



2018
Certus
Annual Report



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The Way Forward

As an SFI, Certus is a successful centre where collaborative projects have led to the adoption and exploitation of research results.

Working with industrial and public partners is a strong opportunity for researchers to validate new ideas, methods and tools. With the constant support of the User Partners, Certus researchers have regularly increased their impact in Software Validation and Verification. In 2018, these efforts have been confirmed with the industrialisation of SWMOD at ABB Robotics, an approach which exploits Constraint Programming and reinforcement learning for scheduling the execution of test cases and optimizing early fault detection by learning from previous test campaigns; with an improved data extraction pipeline at the Cancer Registry; with the experimental evaluation of an unsupervised machine learning approach to classify software logs at Cisco Systems; with the exploration of Unesco-Inria's Software Heritage, the biggest corpus of publicly available software source code, with CRYSTAL.FEAT a hierarchical clustering approach to mine and understand source code.

These efforts of 2018 have been strongly rewarded by the notification of several European and Nationally funded projects. Firstly, we got involved into a proposal for creating the European AI-on-demand platform into the H2020 *AI4EU project*. The project gathers 79 partners to create the platform and aggregate around it a large community of citizen, students, researchers, entrepreneurs, industrial participants interested in Artificial Intelligence.

In this project, we lead eight industrial pilot experiments to exploit the platform and demonstrate its capabilities to address critical problems in robotics, cybersecurity, environment, agriculture, etc. We have also been solicited to define the quality assurance process of the AI assets of the platform. Secondly, by participating to the RCN IKTPLUSS program calling for projects to reduce the digital vulnerabilities, we have been quite successful in attracting new funded projects, namely *secureIT* which will provide software engineers with intelligence software security assessment technologies, *TSAR* which will focus on exploring learning models to detect false data injection attacks in vessel traffic surveillance systems and *SmartMed* which will use the blockchain technology to secure the access of personal medical records. Thirdly, by participating to the very competitive RCN Young Talent FRINATEK Call, Dusica Marijan attracted funding for *T3AS* which will explore the testing of autonomous software systems.

Next year will see the end of the RCN support of Certus under the SFI programme. This is a challenge for us, as it is for all the SFIs. As a logical consequence, a necessary reorganization of our activities will take place at Simula, our hosting institution. However the way forward is well prepared with a portfolio of new National and European projects and a strong bilateral exit strategy prepared with ABB Robotics. We now face new and exciting challenges in terms of software V&V technology design and adoption, which will drive us towards new scientific horizons.



Arnaud Gotlieb
Leader of Certus SFI
Chief Research Scientist
Simula Research Laboratory

We now face new and exciting challenges in terms of software V&V technology design and adoption, which will drive us towards new scientific horizons.





We have no other plans than to finish in the same way as we have run the centre over the last eight years – delivering first-class results in both the academic and industrial areas.

Leader of the Certus Board

We have finished 2018 in style, and we are approaching the final year of the SFI. It's been another year of delivering first class academic and industrial results.

On the industrial side, Kongsberg Maritime has, after thorough consideration, decided to leave the consortium. We regret this, but we also understand the ever-present risk of changing priorities and market challenges in a very competitive business. Due to the short remaining time of the funding period, the board has decided not to bring in new partners. Kongsberg's exit has been handled very smoothly and professionally by the Certus administration, without it affecting the regular operations of the centre.

During 2018 we have spent much time discussing the exit strategy of the centre. Through workshops and discussions, we have seen that all industrial partners have the ambition to continue to invest in research. As we have not identified areas with strong common interests between the partners, the exit strategy will be based on bilateral cooperation between Simula and each individual partner. This also includes Kongsberg Maritime. My own company, ABB Robotics, is already working with Simula on activities that will continue after the end of the funding period for the Certus centre. I am actually writing this column on the flight to Barcelona, where we will have a kick-off meeting for the 20 MEUR project AI4EU. This is an EU research project, under the H2020 ICT program, where ABB Robotics will contribute with one man-year in a work package managed by Arnaud Gotlieb, the leader of Certus. This work is a direct result of the strong cooperation with the Certus SFI.

In September 2018 we had a visit from the Research Council of Norway (RCN). We always appreciate these visits. They give us the opportunity to review status and plans, and receive valuable feedback. The RCN has characterized Certus SFI as a "successful SFI". This is an acknowledgment that goes out to all contributors, and we can be proud that we have been able to fulfil expectations.

We are approaching the end of the funding period, and we have begun to look forward to the activities that will continue after we close down the SFI. However, the RCN expects us to continue at full speed throughout the whole funding period. We have no other plans than to finish in the same way as we have run the centre over the last eight years – delivering first-class results in both the academic and industrial areas.



Jan Christian Kerlefsen
Leader of the Certus Board

Vision and goals

Cost-effective software validation and verification is highly challenging.

Manual testing of large software systems will soon no longer be fully feasible due to the increasing demands of larger systems and vast amounts of data. At Certus, we believe that this challenge can be addressed by using and reusing intelligent testing techniques, namely, techniques inspired from Artificial Intelligence. Embracing constraint optimization, machine learning and data mining research, we envision the design of future tools for facilitating the validation and verification of complex software systems.

Certus works with a selection of public and industry partners, which represent a cross-section of industry and public sector applications in software: ABB Robotics (new partner in 2014), Cisco Systems, Esito, FMC Technologies (2011 - 2014), Kongsberg Maritime, Norwegian Customs (2011 - 2017) and The Cancer Registry of Norway (new partner in 2016). Our goal, in collaboration with these partners, is to determine the future needs within software validation and verification, and to produce research that results in exploitable methodologies and tools for all the partners to test and utilize.

Certus SFI is approaching to an end with its current set-up and organization, but we have paved the way for further bilateral collaborations between Simula and some of the Certus User. Partners by starting up new ambitious projects at the National and European levels.

