2019 RoboCup Symposium

8 July 2019, Sydney, Australia

Contents

Local Organising Chair: Stephan Chalup

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PROGRAM OVERVIEW 2019 RoboCup Symposium, 8 July 2019, Sydney, Australia		
8:30-8:50	Registration	Use badge from RoboCup
08:50 - 09:00	Welcome and Greetings	
9:00 - 9:50	Keynote 1: A Brief History of RoboCup and a Discussion of the Future	Manuela Veloso
9:50 - 10:30	Oral Session 1	2 papers (20 mins each)
	Pedro Peña and Ubbo Visser. Adaptive Walk-Kick on a Bipedal Robot	
	Sergey Triputen, Thomas Weber, Atmaraaj Gopal, Steffen Eißele, Christian Höfert, Kristiaan Schreve and Matthias Raetsch. Efficient and Robust 3D Object Reconstruction based on Monocular SLAM with CNN Semantic Segmentation	
10:30 - 11:10	Poster Teasers – regular papers	18 posters (< 2 mins each)
11:10 - 12:00	Poster Session 1 + Coffee break (Coffee provided at venue)	all posters
12:00 - 13:00	Oral Session 2	3 papers (20 mins each)
	Márton Szemenyei and Vladimir Estivill-Castro. ROBO: Robust, Fully Neural Object Detection for Robot Soccer	
	Anna Kukleva, Asif Khan, Hafez Farazi and Sven Behnke. Utilizing Temporal Information in Deep Convolutional Network for Efficient Soccer Ball Detection and Tracking	
	Miguel Abreu, Luis Paulo Reis and Nuno Lau. Learning to run faster in a humanoid robot soccer environment through reinforcement learning	
13:00 - 14:00	Lunch (Participants organise it themselves at Darling Harbour.)	

14:00 - 14:50	Keynote 2: Creating Robots That See	Peter Corke
14:50 - 15:30	Oral Session 3	2 papers (20 mins each)
	Nick Walker, Yu-Tang Peng and Maya Cakmak. Neural Semantic Parsing with Anonymization for Command Understanding in General-Purpose Service Robots	
	Francisco Leiva, Kenzo Lobos-Tsunekawa and Javier Ruiz-Del-Solar. Collision Avoidance for Indoor Service Robots through Multimodal Deep Reinforcement Learning	
15:30 - 16:10	Poster Teasers – development track papers Poster Teasers – RCF funded projects	11 posters (< 2 mins each) 8 posters (< 2 mins each)
16:10 - 17:00	Poster Session 2 + Coffee break (Coffee provided at venue)	all posters
17:00- 17:50	Keynote 3: Robots in the Wild	Gamini Dissanayake
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	Pascal Schneider, Raphael Memmesheimer, Ivanna Kramer and Dietrich Paulus. Gesture Recognition in RGB Videos Using Human Body Keypoints and Dynamic Time Warping	
	Jacques Saraydaryan, Raphaël Leber and Jumel Fabrice. People management framework using a 2D camera for human-robot social interactions	
18:30 – 19:00	Paper awards and closing remarks	
19:00 - 20:30	Farewell (Participants organise it themselves at Darling Harbour.)	

Poster Session Part 1 (Regular papers)	
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2	Marc Bestmann, Jasper Güldenstein and Jianwei Zhang. High-Frequency Multi Bus Servo and Sensor Communication Using the Dynamixel Protocol
3	Patricio Loncomilla and Javier Ruiz-del-Solar. YoloSPoC: Recognition of Multiple Object Instances by using Yolo-based Proposals and Deep SPoC-based Descriptors
4	Heinrich Mellmann, Benjamin Schlotter and Philipp Strobel. Towards Data Driven Development in RoboCup
5	Jim Martin Catacora Ocana, Francesco Riccio, Roberto Capobianco and Daniele Nardi. Cooperative Multi-Agent Deep Reinforcement Learning in a 2 Versus 2 Free-Kick Task
6	Mohammadreza Kasaei, Nuno Lau and Artur Pereira. A Fast and Stable Omnidirectional Walking Engine for the Nao Humanoid Robot
7	Bernd Poppinga and Tim Laue. JET-Net: Real-Time Object Detection for Mobile Robots
8	Yudai Suzuki and Tomoharu Nakashima. On the Use of Simulated Future Information for Evaluating Game Situations
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2	Zeng Qingyi and Hu Tianshuai. Educational Software Framework Supporting Multiple Hardware Systems for RoboCup@Home
3	Luca Iocchi. European RoboCup@Home Education Challenge 2019
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7	Masaru Shimizu, Fatemeh Pahlevan Aghababa, Amirreza Kabiri, Josie Hughes and Arnoud Visser. Filling the Gap between RCJ Cospace and Virtual Rescue Robot competition
8	Till Hofmann, Ulrich Karras, Tim Niemueller, Mostafa Gomaa, Alain Rohr and Thomas Ulz. Workpiece Tracking and Networking Robustness for the Logistics League

KEYNOTE DETAILS

Keynote 1: Manuela M. Veloso

Title: A Brief History of RoboCup and a Discussion of the Future

Abstract: AI is one of the main topics of interest of today. RoboCup, in its essence, has always been about pursuing the most advanced research on AI and robotics. I will briefly discuss the beginnings of RoboCup and its long-lasting goals, which have been embraced by thousands of AI and robotics researchers for many years and around the world. I will then present what I see as some of the main opportunities for AI and robotics research towards a future where humans and AI can lead a fruitful coexistence. I will conclude with a discussion of some grand challenges for the future of RoboCup.

