Augmented Cellular Meat Production

Rehm, Matthias; Philipsen, Mark Philip; Andersen, Rasmus Skovgaard; Madsen, Ole; Moeslund, Thomas B.

Published in:
6th Aalborg U Robotics Workshop

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

6th Aalborg U Robotics Workshop 2017

Tabel of Contents

6th Aalborg U Robotics workshop
November 27 2017
NOVI, Niels Jernes Vej 10, 9220 Aalborg, Auditorium

09.00	-	09.10	Welcome
09.10	-	10.10	Invited Talk • **Case studies in dynamic manipulation: Robotics and control perspectives** *by Prof. Anton Shiriaev, Department of Engineering Cybernetics, NTNU*
10.10	-	10.30	Coffee
10.30	-	12.00	Technical Session 1 • **Introduction to the EXOTIC project** *Lotte N. S. Andreasen Struijk, Anne Marie Kanstrup, Shaoping Bai, Thomas Bak and Thomas Moeslund* • **Tongue Control of Assistive Robotic Arms** *Lotte N. S. Andreasen Struijk, Rasmus Kobborg, Christian Andersen, Andreas Norman, Max Hildebrand, Rikke Gade and Frederik Bonde* • **Plasticity and Functional Differences Following a BCI-Controlled Robotic Intervention in Spinal Cord Injury** *Kasper Kunz Leerskov, Erika Spaich, Mads Jochumsen and Lotte N. S. Struijk Andreasen* • **Design of a tendon network for a dexterous assistive glove** *Mohamed M. Hamdy, Lotte N.S. Andreasen Struijk, Strahinja Dosen, Erika G. Spaich* • **Semi-autonomous control of artificial limbs** *Strahinja Dosen* • **Exo-Aider: a lightweight upper limb exoskeleton for wheelchair-users** *Dinh-Son Vu and Shaoping Bai*
12.00	-	12.30	Lunch
12.30	-	14.15	Technical session 2 • **Remapping of residual voluntary forearm movements using Bio-Robotics** *Muhammad Ahsan Gull and Shaoping Bai* • **Build your own robot (BYOR)** *Matthias Rehm* • **Recognition and Prediction of Human Actions for Safe Human-Robot Collaboration** *Iker Ceballos, Rasmus S. Andersen and Simon Bøgh* • **A Skill-based Cobot for Industrial Maintenance Tasks** *Paul J. Koch, Marike K. van Amstel, Patrycja Dębska,, David Cerny, Moritz A. Thormann, Adrian J. Tetzlaff , Simon Bøgh and Dimitrios Chrysostomou* • **Augmented Cellular Meat Production** *Matthias Rehm, Mark P. Philipsen, Rasmus S. Andersen, Ole Madsen and Thomas B. Moeslund*

			• **Adaptive and self-learning slaughter robots** *Mark P. Philipsen, Rasmus S. Andersen, Ole Madsen and Thomas B. Moeslund* • **Creative Robotics in Architecture – adaptive concrete extrusion** *Mads Brath Jensen, Isak Worre Foged and Hans Jørgen Andersen*
14.15	-	14.30	Coffee
14.30	-	15.45	Technical session 3 • **Development of Robotic Ice Cutting tool** *Kelvin Koldsø Nygaard and Søren Lauridsen* • **Autonomous Industrial Mobile Manipulator in Smart Production** *Rasmus Eckholdt Andersen, Emil Blixt Hansen, David Cerny, Steffen Madsen, Biranavan Pulendralingam, Simon Bøgh, Dimitrios Chrysostomou, Rasmus Skovgaard Andersen and Rikke Gade* • **Communication flexibility – Robot integration** *Aleksandr Batuev, Andreea Ciontos, Emil Nordsted Sivertsen, Matei Sarivan, Øyvind Holtskog* • **WallMoBot: Wall Mounting Co-Worker Robot** *Rasmus Pedersen, Christoffer Sloth and Thomas Bak* • **Autonomous bathymetry mapping with AAUSHIP.02** *Anders Egelund Kjeldal and Jesper A. Larsen*
15.45	-		Networking • **Snacks and drinks**

Case studies in dynamic manipulation: robotics and control perspectives

Keynote Speaker:
Prof. Anton Shiriaev, Department of Engineering Cybernetics, NTNU

