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Content

1. Executive summary

This deliverable provides a report on training activities for students and others in ACAT as well as about the industrial linking activities performed by the project. Training activities mostly consist of workshops, master and doctoral student training in the framework of the ACAT project, as well as training activities involving wider circles of students, pupils and the general public. The most important industrial linking activities are exhibitions of the project at the IROS conference, Hamburg, 2015 and at the Hannover Fair, 2016 (currently in preparation). However, multiple other presentations to various circles of business have been performed too.

2. Introduction

The ACAT project is based on an idea for very advanced development: translating instructions written for humans into robot executable code with a potential of much reducing the effort required to program robots. As in general robots are very far from human capabilities when cognitive aspects are concerned (especially in the regimes where commonsense knowledge is required) we have started our project with a

new research idea at very low TRLs[1]. The project was a successful attempt into the direction of making more cognitive robots able to execute new instructions in limited domains. However, rightfully so, we could not reach the general system level where immediate commercial interest starts emerging. Thus, our dissemination attracted lots of interest in the research field, as well as through training and education activities, however actual industrial linking was possible to the level where companies are interested in doing further research with us. Some components of our system, specifically gripper optimization, attracted immediate commercial interest.

Further we will describe our attempts and achievements in training activities and industrial linking in more details.

3. Training activities

Organization of symposiums and workshops

Göttingen Symposium on the Semantics of Action: Robotics meets Linguistics. We have started out training activities in the first year of the project by a symposium bringing together robotics researches and linguists. The two day event took place on 10-11.06.2013 at partner UGOE. We had 11 speakers, 5 from ACAT consortium (Dr. E. Aksoy, UGOE, Prof. M. Beetz (UoB), Prof. J. Bateman (UoB, linguistics), Prof. N. Krueger (SDU) and Dr. D. Vitkute-Adzgauskiene (VDU) and 6 invited speakers Prof. Ph. Cimiano (University of Bielefeld, Germany), Dr. Sinan Kalkan (Middle East Technical University, Ankara, Turkey), Prof. T. Kiss (Ruhr University, Bochum, Germany), Prof. S. Müller (FU Berlin, Germany), Prof. M. Pinkal (Saarland University, Germany), Prof. S. Wermter (University of Hamburg, Germany). The audience were researchers and students from the ACAT consortium, students from UGOE as well as researchers from other institutions. The symposium was a success and people expressed interest for further such events. For more information see report on WP6 in PPR1.

Göttingen Workshop on the ”Robotics in the 21st Century”. As the follow up of the above symposium we are currently organizing a high-level workshop on Robotics in the 21st century: Challenges and Promises, International Workshop, 25.9. – 28.9. 2016, Hotel am Rothenberg, Volpriehausen (near Göttingen), Germany. For this we were able to obtain 96,500€ from the Volkwagen Foundation. By now we have received 37 positive responses from speakers and we are attaching a summary and the planned program to this deliverable. In this workshop the ideas of the semantics of action will be one of the central topics and several speakers from ACAT partner institutions will be giving talks (M. Beetz, A.Ude, N. Krüger, F. Wörgötter). The Scope and Program of the workshop are provided in the Appendices A1 and A2.

1st International workshop on Intelligent Robot Assistants: from household chores to industrial applications. The workshop was organized by the partner AAU and took place at the 13th International Conference on Intelligent Autonomous Systems (IAS), Padova, Italy, 15-19 July, 2014. Six novel papers and two extended abstracts were presented during the full-day workshop. During the workshop, the ACAT

[1] "*Technology readiness levels (TRL)* ". European Commission, G. Technology readiness levels (TRL), HORIZON 2020 – WORK PROGRAMME 2014-2015 General Annexes, Extract from Part 19 - Commission Decision C(2014) 4995.

project work was presented and discussed. Official website of the workshop: (http://iras2014.aau.dk/). More information can be found in report on WP6, PPR2.

Human-robot Collaboration in Standardization and R&D Activities. This workshop was taking place at the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS14) in Chicago, USA. Dimitris Chrysostomou (AAU) chaired the session about safety & benchmarking where key researchers of the area presented their latest work. Official website of the workshop: http://www.clawar.org/WorkshopHRC/index.html#tent. More information can be found in report on WP6, PPR2.

AAU Workshop on Robotics. The members of the Robotics & Automation Group have actively participated in the organization and general activities of the AAU Workshop on Robotics throughout the duration of the ACAT project. In the 4th instance of the workshop, Dimitris Chrysostomou presented the latest activities on ACAT project with a talk entitled: "Translation of human instructions to robot programs for industrial assembly tasks".

ROS Danish MeetUp. Members of the Group of Robotics & Automation from the Department of Mechanical & Manufacturing Engineering (AAU) initiated and participated with several talks in the first ROS Danish Meetup. Research activities related with Little Helper 4 and ACAT were presented and discussed with fellow researchers from other universities and technical institutes of Denmark and a number of technical innovations of low-level integration activities were mentioned.

Student training

The ACAT project served as the training environment for doctoral and master students. Numbers of doctoral and master students involved in the ACAT project for different partners are given in the table below.

Partner	No. doct. students	No. master & bachelor students
UGOE	4	1
SDU	3	-
AAU	2	3
VDU	2	2
JSI	3	-
UoB	3	4

However, training activities have reached far beyond the students who were directly involved in the ACAT work. Especially extensive training was happening at the partner AAU. Since the beginning of the project and during the past 3 years, numerous students from various educations and departments of Aalborg University have been introduced to the Little Helper robotic platform and the ACAT context from the members of the Group of Robotics & Automation.