Short biography: Manuela M. Veloso heads of Artificial Intelligence (AI) Research at Jp Morgan. She is Herbert A. Simon University Professor in the School of Computer Science at Carnegie Mellon University. Currently, she is the Head of the Machine Learning Department. She researches in Artificial Intelligence, Robotics, and Machine Learning. She founded and directs the CORAL research laboratory, for the study of autonomous agents that Collaborate, Observe, Reason, Act, and Learn, www.cs.cmu.edu/~coral. Professor Veloso is ACM Fellow, IEEE Fellow, AAAS Fellow, AAAI Fellow, Einstein Chair Professor, the co-founder and past President of RoboCup, and past President of AAAI. Professor Veloso and her students' research with a variety of autonomous robots, including mobile service robots and soccer robots. See www.cs.cmu.edu/~mmv for further information, including publications.

Keynote 2: Peter Corke

Title: Creating Robots That See

Abstract: The technologies of robotics and computer vision are each over 50 years old. Once upon a time they were closely related and investigated, separately and together, in AI labs around the world, but then they went their separate ways. This talk will trace the history of robotics and vision, and define and motivate the problem of robotic vision. It will discuss recent progress at the Australian Centre for Robotic Vision in component technologies such as novel cameras, deep learning for computer vision, transfer learning for manipulation, evaluation methodologies, and also end-to-end systems for applications such as logistics, agriculture, environmental remediation and asset inspection.

Short biography: Peter Corke is a robotics researcher and educator. He is the distinguished professor of robotic vision at the Queensland University of Technology, director of the ARC Centre of Excellence for Robotic Vision and Chief Scientist of Dorabot. His research is concerned with enabling robots to see, and the application of robots to mining, agriculture and

environmental monitoring. He created widely used open-source software for teaching and research, wrote the best selling textbook "Robotics, Vision, and Control", created several MOOCs and the Robot Academy, and has won national and international recognition for teaching including 2017 Australian University Teacher of the Year. He is a fellow of the IEEE and the Australian Academy of Technology and Engineering, former editor-in-chief of the IEEE Robotics & Automation magazine, founding and associate editor of the Journal of Field Robotics, founding multi-media editor and executive editorial board member of the International Journal of Robotics Research, member of the editorial advisory board of the Springer Tracts on Advanced Robotics series, recipient of the Qantas/Rolls-Royce and Australian Engineering Excellence awards, and has held visiting positions at Oxford, University of Illinois, Carnegie-Mellon University and University of Pennsylvania. He received his undergraduate and masters degrees in electrical engineering and PhD from the University of Melbourne.
Twitter @petercorke59, @RoboticVisionAU

Keynote 3: Gamini Dissanayake

Title: Robots in the Wild

Abstract: Past few years have seen the deployment of a new generation of robotic systems in highly challenging applications areas including; road transport, mining, cargo handling, infrastructure maintenance, and urban search and rescue. "Field Robotics" is distinguished from more traditional automation by its focus on autonomous systems in applications that are characterised by unstructured, difficult and often hazardous environments. This talk will provide examples of field robot deployments together with brief descriptions of the key elements of these systems ranging from perception, control to learning.

Short biography: Gamini Dissanayake is the James N Kirby Distinguished Professor of Mechanical and Mechatronic Engineering at University of Technology, Sydney (UTS). He graduated in Mechanical/Production Engineering from the University of Peradeniya, Sri Lanka and received his M.Sc. in Machine Tool Technology and Ph.D. in Mechanical Engineering (Robotics) from the University of Birmingham, England. He taught at University of Peradeniya, National University of Singapore and University of Sydney before joining UTS in 2002. At UTS, he founded the UTS Centre for Autonomous Systems; currently a team of seventy five staff and students working in Robotics. His main contribution to robotics has been in Simultaneous Localisation and Mapping (SLAM), which resulted the most cited journal publication in robotics in the past twenty years. SLAM is the robotic equivalent of a human finding the way in a city without GPS and maps, thus underpins many robot applications ranging from household vacuum-cleaning robots to self-driving cars. He has also been involved in developing field robots for a range of industry applications.

RCS2019 ABSTRACTS

Oral Session 1

Pedro Peña and Ubbo Visser. **Adaptive Walk-Kick on a Bipedal Robot**

Abstract. Using the NAO robot as a testbed, we propose a walk-kick framework that can generate a kick trajectory with an arbitrary direction without prior input or knowledge of the parameters of the kick in the midst of walking while still guaranteeing reaching a reference trajectory. The walk-kick uses kick interpolators from a dynamic kick engine and the walk trajectories generated from adaptive walking engine to generate motions in any direction that allow a robot to reach its destination while also allowing it to move the ball in further distances without transitioning in different states to accommodate both tasks. The system has been extensively tested on the physical robot, taking into account ten different target angles. The stability and reliability of each kick has been evaluated 30 times for each kick motion trajectory while performing demanding motions. Results show that our proposed walk-kick framework and its integration is reliable in terms of the kick directions and stability of the robot overall (< 1% falling rate), and our experiments verify that the walk-kick trajectories were consistent with an average absolute bearing of < 6^{o} within any given direction.