Key Figures

The Certus Centre annual accounts for 2018 shown below are presented in the standard setup used by the Research Council of Norway. In particular regarding funding, “Own financing” refers to funding provided by the host institution, other “public funding” refers to funding provided by the Cancer Registry of Norway, while “other private funding” refers to funding provided by the remaining four user partners.

Cost in NOK 2018

Payroll / indirect expenses	19 981 322
Equipment	163 053
Other operating expenses	774 652
Totals	20 919 027

Funding in NOK 2018

Own financing	5 357 918
Other public funding	1 627 769
Other private funding	4 463 340
From the Research Council	9 470 000
Totals	20 919 027



Organisational Model

Certus Board

- Jan Christian Kerlefsen, Chair, ABB Robotics
- Are Magnus Bruaset, Simula
- Marius Chirstian Liaen, Cisco
- Mette Wam, ESITO AS
- Bjørn Ove Olafsen, Kongsberg Maritime
- Jan F. Nygård, Cancer Registry of Norway

Certus Administration

- Arnaud Gotlieb, Certus Centre Leader
- Tom D. Atkinson, Certus Administrative Manager
- Karoline F. Hagane, Certus Advisor

Partners



Certus Centre Partners

Scientific Projects

- **Project 2:**
Industrial Exploitation
- **Project 7:**
Testing of Data-Intensive Systems
- **Project 8:**
Testing of Real-Time Embedded Systems (RTES)
- **Project 9:**
Smarter Testing of Evolving Software Systems
- **Project 10:**
Data-Driven Predictive Maintenance for Software Systems

User Partners



The Cancer Registry of Norway

Projects 3, 7

The Cancer Registry of Norway (CRN) has been a member of the Certus consortium since 2016. Software systems are an integral part of the effective functioning of any data-intensive organisation such as CRN, but CRN is in a unique position due to the amount of medical data that must be processed confidentially, and kept constantly up to date.

The number of cancer cases in Norway increases every year. This increase implies that more men and women will need cancer treatment, thus escalating the burden of cancer care in our hospitals. The Cancer Registry of Norway's vision is to combat cancer and the suffering this disease inflicts on individuals and their relatives, as well as to mitigate the challenges cancer causes in society. To improve the cancer care, high quality data on diagnostics and treatment given to cancer patients is needed. The Cancer Registry of Norway collects, verifies and recodes these data by means of ICT-systems. It is vital that these processes are conducted correctly and without error.

As a partner of Certus, the CRN wants to improve the internal ICT-systems by using model- based testing and model-driven engineering, including the usage of models for documenting the software development process, automatic generation of code structure and tests from models, and risk-based testing on critical parts of the ICT-system.



simula

Simula Research Laboratory

Projects: 1, 2, 3, 4, 7, 8, 9, 10

Simula Research Laboratory is a non-profit public utility enterprise that performs leading international research within selected fields of information and communications technology (ICT). In 2017, Simula was deemed excellent in all three research areas in an evaluation by international experts organised by the Research Council of Norway (RCN). Simula has since expanded their activities to five research areas. Certus' long-term perspective and strong industrial profile give Simula a unique opportunity to further expand and enhance its position as a leader in software validation and verification research. The Certus centre is one of several research-based innovation projects at Simula within this field.



ABB

Projects: 2, 8

ABB Robotics is a leading supplier of industrial robots and modular manufacturing systems and services. Their work in the Certus Centre focuses on painting systems embedded in industrial robots. Robotics software is a complex, configurable, and highly distributed embedded system. ABB Robotics believes that the key features of a new testing infrastructure should include extensive automatic testing, continuous integration, and the smart selection of test cases. To address this, an ABB Robotics principal engineer started an industrial PhD in 2012 as part of a Certus project, supervised by centre leader Arnaud Gotlieb and University of Stavanger Professor Hein Meling. The PhD concluded in 2015 and the results were exploited at ABB Robotics. Moreover, ABB is also aiming at implementing this research within ABB Robotics' global research and development organization. ABB Robotics became a full partner of Certus in 2014 and will rely on continuous support from researchers at the centre for its implementation project.



Esito

Projects: 2

ESITO is an ICT company that develops and market software tools supporting domain driven design and development. "g9" is a tool that mainly is used in development of mission-critical applications. ESITO's vision is to utilise domain knowledge captured in models and offer its customers tools that give lower lifetime cost and better quality by utilising models and domain driven design in their application development.



Cisco

Projects: 3, 4, 8, 9

Cisco Systems Norway specialises in developing solutions for video collaboration and manufactures a broad portfolio of products designed for all types of meeting spaces. Cisco's collaboration solutions are business critical for a number of large customers across industries like public sector, oil and gas, and finance. As companies become more global with distributed teams, effective ways to support remote collaboration becomes essential to increase productivity and reduce travel.



KONGSBERG

Kongsberg Maritime

Projects: 5, 9

Kongsberg Maritime is one of the largest suppliers of programmable marine electronics worldwide. They deliver systems for dynamic positioning and navigation, marine automation, cargo management and level sensors, maritime training simulators, and position reference systems. These products are paramount in ensuring the reliability and correct functioning of offshore and shipyard systems.

Project 7: Testing of Data-Intensive Systems

What is the purpose of research in this field?

Data-intensive systems are ubiquitous in industry and society. For instance, data-intensive systems at the Cancer Registry of Norway manage data from every screening exam and every case of cancer registered in Norway. This data-intensive system contains millions of records over time from millions of people in the country, and reflects social behaviour. As such it can in fact be called a socio-technical system. Testing socio-technical systems is critical to society, as policy making in the country is dependent on these records. This research focuses on finding pertinent patterns in the time series data in the Cancer Registry's socio-technical system. These patterns reveal population behaviour, outliers, and most importantly, identify areas where intervention is necessary. Another aspect of the research is to develop software interventions, such as the game-based learning app *FightHPV*. This type of app can change societal behaviour toward cancer prevention, and study the effects of such an intervention in the data.

What are the main challenges for industry in interpreting time series data in socio-technical systems?