As a reference, during the academic period 2015-2016 only, we had nearly 200 students instruct the Little Helper robotic platform for educational activities. More specifically:

- From the Dept. of Mechanical & Manufacturing Engineering we had:

    - 80 students from the BSc. of Robotics
    - 40 students from the BSc. of Machine and Production
    - 15 students from the MSc. of Manufacturing Technology
- From the Dept. of Architecture, Design & Media Technology
    - 15 students from the MSc. In Informatics with specialization in Vision, Graphics and Interactive Systems
    - 40 students from the MSc. of Industrial Design
- From the Dept. of Electronic Systems
    - 10 students from the MSc. of Control & Automation
- Elementary school interns
    - The ACAT platform was introduced to two elementary school interns working for two weeks for their robotics project.

The main robotic platform in AAU, called Little Helper 4, had originally proposed and constructed from the students Morten Palmelund-Jensen, Rune Etzerodt and Casper Abildgaard Pedersen in their semester project entitled "Creation of an Autonomous Industrial Mobile Manipulator" and it came into fruition as a Master thesis entitled "Motion Planning in a Skill-Based System" defended in Spring 2014.

The Ph.D. students from the Group of Robotics & Automation, Casper Schou and Rasmus S. Andersen, have been partly employed in the ACAT project throughout the duration of the project. They mainly developed new skills for teaching and execution of ADTs along with further development of HRI interfaces for the skill-based system of Little Helper 4.

Two master students from VDU, Mindaugas Matulis and Mindaugas Maceika, have prepared their master thesis on textual instruction parsing and robotic knowledge storage in ontologies. Furthermore, they have made presentations of their work in the 20-th Joint Lithuanian Universities Conference for Master and Doctoral Students "Information Technologies 2015", April 24, 2015, Kaunas, Lithuania. Topics: Mindaugas Matulis, "Searching for Semantic Meanings Using Knowledge Bases for Robotic Instruction Formation"; Mindaugas Maceika, "Transformation of Textual Instructions to Commands Using Language Technologies and Knowledge Bases". This way, students participating in the ACAT project were spreading information on the ACAT project to a big group of other Lithuanian students in the field of IT.

Events for broader audience (university students from different study fields, high school students as well as general public)

Participation in the Ocean Sampling Day. The Ocean Sampling Day (OSD) is a simultaneous sampling campaign of the world's oceans which took place (for the first time) on the summer solstice (June 21st) in the year 2014. UoB took part in Ocean sampling Day to showcase the results with respect to the CHEMLAB scenario. The event was open to the public and was live-streamed to the WWW via Youtube (Full Video: https://www.youtube.com/watch?v=hIOgxttR3II). Local high school classes and a team from the "Radio Bremen" TV broadcasting station attended the OSD and the overall event had and educational character. For more information see report on WP6 in PPR2.

Presentation in Cafe Scientifique. ACAT project was presented in Cafe Scientifique @ Coffee Inn, Kaunas, Lithuania at Dec 17, 2015 by Prof. Tomas Krilavičius. State of the art in human language comprehension and

translation to robotic instructions was discussed with diverse audience, from pupils to neuroscientists. Presentation attracted a high interest from the audience, including context of the project, i.e. robotic ethics and risks of wider robots deployment, technological advances, both in language technologies and robotics. For more details, see https://www.facebook.com/events/102445400129481/

Newspapers and radio. The head of the research group Professor Ole Madsen has presented and discussed the ACAT context and the future of human-robot interaction and collaboration in several occasions in Danish newspapers, and radio. A brief list is given below:

- Ingeniøren[2]
- Jyllands Posten
- Maskinmesteren[3]

Promotional video for Robotics education in AAU. A promotional video commercial for the robotics education in AAU will include Little Helper 4 and the ACAT human-robot interfaces as an example of innovative and attractive education. It will be broadcasted in national level, inside buses across country.

4. Industrial linking

Industrial linking in ACAT was organized along several lines. First, we were participating in exhibitions and fairs to find new interested partners (new contacts) as well as spread information about the ideas and achieved results of the ACAT project to a wide audience. Second, we managed to establish an actual cooperation with business partner SCHUNK, however not on the entire ACAT system, but on the sub-component allowing optimize grippers for a new task. Third, we had numerous individual talks using already existing business contacts about the ideas of the overall ACAT project, to search for the touch points for further cooperation. Next we give more details about each activity.

Participation in exhibitions and fairs

Exhibition at the IROS conference, Hamburg, Germany, September 28 - October 2, 2015. The ACAT project was presented at the exhibition at the IROS conference, Hamburg, Germany, September 28 - October 2, 2015 (pictures from the stand see in Fig. 1). Symbolic instruction compiler and vision & force based control in the IASSES scenario were the key topics of the exhibition. The interest was relatively high (see movie on the ACAT webpage http://www.acat-project.eu/uploads/download/news/iros2015.mp4). As the exhibition was in a research conference, most visitors were researchers interested in ACAT work. Several companies have been visiting too. Visitors acknowledged the idea of the ACAT project as well as the approach of merging language analytics with robotics as very interesting and worth considering further.

[2] http://mo.infomedia.dk/ShowArticle.aspx?Duid=e532370e&UrlID=6b1166c7-0e52-4fb3-bb32-3c88e33110fe&Link=
[3] http://mo.infomedia.dk/ShowArticle.aspx?Duid=e534ab30&UrlID=6b1166c7-0e52-4fb3-bb32-3c88e33110fe&Link=

Fig. 1. ACAT stand at the exhibition of the IROS conference

Exhibition at the Hannover fair, Hannover Germany, 25-29 April, 2016. Currently, the ACAT project is in preparation to demonstrate the IASSES system at the Hannover fair in the combined stand of Lowers Saxony (Germany). The ACAT stand has been planned as including Little Helper robot and two laptop stands for demonstration of the ACAT Textual Compiler and the OpenEASE system performing robotic data quesries. Leaflet for the Hannover Fair as well as poster have been prepared in cooperation with the organizers of the Lower Saxony stand. The leaflet and the roller prepared for the Hannover Fair are given in appendixes A3 and A4. Participation in the Hannover Fair will allow to find business institutions interested in cooperation in further development of the ACAT project ideas.

