrafted concepts, e.g., "the center and size of each face" [6]. Such symbolic representations seem a reason for the lack of "long-term memory" complained in [6]. It is worth noting the "frame problem" well-known in artificial intelligence [7].

Some have also argued [5] that traditional machine learning approaches are more appropriate than the skull-closed autonomous mental development approach for socially assistive robots, claiming that skull-open external control by an engineer may be better suited when used with vulnerable users. Yet, the high brittleness of symbolic representations and the open-skull interventions also raise concerns with regards to vulnerable users.

Is skull-closed development inappropriate for socially assistive robots that serve vulnerable users? When are emergent representations necessary for assistive robotics applications? What do we mean by an agent being brittle? Can skull-open machine learning resolve the high brittleness? To what extent open-skull interactions provide a more successful route toward robust and safer assistive robots for vulnerable users? How do we understand the fact that human nurses use closed-skull development?

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Call for Participation

IEEE International Conference on Development and Learning and Epigenetic Robotics (ICDL-EpiRob), 2012

Conference: November 7-9, 2012

Location: San Diego, California, USA
Web: http://www.icdl-epirob.org/

General chairs: Javier Movellan (UCSD, US), Matthew Schlesinger (SIU Carbondale, US), Jochen Triesch (FIAS, Germany)
Program Chairs: Yukie Nagai (Osaka Univ. Japan), Ian Fasel (Univ. Arizona, US), Clay Morrison (Univ. Arizona, US)

Call for Paper

IEEE TRANSACTIONS ON
AUTONOMOUS MENTAL DEVELOPMENT

Microdynamics in Interaction: Capturing and Modeling Early Social Learning

We solicit papers that show approaches to bridging macro- and micro-level behavioral research on the "social interaction loop" that supports early learning. By "social interaction loop" we mean action sequences during interactions between learners and teachers. There are many unanswered questions about the content and qualities of those interactions. For example, how is the information available to a new learner selected and shaped by a parent or teacher? How do learners display their knowledge or ability, and how do teachers pick up on this information and adapt to it? The phenomena of interest prototypically focus on human infants and parents, but the same questions can be asked about non-human juvenile-adult dyads, or robot learners with human teachers. There are exciting recent efforts to precisely quantify and describe what these reciprocal interactions provide; that is, to specify the events and mechanisms that support social learning and adaptation.

Contributions can exemplify diverse approaches to studying learning through real-time, contingent, reciprocal interaction (or "co-action"). The focus of manuscripts should be on bridging macro-level (i.e., qualitative; long time-scales) and micro-level (i.e., descriptive, short time-scales) data, analyses, and/or explanations. We encourage a broad range of approaches and phenomena drawn from different disciplines, including but not limited to, anthropology, artificial intelligence, cognitive science, developmental science, ethnography, linguistics, machine learning, neuroscience, robotics, pediatrics, philosophy, psychology). Interested parties are encouraged to contact the editors with questions about the suitability of a manuscript.

Editors:

- Gedeon Deák, UCSD, deak@cogsci.ucsd.edu
- Katharina J. Rohlfing, CITEC, Bielefeld University, kjr@uni-bielefeld.de

Two kinds of submissions are possible:

- Regular papers, up to 15 double column pages, should describe new empirical findings that utilize innovative methodological and/or analytic techniques for extracting structure from rich, high-dimensional behavioral data.
- Correspondence papers, up to 8 double column pages, can focus on one of three more limited goals:
  1. Modeling: Quantitative methods for explaining the sorts of patterns found in social action loops of teacher-learner interactions. Papers should specify how the model can capture the dynamics described above, and/or ways to test those models using further behavioral and modeling studies.
  2. Methods: Practical explanations of novel tools for collecting, coding, and/or analyzing dyadic interaction data. Papers should describe the kinds of interaction-loops for which the method is appropriate, and should explain what gap-bridging challenge is met by using the method.
  3. Theoretical perspectives into social interaction loops, and the importance of bridging micro- and macro-level explanations. Theoretical essays will preferably incorporate insights and constructs from different disciplines (cognitive science, neurobiology, computational models, machine learning, sociology, and ethnology).