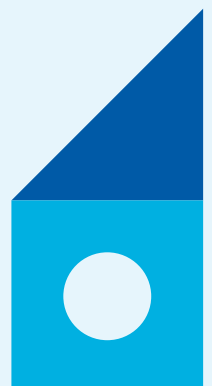
Time series data are essentially measurements of an underlying socio-technical system, but not the real state of the system itself. For instance, it is possible to obtain data points on screening exams taken by people, but not the real state of the disease itself.

The main challenges in interpreting times series data in socio-technical systems are:

- 1) Dealing with data quality in terms of completeness, validity, consistency, timeliness and accuracy of the time series data
- 2) Identifying the ideal representation for the time series data in order to enable quick discovery of interesting patterns
- 3) Establishing statistical significance of conclusions reached based on the data
- 4) Improving performance of algorithms that query millions of records to find patterns
- 5) Creating meaningful visual representations of the time series data to better understand the socio-technical system at a glance
- 6) Predicting the future based on historical time series data on people and their lifestyle factors


Is there room for improvement?

Artificial intelligence techniques, in particular deep learning, hold the promise of generating powerful predictive models from an ever-growing number of data-intensive systems. In data-intensive systems for health, it is crucial to be able to explain predictions and test predictive models for correctness.





In this past year, the project has examined techniques for managing and visualizing time series data, and applying simple linear and statistical approaches for their analysis.



How far has the work come in the past year, and what results are expected by the end of the project?

In this past year, the project has examined techniques for managing and visualizing time series data, and applying simple linear and statistical approaches for their analysis. The main project goals are applying deep learning algorithms to create predictive models from time series data in data-intensive systems, and developing methods to test these predictive models.

What's next

The focus will be on Artificial Intelligence and Nonlinear time series analysis for rich times series data obtained from measurements and sensors in data-intensive systems. In particular, the goal is to advance the field of generative adversarial networks for prediction from time series data and comprehensive testing of these prediction models.

*In 2018, we
deployed SWMOD
at ABB Robotics, a tool
for scheduling the
execution of test cases
over multiple robots.*



Project 8: Testing of Real Time Embedded Systems

SWMOD: Rotational Diversity for Automatic Test Case Scheduling for Robotics Systems

The ABB Robotics's Dynstest global improvement project aims at introducing continuous integration into the software development process of robotics systems. Software validation includes various tasks among which test case scheduling is perceived as the most crucial to ease the testing process and lower the costs of late discovery of software faults. Test case scheduling aims at selecting, distributing and launching the execution of existing tests on a product line of robots and virtual controllers. Since the start of the project, Certus researchers and engineers have engaged in the development of a scheduling component based on constraint programming and advanced matching algorithms originating from Artificial Intelligence research.

In 2018, they invested a great deal of work into the design of a new method that allows a component to rotate the execution of test cases among the robots. This method, termed Rotational Diversity, is considered as an important add-on to the scheduling component, in order to maximize the diversity of tests and their improved scheduling over time. Certus evaluated this algorithm along with a set of search heuristics and published an experimental evaluation for AAAI 2019, one of the two main conferences on Artificial Intelligence research. Researchers successfully deployed the rotational diversity method into a software component at ABB Robotics.

ROBTEST: Stress Testing of Single-Arm Robots Through Constraint-Based Generation of Continuous Trajectories

Testing of Single-Arm Robots (SAR) is challenging, as typical robots involve multiple coordinated subsystems, such as motion and action control, perception and anti-collision systems. Developing convincing test scenarios that place the robot in highly demanding situations is complicated due to the huge number of possible robot workspace configurations. In 2018, Certus introduced RobTest, a tool-supported method for stress testing of single-arm robots that automatically generates optimal collision-free trajectories.

By using advanced Constraint Programming (CP) techniques such as constraint refutation over continuous domains and constraint optimization over graphs, RobTest can generate continuous trajectories that avoid physical obstacles and maximize the load of the various CPUs of the SAR. These trajectories result in automatic robot computer programs that place the SAR in highly demanding test scenarios. Our initial experimental evaluation of RobTest shows promising results.

Project 9: Smarter Testing of Evolving Systems

What is the context of the research?

Continuous Engineering (CE) practices such as Continuous Integration (CI), Continuous Delivery (CDy), Continuous Deployment (CDt), and Continuous Release (CR), are increasingly adopted to meet the demand for incremental software development with rapid feedback. Each of these practices can be characterized by their focus on creating short and automated cycles to give developers early feedback on potential issues and reduce risk by taking repeated incremental steps. These cycles are triggered in response to a new code being committed to the Version Control System via periodic scripts, or simply on developer demand.

A frequently reported challenge for the adoption of CE is the need for systematic analysis of the abundance of data resulting from the automated build, test, and deployment processes. Without CE, a developer would manually build, test or deploy the system, observe the results and immediately react to them. With CE, an automated cycle is started that stores its results in a log, enabling the developer to switch to a new task, and inspect the log later. This approach increases productivity when the cycles are time-consuming. However, it can also lead to the accumulation of vast amounts of unprocessed results, especially in combination with extensive automatic testing.

What has been the focus of the work in 2018?

2018 mainly focused on how the analysis of accumulated CE logs can be automatically supported, and what effort reduction can be achieved. More specifically, the project investigated the challenge of automatically grouping logs of CE runs that failed for the same underlying reasons. The idea is that instead of having to investigate all individual results, automatic log clustering enables a more systematic, coordinated approach where an engineer only needs to investigate a representative for a group of failed runs. After addressing the issues that caused failure, one can reasonably expect that the issues of logs that failed for similar reasons have been accounted for as well (but this may be checked by the next CE run).

What has been achieved?