Abstract:
Humans can amazingly well manipulate objects without firm grasp. After a couple of hours of training, an ordinary person could perform basic tricks in rolling spheres on palms of his or her hands, as it would be done by a contact juggler. These observations indicate feasibility of motion planning and motion control assignments and relative simplicity for a human to learn such agile behaviors despite of diversity of human hands and known imperfections and deficiencies of their motor control systems. These cognitive experiments provoke roboticists to develop benchmark set-ups to mimic or to extend human capabilities. The talk provides a comprehensive discussion on one of such conceptual designs and on the computational challenges associated with planning and controlling rolling motions of objects on a palm of a robotic hand. Here, we explore the so-called "Butterfly robot" example, originally proposed by Drs. Lynch and Mason in 1998 to test different strategies for dynamic manipulations. The robot has two identical plates with smooth boundaries, fixed on a constant distance from each other, so that a ball can freely roll on them. The plates are in the vertical plane and can be rotated by an electrical motor to form stable rolling motions of the ball. The curvature of the plates' boundary changes its sign mimicking a human hand. Along with a comprehensive discussion of the problem, we will provide insights into analytical and computational methods that allowed solving the long-standing task and performing validating experiments. The talk will be concluded by a discussion on related open problems as well as perspectives provided by the development for advancing robotic systems in industrial and service robotic manipulation assignments.

Introduction to the EXOTIC project

Authors:
Lotte N. S. Andreasen Struijk, Anne Marie Kanstrup, Shaoping Bai, Thomas Bak and Thomas Moeslund

Abstract:
Population ageing is challenging the number of available caregivers for individuals with functional disabilities. Exoskeleton (Exo) technology has a great potential to both rehabilitate and empower disabled citizens and to protect caregivers from injuries. However, the technology is facing a paradox: The larger disability, the larger the potential of using an Exo, and yet the harder it is to control it. Additionally, if the technology is not acceptable for the user it will not be used. Acceptance requires an aesthetic system that is applicable in daily life. Therefore, we will initiate a project in 2018 concerning a user-based, tongue-controlled arm/hand Exo as a platform for a full-body AAU bio-exoskeleton: the EXOTIC. We will give a brief introduction to the EXOTIC project, in which it is essential to unite user centred-design, bio-interfacing, artificial intelligence, control and mechanics into the bio-controlled Exo.

Tongue Control of Assistive Robotic Arms

Authors:
Lotte N. S. Andreasen Struijk, Rasmus Kobborg, Christian Andersen, Andreas Norman, Max Hildebrand, Rikke Gade and Frederik Bonde

Abstract:
The current lack of hand-free interfaces to Assistive Robotic Arms (ARM) compromises their use for those most in need: severely paralyzed users. At the same time, it has been shown that the need of assistance can be reduced with up to 41% by use of an ARM. This may have significant prospects for the current yearly societal cost of 1.8 billion kr related to caregivers for severely paralyzed individuals in Denmark alone. Therefore, we have researched in alternative robotic control methods based on tongue interfacing. We will present three different novel control methods: Direct actuator control, Cartesian endpoint control and semiautonomous control of an ARM based on tongue interfacing. The latter is a result of a 4th semester project performed by students from the Bachelor in robotics at AAU.

Plasticity and Functional Differences Following a BCI-Controlled Robotic Intervention in Spinal Cord Injury

Authors:
Kasper Kunz Leerskov, Erika Spaich, Mads Jochumsen and Lotte N. S. Struijk Andreasen

Abstract:
Background: Recent development in the rehabilitation of spinal cord injury (SCI), include the use of powered exoskeletons, which has been shown to be on par with conventional therapy. It is suggested that rehabilitation of SCI patients, can be further facilitated by combining a brain-computer interface (BCI) with the exoskeleton.

Hypothesis: Using a BCI for exoskeleton control, plastic and functional recovery is improved compared to regular exoskeleton training.

Methods: Over the course of a PhD study, a BCI for step-intention detection in able-bodied and SCI patients, will be developed and integrated into the control of an exoskeleton. In a crossover study, subjects will receive exoskeleton training with and without BCI-control. Using measures for changes in the brain and spinal cord, together with functional measures related to gait, the difference in outcomes when using the BCI for exoskeleton control will be analyzed.