Instructions for authors:

http://cis.ieee.org/ieee-transactions-on-autonomous-mental-development.html
We are accepting submissions through Manuscript Central at http://mc.manuscriptcentral.com/tamd-ieee
(please select "Microdynamics" as the submission type)
When submitting your manuscript, please also cc it to deak@cogsci.ucsd.edu and kjr@uni-bielefeld.de.

Timeline:

15 January 2013: Deadline for paper submission
15 April 2013: Notification of the first round of review results
15 July 2013: Final version
20 July 2013: Electronic publication
September 2013: Printed publication

IEEE TRANSACTIONS ON
AUTONOMOUS MENTAL
DEVELOPMENT

Volume 4, Issue 2, June 2012

Link: http://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=6214672&punumber=4563672

From Infant Brains to Robots: A Report From the IEEE International Conference on Development and Learning (ICDL)-International Conference on Epigenetic Robotics (EpiRob) 2011 Conference
Cangelosi, A; Triesch, J. (PDF)

The "Interaction Engine": A Common Pragmatic Competence Across Linguistic and Nonlinguistic Interactions

Pezzulo, G. Page(s): 105 - 123. (PDF)
Abstract: Recent research in cognitive psychology, neuroscience, and robotics has widely explored the tight relations between language and action systems in primates. However, the link between the pragmatics of linguistic and nonlinguistic inter- actions has received less attention up to now. In this paper, we argue that cognitive agents exploit the same cognitive processes and neural substrate-a general pragmatic competence-across linguistic and nonlinguistic interactive contexts. Elaborating on Levinson's idea of an "interaction engine" that permits to convey and recognize communicative intentions in both linguistic and nonlinguistic interactions, we offer a computationally guided analysis of pragmatic competence, suggesting that the core abilities required for successful linguistic interactions could derive from more primitive architectures for action control, nonlinguistic interactions, and joint actions. Furthermore, we make the case for a novel, embodied approach to human-robot interaction and communication, in which the ability to carry on face-to-face communication develops in coordination with the pragmatic competence required for joint action.

Interactive Learning in Continuous Multimodal Space: A Bayesian Approach to Action-Based Soft Partitioning and Learning

Firouzi, H.; Ahmadabadi, M.N.; Araabi, B.N.; Amizadeh, S.; Mirian, M.S.; Siegwart, R. Page(s): 124 - 138 (PDF)
Abstract: A probabilistic framework for interactive learning in continuous and multimodal perceptual spaces is proposed. In this framework, the agent learns the task along with adaptive partitioning of its multimodal perceptual space. The learning process is formulated in a Bayesian reinforcement learning setting to facilitate the adaptive partitioning. The partitioning is gradually and softly done using Gaussian distributions. The parameters of distributions are adapted based on the agent's estimate of its actions' expected values. The probabilistic nature of the method results in experience generalization in addition to robustness against uncertainty and noise. To benefit from experience generalization diversity in different perceptual subspaces, the learning is performed in multiple perceptual subspaces-including the original space-in parallel. In every learning step, the policies learned in the subspaces are fused to select the final action. This concurrent learning in multiple spaces and the decision fusion result in faster learning, possibility of adding and/or removing sensors - i.e., gradual expansion or contraction of the perceptual space-, and appropriate robustness against probable failure of or ambiguity in the data of sensors. Results of two sets of simulations in addition to some experiments are reported to demonstrate the key properties of the framework.

Tool–Body Assimilation of Humanoid Robot Using a Neurodynamical System

Nishide, S. Page(s): 139 - 149 (PDF)
Abstract: Researches in the brain science field have uncovered the human capability to use tools as if they are part of the human bodies (known as tool-body assimilation) through trial and experience. This paper presents a method to apply a robot's active sensing experience to create the tool-body assimilation model. The model is composed of a feature extraction module, dynamics learning module, and a tool-body assimilation module. Self-organizing map (SOM) is used for the feature extraction module to extract object features from raw images. Multiple time-scales recurrent neural network (MTRNN) is used as the dynamics learning module. Parametric bias (PB) nodes are attached to the weights of MTRNN as second-order network to modulate the behavior of MTRNN based on the properties of the tool. The generalization capability of neural networks provide the model the ability to deal with unknown tools. Experiments were conducted with the humanoid robot HRP-2 using no tool, I-shaped, T-shaped, and L-shaped tools. The distribution of PB values have shown that the model has learned that the robot's dynamic properties change when holding a tool. Motion generation experiments show that the tool-body assimilation model is capable of applying to unknown tools to generate goal-oriented motions.

