RobotDoC

Robotics for Development of Cognition

ROBOTDOC International Conference on Development of Cognition

ROBOTDOC INTERNATIONAL CONFERENCE ON DEVELOPMENT OF COGNITION

Osaka, August 16-18, 2013 (co-located with ICDL-EpiRob)

Osaka City Central Public Hall

MARIE CURIE ACTIONS

SEVENTH FRAMEWORK PROGRAMME

CONTENTS

PROGRAMME

Venue*: Osaka City Central Public Hall*
1-1-27 Nakanoshima,Kita-ku,Osaka

Friday August 16

12:00 *arrival*
13:00 Keynote: Masako Myowa-Yamakoshi (*Kyoto University*)
14:00 Cristiano Alessandro, Zurich University
14.20 Claudia Elsner, Uppsala University
14:40 Andrea Handl, Uppsala University
15:00 Kiril Kiryazov, Skovde University
15:20 Naveen Kuppuswamy, Zurich University
15:40 Gauss Lee, Skovde University
16:00 Katrin Solveig Lohan, IIT
16:20 *Coffee and Poster Session 1*
17:20 Narayan Vikram, Bielefeld University

Saturday August 17

9:30 Keynote: Yukie Nagai (*Osaka University*)
10:30 Marek Ruciński, Plymouth University
10:50 Wiktor Sieklicki, Telerobot
11:10 *Coffee*
11.40 Francesca Stramandinoli, Plymouth University
12:00 Anna-Lisa Vollmer, Plymouth University
12:20 Nicolas Navarro-Guerrero, Hamburg University
12:40 Nick Wilkinson, IIT
13:00 *Lunch*
14:20 Junpei Zhong, Hamburg Univeristy
14:40 Szufnarowska Znajdek Joanna, Bielefeld University
15:00 *Coffee and Poster Session 2*
16:00 Discussion group
18:00 *Conference ends*

Sunday August 18

See ICDL-Epirob programme

Day 1: AUGUST 16

ABSTRACTS OF TALKS

Masako Myowa-Yamakoshi, Kyoto University

The Origins of Understanding Self and Other: Developmental and Evolutionary Perspectives

New-born humans are known to possess an elaborate capacity to process information about the external world, as well as about their own bodies. Such characteristics have been explained using the terms such as "innate" and "competence." However, our research team has shown that there is a clear continuity in human sensorimotor development from prenatal to postnatal life. Fetuses have some knowledge of their own bodies. On the basis of such early forms of the self, humans seem to perceive equivalence relations between their own and others' actions from birth (e.g., neonatal imitation). Interestingly, such early characteristics are not restricted to humans: there is a continuum of early self-other matching behaviors in the primate lineage, i.e., chimpanzees and monkeys. I will then show that by the end of the first year of life, humans and chimpanzees attend differently to actions of other individuals. Human infants uniquely and remarkably come to understand the actions of other individuals on the basis of their own sensorimotor and psychological experiences. The basic differences in visual-motor information processing may reflect the core differences in higher-order cognitive functions, such as imitation and action understanding between humans and chimpanzees. I will discuss the emergence of self-awareness by relating it to the function of the mirror system using both phylogenetic and ontogenetic comparisons.

Cristiano Alessandro, Zurich University

Computational implications of the muscle synergy hypothesis

A prominent hypothesis in motor neuroscience suggests that the central nervous system generates desired muscle activations by combining a parsimonious set of predefined primitives called synergies. Most of the evidence for this modularity is based on the analysis of recorded muscle activations, and the results are often descriptive in nature. The implications of this control strategy are still far from understood, and its relations to the task and the dynamical system to be controlled are still under debate. Our work investigates these issues by considering the problem of controlling a simulated mechanical system in accordance with the model of time-varying synergies. In this scenario, the main challenge is the synthesis of a small set of actuations (i.e. synergies) that can be combined to generate effective control signals. This problem leads to a new definition of synergies that is grounded at the level of task, and that is demonstrated in a series of simulations. Further insights are provided by the Dynamic Response Decomposition (DRD), a novel method that is instrumental for the synthesis and the adaptation of a set of synergies. Our results suggest that synergies are strictly tailored to the dynamics of the system and to tasks to be solved. The direct mathematical relation between task-constrains and the minimum required number of synergies confirms such an observation. Finally, we demonstrate that the sole approximation error of the desired input signals does not provide direct

information on the task performance, thus promoting a task-based assessment of the hypothesis of muscle synergies.