Potential significance: In the event of positive results in favor of utilizing the BCI for controlling the exoskeleton, an indication has been given, that BCI technology could be used in rehabilitation with positive effects on recovery.

Design of a tendon network for a dexterous assistive glove

Authors:
Mohamed M. Hamdy, Lotte N.S. Andreasen Struijk, Strahinja Dosen, Erika G. Spaich

Abstract:
Background: An assistive glove could improve the quality of life of patients who suffer from hand impairment. Such a glove must assist performing meaningful tasks and different types of grasping by means of a small and lightweight device. The types of grasps, which are most required by patients are power grasp, pinch grasp, and tripod grasp, which will be the focus of this study.

Purpose: In this study, the authors investigate the ability of the glove to perform the aforementioned grasps using a continuous tendon configuration on the palmar side of the hand and springs over the dorsal side of the hand.

Methods: The springs are responsible for producing the different hand postures (grasps). The tendon on the palmar side is designed to perform a stable grasping even if the object shape is irregular. Finally, a “Stepped differential mechanism” is applied to the fingers to overcome hyperextension and abnormal finger movements while grasping.

Expected results: The proposed tendon configuration is expected to provide the ability to perform stable grasps using different postures (grasp types). The tendon network will be used as a component in the design of a complete glove that will assist patients in daily-life manipulation tasks.

Semi-autonomous control of artificial limbs

Authors:
Strahinja Dosen

Abstract:
Introduction: Modern artificial limbs (exoskeletons, prostheses) are advanced mechatronics systems with many available functions. For example, there are hand prostheses that have individually controllable fingers. However, due to limitations in the human machine interfacing, the users cannot exploit this advanced functionality. In the conventional approach to control, the user is responsible for generating command signals for all the degrees of freedom (DOFs).

Methods: We propose a radically different approach to control. The idea is to equip the artificial limb with additional sensors and cognitive like processing, so that the artificial controller can perceive and react to the environment. The automatic operation is fused with the manual control of the user, resulting in a semi-autonomous system (smart limb).

Results: The experiments in able-bodied subjects and an amputee have demonstrated that the semi-autonomous control has outperformed the classic approach when controlling multiple DOF hand prosthesis. It has also decreased the unwanted compensatory actions, resulting in a more natural use of the limb.

Conclusions: The proposed approach will lead to a new generation of smart limbs that will improve the control of advanced systems, thereby increasing the quality of life of disabled people, and decreasing the rejection rates of these devices.

Exo-Aider: a lightweight upper limb exoskeleton for wheelchair-users

Authors:
Dinh-Son Vu and Shaoping Bai

Abstract:
Exoskeletons are a type of mechanisms beneficial for the rehabilitation, the assistance or the enhancement of human physical abilities. Unfortunately, aging and life hazards cause a decline in physical aptitudes, thus the use of the adequate exoskeleton may alleviate these complications.

In particular, wheelchair-bounded users would benefit of the use of an exoskeleton. Indeed, manipulating objects in the seated-position is challenging since the range of motion of the hand is limited to the mobility and strength of the upper body. Moreover, long periods of the seated-position cause discomfort in the posterior muscle chain. An adjustment of the position of the body would alleviate this inconvenience. In both cases, the assistance of an upper limb exoskeleton would support the user's muscle activities.

The proposed solution – Exo-Aider – is a lightweight exoskeleton focusing on the assistance of the elbow, biceps, and triceps. The particularity of the presented mechanism is its compactness-to-power ratio compared to existing exoskeletons. Indeed, managing the bodyweight requires high torque output from the actuator, which is often synonym of a large mechanical footprint. Two prototypes are under development, one using worm drive system, the other using harmonic drive to deal with the high torque requirement while remaining compact.

Remapping of residual voluntary forearm movements using Bio-Robotics.