Are Robots Appropriate for Troublesome and Communicative Tasks in a City Environment?

Hayashi, K.; Shiomi, M.; Kanda, T.; Hagita, N. Page(s): 150 - 160 (PDF)
Abstract: We studied people's acceptance of robots that perform tasks in a city. Three different beings (a human, a human wearing a mascot costume, and a robot) performed tasks in three different scenarios: endless guidance, responding to irrational complaints, and removing an accidentally discarded key from the trash. All of these tasks involved beings interacting with visitors in troublesome situations: dull, stressful, and dirty. For this paper, 30 participants watched nine videos (three tasks performed by three beings) and evaluated each being's appropriateness for the task and its human-likeness. The results indicate that people prefer that a robot rather than a human perform these troublesome tasks, even though they require much interaction with people.

In addition, comparisons with the costumed-human suggest that people's beliefs that a being deserves human rights rather than having a human-like appearance and behavior or cognitive capability is one explanation for their judgments about appropriateness.

Brain-Like Emergent Spatial Processing

Juyang Weng; Luciw, M. Page(s): 161 - 185 (PDF)

Abstract: This is a theoretical, modeling, and algorithmic paper about the spatial aspect of brain-like information processing, modeled by the developmental network (DN) model. The new brain architecture allows the external environment (including teachers) to interact with the sensory ends and the motor ends of the skull-closed brain through development. It does not allow the human programmer to hand-pick extra-body concepts or to handcraft the concept boundaries inside the brain . Mathematically, the brain spatial processing performs real-time mapping from to , through network updates, where the contents of all emerge from experience. Using its limited resource, the brain does increasingly better through experience. A new principle is that the effector ends serve as hubs for concept learning and abstraction. The effector ends serve also as input and the sensory ends serve also as output. As DN embodiments, the Where-What Networks (WWNs) present three major function novelties-new concept abstraction, concept as emergent goals, and goal-directed perception. The WWN series appears to be the first general purpose emergent systems for detecting and recognizing multiple objects in complex backgrounds. Among others, the most significant new mechanism is general-purpose top-down attention.

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Link: http://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=6298011&punumber=4563672

Guest Editorial: Biologically Inspired Human–Robot Interactions—Developing More Natural Ways to Communicate with our Machines

Harris, C.; Krichmar, L.; Siegelmann, T.; Wagatsuma, H Page(s): 190 - 191 (PDF)

Long Summer Days: Grounded Learning of Words for the Uneven Cycles of Real World Events

Heath, S.; Schulz, R.; Ball, D.; Wiles, J. Page(s): 192 - 203 (PDF)

Abstract: Time and space are fundamental to human language and embodied cognition. In our early work we investigated how Lingodroids, robots with the ability to build their own maps, could evolve their own geopersonal spatial language. In subsequent studies we extended the framework developed for learning spatial concepts and words to learning temporal intervals. This paper considers a new aspect of time, the naming of concepts like morning, afternoon, dawn, and dusk, which are events that are part of day-night cycles, but are not defined by specific time points on a clock. Grounding of such terms refers to events and features of the diurnal cycle, such as light levels. We studied event-based time in which robots experienced day-night cycles that varied with the seasons throughout a year. Then we used meet-at tasks to demonstrate that the words learned were grounded, where the times to meet were morning and afternoon, rather than specific clock times. The studies show how words and concepts for a novel aspect of cyclic time can be grounded through experience with events rather than by times as measured by clocks or calendars.

