New ELLIIT PhD-projects 2021-2025

ELLIIT Call B

On September 30, 2020, the ELLIIT Steering Group decided to fund 14 new projects. Brief information regarding the projects is available below. Please contact the project PI for more information.

Project

Ultra-reliable wireless for 6G applications (B01)

PI: Fredrik Tufvesson (LU), co-PI:Erik G. Larsson (LiU); with Ove Edfors (LU)

This project proposal combines a theoretical approach to ultra-reliable low latency communication for 6G, with channel characterization and modelling for the same purpose, a system wide perspective and hardware friendly approaches for distributed communication, all aiming to maximize diversity and point-to-point communication reliabilities better than 99,999% while still keeping the introduced latency below 100 us.

Baseband Processing for Beyond 5G Wireless (B02)

PI: Liang Liu (LU), co-PI: Håkan Johansson (LiU), co-PI: Yousra Alkabani; with Hazem Ali (HH), Ove Edfors (LU), Süleyman Savas (HH)

This project focuses on efficient digital baseband processing algorithms and hardware for beyond 5G wireless systems. More specifically, the project will explore system-algorithm-hardware-software co-design to tackle new research challenges in the implementation of distributed massive MIMO technology for Large Intelligent Surfaces (LIS) and Cell-free massive MIMO. To achieve this objective, researchers from Lund University, Linköping University, and Halmstad University collaborate to conduct three PhD projects on distributed processing algorithm and architecture, low-complexity digital front ends, and high-level design methodologies using many-core processor architecture. The digital baseband research in this project will cooperate with other ELLIIT projects on system level exploration and analog electronics design to achieve overall implementation efficiency.

Energy-efficient ICs for 6G and radars transceivers (B03)

PI: Atila Alvandpour (LiU), co-PI: Henrik Sjöland (LU)

With 6G the journey towards ever-higher carrier frequencies and bandwidths continues. For the first time in cellular systems, the carrier frequency will exceed 100 GHz and the bandwidth 10GHz. To achieve useful communication distance and radar range, devices and especially base-stations will use beamforming with very large antenna arrays. The goal of this project is research and development of a small sized wideband energy-efficient IC, including RF analog front-end and analog-to-digital converter (ADC) to be used as a building block in 6G equipment for up to Tbit/s communication also capable of high-resolution radar measurements.

5G Security (B04)

PI: Thomas Johansson (LU), co-PI: Simin Nadjm-Tehrani (LiU)

Applications deployed with 5G will be facing several new security challenges. This project will span a variety of research activities in 5G security. This include development and analysis of cryptographic algorithms and protocols working in low latency and constrained environments and study of implementation weaknesses of security protocols through side-channels. This includes investigating the impact of quantum computers on 5G security solutions. We also consider proofs for security of protocols and cross layer analysis of security as well as security mechanisms for 5G IoT applications providing specified privacy features. The project has focus on security in the URLLC use case, where the goal will be end-to-end latencies of a few milliseconds with optimized use of resources and to show that this is possible in presence of some chain of viable security mechanisms.

6G wireless, sub-project: vehicular communications (B05)

PI: Alexey Vinel (HH), co-PI: Maria Kihl (LU); with Fredrik Tufvesson (LU), William Tärneberg (LU), Johan Thunberg (HH)

The project will work with futuristic heterogeneous cooperative automated driving scenarios in smart cities, which will include both traditional and remotely human-driven vehicles as well as computer-driven vehicles in complex city environments with different levels of autonomy. We will address the challenges of scalability, robustness, and accommodate uncertainty in cooperative driving by introducing quality elasticity through a hierarchy of decision-making algorithms placed on different levels in the ecosystem of autonomous vehicles. The hierarchical solution could be based on local decision algorithms in the vehicles, edge cloud coordination of small areas, such as an intersection, and global orchestration of larger areas in order to fulfill more global traffic requirements in, for example, a city. We will enhance the vehicular networking concepts of cooperative awareness (when vehicles exchange information about themselves), collective perception (when vehicles exchange information about objects they have observed by their local sensors) and cooperative maneuvering (when vehicles exchange their trajectories and intentions) to achieve the degrees of flexibility required for the designed decision making algorithms.