DIRA Roadshow, 2015. The RTD work in ACAT was showcased at DIRA (Danish Industrial Robot Association) roadshow, to show how future human-robot interaction and collaboration with advanced robot systems can be achieved by non-robot experts and shop floor workers. A major focus in DIRA was on simple automation solutions that can be implemented without requiring massive investment, increasing productivity and being profitable right down to small batch production.

MEDER 2015. The ACAT platform, Little Helper 4, was presented to the participants of the 3rd IFToMM Symposium on Mechanism Design for Robotics which have been held between 02 June, 2015 and 04 June, 2015 in the premises of Aalborg University.

Danish defence land and mobile systems. The family of Little Helper robots was presented during the activities of the exhibition for the Danish defence land and mobile systems. The exhibition included all 3 Little Helper robots available in the Group of Robotics & Automation of AAU, along with the ACAT platform. The exhibition gathered 64 participants from the defence domain and they were informed about the activities of the ACAT project. Besides, they had the opportunity to instruct the ACAT platform and share their feedback with the members of the research group.

RoboBusiness Europe. SDU has presented the ACAT project at the RoboBusiness Europe (http://www.robobusiness.eu/rb/robobusiness-europe-2014/)

Co-operation between Schunk and SDU on gripper learning

In ACAT, we developed an algorithm to address the important problem of how objects are grasped. This is knowledge that is usually not a part of any instruction sheet, since the human usually solves this problem online by finding a grasp pose and a grasp type (e.g., pinch grasp or poser grasp) once he or she has seen the actual task and the objects involved making use of the dexterity of the human hand. However, in an industrial context such as the IASSES scenario, the application of dexterous grasps is rather uncommon. This is due to the fact that first, dexterous grippers are not yet robust enough to be applied in industrial contexts and second, that the control of such hands is very complex. The most common gripper types by far are therefore two or three finger grippers, often with specialized fingers that allow for optimal alignment (see figure 2). When applying vision, pose uncertainties are introduced and this alignment capability is in particular important to compensate for these uncertainties. The development of such specialized fingers is very time-consuming and as such, an important factor of the time required to set-up of a robot assembly solution.

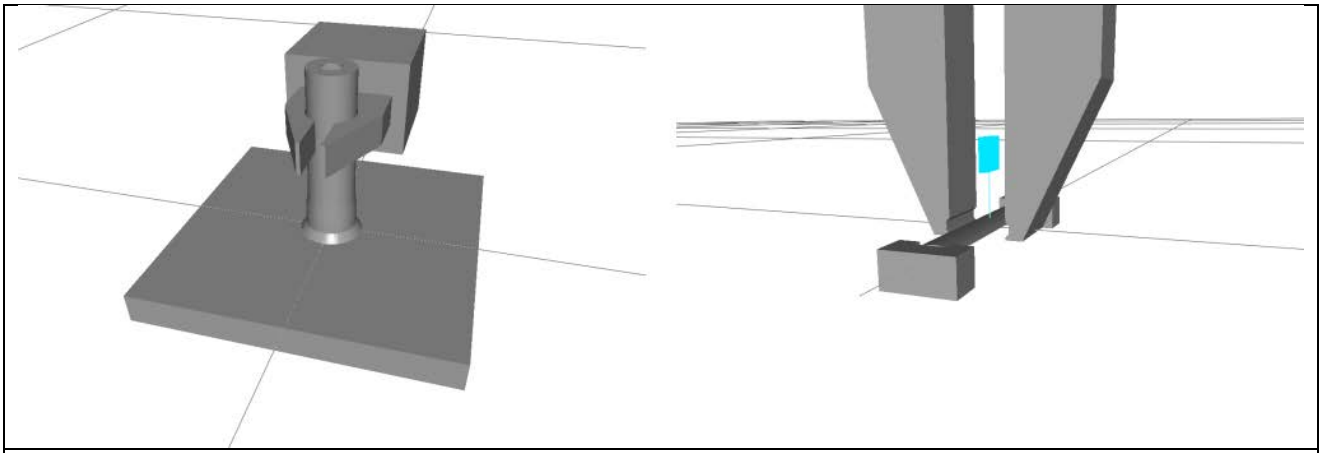


Fig. 2. Gripper quipped with fingers designed for cylindrical object grasping (on the left) and gripper with fingers for countering uncertainties in precise object manipulation (on the right).

In that context in ACAT, we developed an algorithm to compute such fingers in simulation through optimization in simulation [1, 2, 3] The company Schunk got interested in implementing our approach to augment a web-site tool they offer to their customers (see [4] and figure 3). In that context, Ralf Becker, who leads the predevelopment at Schunk, visited SDU on 7/1/2016. In that meeting we discussed ways to integrate our optimization and simulation technology with their web-site tool. For that, we are aiming at funding schemes focusing on bringing prototypes to the market, in particular the "Fast Track to Innovation" scheme.

Proposal of a follow-up project submitted to the FoF call

In an attempt to continue developing ACAT ideas towards commercialization by means of follow-up projects, the three partners most involved with Action Data Table (ADT) representation and generalization in cooperation with Danish Technological Institute (DTI, coordinator) and a strong computer simulation partner Aachen University have submitted a project proposal called Open Assembly, which seeks faster robot programing through ADT adaptation and re-use facilitated by a powerful user interface and advanced simulation system. The project has three companies as partners contributing the business use-cases. This project targets TRLs which raise direct commercial interest and reaches into development of the Open Assembly community, similar to the open platform and/or open content CAD communities. The proposal was submitted to the FOF-11-2016 call.