Claudia Elsner, Uppsala University

Infants' and adults' understanding of other people's actions

During my fellowship, my research focused on infants' development of action understanding as well as the mechanisms behind predictive goal-directed eye movements in adults. In particular, several eye tracking studies investigated how infants anticipate observed actions, such as reaching, and how different factors influence infants' ability to anticipate goals of these actions. In collaboration with the University of Potsdam, an eye tracking study revealed that latencies of goal-directed gaze shifts are modulated by properties of the goal, showing that goal salience affects infants' goal-directed gaze shifts during observation of reaching actions (Henrichs, Elsner, Elsner, & Gredebäck, 2012). In a joint RobotDoC project with the IIT in Genua and the University of Potsdam, it was found that infants rely on information about the certainty of goal selection to make inferences about others' action goals (Henrichs, Elsner, Elsner, Wilkinson, & Gredebäck, 2013). In cooperation with the University of Bielefeld, a series of eye tracking experiments investigated infants' online encoding of receiving gestures during observation of a collaborative action (Elsner, Bakker, Rohlfing, & Gredebäck, submitted). Together, the studies demonstrate that 12-month-old infants are sensitive to social goals and further suggest that 12-month-olds are able to encode the communicative meaning of “give me” gestures. Besides, I studied anticipation of biological motion in adults (Elsner, Falck-Ytter, & Gredebäck, 2012) and, in collaboration with the IIT, the mechanisms behind predictive goal-directed eye movements in action observation using transcranial magnetic stimulation and eye tracking technology (Elsner, D'Ausilio, Gredebäck, Falck-Ytter, & Fadiga, 2013). The joint TMS study provides direct support for the view that a direct matching process implemented in the mirror-neuron system plays a functional role for real-time goal prediction.

Andrea Handl, Uppsala University

Looking at others – infants’ observation of social scenes

In previous research, a lot of investigations have looked at infants’ sensitivity to social cues in dyadic and triadic situations. In comparison, the question how infants perceive social interactions from the perspective of an observer has been fairly neglected. The usage of eye-tracking technique enables us to explore this issue further. In my presentation I am going to provide a short overview on previous eye-tracking studies on the topic, explaining how their findings have inspired current investigations. Furthermore, I am going to present findings from a recent eye-tracking study in 9-, 16-, and 24-month-old infants that were presented with static images of two social partners. The focus of the study was to explore the effect of body orientation and eye status on infants’ gaze shifts. Our findings demonstrate that body orientation as a visual cue is sufficient to inform infants about others’ social engagement. Furthermore, I will introduce a second (and yet ongoing) eye-tracking study that follows up on this question by presenting infants with video clips of conversations. In this study, we are employing a wider range of socially relevant cues which will help to clarify the role of body orientation and eye status in a audio-visual context. Finally, I am going to suggest how these findings can inspire the emerging field of developmental robotics.

Kiril Kiryazov, Skovde University

Grounding emotion appraisal in autonomous humanoids

Animals have to survive in complex environments under the constraints of different resources like food, water, etc. Evolution has provided solutions to these high-dimensional problems with non-trivial complexity. Robots also have to manage different resources like energy usage, workload etc. A cognitive affective architecture is developed using task selection mechanisms based on abstract ethological models. In order to embody and increase the efficiency of the animal task selection mechanisms in the service robotic world, where a robot should cooperate with humans, other bio-inspired mechanisms are used based on the appraisal theory of emotion. These mechanisms help adapting the proper tradeoff between mechanical effort and energy efficiency – which are crucial factors for providing embodied solutions for optimal resource management for physical autonomous robots. Safety as an important aspect of the human-robot interaction was also included into the robot's homeostatic control. Different experiments with two types of humanoid robots are performed showing the role of the arousal component of the architecture for managing efficiently task selection and the effort of the movement and producing sustainable basic-cycles in exemplar two and three resources problems. Experimental designs and architecture extensions for exploiting the role of emotion expression / recognition as an efficient tool for fast and meaningful communication in cooperative tasks are discussed. The arousal state of the robot expressed in a believable way could induce similar one in humans and from another side the robot could adapt its behavior influenced from the human's emotion.

Naveen Kuppuswamy, Zurich University

Exploiting Reduced Dimensionality for Development

The "Curse of Dimensionality" is a key factor affecting the learning and optimisation of motor skills in both biological and artificial systems, thus strongly impacts behaviour. In the first part of this talk, approaches to alleviate the problem based on control dimensionality reduction are presented; such approaches enable a developmental acquisition of motor abilities. Based on a systematic study of the impact of the natural dynamics, and modular control strategies on reduced dimension dynamic behaviour, principles for the mechanical design and control synthesis are proposed for embodied systems. Case studies for the application of these methods are presented in both biological and robotic systems using a variety of simulations. In the final part of the talk the interdiscplinary training experiences in the RobotDoC Training Network shall be presented.

Gauss Lee, Skovde University

Locomotion learning based on a layered CPG architecture

Bio-inspired approaches used for locomotion learning start to catch eyeballs recently in terms of its potential advantages (e.g. versatile adaptation, compilation with learning algorithms) over traditional engineering approaches. In my PhD study, a bio-inspired hierarchical CPG architecture is deeply investigated and applied to model crawling and walking on a humanoid platform (the NAO robot). The study starts with a fundamental and generic four-cell model and is further extended to a layered architecture (Least Sensory Feedback CPG Model) in which the four-cell CPG network works as a

clocking layer. Finally, a layered CPG architecture based on motor primitives is proposed as a generic model of locomotion learning. As the CPG architecture is a parameterized in the high-dimensional space, P-eNAC (positive episodic natural actor critic) is used to learn all the parameters pertaining to the functionalities of sensory feedback integration and postural control. With the natural-actor-critic learning mechanism, the CPG architecture turns out to be Natural CPG-Actor-Critic. In a conclusion, an explanation on the basis of dynamical systems theory and related cognitive/philosophical theories is given to highlight the meaningfulness of my research.