Authors:
Muhammad Ahsan Gull and Shaoping Bai

Abstract:
Bio Robotics are the hallmark of modern neural engineering that promise to enhance the mobility and manipulability of patients who are unable to perform motor task. However, decoding of neuro-muscular signatures into certain sets of instructions, for optimal control of a prosthetic device, have proved to be the biggest challenge in this area.
The recent research focuses on the development and control of upper limb prosthetic device, which can be controlled by fusion of EEG-EMG based control interface. Commercially available dry electrodes have been deployed to record EEG and EMG signals for forearm volunteer movement. Both signatures are separately processed and combined as a parallel controller input. After the pre-processing of data, a unique spatial-temporal based feature extraction technique have been used and the obtained feature vector is then fed to the classifier. Three different classifiers (includes Quadratic SVM, Quadratic Discriminant Analysis and MLP) have been evaluated for voluntary forearm motion recognition. After the classification, the control interface get the command from the classifier and actuate the prosthetic device via Neural Network based adaptive controller. This will allow the system to handle the time invariancy, non-linearity, latency and instability issues in an external environment. Additionally, the design requirements replicate the speed and natural movement of human arm.

Build your own robot (BYOR)

Author:
Matthias Rehm

Build your own robot for independent living is an exploratory project with the overall goal of developing a concept of social robots as do-it-yourself aid that can be broadly used by different groups of people with cognitive and physical impairments. Based on empirical data from Senhjerneskadecenter Nord, a residential home for people suffering from severe impairments due to acquired brain injury, the project focuses on developing robots for daily cognitive guiding and reminding tasks. The vision for the project is to create a toolbox for developing individualized solutions that match the need of each specific citizen. By creating the possibility for experimenting with the task of building real and functional robots, we aim at increasing citizens' independence and quality of life, while at the same time strengthening social competences and supporting the feeling of being in control over one's own life. The project thus has two layers: (i) Co-creation of individualized social robots, and (ii) evaluation of the robots in use. I will report on the first layer, which is funded by Helsefonde and Spar Nord Fonden.

Recognition and Prediction of Human Actions for Safe Human-Robot Collaboration

Authors:
Iker Ceballos, Rasmus S. Andersen and Simon Bøgh

Abstract:
Collaborative industrial robots are creating new opportunities for collaboration between humans and robots in shared workspaces. In order for such collaboration to be efficient, robots - as well as humans - need to have an understanding of the other's intentions and current ongoing action. In this work, we propose a method for learning, classifying, and predicting actions taken by a human. Our proposed method is based on the human skeleton model from a Kinect. For demonstration of our approach we chose a typical pick-and-place scenario. Therefore, only arms and upper body are considered; in total 15 joints. Based on trajectories on these joints, different classes of motion are separated using partitioning around medoids (PAM). Subsequently, SVM is used to train the classes to form a library of human motions. The approach allows run-time detection of when a new motion has been initiated, early prediction of the motion class based on the first fraction of the movement, and classification of the motion when it has neded. Additionally, the approach makes it possible to expand the library of human motions in run-time by detection of previously unknown motion types.

A Skill-based Cobot for Industrial Maintenance Tasks

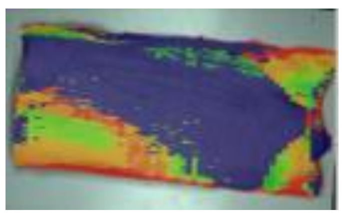
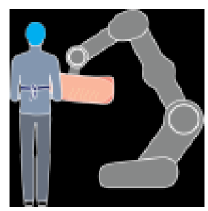
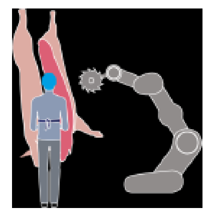
Authors:
Paul J. Koch, Marike K. van Amstel, Patrycja Dębska,, David Cerny, Moritz A. Thormann, Adrian J. Tetzlaff , Simon Bøgh and Dimitrios Chrysostomou

Abstract:
In this work, we demonstrate the concept of a sensor based robot co-worker working in flexible industrial environments alongside human operators. A realisation of a robot co-worker scenario is developed in order to demonstrate the implementation of a robot co-worker from the starting point of an autonomous industrial mobile manipulator. The cobot is applied on the industrially relevant task of screwing by the use of a skill-based approach. The goal was to utilise an existing robotic platform, Little Helper 3, equipped with collaborative manipulator KUKA LWR IV+ to solve a task of turning screws on a mould randomly placed in the workspace of the manipulator, while ensuring safety of the human operator by vision based safety zones. Moreover, function flexibility is provided by implementation of a tool exchanger, and user-friendliness of human-robot interaction is secured by development of GUI for robot control. The prototype robot co-worker demonstrated successfully technologies such as vision-based screw detection, motion planning of the manipulator in constrained spaces, safe humanrobot interaction according to dynamic safety zones, quick tool exchange according to the task and intuitive human-robot interfaces.