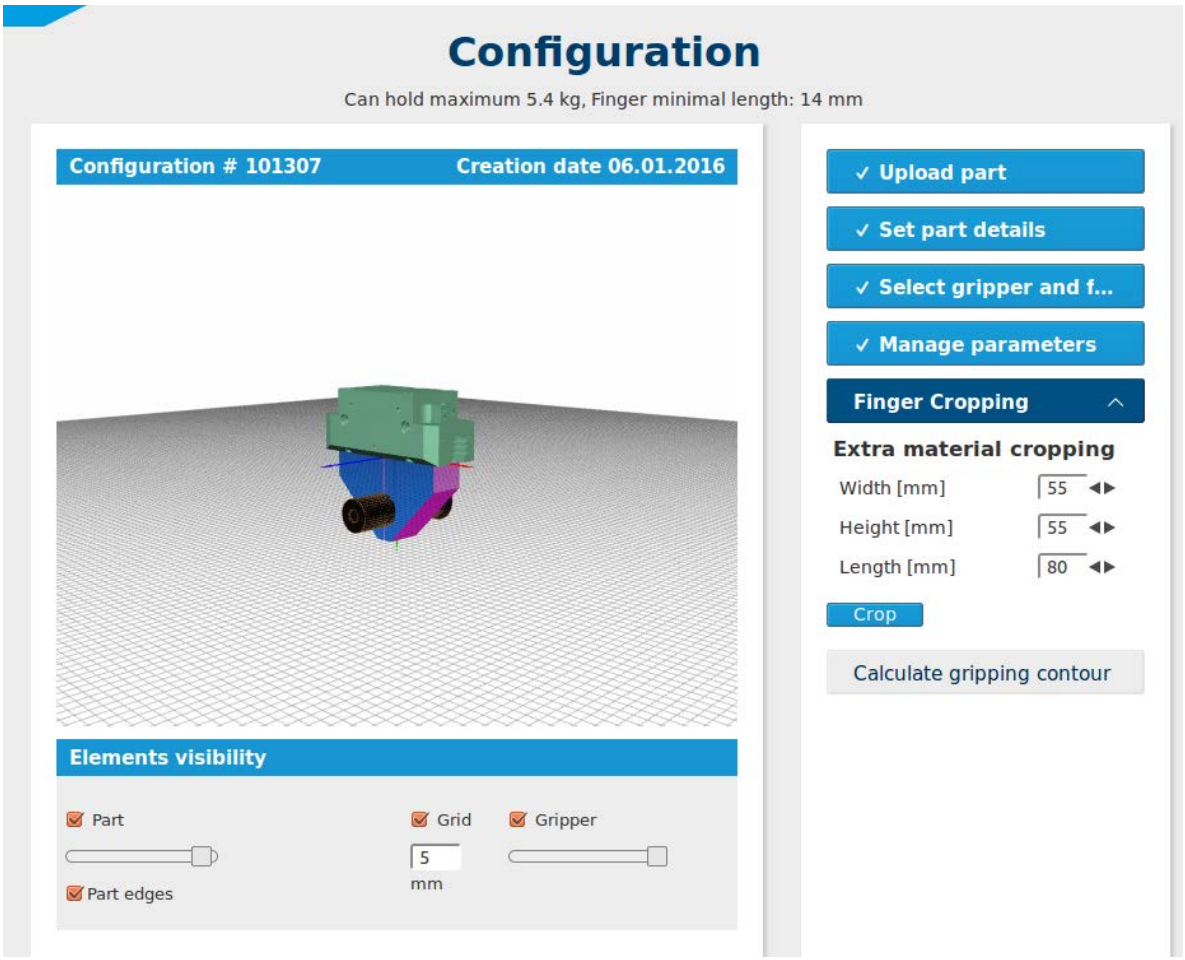


Fig. 3. Schunk eGrip - an online tool for designing gripper fingers.

Business contacts of individual partners

Individual partners were working in presenting ACAT to known business contacts. Further we describe those individual initiatives.

MADE consortium. Partners SDU and AAU have been discussing the ACAT approach with members of the MADE (Manufacturing Academy of Denmark) consortium, the Danish initiative for promoting innovative manufacturing and production in national level.

Smart Production and Wireless Factory projects. The ACAT robotic platform and its intuitive human-robot interfaces have been used as a base for discussion by partner AAU for further development in the "Smart Production" and "The Wireless Factory" projects. Both projects are focused on the research and development of Industry 4.0 manufacturing platforms. They will incorporate the latest technological advancements in smart robotic systems, safe collaborative robot manipulators, Internet of Things and wireless internet breakthroughs.

Grundfos. Grundfos A/S is a global leader in advanced pump solutions and a trendsetter in water technology. One of the main experiments in the ACAT project originates from the actual pump production

of Grundfos. Throughout the duration of the ACAT project, Grundfos provided an actual instruction sheet used to produce one of their pumps along with components of the pump itself. The Group of Robotics & Automation in AAU has presented the ACAT activities to Grundfos employees in numerous occasions and it is planned that a number of them will participate in the future HRI tests of the ACAT system.

Universal Robots (UR). Since LH4 is using the UR5 as a main robotic manipulator in the ACAT context, several discussions have been taken place between employees and technicians of the largest robotics company in Denmark and the members of the Groups of Robotics & Automation from AAU. The main focus was the low-level technical improvements in the robot controller as well as contributions of high-level plugins for future editions of the human-robot interface of the robot manipulator.

Danish Meat Research Institute (DMRI). The ACAT system and its capabilities to translate human instructions to robot commands were the main theme of the discussions that took place between the Group of Robotics & Automation (AAU) and DMRI. DMRI is the international leading research and innovation centre within food of animal origin and they are highly interested in the potential of using robots to remotely execute complicated tasks where humans are not allowed due to hygiene restrictions.

Discussion with industrial visitors at AAU. The ACAT system and its innovations have been presented to visitors from industry multiple times duoring the last year of the ACAT project. The list of visitors includes key players in their respective industrial domains such as:

- Danfoss (another leading Danish pump manufacturer)[4],
- GPV (a leader in production of EMS solutions)[5],
- Arla (a world leader in production of dairy products)[6],
- Bila (a leading company in advanced system integration)[7],
- Eltronic (a leader in developing intelligent production plants)[8].