Katrin Solveig Lohan, Italian Institute of Technology

Studying attention mechanisms, language acquisition and gazing behaviour in children and adults for improving the robot's interaction strategies

Under the umbrella of Human-Robot interaction (HRI), two main areas have been the focus of my work, the development and studying of a keyword spotting and learning system, studying the attention system of the iCub. These areas were researched with the underlying goal of developing a robotic system that can be perceived as a child-like one.
Keyword spotter. A first step was taken by analysing data from a HRI study Lohan et al. (2012). A Keyword spotting system was designed to follow the concept of understanding action and language acquisition as a binding process and to learn keywords only based on interaction (Dondrup et al. (2012), Dondrup 2012). This work was based on the HRI study conducted in the ITALK project in cooperation with the Bielefeld University and the University of Hertfordshire. Based on this Keyword System, object descriptions can be extracted and even a simple feed-forward neural network can learn the extracted words and even their connections for independent speakers. The underlaying multimodal approach, which is combining action detection and sound filtering, is supporting the Keyword detection.
Gazing behaviour. The gazing behaviour produced by the attention system of the iCub was compared with the gazing behaviour of 14-month-old infants Lohan, Rea & Metta (2013). In tutoring situations with a robot, the interplay between the use of language and gazing behaviour was studied (Lohan, Fischer, Dondrup & Nehaniv (2013), Fischer et al. (2013). To understand this interplay in greater depth, the effect on the anticipatory gazing behaviour was studied on 14-month-old infants (Sciutti, Lohan, Gredeback, Koch & Rohlfing (2013), Sciutti, Rohlfing, Lohan, Koch & Gredeback (2013).

Narayan Vikram, Bielefeld University

Saliency as a guide to Visual Attention

The ability to attend important regions of a scene constitutes one of the principal aspects of cognition. Visual attention thus acts as a controller in shifting the perception to different locations depending on the context and saliency. This talk will describe a stochastic approach to predict visual attention by modelling visual saliency. The said approach attains robust performance in automatically predicting human eye-gaze on natural scenes. Experimental results on different eye-gaze datasets along with a comparative analysis will be further presented. The talk will conclude with a moderate discussion about the problems which hinder the existing saliency based approaches. In addition, several specific problems pertaining to saliency and attention which merits investigation will be pointed.

DAY 2: AUGUST 19

ABSTRACTS OF TALKS

Yukie Nagai, Graduate School of Engineering, Osaka University

Development of Self through Other: Emergence of Mirror Neuron System and Social Interaction

Recognition of self and other is a cornerstone for cognitive development. Human infants acquire different levels of self (e.g., ecological self and interpersonal self) through interaction with the environment. We have been investigating how infants become aware of self and other and thus establish social interaction from a constructive point of view. My talk first presents our robotic model for the emergence of the mirror neuron system (MNS). We hypothesize that the MNS originates in non-differentiated self and other in early infancy. Their immature ability to perceive spatiotemporal contingency diminishes the difference between self and other, which highlights the "like-me" property of other individuals. The second part of my talk focuses on the development of social interaction. When infants establish contingent reactions such as turn taking and joint attention has been analyzed. Our results demonstrate that both infants and caregivers shape the interaction and thus mutually facilitate the development. These results will be discussed in relation to recent findings about developmental disorders. It has been suggested that an essential characteristic of autism is a difficulty in integrating sensorimotor information rather than in social interaction. I emphasize the potential of our computational approach to better understanding the mechanism of developmental disorders.

Marek Ruciński, Plymouth University

Modelling Learning to Count in Humanoid Robots

I am going to present research on modelling learning to count in humanoid robots. Learning to count is an important milestone in the acquisition of mathematical skills by children. Its primary role the establishing of a mapping between inexact pre-verbal quantifications skills and (exact) symbol manipulation capabilities. Two aspects of learning to count that are given a special attention. The first one is connected with counting gestures. It is well established that such gestures play an important role in learning to count. For example, while the skill develops, they improve counting accuracy. The exact nature of this contribution is however still not understood. I use the humanoid robot iCub to design a robotic cognitive model and show its usefulness in investigating the contribution of gestures to learning to count. The robot is a source of artificial proprioceptive signals which are available, along with visual information, to an artificial recurrent neural network that is tasked to count using sequential enumeration. I present results of simulations that reveal that the spatial correspondence between the objects being counted and the counting gesture is critical in the context of the counting task. The second aspect of learning to count that is looked at in my work is the ontogeny of the spatial-numerical associations. Several lines of evidence suggest that the representations of space and numbers in the brain are interrelated, one of them being the SNARC effect (Spatial-Numerical Associations of Response Codes). Existing models of the effect address the nature of the mechanisms involved, but not how the phenomenon arises. I present a modelling experiment that, using the iCub

robot, shows that the SNARC effect may emerge when children are repeatedly exposed to systematic spatial biases during learning do count.

Wiktor Sieklicki, Telerobot

Investigation of a one-axis torque sensor for joint level torque control of the iCub 2.0 humanoid robot

Humanoid robot ICub uses four 6-axes Torque/Force sensors placed in each leg and hand. In order to provide better movements' accuracy and improve walking abilities of the robot, torque in each robot's joint is considered to be measured. One-axis torque sensors designed specifically for this reason were placed in the kinematic chain of each powering unit of the robot. Readouts of those sensors appeared to have a hysteresis though. For this reason a series of sensor's tests were commissioned. The task was to define a reason of the drawback, possibly minimize the hysteresis and design a hysteresis-free sensor. A verification of an existing one-axis torque sensor readings for the iCub robot was showing high readouts hysteresis (residuals of up to 25% of the applied load) and nonlinearity while diverse loads were applied to the sensor. Similar behavior was noticed for commercially available torque-force sensors. Several new designs were tested and the most up-to-date design shows the hysteresis of up to approximately 3% of the applied load under repetitive static tests.