Robust and Secure Control over the Cloud (B06)

PI: Anton Cervin (LU), co-PI: Zebo Peng (LiU); with Karl-Erik Årzén (LU), Petru Eles (LiU)

The project will explore how the Cloud, with its virtually infinite compute capacity, can improve the security and performance of feedback control systems. In one part, we will research verifiable computation protocols (VPC) for secure outsourcing of cloud-based control computations. In another part, we will investigate the interplay between local and cloud-based control computations and derive guarantees on robustness and performance. There is an interesting trade-off between security, round-trip delay, and control performance that will also be studied. The design techniques will be verified in experiments, where physical processes are controlled remotely over the Cloud.

Quality assurance in continuous software engineering (B07)

PI: Nauman bin Ali (BTH), co-PI: Emelie Engström (LU); with Martin Höst (LU), Muhammad Usman (BTH), Jürgen Borstler, Claes Wohlin, Per Runeson, Kai Petersen

Software quality assurance includes preventive, diagnostic and corrective mechanisms to ensure the design and development of high-quality software systems. Advances in technology, like cloud computing and modern toolchains for automated builds, testing and deployment, have enabled organizations engaging in continuous software engineering to deploy a new version of a system ever more rapidly. This new way of working requires automation and puts new requirements in terms of the role and responsibilities of quality assurance.

In this project, we will explore the interaction between automated and manual data analysis in such contexts. We will investigate the use of data analytics and visualizations to help software engineers interpret the massive amount of data available due to activities like code analysis, version management, code reviews, testing and product usage. Furthermore, to support the integration of research activities and results in the industrial context, we will advance the work on improving the knowledge co-creation between industry and academia in software quality assurance.

Cloud Tooling for Large-Scale Cyber-Physical System Model-Based Development (B08)

PI: Görel Hedin (LU), co-PI:Adrian Pop (LiU); with Niklas Fors (LU), Martin Sjölund (LiU), Lena Buffoni (LiU) Peter Fritzon (LiU)

By using high-level modeling languages like Modelica or Bloqqi, complex systems can be modeled in a compact and natural way, reusing libraries for different engineering domains. The project develops novel techniques for supporting cloud-based tooling for such languages. The Lund part of the project focuses on the generation of cloud components from high-level specifications, general enough to handle the complex static semantics of cyber-physical modelling languages. The Linköping part of the project focuses on simulation-based verification of requirements using a combination of equation-based models and machine learning trained surrogate models, an easier-to-use and more expressive requirement language, and traceability in cloud-based development environments.

Collaborative robotics (B09)

PI: Patrick Doherty (LiU), co-PI: Elin Anna Topp (LU); with Anders Robertsson (LU), Mariusz Wzorek, Piotr Rudol, Jacek Malec

Dynamic and seamless interaction between collections of humans and robotic systems in achieving complex common goals and information exchange is an essential component in collaborative robotics. In this context, distributive situation awareness is essential for supporting collective intelligence in teams of robots and human agents where it can be used for both individual and collective decision support. Additionally, one mechanism to achieve the appropriate communication between autonomous systems and humans is mixed–initiative interaction, as it allows for a genuine two–way communication through which it is possible to convey insights into the internal state of a system as well as to assess and resolve ambiguous situations in interaction. This project is multi-disciplinary in that it combines research with the topics of distributed situational awareness and mixed-initiative interaction. It also has as a goal to develop field tested systems in the area of emergency rescue using a combination of both robotic and human agents, in particular Unmanned Aircraft Systems and their interaction with human rescuers and support personnel.