Rubedo Systems (Lithuania). ACAT project was presented to Rubedo Systems, UAB, a well established company working in medical physics and robotics area. Possibilities to use results of ACAT in industrial setting were discussed. Rubedo expressed opinion that some results are still to theoretical, but some ideas and components are of interest, hence further meetings and discussions were planned. (Rubedo Systems, UAB, Kaunas, Lithuania, November 18, 2015).

TokenMill (Lithuania). ACAT project was discussed with the semantic and language technologies company TokenMill, UAB (Vilnius, Lithuania, November 27, 2015). The TokenMill team was quite impressed with such a novel application of language technologies. TokenMill proposed some good ideas of improving performance of certain LT components, and industrial level requirements for setup, while they expressed an interest in some techniques used in extracting data, representing it in knowledge base and inferencing actions from it. It was decided to arrange at least one more meeting to discuss transferability of some techniques and ideas to other application areas, as well as improving information extraction in ACAT using machine learning techniques.

[4] http://www.danfoss.com/home/
[5] http://www.gpv-group.com/What-we-do-211.aspx
[6] http://www.arla.com/
[7] http://www.bila.dk/
[8] http://www.eltronic.dk/

The follow-up meeting was taking place on January 3, 2016. Possibilities to use results of ACAT, directions how to improve them as well as to apply text analytics in different industrial settings, were discussed. TokenMill was interested in the ideas, especially extension of text analytics to industrial setting, hence further meetings and discussions were planned.

5. Conclusions and continuation of work after the end of the project

The ACAT project had numerous education and industrial linking activities.

Education activities included organizing workshops and symposia, education of students through work in the ACAT project as well as education of a broader audience. The specialized symposium organized by the coordinator UGOE in the beginning of the project was great success and encouraged organization of the even higher level event in cooperation of HeKKSaGON network of German and Japan universities, which will take place as continuation of the ACAT work after the end of the project with additional substantial financing from Volkwagen Foundation.

Industrial linking was organized through participation in exhibitions and fairs, among those exhibition at the high level robotic conference IROS, Hamburg, Germany, 2015 as well as the world-known Hannover Fair, Hannover, Germany, 2016 as well as individual contacts from different partners. The industrial linking has led to writing a proposal to the Horizon 2020 FoF call for continuation of research together with business partners. The proposal draws up a plan to develop the ACAT system up to the higher Technology Readiness Levels where direct commercial interest emerges. Separate components of the ACAT system have raised commercial interest already, where for example a cooperation between SDU and commercial partner Schunk has been established.

6. References

[1] A. Wolniakowski, K. Miatliuk, N. Kr̈uger, and J. A. Rytz, “Automatic evaluation of task-focused parallel jaw gripper design”, International Conference on Simulation, Modeling, and Programming for Autonomous Robots, 2014.

[2] A. Wolniakowski, J. A. Jorgensen, K. Miatliuk, H. G. Petersen, and N. Krüger, “Task and context sensitive optimization of gripper design using dynamic grasp simulation”, 20th International Conference on Methods and Models in Automation and Robotics, 2015.

[3] A. Wolniakowski, K. Miatliuk, Z. Gosiewski, J. A. Jørgensen, L. Bodenhagen, H. G. Petersen, N. Krüger, “Task and Context Sensitive Gripper Design Learning Using Dynamic Grasp Simulation”, Journal of Intelligent and Robotic Systems, 2016.

[4] Schunk GmbH, Schunk eGrip [online]. Available: http://www.schunk-produkte.com/en/tools/3d-designtool-egrip.html

7. Appendices

Appendix A1:

Robotics in the 21st century: Challenges and Promises

International Workshop

25.9. – 28.9. 2016

Hotel am Rothenberg, Volpriehausen (near Göttingen), Germany

Organized by ACAT and HeKKSaGON[1] (see *) with extended Program Committee (alphabetically):

	Y. Aloimonois (Maryland)
	*M. Asada, Osaka Univ.
Co-chair	*T. Asfour, KIT
	*E. Badreddin, Univ. Heidelberg
	A. Billard, EPFL
	O. Khatib, Standford
	*K. Kosuge, Tohoku Univ., Sendai
	J.P. Laumound, LAAS
	*F. Matsuno, Kyoto Univ.
Co-chair	*K. Mombaur, Univ. Heidelberg
	C. Torras, CSIC
Chair	*F. Wörgötter, Univ. Göttingen

Background: Robotics is a continuously growing field where basic research makes advances across a wide variety of subfields and where industrial demands massively drive the publicly most visible developments. This, however, has created a somewhat slanted view of this field and academic research, thus, currently feels a certain degree of pressure to re-specify the scientific field called "Robotics" without leaving industrial partners out, but also without too strongly leaning towards commercial requirements. In particular there is also a strong need to better account for the heavily interdisciplinary character of this field and to find measures for better integration of the different contributing scientific areas.

Goal: The *International Workshop "Robotics in the 21st century: Challenges and Promises"* intends to discuss this set of problems: **How to re-specify robotics and how to define the currently most relevant core research and development questions?** The central question currently is: How can robotics in the 21st century better contribute to the advancement of basic research and at the same time maintain a leading role also for future industrial developments.

The specific goals of this WS are:

1) To provide a topical overview across the current advances in robotics in several workshop sessions (see tentative program) with specific focus on integrative and interdisciplinary aspects.
2) To discuss measures and ways forward for better outreach and interactions with adjacent technical as well as other (biological, cognitive, etc.) fields. And linked to this specially also:
3) To critically discuss the role of academic robotic research and to define the currently existing challenges for this field in view of the ever increasing competition by globally active companies. We phrase this by the following pointedly formulated questions:
    a. Will – through this competition – academic robotic research become marginalized?
    b. How can academic robotic research remain distinct and "not just follow" industrial demands?
    c. In view of (too) short funding cycles: How can academic robotic research follow long-term goals and provide truly novel insights of lasting benefit to the field and with impact onto society?
    d. How can those ethical issues be successfully addressed that gradually begin to arise by advanced robotics applications?