Francesca Stramandinoli, Plymouth University

Towards the Grounding of Abstract Concepts: An Embodied Approach

In contrast to other forms of communication, language is a combinatorial system that permits the conveyance of new messages and concepts by combining simple words together. Recent evidence has suggested that the human motor system is also hierarchically organized; that is, low level motor primitives can be integrated and recombined in different sequences in order to perform novel tasks. Furthermore, studies in neuroscience and the behavioural sciences have demonstrated that language is embodied in perceptual and sensorimotor knowledge. We present a neuro-robotic model for the integration of compositional actions and symbol manipulation capabilities in order to bootstrap higher-level cognitive capabilities. Sequences of linguistic inputs that a robot can interpret in terms of its internal language and motor repertoire, lead to the development of higher-order concepts grounded on simple action primitives and words. To model the mechanisms that underlie motor and linguistic sequence processing recurrent neural networks have been used. Simulation results have shown that more general concepts can be grounded through the integration of perceptual and sensorimotor knowledge. The model has also exhibited the capability to generalize new concepts by rearranging its internal language and motor repertoire. Furthermore, tests performed in incongruent conditions between the perceptual and linguistic stimuli have demonstrated that proper naming of objects and actions facilitates language categorization. By undertaking the interdisciplinary training activities provided by the RobotDoC Marie Curie Initial Training Network I had numerous opportunities to improve my research skills and to attend many international conferences and workshops, comprising events related to personal development and effectiveness and communication skills which had a tremendous impact on the progression of my scientific career. The sharing of knowledge with experts and young researchers in the RobotDoC network fostered my creative thinking and provided opportunities to engage in productive collaborations.

Anna-Lisa Vollmer, Plymouth University

Do Beliefs and Robot Feedback Affect the Alignment to a Robot's Actions?

Interlocutors in a dialog align on many aspects of behavior (e.g. word choice, speech rate, syntactic structure, gestures, and facial expressions). Such alignment has been proposed to be the basis for communicating successfully. Thus, we suggest alignment could be beneficial for smooth human-robot interaction and – in the domain of manual actions – facilitate robot action learning from demonstration. Recent research put forward a mediated communicative design account of alignment according to which interlocutors align stronger when they believe it will lead to communicative success. Branigan et al. showed that when interacting with an artificial computer dialog system, participants aligned their lexical choices more to an artificial system they believed to be basic than to one they believed to be advanced. Interestingly, they argued that the system's feedback did not dynamically update participants' beliefs and affect alignment as it is the case in human-human social interaction. In this talk, alignment will be discussed in the context of robot learning from demonstration. Specifically, in studies we have extended Branigan et al.'s results by investigating if participants align to a humanoid robot interaction partner's manual actions. We analyzed alignment taking into account participants' beliefs about and feedback from their robot interaction partner.

Nicolas Navarro-Guerrero, Hamburg University

Neurocomputational mechanisms for self-protective robot behaviour

Self-protective neural circuits belong to the most important and essential capabilities of any organism. They are believed to provide the basis for more complex and motivated behaviour. Although many of these innate responses are hard-coded in the neural system, they are not sufficient for the organisms' survival. They have to adapt to new and unexpected situations within their lifetime and thereby be able to interact effectively with their environment. A key component of the lifetime adaptation is the formation of associations between environmental predictors and relevant events, which may be learned with punishment and reward learning. We hypothesize that a deeper understanding and integration of innate and learned protective mechanisms could be helpful in developing future robot generations, making them more adaptable and robust. In this research project, we are studying and developing neurocomputational self-protective mechanisms for a humanoid service robot such as association of appetitive stimuli and more importantly associations of aversive or noxious stimuli. Our first experiment addresses reward-driven learning where a robot is trained to seek for appetitive stimuli. Here a reinforcement learning (SARSA) algorithm is optimized to learn in a real-world scenario and manoeuvre a humanoid robot towards a charging station. In a second experiment we study the role of noxious stimuli on the formation of anticipatory behaviour. This experiment is based on Pavlovian and instrumental conditioning and how environmental cues can be used to anticipate negative outcomes. A hybrid approach using an echo state network (ESN) and a dopamine modulated Pavlovian conditioning was used to anticipate painful signal based on auditory cues. Finally, our current research focuses on emulated pain signals due to their important role in attracting attention and modulating decision making and action. Pain is an unpleasant sensory experience associated with actual or potential damage and thus a strong indicator for behaviour readjustment. However maladaptive behaviours may arise leading to persistent avoidance behaviour and ironically to more pain and long-term disability. Particularly, we are studying the boundaries between adaptive and

maladaptive withdrawal behaviours in a motor learning task. We design, implement and evaluate an actor-critic learning algorithm (CACLA) which can learn to teach a humanoid robot to reach for a moving target.