Augmented Cellular Meat Production

Authors:
Matthias Rehm, Mark P. Philipsen, Rasmus S. Andersen, Ole Madsen and Thomas B. Moeslund

Abstract:
The project is focused on a collaborative robot cell concept as an alternative to the serial production line that is currently used in major slaughterhouses. With a robot cell, where a robot and an operator share tasks and workload, we get the strength of the robot and the flexibility of the operator. This will help reduce the repetitive stress injuries that plague workers in the industry and it will ease the transition to fully automated robots that can perform the entire process by themselves. The project requires innovation in the way humans and robots collaborate and the development of robots that can adapt to the high variation in both products and the interaction with humans. The project contains three labor-intensive cases.

Case 1 Case 2 Case 3

The first case, *sensing assistance*, will visualize information about the product to the operator. The second, *robot assistant*, will present the product optimally to the operator. The third case, *co-worker robot*, will allow an operator and a robot to perform different tasks simultaneously inside a shared workspace.

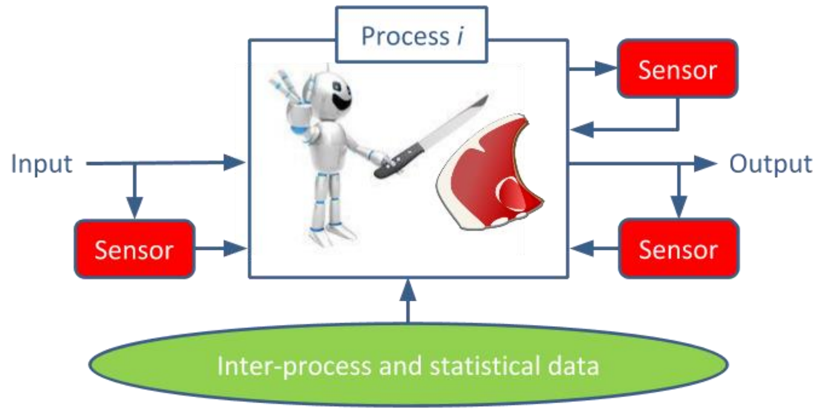
This is a 32 mill. Kr. IFD project lead by DMRI. The project starts ultimo 2017 and runs for four years.

Adaptive and self-learning slaughter robots

Authors:
Mark P. Philipsen, Rasmus S. Andersen, Ole Madsen and Thomas B. Moeslund

Abstract:
The project is concerned with research in adaptive learning algorithms. The algorithms will enable robots to react to variations in input, perform ongoing corrections during operations and make adjustments to subsequent operations based on evaluation of the output. The Figure shows how a process is adapted based on measurements of the product before, during and after processing. The novelty lies primarily in adapting based on measurements made during and after the process.

In processes such as the slaughtering of animals and processing of meat, the carcasses and cuts vary in size and composition. The traditional control systems for automatic processes in slaughterhouses rely on strict standardization of these products. When this cannot be guaranteed, automation is either abandoned or large margins of error are introduced, resulting in high cost and suboptimal utilization of the resources. Moreover, customers require that the end-product is customized according to their individual preferences, something traditional automated systems have difficulties handling. With large variations in both input and output, an adaptive robot platform is preferable to more dedicated production machinery.



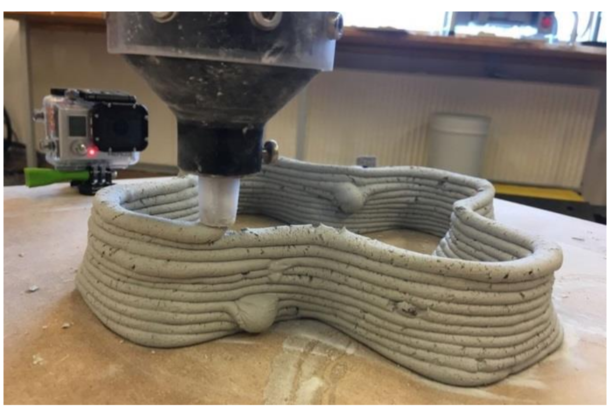
This is an industrial PhD project lead by DMRI. The project started Primo 2017 and runs for three years.