[1] The HeKKSaGOn network consists oft he universities of Heidelberg, Kyoto, Karlsruhe, Sendai (Tohoku), Göttingen and Osaka.

Scientific Program: The program consists of seven thematically organized sessions (see below). One poster session and several discussions of the above introduced questions 3,a-d chaired by a board (panel-style discussions).

1. **Session: Modern AI and Robotic-AI**
   Massive and successful approaches have recently emerged in artificial intelligence (AI), for example data structuring, data/information mining (some current catch words are: "big data", "deep learning", etc.), planning, decision making, reasoning, etc. Most if not all of these approaches have focused on non-behaving systems addressing high level text and image information with the goal to structure the data and extract human-useful information. Robots need entirely different types of information though. Some examples are low-level aspects ("schemata") for optimal manipulation or strategies for basic interaction with humans. This information is usually not present in text-related sources and Modern-AI cannot directly aid robotics. Several (mostly) European projects (like RoboEarth, RoboHow, Poeticon++, ACAT, Xperience, etc.) exist that try to bridge the gap between Modern-AI and Robotic-AI and it has been acknowledged that naïve transfer of data and methods between these sub-fields is not possible. This session will discuss communalities and differences between these fields, trying to arrive at better conclusions of how to bring this together.
2. **Session: Robot Cognition and Semantics**
   There is still a massive difference between the very limited cognitive properties of robots and those of humans (even those of some animals). This problem is widely acknowledged and several streams have emerged during the last decades (for example – prominently – "embodied cognition") or concepts of Object-Action Complexes and Structural Bootstrapping that have discussed this problem. Strong attempts have been made to better understand human problem solving not just as such but in conjunction with the development of algorithms that would allow robots to better "understand" their world. This session will, thus, address these issues and discuss the shortcomings of current cognitive robotics-approaches.
3. **Session: Learning and Autonomy**
   This topic has been chosen much in view of the (possible) conflict of current advanced developments in academic research and the still very few existing applications in industry of autonomous systems in robotics and automation. Clearly more and more statements have emerged during the last years where main industrial robotic developers or appliers have uttered the desire for more autonomy. Alas, there is a very wide gap between quite impressive autonomous robotic systems that have emerged from academic research and the very limited transfer of this to industry. As a consequence this session builds on this gap and wishes to suggest ways forward to bridge it.
4. **Session: Engineering Robotics Systems**
   This session puts an emphasis on aspects of "classical" robotics approaches. Traditional engineering, mechatronics, sensing&actuation and other aspects have led and are still leading to the most impressive robotic- and automation systems in academia and industry (Asimo/Honda, ARMAR/KIT, Justin/DLR, NAO/Aldebaran, iCub/IIT, Atlas/BostenDynamic, HRP2/KAWADA, DB-CB/ATR) and very strong groups are operating here internationally. It seems therefore desirable in the context of this WS to provide an overview across the situation in this sub-field and to discuss it in conjunction with other "non-classic" fields for example those presented in Sessions 1-3.
5. **Session: Robotics link to neurobiology, other biological sciences and psychology**
   Arguably these are the fields outside core-robotics to which the strongest interdisciplinary links exist. In spite of this, robotics remains often "shy" in adopting ideas from these fields. Clearly many times transfer to robotics of results from any biological substrate requires much algorithmic re-thinking and often massive alterations – an effort many of us do not wish to engage in. Still, it seems this is only part of the problem. Different cultures exist in the biological/psychological domains as compared to robotics leading to difficulties in cross-linking these fields. As a consequence currently there are a few bio/neuro-robotic systems existing none of which, however, has made into the domain of truly

complex (e.g. humanoid) robots. A striking example is that there are no robotic manipulations systems existing as yet that operate “with neurons”. Humans do! Hence it should be possible even in an industrial context to achieve this with robots for example to arrive at more general assembly systems. The human brain project (HBP, https://www.humanbrainproject.eu) attempts neural robotic control by a large scale effort. This session shall provide an overview across these fields and discuss not only the HBP efforts but also possibly other strategies to achieve more powerful biologically-modeled robot systems.

6. **Session: Motion and behavior generation for complex robots**

   Humans and animals move gracefully, fast, with high compliance, accuracy, and efficiency while being very robust with respect to perturbations. With a few impressive exceptions, it is – alas – still fair to say that these attributes do not yet apply to robotic motion. Take walking as an example. Explicit control (ZMP-control) works but renders often inflexible systems, which require very high computing power to calculate the fine points of the joints’ trajectories and result in much more conservative motions than can be observed in biological systems. Animals rely on implicit control mechanisms – often reflex based – which give them moment-to-moment flexibility on top of which motion planning takes place by ways of higher brain centers. Some robotic systems, which to some degree perform nicely, are trying the same, starting at purely passive walkers and extending this by some control mechanisms. However, these systems most often suffer from a lack of higher level (cognitive) motion planning, which according to our current knowledge would have best to be based on explicit control methods. So far, there is no unified perspective on these different – biological versus conventional – control concepts, and no successful attempts yet to bring them together. The different perspectives on motion control and generation should be the center of the discussion for this topic.

7. **Session: Societal impact and robotic ethics**

   Particularly academic robotic research envisions that robots may in the not-too-far future become highly capable and autonomous. Thus, society will then be confronted with artificial agents that might be very similar to humans. Too often has this scenario been put on display by the media and many a time in a flashy and unguided way. Thus, there are two central aspects that underlie this topic: (a) the need for and the definition of a shared human-robot ethics and (b) the urgent requirement to interact with the public and educate an understanding of the advantages and possible dangers of (autonomous) robots, the latter being possibly more important at this point of time. This session will, thus, address these issues for providing longer term perspectives of robots in our society.