Nicholas Wilkinson, Italian Institute of Technology

Inter-facial relations; an embodied approach to the social instinct

The RobotDoc project has provided a uniquely inspiring and multi-disciplinary research and training environment, which has enabled the development of productive collaborations between the Istituto Italiano di Tecnologia and the Child and Baby Lab at Uppsala University. Combining theory driven modeling with data driven testing, we are investigating the origins and phenotypic implementation of the "social instinct" in newborn babies. We have investigated various "innate predispositions" including face detection, biological motion detection, contingency detection and face-voice integration. Currently, the dominant perspective in developmental psychology proposes that newborn social abilities indicate the existence of genetically specified internal representations, with a number of modules evolved for face detection, contingency detection etc. combining to provide a "life detector", thought to be evolutionarily ancient and implemented primarily in sub-cortical regions of the brain. Our over-arching hypothesis is that many of these social-attentional biases can instead be explained in terms of spatio-temporal resonance between interacting transceiver arrays. Internal representations and models of conspecifics are unnecessary, because the body by definition already provides an excellent model of the other. We will present results from minimal simulations and embodied humanoid experiments, showing how collapsing of the spatial and modal extent of this observably existing "model" via inter-sensory integration can provide a powerful attentional bias for conspecifics. This spatial resonance, combined with temporal resonance via active deployment of sensors, gives rise to synchronization dynamics from which the various facets of the social instinct emerge in natural way. The analysis enables a number of predictions. If these turn out to be accurate, our theoretical results on the role of embodiment in social interaction have profound implications for the study of social and perceptual development.

Junpei Zhong, Hamburg Univeristy

Neural modeling of hierarchical prediction mechanism in cortical areas

In cortical areas, a mechanism of compensation for processing delays via prediction is necessary so that they encode present, not past, events. To realize this compensation in the context of neural networks from the mirror neuron system, sensorimotor integration as well as visual cortex, we suggest to use recurrent connections to create an internal memory to store the previous dynamics. For a general analysis, we firstly emphasized that a short-term memory should exist within the mirror neuron system to assist with the action understanding and prediction. A recurrent network with parametric biases was thus applied to realize this system function in which the parametric bias units recognize and encode robot walking patterns. Furthermore, in the second experiment of the task, we focused on the encoding of information in the higher visual pathway, which allows for motor-relevant representations. Specifically, the convergence of ventral and dorsal pathways with predictive functions may give rise to the understanding of object affordance and object manipulation and its

control. To model this, we designed a recurrent predictive network with a horizontal product where the information of object feature and object movement becomes successfully separated in its two hidden layers. We also found that such recurrent connections for sensory latency compensation also support smoother and faster behaviours in sensorimotor integration tasks. For example, in the third experiment, the latency of the sensorimotor cycle of a robot may affect the response time for the motor action. We expanded the use of recurrent connections in the sensorimotor system, particularly in the sensory prediction part, so that the recurrent connections can compensate the delay in the sensory percepts. A continuous actor-critic automaton (CACLA) algorithm was also applied in the generation of smooth behaviours corresponding to the predictive sensory percepts. Experiments showed that the predictive sensorimotor architecture successfully increases the speed and robustness of the robot docking experiment.

Szufnarowska Znajdek Joanna, Hamburg Univeristy

Social development of dialogical rules

In a longitudinal naturalistic study, we observed German mothers interacting with their infants when they were 3 and 6 months old. We explored whether eye contact is reinforced selectively by behavioral modification in the input provided to infants. Applying a microanalytical approach, we analysed how the mother draws the infant's attention to herself and how she tries to maintain attention when the infant is looking at her. Results showed that eye contact is reinforced by specific infant-directed practices: interrogatives and conversational openings, multimodal stimulation, repetition and imitation. The second study analysed the course of interaction between mothers and their two-month-old infants. Mother-infant dyads from Poland were videotaped during a peek-a-boo play which is a highly structured form of interaction. We found that infants were most likely to smile after the first unit of play when the interaction pattern became more familiar to them. However, they responded with a smile in a given unit only when the mothers were able to attract their attention within one second after uncovering. As long as the infants smiled, the mothers continued the play. The mothers motivated their infants to take a turn in form of social smile and responded contingently to it with at least three different modalities. Our results suggest, that social smile of the infant is the product of establishing the mutual gaze, that it is a basis for further turn-taking and serves as a 'hook' for the mother to continue the interaction.

POSTER SESSION 1

Anara Sandygulova, School of Computer Science and Informatics, University College, Dublin

Individual Robot Interaction (IRI)

In environments where robotic systems are deployed people often have different requirements. Resources and tasks present in these environments are often assigned to more than one person at a time. However, current robotic systems lack the support of multi-user task achievement while ensuring seamless personalized interaction. My research aims to exploit the advantages of ubiquitous monitoring services of intelligent robotic systems to distinguish individuals in a shared environment in order to provide personalized, controllable and effective interaction for its every occupant.

Christopher Beck, Bristol University, Robotics Laboratory

Manipulation of Objects for the Extraction of Text (MOET)

Christopher B., Broun A. & Trust L.

Embedded text on an object can hold crucial information for the holder. This information can range from a sell by date to what the object contains. My work looks to locate and understand text and its structure in unconstrained natural scene images. The Project as a whole presents a robotic platform that can grasp and manipulate objects so as to discover text regions, and then based on the text and 3D model information gained to further manipulate the object to enhance and explore these regions.