Sergey Triputen, Thomas Weber, Atmaraaj Gopal, Steffen Eißele, Christian Höfert, Kristiaan Schreve and Matthias Raetsch. **Efficient and Robust 3D Object Reconstruction based on Monocular SLAM with CNN Semantic Segmentation**

Abstract. Various applications implement slam technology, especially in the field of robot navigation. We show the advantage of slam technology for independent 3d object reconstruction. To receive a point cloud of every object of interest void of its environment, we leverage deep learning. We utilize recent cnn deep learning research for accurate semantic segmentation of objects. In this work, we propose two fusion methods for cnn-based semantic segmentation and slam for the 3d reconstruction of objects of interest in order to obtain a more robustness and efficiency. As a major novelty, we introduce a cnn-based masking to focus slam only on feature points belonging to every single object. Noisy, complex or even non-rigid features in the background are filtered out, improving the estimation of the camera pose and the 3d point cloud of each object. Our experiments are constrained to the reconstruction of industrial objects. We present an analysis of the accuracy and performance of each method and compare the two methods describing their pros and cons.

Oral Session 2

Márton Szemenyei and Vladimir Estivill-Castro. **ROBO: Robust, Fully Neural Object Detection for Robot Soccer**

Abstract. Deep Learning has become exceptionally popular in the last few years due to its success in computer vision [1, 2, 3] and other fields of AI [4, 5, 6]. However, deep neural networks are computationally expensive, which limits their application in low power embedded systems, such as mobile robots. In this paper, an efficient neural network architecture is proposed for the problem of detecting relevant objects in robot soccer environments. The ROBO model's increase in efficiency is achieved by exploiting the peculiarities of the environment. Compared to the state-of-the-art Tiny YOLO model, the proposed network provides approximately 35 times decrease in run time, while achieving superior average precision, although at the cost of sligthly worse localization accuracy.

Anna Kukleva, Mohammad Asif Khan, Hafez Farazi and Sven Behnke. **Utilizing Temporal Information in Deep Convolutional Network for Efficient Soccer Ball Detection and Tracking**

Abstract. Soccer ball detection is identified as one of the critical challenges in the RoboCup competition. It requires an efficient vision system capable of handling the task of detection with high precision and recall and providing robust and low inference time. In this work, we present a novel convolutional neural network (CNN) approach to detect the soccer ball in an image sequence. In contrast to the existing methods where only the current frame or an image is used for the detection, we make use of the history of frames. Using history allows to efficiently track the ball in situations where the ball disappears or gets partially occluded in some of the frames. Our approach exploits spatio-temporal correlation and detects the ball based on the trajectory of its movements. We present our results with three convolutional methods, namely temporal convolutional networks (TCN), ConvLSTM, and ConvGRU. We first solve the detection task for an image using fully convolutional encoder-decoder architecture, and later, we use it as an input to our temporal models and jointly learn the detection task in sequences of images. We evaluate all our experiments on a novel dataset prepared as a part of this work. Furthermore, we present empirical results to support the effectiveness of using the history of the ball in challenging scenarios.

Miguel Abreu, Luis Paulo Reis and Nuno Lau. **Learning to run faster in a humanoid robot soccer environment through reinforcement learning**

Abstract. Reinforcement learning techniques bring a new perspective to enduring problems. Developing skills from scratch is not only appealing due to the artificial creation of knowledge. It can also replace years of work and refinement in a matter of hours. From all the developed skills in the RoboCup 3D Soccer Simulation League, running is still considerably relevant to determine the winner of any match. However, current approaches do not make full use of the robotic soccer agents' potential. To narrow this gap, we propose a way of leveraging the Proximal Policy Optimization using the information provided by the simulator for official RoboCup matches. To do this, our algorithm uses a mix of raw, computed and internally generated data. The final result is a sprinting and a stopping behavior that work in tandem to bring the agent from point a to point b in a very short time. The sprinting speed stabilizes at around 2.5m/s, which is a great improvement, over current solutions. Both the sprinting and stopping behaviors are remarkably stable.

Oral Session 3

Nick Walker, Yu-Tang Peng and Maya Cakmak. **Neural Semantic Parsing with Anonymization for Command Understanding in General-Purpose Service Robots**

Abstract. Service robots are envisioned to undertake a wide range of tasks at the request of users. Semantic parsing is one way to convert natural language commands given to these robots into executable representations. Methods for creating semantic parsers, however, rely either on large amounts of data or on engineered lexical features and parsing rules, which has limited their application in robotics. To address this challenge, we propose an approach that leverages neural semantic parsing methods in combination with contextual word embeddings to enable the training of a semantic parser with little data and without domain specific parser engineering. Key to our approach is the use of an anonymized target representation which is more easily learned by the parser. In most cases, this simplified representation can trivially be transformed into an executable format, and in others the parse can be completed through further interaction with the user. We evaluate this approach in the context of the RoboCup@Home General Purpose Service Robot task, where we have collected a corpus of paraphrased versions of commands from the standardized command generator. Our results show that neural semantic parsers can predict the logical form of unseen commands with 89% accuracy. We release our data and the details of our models to encourage further development from the RoboCup and service robotics communities.