The team developed an automatic clustering pipeline for CE logs, so that an engineer diagnosing an issue only needs to investigate a few representative sequences. This pipeline is highly configurable and has allowed us to empirically investigate how clustering results are impacted by exploiting alternative techniques. For example, the frequency with which events occur in success and failure logs, or the contrast between events that only occur in failure logs versus events that also occur in success logs. Moreover, the project has empirically investigated the impact of the optional inclusion of different dimensionality reduction techniques and the choice of alternative criteria for merging clusters in the Hierarchical Agglomerative Clustering algorithm. One of the main findings was that including dimensionality reduction helps to significantly decrease the sensitivity of a clustering pipeline to parameter choices, and thereby increases its robustness for handling different inputs.



What's next

Plans for 2019 are focused on log diagnosis: CE logs can be long and tedious to understand, and the team recognizes the need for intelligent techniques to summarize or highlight the events that are characteristic for a given log (or cluster of logs). This diagnosis aims to help engineers to understand what the root causes of CE failures are.

2018 mainly focused on how the analysis of accumulated CE logs can be automatically supported, and what effort reduction can be achieved.



Project 10: Data-Driven Predictive Maintenance for Software Systems

What is predictive maintenance?

Software maintenance is considered a broad activity covering software evolution and enhancement of capabilities, but also error correction (for example integration/ interoperability errors), as well as software optimizations, which if not addressed in a timely manner will lead to failures. Software/system maintenance costs incur between 50-80% of the lifetime cost of software, and are increasingly growing, as systems become more complex and interdependent (e.g. cyber-physical systems). The aim of predictive maintenance is to predict system failures, and provide warnings that enable timely prevention of failures.

What is the main goal of Project 10?

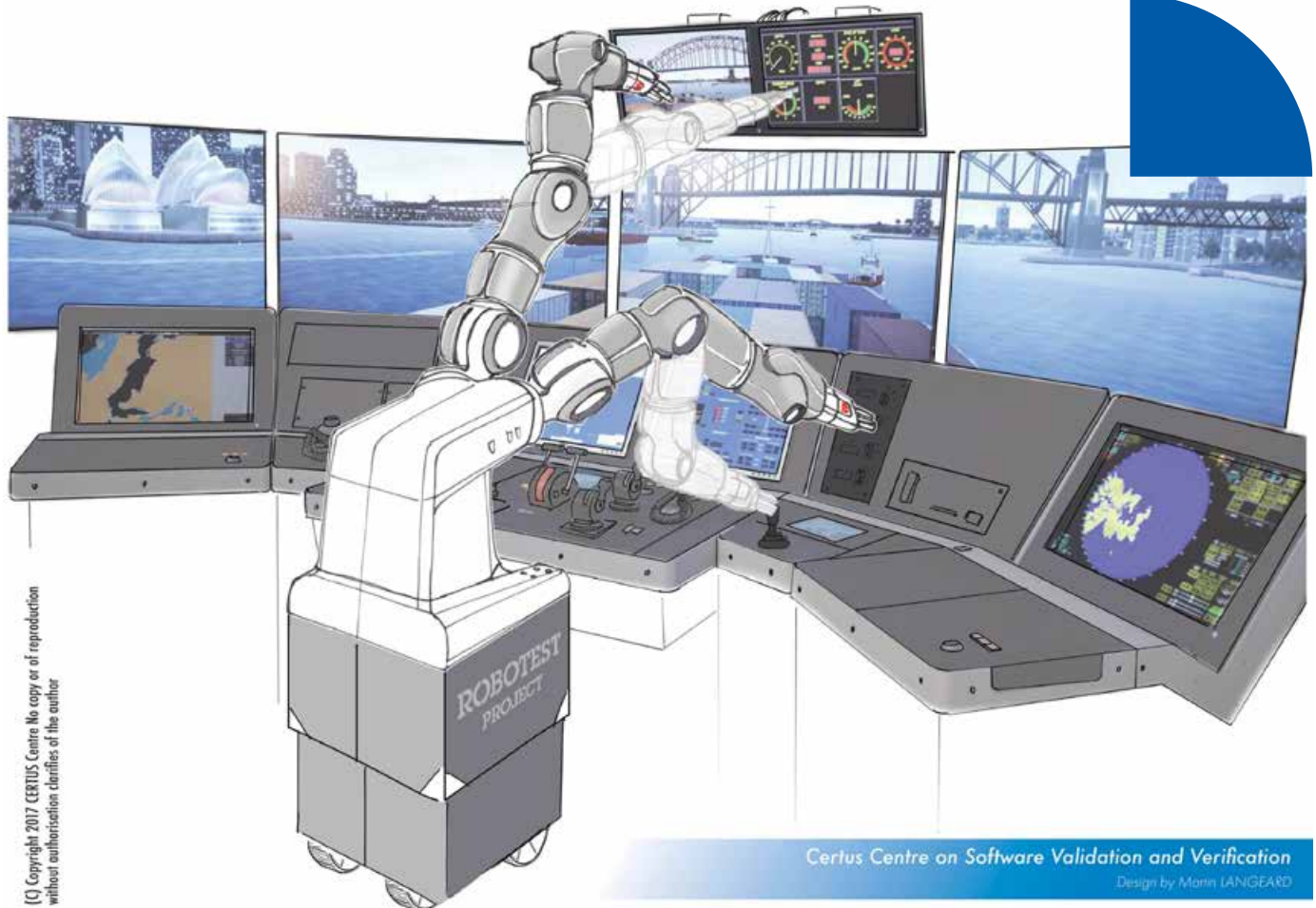
The project focuses on developing novel techniques for predictive maintenance of software-intensive systems, aimed at enabling more cost-effective operation of complex industrial systems. Such predictive maintenance techniques use machine learning algorithms for efficiently leveraging heterogeneous information sources, combining historical and live data obtained from system development, testing, and operation, in order to enable identification of system/component failures as early as possible. These techniques can improve system operation efficiency and reduce system maintenance costs and downtime.

Who are the industrial partners in the project?

Project partners are ABB Robotics and Cisco Systems. For ABB the goal is to implement performance analytics in regression testing of industrial robotics software. Cisco has as its goal to investigate the use of ML-based predictive maintenance for reducing software maintenance costs and improving the efficiency of operating video conferencing systems.