List of currently confirmed speakers (alphabetically):

1. Alin Albu-Schäffer, TU München, Informatik, Sensorbasierte Robotersysteme & intelligente Assistenzsysteme, München, Germany
2. Yiannis Aloimonos, University of Maryland, Department of Computer Science and Computer Vision Laboratory, Maryland, MD, USA
3. Shinya Aoi, Kyoto University, Department of Aeronautics and Astronautics, Kyoto, Japan
4. Minoru Asada, Osaka University, Institute for Academic Initiatives, Osaka, Japan
5. Tamim Asfour, Karlsruhe Institute of Technology (KIT), Institute for Anthropomatics, Karlsruhe, Germany
6. Essam Badreddin, Universität Heidelberg, ZITI - Department for Computer Engineering, Mannheim, Germany
7. Michael Beetz, University Bremen, Institute for Artificial Intelligence, Bremen, Germany
8. Aude Billard, LASA Laboratory, Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland
9. Rainer Bischoff, KUKA Laboratories GmbH, Research & Predevelopment, Augsburg, Germany
10. Oliver Brock, Technische Universität Berlin, Fakultät IV, Robotics and Biology Laboratory, Berlin, Germany
11. Joanna J. Bryson, University of Bath, Department of Computer Science,Bath, United Kingdom
12. Wolfram Burgard, Albert-Ludwigs-Universität Freiburg, Department of Computer Science, Freiburg, Germany
13. Gordon Cheng, TU München, Institute for Cognitive Systems (ICS), München, Germany
14. Rüdiger Dillmann, Karlsruher Institut für Technologie, Institut Anthropomatik, Humanoids & Intelligence Systems, Karlsruhe, Germany
15. Rod Grupen, University of Massachusetts, Computer Science Department, Amherst, Massachusetts, USA
16. Auke Ijspeert, EPFL STI IBI BIOROB, Department of Computer Science, Lausanne, Switzerland
17. Markus Klaiber, Fa. Schunk, Lauffen, Germany
18. Kazuhiro Kosuge, Tohoku University, Department of Bioengineering and Robotics, Sendai, Japan
19. Norbert Krüger, South Danish University, The Maersk Institute, Odense, Denmark
20. Dana Kulic, University of Waterloo, Faculty of Engineering, Ontario, Canada
21. Yasuo Kuniyoshi, University of Tokyo, Department of Mechano-Informatics, Tokyo, Japan
22. Jean Paul Laumound, LAAS-CNRS, Toulouse, France
23. Fumitoshi Matsuno, Kyoto University, Department of Mechanical Engineering and Science, Kyoto, Japan
24. Katja Mombaur, Ruprecht-Karls-University Heidelberg, Interdisciplinary Center for Scientific Computing, Heidelberg, Germany
25. Yukie Nagai, Osaka University, Department of Adaptive Machine Systems, Osaka, Japan
26. Angelika Peer, University of the West of England, Department: FET - Engineering, Design and Mathematics, Bristol, United Kingdom
27. Jan Peters, Intelligent Autonomous Systems, Computer Science Department, Technische Universität Darmstadt, Germany
28. Bruno Siciliano, Università degli studi di Napoli, Department of Electrical Engineering and Information, Napoli, Italy
29. Roland Siegwart, ETH Zürich, Inst. f. Robotik u. Intell. Syst., Zürich, Switzerland
30. Satoshi Tadokoro, Tohoku University, Human-Robot Informatics, Tohoku, Japan
31. Minija Tamosiunaite, Georg-August-Universität Göttingen, Neural Control and Robotics, Computer Vision, Kaunas, Lithuania
32. Carme Torras, University of Barcelona, Mathematics and Computer Science, Barcelona, Spain
33. Marc Toussaint, Universität Stuttgart, Computer Science Department, Stuttgart, Germany
34. Ales Ude, JSI Jozef Stefan, Department of Brain Robot Interface, Ljubljana, Slovenia
35. David Vernon, University of Genoa, Cognitive Systems, Genoa, Italy
36. Florentin Wörgötter, Georg-August-Universität Göttingen, Department of Computational Neuroscience, Göttingen, Germany
37. Tom Ziemke, University of Skövde, Dept. of Computer and Information Science, Skövde, Sweden

Appendix A2:

Program:

Robotics in the 21st century: Challenges and Promises

International Workshop

25.9. – 28.9. 2016

Hotel am Rothenberg, Volpriehausen (near Göttingen), Germany

Saturday 24. 09. 2016
Arrival and Registration

Sunday 25. 09. 2016	
Time	
08:30-09:00	Registration and Welcome Coffee
09:00-09:10	Welcome by the organizers and general information
Session 1:	**Modern AI and Robotics-AI**
09:10-10:40	Invited Talks
10:40-11:00	Coffee Break
Session 1:	**Modern AI and Robotics-AI**
11:00-12:30	Invited Talks
12:30-13:30	Lunch
Session 2:	**Robot Cognition and Semantics**
13:30-15:30	Invited Talks
15:30-16:00	Coffee Break
Session 2 & 3:	**Robot Cognition and Semantics & Engineering Robotics Systems**
16:00-18:30	Invited Talks
18:30	Reception
19:30	Dinner

Monday 26. 09. 2016	
Time	
Session 3:	**Engineering Robotics Systems**
08:30-10:30	Invited Talks
10:30-11:00	Coffee Break
Session 4:	**Learning and Autonomy**
11:00-12:30	Invited Talks
12:30-13:30	Lunch
Session 4:	**Learning and Autonomy**
13:30-15:30	Invited Talks
15:30-16:00	Coffee Break
Session:	**Selected Talks and Poster Spotlights**
16:00-17:00	4 selected talks from participants
17:00-18:00++	30 poster spotlights, 2 min each (for best 30 posters)
18:30-20:00	Dinner
20:00-22:00	**Posters and Wine**