Francisco Leiva, Kenzo Lobos-Tsunekawa and Javier Ruiz-Del-Solar. **Collision Avoidance for Indoor Service Robots through Multimodal Deep Reinforcement Learning**

Abstract. In this paper, we propose an end-to-end approach to endow indoor service robots with the ability to avoid collisions using Deep Reinforcement Learning (DRL). The proposed method allows a controller to derive continuous velocity commands for an omnidirectional mobile robot using depth images, laser measurements, and odometry based speed estimations. The controller is parameterized by a deep neural network, and trained using DDPG. To improve the limited perceptual range of most indoor robots, a method to exploit range measurements through sensor integration and feature extraction is developed. Additionally, to alleviate the reality gap problem due to training in simulations, a simple processing pipeline for depth images is proposed. As a case study we consider indoor collision avoidance using the Pepper robot. Through simulated testing we show that our approach is able to learn a proficient collision avoidance policy from scratch. Furthermore, we show empirically the generalization capabilities of the trained policy by testing it in challenging real-world environments. Videos showing the behavior of agents trained using the proposed method can be found at https://youtu.be/ypC39m4BlSk

Oral Session 4

Pascal Schneider, Raphael Memmesheimer, Ivanna Kramer and Dietrich Paulus. **Gesture Recognition in RGB Videos Using Human Body Keypoints and Dynamic Time Warping**

Abstract. Gesture recognition opens up new ways for humans to intuitively interact with machines. Especially for service robots, gestures can be a valuable addition to the means of communication to, for example, draw the robot's attention to someone or something. Extracting a gesture from video data and classifying it is a challenging task and a variety of approaches have been proposed throughout the years. This paper presents a method for gesture recognition in RGB videos using OpenPose to extract the pose of a person and Dynamic Time Warping (DTW) in conjunction with One-Nearest-Neighbor (1NN) for time-series classification. The main features of this approach are the independence of any specific hardware and high exibility, because new gestures can be added to the classifier by adding only a few examples of it. We utilize the robustness of the Deep Learning-based OpenPose framework while avoiding the data-intensive task of training a neural network ourselves. We demonstrate the classification performance of our method using a public dataset.

Jacques Saraydaryan, Raphaël Leber and Jumel Fabrice. **People management framework using a 2D camera for human-robot social interactions**

Abstract. In order to perform tasks and other socially acceptable human-robot interactions, domestic robots need the ability to collect various information about people. In this paper, we propose a framework that allows the extraction of high-level person features from a 2D camera in addition to tracking people over time. The proposed people management framework aggregates body and person features including an original pose estimation using only a 2D camera. At this time, people pose and posture, clothing colors, face recognition are combined with tracking and re-identification abilities. This framework has been successfully used by the LyonTech team in the RoboCup@Home 2018 competition with a Pepper robot from SoftBank Robotics where its utility for domestic robot applications was demonstrated.

Poster Session Part 1 (Regular papers)

Josie Hughes, Masaru Shimizu and Arnoud Visser. **A Review of Robot Rescue Simulation Platforms for Robotics Education**

Abstract. This review explores a natural learning curve which gives an appropriate RoboCup Rescue challenge at the right age. Children who got involved in the age group 14+ should continue their learning experience until they reach graduate level. To reduce the cost of such a learning experience, simulation is an attractive option in a large part of the world. The realism of the simulations and challenges should increase step-by-step, which are supported by more powerful but also more complex interfaces at each level / age-group. The result is a natural learning curve which allows for life-long learning. In this paper, we detail the requirements for such a platform and review a number of different simulation platforms and accompanying interfaces focusing on suitability for use for education rescue robotics. Resulting from this review of simulation platforms, a case-study of an example 'game field' rescue simulation platform suitable for students at different points along the learning curve.

Marc Bestmann, Jasper Güldenstein and Jianwei Zhang. **High-Frequency Multi Bus Servo and Sensor Communication Using the Dynamixel Protocol**

Abstract. High-frequency control loops are necessary to improve agility and reactiveness of robots. One of the common limiting bottlenecks is the communication with the hardware, i.e., reading of sensors values and writing of actuator commands. In this paper, we investigate the performance of devices using the widespread Robotis Dynamixel protocol via an RS-485 bus. Due to the limitations of current approaches, we present a new multi-bus solution which enables typical humanoid robots used in RoboCup to have a control loop frequency of more than 1 kHz. Additionally, we present solutions to integrate sensors into this bus with high update rates.

Patricio Loncomilla and Javier Ruiz-del-Solar. **YoloSPoC: Recognition of Multiple Object Instances by using Yolo-based Proposals and Deep SPoC-based Descriptors**

Abstract. The recognition of particular objects instances (e.g. my coffee cup or my wallet) is an important research topic in robotics, as it enables tasks like object manipulation in domestic environments in real-time. However, in recent years most efforts have been aimed to solve generic object detection and object class recognition problems. In this work, a method for performing recognition of par-ticular objects instances, named YoloSPoC, is proposed. It is based on generation of high-quality object proposals by using YOLOv3, computing descriptors of these proposals using a MAC (Maximal Activation of Convolutions) based ap-proach, recognizing the object instances using an open-set nearest neighbor clas-sifier, and filtering of overlapping recognitions. The proposed method is com-pared to state-of the-art methods based on local features (SIFT and ORB based methods) using two datasets of home-like objects. The obtained

results show that the proposed method outperforms existing methods in the reported experiments, being robust against conditions like (i) occlusions, (ii) illumination changes, (iii) cluttered backgrounds, (iv) presence of multiple objects in the scene, (v) presence of textured and non-textured objects, and (vi) object classes not available when training the proposal generator.

Heinrich Mellmann, Benjamin Schlotter and Philipp Strobel. **Towards Data Driven Development in RoboCup**

Abstract. Conducting games in RoboCup incurs high cost in terms of effort, time, and money. The scientific outcome, however, is quite limited and often not very conclusive. Especially, analyzing and drawing conclusions about the performance of complex processes like decision making of an individual robot or the behavior on the team level poses a considerable challenge. Collecting more data during the competition games will help to analyze the performance of algorithms, identify errors and areas for improvement, and make more significant statements regarding the performance of the robots. In this work we investigate the possibilities for collection of the large scale RoboCup data and its analysis. We present a system for automatic recording of synchronized videos of RoboCup games and an application for exploration and annotation of large sets of RoboCup-related data. We also present data sets collected during the competitions in 2018 and an algorithm for visual detection and tracking of robots in the RoboCup videos. A first empirical evaluation shows promising results and demonstrates how such data can be integrated and used to validate robot's behavior.