Daniel Jachyra, University of Information Technology and Management in Rzeszów

Extension of Motivated Learning Agent

This paper focuses on the novel opportunistic behavior of an intelligent agent. It extends previously developed motivated learning mechanism to opportunistic behavior in a multi task situation. Here I describe virtual world implementation of autonomous opportunistic agent learning in a dynamically changing environment. This agent is able to create abstract goals, and taking advantage of arising opportunities to improve their performance. Agent agent and its environment is developed in NeoAxis Game Engine. An intelligent agent has the ability to recognize new situations and important events through interactions with its environment. Therefore, the agent must be able to perceive and interpret external signals from the environment. This allows it to accurately and dynamically predict new situations, so that the agent can make decisions and act according to its objectives. The preferred approach is to have minimum supervision over the agent's actions and learning process, such that it can adapt to an unknown and changing environment that is quite often hostile to the agent. In contrast to reinforcement learning, a motivated learning system was developed to allow the agent to develop its own motivations and goals. Finally an opportunistic agent achieves better results than an agent based on motivated learning only. It does so by minimizing the average overall pain/need signal rather than a dominating need. This work applies to the design of autonomous embodied systems (robots) learning in real time how to operate in a complex environment.

Konstantinos Theofilis, University of Hertfordshire

Humanoid Social Robotics: Communicative imitation and development

My thesis is focused on the developmental mechanisms of communicative imitation and social learning and their importance in maintaining and improving the context of an interaction. Using the iCub humanoid robot as a platform, models for these mechanisms are developed and evaluated. Special emphasis is given on the role of synchronisation during interaction and how it affects the exchange of information, the maintenance of the interaction loop and the imitation learning. The main experiments involve HRI studies where the human participants play an imitation game with the robot, ordering and stacking cubes. The turn-taking is not fixed and temporal emphasis is used to extract the end goal and subgoals of the task in the game. Also, the system is analysing the human's gestures, body movement and gaze and the robot reproduces them in a similar tempo. The hypothesis is that if a robot has the same rhythm as a human in the communication (imitating the communicative actions of the human), the turn-taking is more effective and the interaction more engaging, leading to a more natural and sustainable human-robot interaction. The preliminary results are promising and highlight the importance of time and rhythm in imitation in general and communicative imitation in particular.

Kristina Rebrova, Comenius University (SK)

A robotic model of mirror-neuron based action-understanding

Action understanding is a crucial cognitive capacity in both humans and animals. Neural and behavioral evidence has proven that understanding of the observed action requires more than sole visual assessment. Some theories, like the common coding theory, even claim that action and perception are on a high level represented in a common framework. It has been shown that observation of action or even hearing action verbs elicits responses in motor areas of the brain, called motor resonance. A possible neural substrate for such phenomena are the mirroring responses of motor neurons found in macaque monkeys (and recently in humans). Mirror neurons are motor cells that fire also when the subject observes a particular movement without motor involvement of the observer thus matching the observed movement with its representation in the observer's own motor repertoire. Our aim is to design and implement ANN-based models of common coding and mirror neuron system for cognitive robots, namely for a simulated iCub. Our models are composed of several processing modules and hierarchically organized. The main idea is to endow the robot with common coding and/or mirror neuron circuitry to allow it to bind the motor patterns with the perceptual information and provide a basis for understanding actions of other agents. Subsequently, in line with evidence from neuropsychology, we might also provide an agent with a capacity to name actions it perceives and to execute actions on verbal command.

Kyuhwa Lee, Imperial College, London

A Syntactic Approach to Robot Imitation Learning using Probabilistic Activity Grammars

We propose a syntactic approach to imitation learning that captures important task structures in the form of probabilistic activity grammars from a reasonably small number of samples under noisy conditions. We show that these learned grammars can be recursively applied to help recognize unforeseen, more complicated tasks that share underlying structures. The grammars enforce an observation to be consistent with previously observed behaviors which can correct unexpected, out-of-context actions due to errors of the observer and/or demonstrator. To achieve this goal, our method 1) actively searches for frequently occurring action symbols that are subsets of input samples to uncover the hierarchical structure of the demonstration, and 2) considers

the uncertainties of input symbols due to imperfect low-level detectors. We evaluate the proposed method using both synthetic data and two sets of real-world humanoid robot experiments. In our Towers of Hanoi experiment, the robot learns the important constraints of the puzzle after observing demonstrators solving it. In our Dance Imitation experiment, the robot learns 3 types of dances from human demonstrations. The results suggest that under reasonable amount of noise, our method is capable of capturing the reusable task structures and generalizing them to cope with recursions.