The project focuses on developing novel techniques for predictive maintenance of software-intensive systems, aimed at enabling more cost-effective operation of complex industrial systems.





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Certus Centre on Software Validation and Verification
Design by Martin LANGEARD

How can intelligent performance analytics aid software development?

Monitoring the results of test runs during software development and version release is crucial for validation engineers. They can learn from previous test results in order to predict the most error-prone parts of a tested application, or to prioritize some test cases based on their fault-revealing capabilities as observed in previous runs. These monitoring and learning tasks are grouped under the generic term of “smart analytics” or “intelligent performance analytics”.

What are some challenges in this research field?

As predictive maintenance operates with large amounts of real-time system operational data, the challenges lie in efficiently analysing relevant data and developing cost-effective algorithms able to accurately predict the future trend of system failures.

New projects in the Certus Exit Strategy

The Certus Exit Strategy is built on two pillars: A bilateral collaboration project between Simula and ABB Robotics and new projects funded at the National and European levels.

The bilateral collaboration is built on specific needs related to the maintenance of exploited tools and transferred expertise in the domain of Artificial Intelligence for Software V&V. The new projects cover topics such as the reduction of digital vulnerabilities in software projects, the testing of learning robots and the validation of autonomous systems.

Software Validation and Verification via Artificial Intelligence

Acronyme: VIVA mobility grant

Project period:
2018-2018

Funding source:

RCN (Aurora mobility grants for researcher exchange with France 2018)

Partners:

Simula Research Laboratory
LIRMM/University of Montpellier,
France

VIVA aimed at exploring Artificial Intelligence methods for Software Verification and Validation, by strengthening the scientific collaboration between two teams, namely LIRMM located in Montpellier, France and Certus researchers of the Simula Research Laboratory (SIMULA), located in Lysaker, Norway. Through several bilateral visits and scientific exchanges, the project was a crucial vector in 2018 to achieve successful results in terms of competence growing, paper publications and preparation of new results. VIVA involved the participation of Certus PhD students (Carlo Ieva, Mathieu Collet from SIMULA), Postdoc (Mehdi Mamar from LIRMM) and senior scientists (Arnaud Gotlieb from SIMULA and Nadjib Lazaar from LIRMM).

Testing of Learning Robots

T-Largo

Project period:
2018-2022

Funding source:

RCN (FRINATEK/IKTPLUS 2018)

Partners:

Simula Research Laboratory
Collaborators from ABB Robotics,
LIRMM, University of Bristol

The future of industrial robotics is rooted in the development of robots that can collaborate and learn with humans. These collaborative robots would have the ability to evolve and improve their behaviours through the usage of machine learning algorithms. However, understanding how to control and test the learning skills of uncaged, single- or multi-arm robots and their ability to safely interact with humans is challenging as their expected improvements is not precisely known. Testing such robots is becoming a crucial research area where the combination of expertise in software testing, machine learning and robotics is strongly required. The ambition of the multi-disciplinary T-LARGO project is to develop a new scientific and technological foundation enabling the testing of learning collaborative robots. Its main objective is the construction of an open test platform dedicated to collaborative robots while its impact lies in major scientific breakthroughs on how to test and control robots equipped with artificial intelligence.



The European AI On-demand Platform

AI4EU

Project Period:
2019-2021

Funding source:
H2020 (LEIT ICT-26)

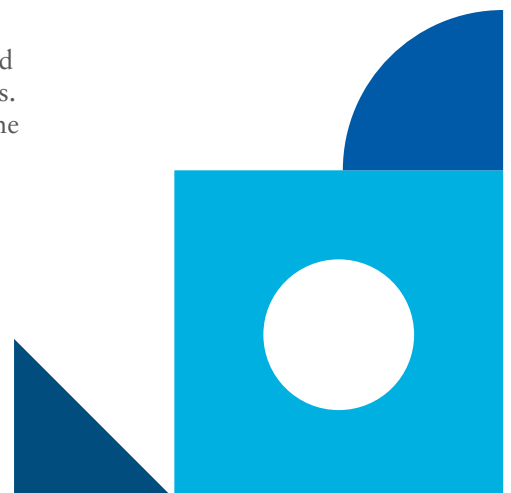
Partners:

The project is coordinated by THALES. AI4EU gathers 79 partners from all over Europe. Simula Research Laboratory leads WP6 of the project and is an Executive Board member of the project.

Artificial Intelligence is a disruptive technology of our times with expected impacts rivaling those of electricity or printing. Resources for innovation are currently dominated by giant tech companies in North America and China. To ensure European independence and leadership, we must invest wisely by bundling, connecting and opening our AI resources. AI4EU will efficiently build a comprehensive European AI-on-demand platform to lower barriers to innovation, to boost technology transfer and catalyse the growth of start-ups and SMEs in all sectors through Open calls and other actions.

The platform will act as a broker, developer and one-stop shop providing and showcasing services, expertise, algorithms, software frameworks, development tools, components, modules, data, computing resources, prototyping functions and access to funding. Training will enable different user communities (engineers, civic leaders, etc.) to obtain skills and certifications. The AI4EU Platform will establish a world reference, built upon and interoperable with existing AI and data components (e.g. the Acumos open-source framework, QWT search engine..) and platforms.

It will mobilize the whole European AI ecosystem and already unites 80 partners in 21 countries including researchers, innovators and related talents. Eight industry-driven AI pilots will demonstrate the value of the platform as an innovation tool. In order to enhance the platform, research on five key interconnected AI scientific areas will be carried out using platform technologies and results will be implemented. The pilots and research will showcase how AI4EU can stimulate scientific discovery and technological innovation. The AI4EU Ethical Observatory will be established to ensure the respect of human centred AI values and European regulations. Sustainability will be ensured via the creation of the AI4EU Foundation. The results will feed a new and comprehensive Strategic Research Innovation Agenda for Europe.