Jim Martin Catacora Ocana, Francesco Riccio, Roberto Capobianco and Daniele Nardi. **Cooperative Multi-Agent Deep Reinforcement Learning in a 2 Versus 2 Free-Kick Task**

Abstract. In multi-robot reinforcement learning the goal is to enable a team of robots to learn a coordinated behavior from direct interaction with the environment. Here, we provide a comparison of the two main approaches to tackle this challenge, namely independent learners (IL) and joint-action learners (JAL). IL is suitable for highly scalable domains, but it faces non-stationarity issues. Whereas, JAL overcomes non-stationarity and can generate highly coordinated behaviors, but it presents scalability issues due to the increased size of the search space. We implement and evaluate these methods in a new multi-robot cooperative and adversarial soccer scenario, called 2 versus 2 free-kick task, where scalability issues affecting JAL are less relevant given the small number of learners. In this work, we implement and deploy these methodologies on a team of simulated NAO humanoid robots. We describe the implementation details of our scenario and show that both approaches are able to achieve satisfying solutions. Notably, we observe joint-action learners to have a better performance than independent learners in terms of success rate and quality of the learned policies. Finally, we discuss the results and provide conclusions based on our findings.

Mohammadreza Kasaei, Nuno Lau and Artur Pereira. **A Fast and Stable Omnidirectional Walking Engine for the Nao Humanoid Robot**

Abstract. This paper proposes a framework designed to generate a closed-loop walking engine for a humanoid robot. In particular, the core of this framework is an abstract dynamics model which is composed of two masses that represent the lower and the upper body of a humanoid robot. Moreover, according to the proposed dynamics model, the low-level controller is formulated as a Linear- Quadratic-Gaussian (LQG) controller that is able to robustly track the desired trajectories. Besides, this framework is fully parametric which allows using an optimization algorithm to find the optimum parameters. To examine the performance of the proposed framework, a set of simulation using a simulated Nao robot in the RoboCup 3D simulation environment has been carried out. Simulation results show that the proposed framework is capable of providing fast and reliable omnidirectional walking. After optimizing the parameters using genetic algorithm (GA), the maximum forward walking velocity that we have achieved was 80.5cm/s.

Bernd Poppinga and Tim Laue. **JET-Net: Real-Time Object Detection for Mobile Robots**

Abstract. In most applications for autonomous robots, the detection
of objects in their environment is of significant importance. As many robots are equipped with cameras, this task is often solved by image processing techniques. However, due to limited computational resources on mobile systems, it is common to use specialized algorithms that are highly adapted to the respective scenario. Sophisticated approaches such as Deep Neural Networks, which recently demonstrated a high performance in many object detection tasks, are often difficult to apply. In this paper, we present JET-Net (Just Enough Time), a model frame for efficient object detection based on Convolutional Neural Networks. JET-Net is able to perform real-time robot detection on a NAO V5 robot in a robot football environment. Experiments show that this system is able to reliably detect other robots in various situations. Moreover, we present a technique that reuses the learned features to obtain more information about the detected objects. Since the additional information can entirely be learned from simulation data, it is called Simulation Transfer Learning.

Yudai Suzuki and Tomoharu Nakashima. **On the Use of Simulated Future Information for Evaluating Game Situations**

Abstract. A FOrward Simulation for Situation Evaluation (FOSSE) approach for evaluating game situations is proposed in this paper. FOSSE approach considers multiple future situations to quantitatively evaluate the current game situations. Since future situations are not available during an ongoing game in real time, they are generated by what is called forward simulation. Then the current game situation is evaluated using the future game situations as well as the current situation itself. First, we show the evaluation performance can be increased by using succes- sive situations in time through preliminary experiments. Especially, the effectiveness of

using future information rather than using past informa- tion is shown. Then, we present FOSSE approach where both the current and the future information of game situations are used to evaluate the current game situation. In the FOSSE approach, the future game situations are generated by forward simulation. Computational experiments are conducted to investigate the effectiveness of the proposed approach.

Takuya Fukushima, Tomoharu Nakashima and Hidehisa Akiyama. **Similarity Analysis of Action Trajectories based on Kick Distributions**

Abstract. This paper discusses the validity of similarity measures for action trajectories based on kick distributions. We focus on action trajectories for analyzing team strategies. Kick distribution is then obtained from the action trajectories, which allows us to quantitatively calculate the dissimilarity (or distance) between two team strategies. In this paper, three distance metrics are investigated as the similarity measure: Earth mover's distance, L2 distance, and Jensen-Shannon divergence. A series of numerical experiments are conducted to compare the evaluation of the similarity obtained by the distances with human subjective evaluations. The effectiveness of the distance metrics is also discussed in terms of the computational cost for calculating the distance.

Valentin Gies, Thierry Soriano, Christopher Albert and Nicolas Prouteau. **Modelling and Optimisation of a RoboCup MSL coilgun**

Abstract. This paper focuses on the modelling and optimization of a RoboCup Middle Size League (MSL) coil-gun. A mechatronic model coupling electrical, mechanical and electromagnetic models is proposed. This model is used for optimizing an indirect coil-gun used on limited size robots at the RoboCup for kicking real soccer balls. Applied to a well defined existing coil gun [6], we show that optimizing the initial position of the plunger and the length of a plunger extension leads to increase the ball speed by 30% compared to the results presented in a previous study.