Learning Through Imitation: a Biological Approach to Robotics

Chersi, F. Page(s): 204 - 214 (PDF)

Abstract: Humans are very efficient in learning new skills through imitation and social interaction with other individuals. Recent experimental findings on the functioning of the mirror neuron system in humans and animals and on the coding of intentions, have led to the development of more realistic and powerful models of action understanding and imitation. This paper describes the implementation on a humanoid robot of a spiking neuron model of the mirror system. The proposed architecture is validated in an imitation task where the robot has to observe and understand manipulative action sequences executed by a human demonstrator and reproduce them on demand utilizing its own motor repertoire. To instruct the robot what to observe and to learn, and when to imitate, the demonstrator utilizes a simple form of sign language. Two basic principles underlie the functioning of the system: 1) imitation is primarily directed toward reproducing the goals of observed actions rather than the exact hand trajectories; and 2) the capacity to understand the motor intentions of another individual is based on the resonance of the same neural populations that are active during action execution. Experimental findings show that the use of even a very simple form of gesture-based communication allows to develop robotic architectures that are efficient, simple and user friendly.

Context-Based Bayesian Intent Recognition

Kelley, R.; Tavakkoli, A.; King, C.; Ambardekar, A.; Nicolescu, M.; Nicolescu, M. Page(s): 215 - 225 (PDF)

Abstract: One of the foundations of social interaction among humans is the ability to correctly identify interactions and infer the intentions of others. To build robots that reliably function in the human social world, we must develop models that robots can use to mimic the intent recognition skills found in humans. We propose a framework that uses contextual information in the form of object affordances and object state to improve the performance of an underlying intent recognition system. This system represents objects and their affordances using a directed graph that is automatically extracted from a large corpus of natural language text. We validate our approach on a physical robot that classifies intentions in a number of scenarios..

Reciprocity and Retaliation in Social Games With Adaptive Agents

Asher, D.E.; Zaldivar, A.; Barton, B.; Brewer, A.A.; Krichmar, J.L. Page(s): 226 - 238 (PDF)

Abstract: Game theory has been useful for understanding risk-taking and cooperative behavior. However, in studies of the neural basis of decision-making during games of conflict, subjects typically play against opponents with predetermined strategies. The present study introduces a neurobiologically plausible model of action selection and neuromodulation, which adapts to its opponent's strategy and environmental conditions. The model is based on the assumption that dopaminergic and serotonergic systems track expected rewards and costs, respectively. The model controlled both simulated and robotic agents playing Hawk-Dove and Chicken games against subjects. When playing against an aggressive version of the model, there was a significant shift in the subjects' strategy from Win-Stay-Lose-Shift to Tit-For-Tat. Subjects became retaliatory when confronted with agents that tended towards risky behavior. These results highlight the important interactions between subjects and agents utilizing adaptive behavior. Moreover, they reveal neuromodulatory mechanisms that give rise to cooperative and competitive behaviors.

Towards a Platform-Independent Cooperative Human Robot Interaction System: III An Architecture for Learning and Executing Actions and Shared Plans

Lallee, S.; Pattacini, U.; Lemaignan, S.; Lenz, A.; Melhuish, C.; Natale, L.; Skachek, S.; Hamann, K.; Steinwender, J.; Sisbot, E.A.; Metta, G.; Guitton, J.; Alami, R.; Warnier, M.; Pipe, T.; Warneken, F.; Dominey, P.F. Page(s): 239 - 253 (PDF)

Abstract: Robots should be capable of interacting in a cooperative and adaptive manner with their human counterparts in open-ended tasks that can change in real-time. An important aspect of the robot behavior will be the ability to acquire new knowledge of the cooperative tasks by observing and interacting with humans. The current research addresses this challenge. We present results from a cooperative human-robot interaction system that has been specifically developed for portability between different humanoid platforms, by abstraction layers at the perceptual and motor interfaces. In the perceptual domain, the resulting system is demonstrated to learn to recognize objects and to recognize actions as sequences of perceptual primitives, and to transfer this learning, and recognition, between different robotic platforms. For execution, composite actions and plans are shown to be learnt on one robot and executed successfully on a different one. Most importantly, the system provides the ability to link actions into shared plans, that form the basis of human-robot cooperation, applying principles from human cognitive development to the domain of robot cognitive systems.

Editor : Pierre-Yves Oudeyer, INRIA Editorial Assistants : Adrien Baranes and Paul Spears
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