Leo Tomasevic, ISTC-CNR Laboratory of Electrophysiology of Translational Neuroscience

Non-invasive investigation of sensorimotor control for future development of Brain-Machine-Interface (BMI)

Tracking for any BMI intervention on the human motor system, two crucial elements are 1. markers of the motor system relevant for the movement planning and execution and 2. the ability to test 'online' these markers. In this perspective I have used non-invasive electrophysiological techniques to investigate the primary motor area (M1) behavior from different point of view: 0. Developing a device for a simple and reliable assessment of the sensorimotor system by EEG/EMG/MEG/fMRI/TMS technologies, 1. investigating the properties of a suitable marker of the primary motor area functionality, i.e. the cortico-muscular coherence (CMC), 2. studying the trial-to-trial variability of crucial primary sensorimotor measures. Firstly I have examined M1 activation during voluntary isometric contraction employing the ad-hoc developed device that records and produces a feedback of the level of force during hand gripping (Interacting Pressure Sensor. InPresS). The CMC measures showed the M1 features relevant for movement control during human development and connectivity changes depending on fatigue levels –in multiple sclerosis (MS) patients- revealing the importance of individuals and states to be taken into account for any further application. Using electroencephalographic recordings simultaneously with transcranial magnetic stimulation (TMS/EEG), I have obtained results indicating that the connectivity properties- both centrally and in the connection with the environment- depend on the involuntary trial-to-trial variability of motor pathway activation. This is an archetypal propriety of any measurable attribute of the nervous system and represents the fundamental limit for the online assessment for any application.

Martin Peniak, Plymouth University

Aquila 2.0 - Software Architecture for Cognitive Robotics

The modelling of the integration of various cognitive skills and modalities requires complex and computationally intensive algorithms running in parallel while controlling high performance systems. The distribution of processing across many computers has certainly advanced our software ecosystem and opened up research to new possibilities. While this was an essential move, we would like to augment the possibilities in cognitive robotics research by providing an easy-to-use, hi-performance, modular and scalable software architecture. This paper presents Aquila 2.0, an open-source cross-platform software architecture that makes use of independent heterogeneous CPU-GPU modules that can run anywhere across the network in any number of instances and using any number of available GPU devices. These modules are loosely coupled with their graphical user interfaces dynamically generated by Aquila on demand. Aquila is cross-platform and runs on Linux, OSX and Windows and its dependencies are Qt (graphical user interfaces), YARP (communication over network) and CUDA (GPU-accelerated code). Aquila modules can be easily managed and visualised via Aquila. The modules can be used either from the terminal or via Aquila with an additional advantage of module management and visualisation features. Finally, the modules can also spawn other modules anywhere on the network and use their functionalities.The inherent modularity of this cross-platform architecture coupled with

its ability to achieve hi-performance via GPU processors are directly enhancing its scalability, usability and reuse.

POSTER SESSION 2

Nikolas Hemion, Bielefeld University

Developmental Integration of Sensorimotor Mappings

Sensorimotor mappings, such as kinematic transformations or control policies, are essential tools for robots to solve tasks. In the developmental robotics and machine learning literature, the question of how robots can learn sensorimotor mappings from own experiences is often investigated, enabling robots for example to learn to reach for objects, to balance poles or to swing tennis rackets. However, the important problem of how multiple sensorimotor mappings can be integrated into a single system in a developmental way is rarely addressed. Instead, either only a single sensorimotor mapping is used, and thus the robot's function is limited to a single task, or traditional symbolic methods are employed that have several limitations and require the designer to provide additional task-specific knowledge, and thus cannot be employed by the robot autonomously. This poster discusses the question of how sensorimotor mappings can be integrated generically in a robotic system. We argue that this issue should also guide the choice and the design of learning methods and representations. Specifically, we propose that redundancies in sensorimotor tasks can be usefully exploited for the purpose of integration, and thus that learning methods should be able to retain information about redundancies. These considerations lead us towards the design of a generic building block, which could be the basis for a developmentally plausible cognitive architecture.

Rony Novianto, University of Technology Sydney (UTS) Sydney

Robot Cognitive Architecture for Open and Complex Environment

In the history of artificial intelligence (AI), researchers have been discovering various AI components, such as algorithms, mechanisms and representations, for building intelligent agents and solving specific problems. There have been enormous on-going efforts to integrate strengths and capabilities of these components into a unifying coherent cognitive architecture in order to build more complex agents and solve more challenging problems. However, three striking issues becomes apparent when these cognitive architectures are applied to open and complex robotics problems. First, existing cognitive architectures are too restricted on the kind of components that can be integrated. Second, they are inadequate to support the core capabilities required by robots. Third, they are inflexible to adapt to changes required by multi-paradigm components. As a consequence, it comes to little surprise that cognitive architectures are not used in many open and complex robotics problems. In this poster, I describe ASMO cognitive architecture that can address all of these three issues. Inspired by attention, emotion and learning in human, ASMO treats each component as an independent self-governed black box process that competes and votes for attention to get access. Emotion is used to bias the attention demanded by these components. Learning is used to modify the votes so as to improve performance. Applying ASMO to various robot platforms, including Willow Garage PR2 and Aldebaran Nao, demonstrates ASMO's capabilities to address all of the three issues identified. ASMO allows researchers to focus more on developing the components and less worrying about how they are used by or interact with other components.

Roy Someshwar, Ben Gurion University of Negev, Israel & Umea University

An Adaptive H-R Synchronization Model: Towards developing "Conscious Robots"

Human-Robot (H-R) synchronization is one of the challenges of Human-Robot Collaboration (HRC). The lack of cognitive ability in Robot makes synchronization difficult. A novel method is presented that provides a balance between synchronization and autonomy, typically observed in human behavior. The method is based on the ability of the chaotic neuronal networks to generate creative 2D and 3D patterns [Gontar V, 2007]. It is shown that these patterns contain very rich information which could be effectively used for robot decision making. Each neuron of the proposed neuronal network is simulated by difference equations with embedded chaotic regimes under appropriate parameters. This information is then fed into the biologically inspired MLP(Multi-Level Pattern) algorithm [Madison,2009] which is then translated into real-time motor commands of the robot. The resulting behavior is completely deterministic (as the solution of a non-linear dynamical system), adaptive and shows a creative emergent behavior. This is a small step towards developing "Conscious Robots".