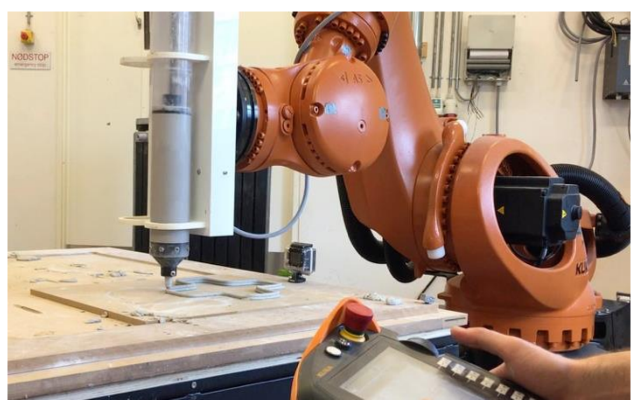
Creative Robotics in Architecture – adaptive concrete extrusion

Authors:
Mads Brath Jensen, Isak Worre Foged and Hans Jørgen Andersen

Abstract:
Current software developments allow architects to work with both multi-performative design explorations, including simulations and analysis of ex. thermal and structural properties, and fabrication aspects in the same visual programming environment. This means that architects can visually explore the shape and form of a design object and in the same software environment simulate the movements needed for a robotic arm to fabricate the designed object; thereby ensuring that fabrication of the object is feasible.

In our current research project, we seek to explore the adaptive fabrication of multi-performative concrete bricks (see image below). Through the design of a computational framework, capable of encompassing structural and thermal analysis, as well as generation and simulation of the proposed robotic fabrication of concrete brick designs, the project investigates the implementation of a bi-directional and algorithmically-based design approach capable of incorporating adaptive sensor-based robotic fabrication. The projects' contribution to the field of architecture will be the development of a computational design framework capable of generating intelligent/informed concrete bricks for build structures; thereby facilitating a higher level of structural, thermal, fabrication, and material specificity within the design and construction of architectural structures.





Development of Robotic Ice Cutting tool

Authors:
Kelvin Koldsø Nygaard and Søren Lauridsen.

Supervised by: Ole Madsen and Simon Bøgh

Abstract:
Presentation of work conducted in relation to master thesis

Project in collaboration Odico Formworks Robotics ApS

The ICEHOTEL in northern Sweden is constructed of ice and snow from the nearby river for the past 28 years with the same manufacturing processes.
The purpose of the project was to develop a robotic cutting tool that can process harvested ice from the Torne River and thereby introduce new manufacturing methods that present architects and artists with new design possibilities.
The work was conducted with a Danish technology company that has developed a CAD/CAM software for robots and technology utilizing planar hot wire cutting in EPS foam.
A robotic cutting tool was developed by a three-step process, including:

- A study of ice, with an emphasis on mechanical properties relevant to the cutting process and relevant cutting techniques was explored.
- A development phase of the robotic tool with use of the lean startup method.
- A validation and determination of the relevant process parameters.

The tool performs planar cutting, thereby removing material more efficiently, when compared with milling. The tool cuts with a fast wire, thereby allowing for changing the direction during cutting and allowing for cutting of complex shapes. The underlying cutting method was implemented and tested at ICEHOTEL in Kiruna, Sweden.