Tuesday, 27. 09. 2016	
Time	
Session 5:	**Robotics link to Neuro/Bio/Psycho**
08:30-10:30	Invited Talks
10:30-11:00	Coffee Break
Session 5:	**Robotics link to Neuro/Bio/Psycho**
11:00-12:00	Invited Talks
12:00-13:30	Plenary discussion 1
13:30-15:00	Lunch
15:00-22:00	Excursion and Dinner

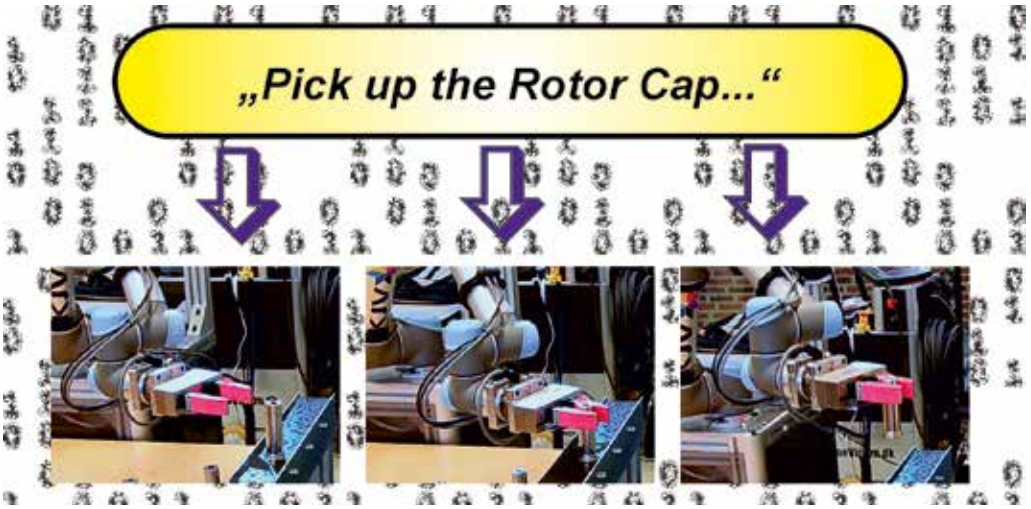
Wednesday 28. 09. 2016	
Time	
Session 6:	**Motion and Behavior Generation**
08:30-10:30	Invited Talks
10:30-11:00	Coffee Break
Session 6:	**Motion and Behavior Generation**
11:00-12:30	Invited Talks
12:30-13:30	Lunch
Session 7:	**Robotic Ethics and Philosophy**
13:30-15:30	Invited Talks
15:30-16:00	Coffee Break
Session 7:	**Robotic Ethics and Philosophy**
16:00-17:00	Invited Talks
17:00-18:30	Plenary discussion 2 and concluding remarks
18:30	Farewell Dinner

Thursday, 29. 09. 2016
Departure

Appendix A3:

Roboterprogrammierung durch Instruktion

Instruction-Based Robot Programming



Automatische Übersetzung von Anweisungen in Roboterprogramme
Automatic translation of human instructions into robot code

Automatisierung erfordert normalerweise langwierige und teure Programmierung von Anlagen und Robotern. Speziell kleine Produktserien werden deswegen oft noch rein manuell gefertigt. Wie wäre es jedoch, wenn es einem Roboter gelänge Anweisungen, die eigentlich für menschliche Arbeiter gemacht worden sind, zu lesen und daraus direkt ein funktionsfähiges Roboterprogramm zu generieren? Das hier vorgestellte System, entwickelt im Rahmen des europäischen Forschungsprojektes ACAT (EU-FP7„Action Categories“), koordiniert durch die Georg-August-Universität Göttingen, hat dieses Ziel verfolgt. Es wird hier eine Anlage vorgestellt, die für Menschen gemachte Anweisungen in Roboterprogramme „übersetzt“ und durchführt. Ein Benutzer kann eine Anweisung, wie z.B. „pick up the rotor cap and put it on its holder“, eintippen und die Anlage erzeugt daraus ein ausführbares Roboterprogramm. Durch Verkettung mehrerer Anweisungen können so komplexe Prozesse erzeugt werden.
Diese neuartige Art der Roboterprogrammierung sollte es auch kleineren Firmen ermöglichen Automatisierungsanlagen anzuschaffen und ohne Expertenwissen zu betreiben.

Kooperationspartner:

Universität Bremen

Institut "Jožef Stefan" Ljubljana, Slovenija

VYTAUTAS MAGNUS UNIVERSITY

Conventional automation requires time-consuming and costly programming of robots. Small companies, therefore, still use manual assembly, instead. The European ACAT project (“Action Categories”), coordinated by the Georg-August-University Göttingen, has addressed this problem and designed a system that allows programming a robot using instructions made for human workers. If you tell the system to „pick up the rotor cap and put it on its holder“, it will compile a robot-executable program from this instruction.
This new way of programming robots should also allow smaller companies to invest in automation and to program their machines without expert knowledge.

III. Physikalisches Institut
Biophysik

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http://www.acat-project.eu

Appendix A4:

GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN

Roboterprogrammierung durch Instruktion

Instruction-Based Robot Programming

Automatisierung erfordert teure Programmierung. Das ACAT System vereinfacht dies, indem es Anweisungen für Arbeiter liest und daraus ein Roboterprogramm erstellt. Diese neuartige Art der Roboterprogrammierung kann es auch kleineren Firmen erlauben Automatisierungsanlagen anzuschaffen und ohne Expertenwissen zu betreiben.

Conventional automation requires costly programming of robots. The ACAT system makes this easier. It translates instructions made for workers into a robot-executable program. This new way of programming robots allows smaller companies to invest in automation and to program their machines without expert knowledge.

III. Physikalisches Institut