Geometrically Constrained Learning for Vision (B10)

PI: Michael Felsberg (LiU), co-PI: Anders Heyden (LU); with Mårten Wadenbäck (LiU)

The project deals with using geometrical constraints for different vision tasks, such as navigation and map-making. In particular, we will look at using one or several homographies (describing the relation between corresponding feature points on planar surfaces), which is a very common situation in both man-made and natural environments. We will investigate incorporation of constraints obtained from homographies into different deep-learning networks, such as convolutional neural networks and also investigate the underlying geometrical constraints imposed by one or several homographies under different conditions on the intrinsic camera parameters. There are several applications of the project within SLAM, UAVs etc.

Local Positioning Systems (B11)

PI: Kalle Åström (LU), co-PI: Fredrik Gustafsson (LiU); with Magnus Oskarsson (LU), Bo Bernhardsson (LU), Fredrik Tufvesson (LU), Gustaf Hendeby (LiU), Isaac Skoog (LiU).

Mapping, positioning and localization are key enabling technologies for a wide range of applications. Within ELLIIT there are several strong research groups that do fundamental research within this area for many sensor modalities, e.g. vision, radio, audio, magnetometers, radar and sonar. Within this ELLIIT project "Local Positioning Systems 2021-2025" we will concentrate on two PhD student projects, (i) Machine learning for Structure from Sound and (ii) Wearable Microphone Arrays.

Visual Feature Based Data Reduction (B12)

PI: Ingrid Hotz (LiU), co-PI: Bo Bernhardsson (LU); with Anders Ynnerman (LiU), Michael Dogget (LU), Jonas Unger (LiU), Bo Bernhardsson (LU)

Developing Brain-Computer interfaces (BCIs) is a challenging goal that, however, is becoming more and more realistic. Brain imaging and measurement methods provide valuable data to gain the necessary knowledge about the complex functionality of the brain. The goal of the project is to make such brain data accessible for effective exploitation in medical and technological applications. The underlying concept is to develop sparse representations that can be used to guide a visual exploration process. We plan to approach this challenge by combining geometric and topological methods for dimension reduction, with learning methods to classify the obtained features, and modern interaction and rendering facilities to communicate the results.

Scalable Optimization for Learning in Control (B13)

PI: Anders Hansson (LiU), co-PI:Anders Rantzer (LU); with Johan Löfberg (LiU), Richard Pates (LU)

Large-scale engineering applications put new demands on control theory, as most existing methods for analysis, design and verification do not scale well with increasing complexity. Furthermore, new powerful algorithms for machine learning are increasingly being used for control engineering purposes, further adding to the complexity of analysis and verification. To counteract this, there is a strong demand for scalable optimization methods and corresponding information interfaces. Important applications areas are autonomous transportation, manufacturing and robotics. The purpose of the proposed project is to address the complexity challenges by developing and exploiting new optimization algorithms suitable for parallel and/or distributed implementation.

Autonomous Force-Aware Swift Motion Control (B14)

PI: Anders Robertsson (LU), co-PI: Lars Nielsen (LiU); with Björn Olofsson (LiU/LU) and Erik Frisk (LiU)

The research program for this project has a number of steps for moving autonomous force-aware swift motion control forward. Our recently derived novel methods for at-the-limit maneuvering will be extended to new scenarios, where previously non-dynamic kinematic models (with non-holonomic motion constraints) have been used under, sometimes highly restrictive, assumptions on limited slip and upper-bounded velocities. For example, maneuvering in highway driving at higher speeds (typically 70 km/h and higher) implies that consideration of the forces involved, i.e., the dynamic behavior, is of importance, e.g., if heavy-duty vehicles with their inherent roll sensitivity or mobile platforms with heavy manipulators onboard are considered. The new perspective has high potential to lead to new significant results with regard to planning and control strategies for a wide range of vehicle-maneuvering and robotic manipulation scenarios, and will also treat scenarios with multiple vehicles and moving robots, in traffic or on work sites. The core of the project is scientific questions in swift motion control that is safe, resilient, and efficient.