Yoshiaki Mizuchi and Tetsunari Inamura. **Estimation of Subjective Evaluation of HRI Performance Based on Objective Behaviors of Human and Robots**

Abstract. The conventional approach to the evaluation of the performance of human-robot interaction (HRI) is subjective evaluation, such as the application of questionnaires. As such subjective evaluation is time- consuming, an alternative automatic evaluation method based on only objectively observable factors (i.e., human reaction behavior) is required for autonomous learning by robots and for scoring in robot competi- tions. To this end, we aim to investigate the extent to which subjective evaluation results can be approximated using objective factors. As a case study, we designed and carried out a VR-based robot-competition task in which the robot was required to generate comprehensible and unambiguous natural language expressions and gestures to guide inex- pert users in everyday environments. In the competition, both event data and human behavioral data (i.e., interaction histories) were observed and stored. Additionally,

to acquire subjective evaluation results, we asked third-parties to evaluate the HRI performance by reviewing the stored interaction histories. From the analysis of the relationship between objective factors and subjective evaluation results, we demonstrate that the subjective evaluation of HRI can indeed be reasonably approximated on the basis of objective factors.

Meisam Teimouri, Mohammad Hossein Delavaran and Mahdi Rezaei. **A Real-Time Ball Detection Approach Using Convolutional Neural Networks**

Abstract. Ball detection is one of the most important tasks in the context of soccer-playing robots. The ball is a small moving object which can be blurred and occluded in many situations. Several neural network based methods with different architectures are proposed to deal with the ball detection. However, they are either neglecting to consider the computationally low resources of hu-manoid robots or highly depend on manually-tuned heuristic methods to extract the ball candidates. In this paper, we propose a new ball detection method for low-cost humanoid robots that can detect most soccer balls with a high accuracy rate of up to 97.17%. The proposed method is divided into two steps. First, some coarse regions that may contain a full ball are extracted using an iterative method employing an efficient integral image based feature. Then they are fed to a light-weight convolutional neural network to finalize the bounding box of a ball. We have evaluated the proposed approach using a comprehensive dataset and the experimental results show the efficiency of our method.

Pavel Makarov, Tolga Yirtici, Nurullah Akkaya, Ersin Aytac, Gorkem Say, Gokhan Burge, Berk Yilmaz and Rahib Abiyev. **A Model-Free Algorithm of Moving Ball Interception by Holonomic Robot Using Geometric Approach**

Abstract. In this paper, one common problem for the teams competing in the RoboCup Small Size League (SSL) is addressed, namely the interception of a moving ball at an arbitrary aspect angle relative to the direction of the shot. We present a simple, robust and efficient algorithm for the interception of a moving ball by an omnidirectional SSL robot. The algorithm, designed on the basis of a heuristic approach, requires minimal knowledge of robot dynamics and relies on two key ideas. The first idea is the consideration of ball motion via transition to a reference frame where the ball is static, and the second one is planning the motion of the robot in such a reference frame from the geometric viewpoint. Experiments conducted in a real SSL environment confirmed the beneficial properties of the algorithm: it provides successful interception in a variety of scenarios, characterized by different directions of ball motion and the positional relationships between the ball, robot and goal.

Erick Jesus Romero Kramer, Argentina Ortega Sainz, Alex Mitrevski and Paul G. Plöger. **Tell Your Robot What To Do: Evaluation of Natural Language Models for Robot Command Processing**

Abstract. The use of natural language to indicate robot tasks is a convenient way to command robots. As a result, several models and approaches capable of understanding robot commands have been developed, which, however, complicates the choice of a suitable model for a given scenario. In this work, we present a comparative analysis and benchmarking of four natural language understanding models - Mbot, Rasa, LU4R, and ECG. We particularly evaluate the performance of the models to understand domestic service robot commands by recognizing the actions and any complementary information in them in three use cases: the RoboCup@Home General Purpose Service Robot (GPSR) category 1 contest, GPSR category 2, and hospital logistics in the context of the ROPOD project.

Alex Mitrevski, Abhishek Padalkar, Minh Nguyen and Paul G. Plöger. **"Lucy, Take the Noodle Box!": Domestic Object Manipulation Using Movement Primitives and Whole Body Motion**

Abstract. For robots acting - and failing - in everyday environments, a predictable behaviour representation is important so that it can be utilised for failure analysis, recovery, and subsequent improvement. Learning from demonstration combined with dynamic motion primitives is one commonly used technique for creating models that are easy to analyse and interpret; however, mobile manipulators complicate such models since they need the ability to synchronise arm and base motions for performing purposeful tasks. In this paper, we analyse dynamic motion primitives in the context of a mobile manipulator - a Toyota Human Support Robot (HSR)- and introduce a small extension of dynamic motion primitives that makes it possible to perform whole body motion with a mobile manipulator. We then present an extensive set of experiments in which our robot was grasping various everyday objects in a domestic environment, where a sequence of object detection, pose estimation, and manipulation was required for successfully completing the task. Our experiments demonstrate the feasibility of the proposed whole body motion framework for everyday object manipulation, but also illustrate the necessity for highly adaptive manipulation strategies that make better use of a robot's perceptual capabilities.