Autonomous Industrial Mobile Manipulator in Smart Production

Authors:
Rasmus Eckholdt Andersen, Emil Blixt Hansen, David Cerny, Steffen Madsen, Biranavan Pulendralingam, Simon Bøgh, Dimitrios Chrysostomou, Rasmus Skovgaard Andersen and Rikke Gade

Abstract:
In the emerging fourth industrial revolution, shared data and increased intelligence throughout production facilities provide an increasingly viable basis for integration of novel technologies such as mobile manipulators. Such robots are themselves cyber-physical systems and can add flexibility to Industry 4.0-ready productions. In this work, the mobile manipulator Little Helper 6 (LH6) is integrated into AAU's Industry 4.0 demonstration setup. A ROS-based program, called Skill-Based System is used to program the LH6 using intuitive skills designed for non-robot experts. The LH6 consists of a mobile platform, manipulator, gripper, 3D camera and a 2D camera. The camera systems are used to do precise 3D position calibration using QR-codes, object recognition using machine learning and object pose estimation. Two part-feeding tests were performed; using a tray (sample size of 20) and smart phone covers (sample size of 10). The LH6 performs with a success rate of 64% when part-feeding trays and 60% for covers with the main source of errors being the navigation system not reaching the final position and unsynchronized communication with the Smart Production. The tests successfully demonstrated how mobile manipulators can be used in a flexible production, although more development is required before it is ready for industrial deployment.

Communication flexibility – Robot integration

Authors:
Aleksandr Batuev, Andreea Ciontos, Emil Nordsted Sivertsen, Matei Sarivan and Øyvind Holtskog

Supervisor: Casper Schou

Abstract:
In the light of Industrie 4.0, robotic manipulators need to present certain flexibility. Our project aims to create a ROS application (package), which interface multiple manipulators and grippers for easier programming and usage. Some specific drivers are created which later are implemented with a Skill Based System under development in Aalborg University. The main purpose of this project is to make it easier to replace manipulators when they break down or when the task at hand requires a different type of manipulator. This also means that the software is vendor independent and it works with industrial and collaborative robots regardless.
The Skill Based System (SBS) comes with a graphical user interface that makes it possible for operators to easily program the manipulators without any coding knowledge. The project is conducted in collaboration with Eltronic A/S, a company which is highly interested in the potential of ROS, an open source platform, which has to offer an abundance of tools to make this project possible.
The progress so far allows us to connect our own built driver for KUKA Agilus, and existing drivers for UR to the Skill Based System, together with Robotiq and Schunk grippers, and run simulations.

Keywords: Industrie 4.0, ROS, industrial manipulators, collaborative manipulators, Skill Based System

WallMoBot: Wall Mounting Co-Worker Robot

Authors:
Rasmus Pedersen, Christoffer Sloth and Thomas Bak

Abstract:
In this talk I will give an introduction to the WallMoBot project, which is funded by Innovation Fund Denmark. The project is concerned with developing a wall-mounting robot to improve the work environment by alleviating heavy lifting and possibly improve productivity. The focus is on installing glass walls in office buildings, where each wall consist of several glass panels up to 3.5 meters in length and a weight up to 150 kg. The panels are installed with accuracies down to 1 mm. Therefore, a human operator is overlooking the installation and provides inputs to the robot.

I will present a control system architecture enabling a human operator to directly manipulate the position of the glass panel by physically interacting with the robot. The idea is to use “low” cost load cells in each joint and combine this with a model of the robot to estimate the operators input force, which is subsequently used in an impedance control. I will provide a model of the system and the operator which makes it possible to distinguish between intentional contact between human and robot, and accidental collisions with e.g., the ceiling. Lastly, simulation studies are provided to demonstrate the performance of the proposed control system.

Autonomous bathymetry mapping with AAUSHIP.02

Authors:
Anders Egelund Kjeldal and Jesper A. Larsen

Abstract:
The scope of this project is to design a system to autonomously perform hy- drographic maps of the seafloor. These maps is intended to aid large ships navigating the shallow waters of the Limfjord. The proposed solution uses an autonomous surface vessel equipped with a multibeam echosounder to autonomously survey a specified area.

In order for the vessel to be able to map areas where other ships are present, it needs first of all to observe obstacles, being it other ships, boys, peers etc., which is achieved by the use of Lidar, Radar and cameras. This is fed to a path-planner in order to correctly circumnavigate these. This is especially important for other ship traffic in order to clearly show the intent of the vessel and to yield when needed. Finally the path following controller is implemented using nonlinear control theory to robustly keep the generated trajectory. Additionally a Kalman filter is used to fuse GPS and IMU data in order to improve the vessels attitude and position knowledge.