Salomon Ramirez Contla, Plymouth University

Peripersonal space in the iCub Robot

Peripersonal space is the space immediately surrounding the body where we can reach without location displacement. This near space is distinguished from the far space (the one beyond the reach of our limbs) because in the former we perceive potential interaction. Our actions in the peripersonal space are the first contact we have with our environment. Active-vision (sensor information directly controlling movement) allows robots perform exploration. Behaviours led from it have been traditionally used on mobile robots. However, they are also useful for exploring the near space in a humanoid robot. Robot peripersonal space in has not been widely explored. Its study could allow us to create robots that interact with the world in more human-like ways. This project studies mechanisms that allow the development of an encoding of near space in nonretinal coordinate systems. It also explores strategies for early behaviours for reaching and the acquisition of them by progressively increasing the control of the arm's joints. We believe skills such as these are essential in the bottom-up emergence of cognition. Neural network models are used in our studies. In one study a controller allowed the robot to asses reachability of presented targets. The robot generalised for variable lengths of its arm when it is trained with data originated in experience phases. Another part of the work explored benefits of progressively unlocking degrees of freedom of the robot's arm in the development of a reaching behaviour. In both studies the incoming data was originated by an active-vision visual system.

Sao Mai Nguyen, Flowers Team, Inria, Bordeaux

Structured Exploration of the environment through Goal-Babbling for an Interactive Learner

The promise of robots operating in human environments on a daily basis and on the long-term points out the importance of adaptivity to the environment and the users, and of life-long learning. Two classical learning strategies are often used: imitation learning and intrinsically-motivated/curiosity-driven autonomous exploration. We propose to investigate the relationship between these two methods. Starting from the study of two concurrent methods, we ended up building an algorithmic architecture where relationships between the two strategies intertwine into a hierarchical structure, called Socially Guided Intrinsic Motivation with Active Choice of Teachers and Strategies (SGIM-ACTS).Indeed, we build an intrinsically motivated active learner which learns to achieve various outcomes by generalising from data samples which it chooses by using several learning strategies. It actively learns online which data collection strategy is most efficient for improving its competence and generalising over its experience to achieve new outcomes. The interactive learner thus learns

multiple tasks in a structured manner, discovering by itself developmental sequences.By studying SGIM-ACTS, we contribute to different fields of machine learning:
- imitation learning : we explore the questions of what, how, when and who to imitate, and propose a unified structure to address at the same time these fundamental questions of imitation learning. In particular, we investigate in interactive learning : we analyse and identify advantages of combining autonomous exploration and socially guided exploration, and build an agent which decides by itself when to interact with teachers.
- multi-task learning and goal-directed learning : Our system can discover the structure of its environment by a goal-oriented exploration. In classical approaches, goal-directed learning approaches have been studied in autonomous learning as a way to focus on different goals to guide policy exploration. In contrast, in imitation learning, efforts have focused more on goal understanding or intentionality. Here we propose a unified architecture to approach goal-oriented imitation learning and goal-directed autonomous exploration.
- active learning : we investigate different levels of active learning : the learner can decide which action to take, or which goal to aim, or which strategy to use. Its decisions are made online, driven by artificial curiosity based on its monitoring of learning progress.
- hierarchical learning : we propose a hierarchical learning architecture to learn on several levels: policy, outcome, and strategy spaces. The learner relies on hierarchical active decisions of what and how to learn driven by empirical evaluation of learning progress for each learning strategy..

Umar Shoaib, DAUIN, Politecnico di Torino (IT)

Natural Human Robotics Interaction

Communication is an essential phenomenon and integral part of our daily life. The communication systems allow us to communicate with anyone, at any time, and from anywhere in world, suggest that being without ommunication is unnatural and isolating our self. Learning is essential for an autonomous robot system. The range of unexpected situations it can handle while performing its task, depends on its ability to adapt. Recent developments have taken autonomous robots beyond industrial settings, for example at home as toys and cleaners. However, production models usually interact with their environment following a fixed control strategy, which limits their range of applications. More adaptable robots require control strategies that learn more and better from interactions with their environment in a manner that is both natural and practical for the users. In particular, robots will need to be capable of understanding natural language instructions in order to learn new tasks and receive guidance and feedback on task execution from non-technical users in a natural way. This necessity is especially evident in assistive contexts, where robots are interacting with people with disabilities, age- related (e.g., reduced mobility, limited eyesight) or otherwise (e.g., individuals post-stroke), as the users may not be able to teach the robot new tasks and/or provide feedback by demonstration. The quality of a robot's performance is critically dependent on robust, accurate, and timely perception. One potential solution to this challenge is the development of assistive robots. Working in a human environment, the robot must engage in a safe and acceptable way. It must understand user's intention clearly, continuously adapt its behavior to dynamics, prevent on-site hazards for the remote operators and user comply physical interaction with human.

Day 3: March 20

Refer to EIROB-ICDL Programme