New projects in the Certus Exit Strategy



AI-Driven Testing of False Data Injection Attacks Against Transport Infrastructures

TSAR

Project period:
2019-2022

Funding source:
RCN (IKTPLUSS Reducing Digital Vulnerabilities)

Partners:
Simula Research Laboratory
StatSat AS

.....

In transport infrastructures, vessel traffic services, air-traffic management and connected cars all rely on unauthenticated and un-encrypted messages transfer that renders these services vulnerable to cyber-attacks. Typical attacks such as False Data Injection Attacks (FDIA) are difficult to detect as they alter the semantics of the data (e.g., by adding/removing/multiplying elements on a real-time control equipment), while preserving the syntactical correctness of the messages.

Identifying these attacks and classifying them as serious threats or unintentional false data has become a major challenge of traffic monitoring authorities. The TSAR project aims at demonstrating that recent advances in Artificial Intelligence (AI) can be leveraged in the automatic detection of FDIA in transport infrastructures. By combining realistic threat data generation based on constraint-based software testing techniques and automatic detection with deep reinforcement learning, TSAR will propose a new technology for automatic FDIA generation and detection. This technology will be empirically evaluated with end-users from the maritime domain and combined with FDIA prevention in two other domains, namely air traffic control and connected cars. By leveraging automatic detection of FDIA in traffic management systems, TSAR will also prepare the ground for the upcoming revolution in traffic management of self-driving vessels, aircrafts and cars.

Theory, methods, and tools for testing autonomous systems

T3AS

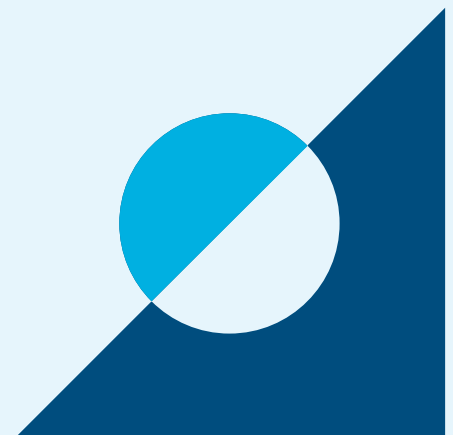
Project period:
2019-2022

Funding source:
FRIPRO

Autonomous systems are emerging technologies that are impacting a range of industries and many areas of human life nowadays.

Autonomous technologies offer a significant opportunity to enhance economy and society, but they may also cause harm if they malfunction. T3AS addresses great open challenges of testing autonomous systems, to prevent their malfunctioning, and to ensure their safe and fault-free behaviour.

The project is developing novel methods and tools based on artificial intelligence for making autonomous systems dependable and safe for their users and environment.



New projects in the Certus Exit Strategy

Reducing Digital Vulnerabilities by Providing Software Engineers with Intelligent Automated Software Security Assessment Technology

secureIT

Project period:
2019-2023

Funding source:
RCN IKTPLUSS

Partners:
Cisco Norway
mnemonics
Bergen University (NO)
North Carolina State University (USA),
Fondazione Bruno Kessler (IT)
Open University (NL)
Loyola University Maryland (USA)
.....

The main goal of the secureIT project is to significantly reduce the vulnerability of software systems. This is done by developing intelligent analysis technology that will help software engineers by automatically detecting vulnerabilities in source code during development, well before they can be exploited.

To create this technology, the project will address two fundamental challenges: (1) Vulnerability prediction based on the detection of vulnerability smells and security anti-patterns. Vulnerability smells are symptoms of source code that negatively impact software security. These are not concrete errors but indication of weaknesses that increase the risk of a security problem. Security anti-patterns are patterns in source code that are known to lead to security issues.

(2) Vulnerability prediction by automatically learning common patterns from existing software and detecting how the source code of the investigated system deviates from the learned patterns. This is somewhat similar to the way that credit card companies detect suspicious transactions and avoid fraud.





SMARTMED

Project period:
2019-2022

Funding source:
RCN IKTPLUSS

Partners:
Coordinated by UiO

The primary goal of the SMARTMED-project is to improve the security and privacy of sharing medical records using blockchain technology and smart contracts. Blockchain technology uses an immutable ledger to provide accountability, which can greatly improve security.

Security violation of medical records is an increasing problem which we think blockchain technology can alleviate. The smart contracts are used to manage the consent and privacy of patients' medical records. For various reasons, such as the GDPR, privacy has become more demanding. The secondary goal of the SMARTMED-project is to build competence in blockchain technology and smart contracts in Norway.



Certus Centre Personnel

Centre director

- Gotlieb, Arnaud - Centre Leader – Chief Research Scientist

Key researchers

- Ieva, Carlo - Senior Research Engineer
- Marijan, Dusica - Research Scientist
- Moonen, Leon - Senior Research Scientist
- Sen, Sagar - Research Scientist

Visiting researchers

- DiCosmo, Roberto
- Lazaar, Nadjib
- Mاماar, Medhi

PHD Students With Support From CERTUS Centre Budget

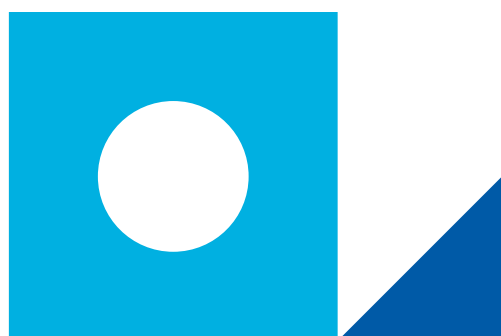
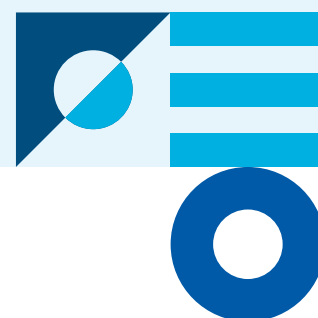
- Collet, Mathieu
- Pradhan, Dipesh
- Rosenberg, Carl-Martin
- Spieker, Helge