Maximilian Beuermann, Marie Ossenkopf and Kurt Geihs. **Positioning of Active Wheels for Optimal Ball Handling**

Abstract. The RoboCup is an international competition in robot science. In the Middle Size League (MSL), which is one of the robotic soccer leagues, dribbling a ball is an essential capability. This task needs both hardware and software consideration. The position of the active dribbling wheels determines the movement possibilities of the dribbling robot and software control can only limitedly make up for poor hardware design decisions. We present a guide that leads through the decision-making process for positioning the wheels of the ball handle mechanism. We show a variety of considerations that need to be taken into account when designing a ball handle mechanism. We weight the requirements and conclude an optimal positioning for the ball handle mechanism of the Carpe Noctem Cassel team. We also present the kinematic solution of the ball actuation for the essential movement directions.

Marcos Laureano and Flavio Tonidandel**. Analysis of the PSO Parameters for a Robots Positioning System in SSL**

Abstract. The changes in the Small Size League rules have brought greater possibilities of playing. With the increased complexity of soccer matches, the positioning of the robots has become important as a defense and attack mechanism. The learning of opposing team game playing has been shown to be effective, but an SSL soccer match indicates the need for solutions that analyze the strategy of the opposing team during the game and make any necessary adaptations. This paper proposes the use of the Particle Swarm Optimization (PSO) algorithm as an option to determine the positioning during the match. A prototype has been developed to validate the configuration parameters. Experiments in a simulator, analysis of game logs and results in a real matches have demonstrated the feasibility of applying the PSO algorithm to find the robots positions.

Benoit Renault, Jacques Saraydaryan and Olivier Simonin. **Towards S-NAMO: Socially-aware Navigation Among Movable Obstacles**

Abstract. In this paper, we present an in-depth analysis of Navigation Among Movable Obstacles (NAMO) literature, notably highlighting that social acceptability remains an unadressed problem in this robotics nav- igation domain. The objectives of a Socially-Aware NAMO are defined and a first set of algorithmic propositions is built upon existing work. We developed a simulator allowing to test our propositions of social mov- ability evaluation for obstacle selection, and social placement of objects with a semantic map layer. Preliminary pushing tests are done with a Pepper robot, the standard platform for the Robocup@home SSPL1, in the context of our participation (LyonTech Team).

Poster Session Part 2 (Development track)

Mikhail Prokopenko and Peter Wang. **Gliders2d: Source Code Base for RoboCup 2D Soccer Simulation League**

Abstract. We describe Gliders2d, a base code release for Gliders, a soccer simulation team which won the RoboCup Soccer 2D Simulation League in 2016. We trace six evolutionary steps, each of which is encapsulated in a sequential change of the released code, from v1.1 to v1.6, starting from agent2d-3.1.1 (set as the baseline v1.0). These changes improve performance by adjusting the agents' stamina management, their pressing behaviour and the action-selection mechanism, as well as their positional choice in both attack and defense, and enabling riskier passes. The resultant behaviour, which is sufficiently generic to be applicable to physical robot teams, increases the players' mobility and achieves a better control of the field. The last presented version, Gliders2d-v1.6, approaches the strength of Gliders2013, and outperforms agent2d-3.1.1 by four goals per game on average. The sequential improvements demonstrate how the methodology of human-based evolutionary computation can markedly boost the overall performance with even a small number of controlled steps.

Niklas Fiedler, Hendrik Brandt, Jan Gutsche, Florian Vahl, Jonas Hagge and Marc Bestmann. **An Open Source Vision Pipeline Approach for RoboCup Humanoid Soccer**

Abstract. We are proposing an Open Source ROS vision pipeline for the RoboCup Soccer context. It is written in Python and offers sufficient precision while running with an adequate frame rate on the hardware of kid-sized humanoid robots to allow a fluent course of the game. Fully Convolutional Neural Networks (FCNNs) are used to detect balls while conventional methods are applied to detect robots, obstacles, goalposts, the field boundary, and field markings. The system is evaluated using an integrated evaluator and debug framework. Due to the usage of standardized ROS messages, it can be easily integrated into other teams' code bases.

Alex Mitrevski and Paul G. Plöger. **Reusable Specification of State Machines for Rapid Robot Functionality Prototyping**

Abstract. When developing robot functionalities, finite state machines are commonly used due to their straightforward semantics and simple implementation. State machines are also a natural implementation choice when designing robot experiments, as they generally lead to reproducible program execution. In practice, the implementation of state machines can lead to significant code repetition and may necessitate unnecessary code interaction when reparameterisation is required. In this paper, we present a small Python library that allows state machines to be specified, configured, and dynamically created using a minimal domain-specific language. We illustrate the use of the library in three different use cases - scenario definition in the context of

the RoboCup@Home competition, experiment design in the context of the ROPOD project1, as well as specification transfer between robots.

Yudai Suzuki, Takuya Fukushima, Lea Thibout, Tomoharu Nakashima and Hidehisa Akiyama. **Game-Watching Should be More Entertaining: Real-Time Application of Field-Situation Prediction to a Soccer Monitor**

Abstract. This paper describes an extension to a soccer monitor used in the RoboCup Soccer Simulation 2D League. The aim of the exten- sion is to make the experience of watching games more entertaining. The audio effects and the visualization are focused on this purpose. The ex- tended soccer monitor simulates the supporters' excitement in watching a game by estimating the time cycle until the next goal, which is called SituationScore. This paper describes how SituationScore is obtained using a machine learning model and also describes the resulting soccer monitor.
- github : https://github.com/rinmunagi/spectator_app
- YouTube demo : https://youtu.be/J_NgcwcFtQI

Takashi Yamamoto, Yutaro Takagi, Akiyoshi Ochiai, Kunihiro Iwamoto, Yuta Itozawa, Yoshiaki Asahara, Yasukata Yokochi and Koichi Ikeda. **Human Support Robot as Research Platform of Domestic Mobile Manipulator**

Abstract. The Human Support Robot (HSR) has been used in Domes- tic Standard Platform League (DSPL) of RoboCup@Home since RoboCup Nagoya in 2017. Currently, the number of HSR users is expanding to 44 sites in 12 countries worldwide (as of 30th March, 2019). In this paper, we explain the design concept of HSR, and examples of recent activi- ties of the developers community. We hope that it would contribute to RoboCup and researchers.