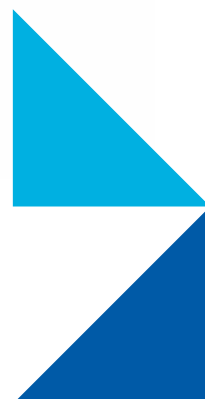
PhD students working on projects in the CERTUS Centre with financial support from other sources

- Ahuja, Mohit Kumar

Administrative personnel with financial support from the CERTUS Centre budget

- Atkinson, Tom David
- Hagane, Karoline





Scientific awards, merits, committee work, chairs and positions during 2018

Arnaud Gotlieb

Track co-chair

- CP'18 24th Int. Conf. on Principles and Practice of Constraint Programming, Lille, France, Aug. 2018

Program Committees

- QRS'18 18th IEEE Int. Conf. on Software Quality, Reliability and Security, Lisbon, Portugal, Jul. 2018
- IJCAI-ECAP'18 Int. Joint Conf. on Artificial Intelligence, Stockholm, Sweden, July 2018
- TAP'18 12th Int. Conf. on Tests and Proofs, Toulouse, France, Jun. 2018
- ICTAI'18 30th Int. Conf. on Tools with Artificial Intelligence, Volos, Greece, Nov. 2018
- FIP-ICTSS'18 30th IFIP Int. Conf. on Testing Software and Systems, Cadiz, Spain, Oct. 2018

Keynote Speaker

- Artificial Intelligence in Software Testing: An Overview – 10ème Comité Français du Test Logiciel, Apr. 10th, 2018, Paris, France.

Dusica Marjan

Program Committees

- Organising committee member, SER&IP workshop at International Conference on Software Engineering, May 2018, Gothenburg Sweden
- Program committee member, International Conference on Software Quality, Reliability, Security, July 2018, Portugal
- Program committee member, SEIP track at International Conference on Software Engineering, May 2018, Gothenburg Sweden
- Program committee member, International Conference on Fundamentals and Advances in Software System Integration, September 2018, Italy

Leon Moonen

Distinguished Reviewer Awards

- IEEE Int'l Conf. on Source Code Analysis and Manipulation (SCAM), September 23-24 2018, Madrid, Spain
- IEEE Int'l Conf. on Program Comprehension (ICPC), May 27-28 2018 Gothenburg, Sweden

Steering Committees

- Int'l Workshop on Pattern Promotion and Anti-pattern Prevention (PPAP)
- High Integrity Systems Forum (HISF)

Program Committees

- IEEE Int'l Conf. on Software Maintenance and Evolution (ICSME), September 23-29 2018, Madrid, Spain
- IEEE Int'l Conf. on Source Code Analysis and Manipulation (SCAM), September 23-24 2018, Madrid, Spain
- IEEE Int'l Conf. on Program Comprehension (ICPC), May 27-28 2018 Gothenburg, Sweden Euromicro Conference on Software Engineering and Advanced Applications (SEAA) track on Software Engineering and Technical Debt (SEaTeD), August 29–31 2018, Prague, Czech Republic

Sagar Sen

Program Committees

- SANER 2018 IEEE Int. Conf. on Software Analysis, Evolution, Reengineering - Industry Track
- SER&IP 2018 Int. Workshop on Software Engineering Research and Industrial Practice
- ISSRE 2018 IEEE International Symposium on Software Reliability Engineering



Certus Publications 2018

Articles in International Journals

1. **Aggregating Association Rules to Improve Change Recommendation**
Thomas Gramstad Rolfsnes, Leon Moonen, Stefano “Di Alesio”, Razieh Behjati, David Binkley
Journal of Empirical Software Engineering (EMSE), vol. 23, issue 2, Apr. 2018, pp. 987–1035, Springer
2. **What are the Effects of History Length and Age on Mining Software Change Impact?**
Leon Moonen, Thomas Gramstad Rolfsnes, David Binkley, Stefano “Di Alesio”
Journal of Empirical Software Engineering (EMSE), vol. 23, issue 4, Mar. 2018, pp. 2362–2397, Springer
3. **Employing Multi-Objective Search to Enhance Reactive Test Case Generation and Prioritization for Testing Industrial Cyber Physical Systems**
Aitor Arrieta, Shuai Wang, Urtzi Markiegi, Goiuria Sagardui, Leire Etxeberria
IEEE Transactions on Industrial Informatics (TII), vol. 14, issue 3, pp. 1055–1066, IEEE
4. **Discovering Program Topoi via Hierarchical Agglomerative Clustering**
Carlo Ieva, Arnaud Gotlieb, Souhila Kaci, Nadjib Lazaar
IEEE Transactions on Reliability, vol. 67, issue 3, Jan. 2018, pp. 758–770, IEEE Reliability Society
5. **Certus: an organizational effort towards research-based innovation in software verification and validation**
Sagar Sen, Dusica Marijan, Arnaud Gotlieb
International Journal of Systems Assurance Engineering and Management, vol 9, issue 2, pp. 313–322, Springer
6. **CBGA-ES+: A Cluster-Based Genetic Algorithm with Non-Dominated Elitist Selection for Supporting Multi-Objective Test Optimization**
Dipesh Pradhan, Shuai Wang, Shaikat Ali, Tao Yue, Marius Liaaen
IEEE Transactions on Software Engineering, IEEE

Referred Proceedings

1. **REMAP: Using Rule Mining and Multi-Objective Search for Dynamic Test Case Prioritization**
Dipesh Pradhan, Shuai Wang, Shaikat Ali, Tao Yue, Marius Liaaen
11th IEEE Conference on Software Testing, Validation and Verification (ICST), IEEE
2. **Discovering Program Topoi Through Clustering**
Carlo Ieva, Arnaud Gotlieb, Souhila Kaci, Nadjib Lazaar
Proceedings of the Thirty-Second IAAI/AAAI Conference on Innovative Applications of Artificial Intelligence, AAAI Press
3. **Practical Selective Regression Testing with Effective Redundancy in Interleaved Tests**
Dusica Marijan, Marius Liaaen
Proceedings of the 40th International Conference on Software Engineering: Software Engineering in Practice (ICSE-SEIP’18), pp. 153–162, ACM
4. **DevOps Improvements for Reduced Cycle Times with Integrated Test Optimizations for Continuous Integration**
Dusica Marijan, Sagar Sen, Marius Liaaen
2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC), pp. 22–27, IEEE
5. **DevOps Enhancement with Continuous Test Optimization**
Dusica Marijan, Sagar Sen
The 30th International Conference on Software Engineering and Knowledge Engineering (SEKE), pp. 535–536, KSI Research Inc. and Knowledge Systems Institute Graduate School
6. **Towards Hybrid Constraint Solving with Reinforcement Learning and Constraint-Based Local Search**
Helge Spieker, Arnaud Gotlieb
Data Science meets Optimization Workshop at Federated Artificial Intelligence Meeting
7. **Improving Problem Identification via Automated Log Clustering using Dimensionality Reduction**
Carl Martin Rosenberg, Leon Moonen
12th International Symposium on Empirical Software Engineering and Measurement (ESEM 2018), pp. 1–10, ACM
8. **The Case for Adaptive Change Recommendation**
Sydney Pugh, Dave Binkley, Leon Moonen
18th IEEE International Working Conference on Source Code Analysis and Manipulation (SCAM), Sept. 2018, pp. 129–138, IEEE
9. **Stratified Constructive Disjunction and Negation in Constraint Programming**
Arnaud Gotlieb, Dusica Marijan, Helge Spieker
Proc. of IEEE Int. Conf. on Tools with Artificial Intelligence (ICTAI-18). Volos, Greece. Nov. 2018, pp. 106–113, IEEE
10. **On the Use of Automated Log Clustering to Support Effort Reduction in Continuous Engineering**
Carl Martin Rosenberg, Leon Moonen
25th Asia-Pacific Software Engineering Conference (APSEC 2018), Dec. 2018 pp. 179–188, IEEE

Edited Books

1. **Fifth International Workshop on Software Engineering Research and Industrial Practice**
Rakesh Shukla, Dusica Marijan, Markus Borg, Ye Yang
May 2018, Gothenburg, Sweden, ACM

Certus Publications 2018

Technical Reports

1. Employing Rule Mining and Multi-Objective Search for Dynamic Test Case Prioritization
Dipesh Pradhan, Shuai Wang, Shaukat Ali, Tao Yue, Marius Liaaen
Simula Research Laboratory
2. Automated Test Case Implantation to Test Untested Configurations: A Cost-Effective Search-Based Approach
Dipesh Pradhan, Shuai Wang, Tao Yue, Shaukat Ali, Marius Liaaen
Simula Research Laboratory

Posters

1. Different Cycle, Different Assignment: Diversity in Assignment Problems with Multiple Cycles
Helge Spieker, Arnaud Gotlieb, Morten Mossige
AAAI-18, New Orleans, Louisiana, USA, Student Abstract
2. Constraint-Based Generation of Trajectories for single-Arm Robots
Mathieu Collet
Arnaud Gotlieb, Morten Mossige
CP2018, Lille, France, Aug. 2018

Public Outreach

1. Breath, breathing and the sensing of breathing.
Alexander Refsum Jensenius, Njål Sparbo, Sagar Sen, Elisabeth. Edvardsen
MusicLab vol. 2; Apr. 2018, Workshop, University of Oslo (UiO)

Miscellaneous

1. Data set for the paper What are the Effects of History Length and Age on Mining Software Change Impact?
Leon Moonen, Thomas Gramstad Rolfsnes, David Binkley, Stefano “Di Alesio”
Mar. 2018, Zenodo

Talks

1. Reinforcement Learning for Automatic Test Case Prioritization and Selection in Continuous Integration
Helge Spieker, Arnaud Gotlieb, Dusica Marijan, Morten Mossige
Gesellschaft für Informatik Software Engineering Conference 2018 (SE18), Ulm, Germany
2. REMAP: Using Rule Mining and Multi-Objective Search for Dynamic Test Case Prioritization
Dipesh Pradhan, Shuai Wang, Shaukat Ali, Tao Yue, Marius Liaaen
IEEE Conference on Software Testing, Validation and Verification (ICST), Västerås, Sweden
3. Artificial Intelligence in Software Testing: An Overview. Application to Industrial Robotics
Arnaud Gotlieb
French Days on Software Testing (JFTL'18), Paris, France
4. AI-Powered Testing of Industrial Robots
Arnaud Gotlieb
ALTEN TalentCamp, Paris, France
5. Estimating Objective Boundaries for Constraint Optimization Problems
Helge Spieker, Arnaud Gotlieb
NordConsNet Workshop, Gothenburg, Sweden
6. Practical selective regression testing with effective redundancy in interleaved tests
Dusica Marijan
International Conference on Software Engineering (ICSE), Gothenburg, Sweden
7. SW Testing: Can ML save us?
Carl Martin Rosenberg, Marius Liaaen
NDC TechTown 2018, Kongsberg, Norway
8. Boundary Estimation: Learning Boundaries for Constraint Optimization Problems
Arnaud Gotlieb, Helge Spieker
International Symposium on Mathematical Optimization (ISMP'18), Bordeaux, France

Statistics on Certus Publications 2018

The Development Of Certus Publications									
	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL
Journal articles	3	12	13	10	10	13	15	6	82
Edited books			1	2		2	1	1	7
Proceedings, referred	11	24	35	22	13	25	23	10	163
Book chapters	1	1	1	1	2		2		8
Talks, keynote		1		3		2	4	2	12
PhD Theses		3			2				5
Proceedings, non-referred		1							1
Posters		1			1		5	2	9
Technical reports	4	8	3	3	3	9	5	2	37
Talks, invited		1	1	1	6	3	15	2	29
Talks, contributed		3	1	5	5	2	15	4	35
Miscellaneous		1	1					2	4
TOTAL	392								





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