Marcus M. Scheunemann and Sander G. van Dijk. **ROS 2 for RoboCup**

Abstract. There has always been much motivation for sharing code and solutions among teams in the RoboCup community. Yet the transfer of code between teams was usually complicated due to a huge variety of used frameworks and their differences in processing sensory information. The RoboCup@Home league has tackled this by transitioning to ROS as a common framework. In contrast, other leagues, such as those using humanoid robots, are reluctant to use ROS, as in those leagues real-time processing and low-computational complexity is crucial. However, ROS 2 now offers built-in support for real-time processing and promises to be suitable for embedded systems and multi-robot systems. It also offers the possibility to compose a set of nodes needed to run a robot into a single process. This, as we will show, reduces communication overhead and allows to have one single binary, which is pertinent to competitions such as the 3D-Simulation League. Although ROS 2 has not yet been announced to be production ready, we started the process to develop ROS 2 packages for using it with humanoid robots (real and simulated). This

paper presents the developed modules, our contributions to ROS 2 core and RoboCup related packages, and most importantly it provides benchmarks that indicate that ROS 2 is a promising candidate for a common framework used among leagues.

Felix Thielke and Arne Hasselbring. **A JIT Compiler for Neural Network Inference**

Abstract. This paper describes a C++ library that compiles neural network models at runtime into machine code that performs inference. This approach in general promises to achieve the best performance possible since it is able to integrate statically known properties of the network directly into the code. In our experiments on the NAO V6 platform, it outperforms existing implementations significantly on small networks, while being inferior on large networks. The library was already part of the B-Human code release 2018 [12], but has been extended since and is now available as a standalone version that can be integrated into any C++14 code base [18].

Nizar Massouh, Lorenzo Brigato and Luca Iocchi. **RoboCup@Home-Objects: Benchmarking Object Recognition for Home Robots**

Abstract. This paper presents a benchmark for object recognition in- spired by RoboCup@Home competition and thus focusing on home robots. The benchmark includes a large-scale training set of 196 K images labelled with classes derived from RoboCup@Home rulebooks, two medium-scale test sets (one taken with a Pepper robot) with different objects and different backgrounds with respect to the training set, a robot behavior for image acquisition, and several analysis of the results that are useful both for RoboCup@Home Technical Committee to define competition tests and for RoboCup@Home teams to implement effective object recognition components.

Valerio Di Giambattista, Mulham Fawakherji, Vincenzo Suriani, Domenico Bloisi and Daniele Nardi. **On Field Gesture-based Robot-to-robot Communication with NAO Soccer Players**

Abstract. Gesture-based communication is commonly used by soccer players during matches to exchange information with teammates. Among the possible forms of gesture-based interaction, hand signals are the most used. In this paper, we present a deep learning method for recognizing robot-to-robot hand signals exchanged during a soccer game. A neural network for estimating human body, face, hands, and foot position has been adapted for the application in the robot soccer scenario. Quantitative experiments carried out on NAO V6 robots demonstrate the effectiveness of the proposed approach. Source code and data used in this work are made publicly available for the community.

Amir Gholami, Milad Moradi and Majid Majidi. **A Simulation Platform Design and Kinematics Analysis of MRL-HSL Humanoid Robot**

Abstract. This paper introduces MRL-HSL multibody simulation for the hu-manoid robot based on Matlab/ Simulink and Simscape software, which can be used for designing control systems, enhancing the stability of the robot and etc. purpose. MRL-HSL real-time simulation is a virtual humanoid robot which is the safe way of educational and research purpose without damaging to the robot in the real environment and reducing the cost of implementation. The structure of the robot includes a rigid multibody of the robot, actuators, sensors and it can be developed simply for other types of robots. For the gaiting purpose and other movement control designing aims, the forward kinematics is solved by Denavit Hartenberg (D-H) method and the analytical solution is used for solving the inverse kinematics. The kinematics chain consists of the head, Legs and arms of the humanoid robot. The cad models of each part of the virtual humanoid robot designed by SolidWorks software.

Brandon Zahn, Jake Fountain, Trent Houliston, Alexander Biddulph, Stephan Chalup and Alexandre Mendes. **Optimization of Robot Movements using Genetic Algorithms and Simulation**

Abstract. This work describes the optimization of two robot move- ments in the context of the Humanoid league competition at RoboCup. A multi-objective genetic algorithm (MOGA) was used in conjunction with the real-time physics simulator Gazebo. The motivation for this work was that the NUbots team, from the University of Newcastle, lacked a simulation platform for their soccer-playing robots. Gazebo was the pre- ferred choice of simulator, offering built-in compatibility with the Robot Operating System (ROS). The NUbots robot software, however, uses a proprietary message-passing framework in place of ROS. This work thus describes the pathway to use Gazebo with non-ROS compliant applications. In addition, it describes how MOGA can be used to optimize complex movements in an effcient manner. The two robot movements optimized were a kick script and the walk engine. For the kick script, the resulting optimal configuration improved the kick distance by a factor of six, with 50% less torso sway. For the walk engine, the forward speed increased by 50%, with 38% less torso sway, compared to the manually-tuned walk engine.