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Description

Education

- December 2000. Ph.D. in Computer Science from University of Rennes I, France. Supervisor: Professor Charles Consel, Bordeaux Institute of Technology/INRIA (France).
- June 1997. Master of Science in Computer Science from University of Aarhus, Denmark. Supervisor: Professor Olivier Danvy, Yale-NUS College (Singapore).

Current and most recent positions held

01/09/2005– University of Southern Denmark:
· 01/03/2021– Full Professor in Aerial Robotics, SDU UAS, Maersk McKinney Moller Institute.
· 01/09/2005–01/03/2021 Associate Professor, Maersk McKinney Moller Institute.
· Research in software for aerial/distributed/modular/industrial/agricultural robotics; teaching.
· Member of SDU UAS since 2017.
· Founding member of SDU Software Engineering 2015-2017.
01/09/2000–01/09/2005 University of Aarhus:
· Assistant Professor in Computer Science.
· Member of the Object-Oriented Software Systems group under Professor Ole Lehrmann Madsen.
· Main activities: Research in program analysis and transformation, pervasive computing; teaching.

Research interests

I am interested in the design and implementation of programming languages and other high-level software abstractions for aerial, mobile, and self-organizing robots with a focus on safety, reliability and robustness.
My research areas include aerial robots (drones, UAS), programming languages, modular robots, agricultural robots, software safety, domain-specific languages, program analysis and transformation, program generation, distributed embedded systems, software architecture, object-oriented software development, pervasive computing, and spatial computing.

Scientific qualifications, vision, and accomplishments

I combine a strong computer science background with significant experimental robotics experience. I am a central member of the program generation community and a respected member of robotics software engineering community.
My scientific vision concerns the challenge of programming robots in a way that is effective, precise, and safe. Mainstream approaches rely on a combination of brittle low-level programming and black-box control based on planning or artificial intelligence. I believe declarative domain-specific languages form a middle road that is effective (due to the high-level nature of declarative languages), precise (language semantics can define what the robot will do), and safe (by limiting expressiveness where needed).
My main scientific accomplishments are centered around programming languages, and include:
- Described a method for the design of adaptive, energy-aware software for aerial robots that takes into account both the mechanical and computational energy requirements.
- Discovered a synergy between reversible computing principles and the control of robots, enriching our fundamental understanding of reversible computing and experimentally demonstrating significant advantages for robust robot control.
- Designed and experimentally demonstrated the first safety-oriented programming languages for robots, facilitating the use of formal methods to ensure safety in robotic applications.
- Experimentally demonstrated the first use of high-level languages to reliably program modular robots, improving the programmability and robustness of unreliable swarming robot systems.
- Designed and implemented the first working partial evaluator for object-oriented languages, thus defining the underlying meaning of staged computation for the object-oriented paradigm.

- Demonstrated the feasibility of on-the-fly bytecode decompression for low-end embedded systems, resulting in a patented invention for programming smartcards.

In addition I have made scientific contributions within a wide range of topics, including functional programming, artificial intelligence, embedded systems, pervasive computing, software components, distributed robotics, programmable hardware, supply chains, rehabilitative robotics, software language engineering, computer vision, and reversible computing. My work on the DroneID system has impacted standardization of European drone tracking through the SESAR JU PODIUM project.

1997-2021 published 103 peer-reviewed articles in international scientific journals, conferences and workshops. Google citations: total number of citations is 1589 and h-index is 22. Other publications include 10 proceedings, 2 scientific theses, and one patent.

Academic service

- Since 2019: Member of the International Journal of Robotic Computing (IJRC) Editorial Board.
- 2013-2019: Chair of IFIP Working Group 2.11 on Program Generation (hosts yearly meetings among leading researchers in program generation); previously Vice-Chair 2011-2013 and member since 2008.
- 2018-2020: Chair of the Steering Committee for ACM GPCE (the main conference in program generation), Vice Chair 2017-2018, Member since 2013.
- Since 2018: Member of the editorial board of Elsevier Journal of Computer Languages (COLA), successor to Elsevier COMLAN where I was member of the editorial board since 2015.
- 2015-2019: Member of Management Committee of ICT COST Action IC-1405 on Reversible Computing, Chair of the IC-1405 Working Group on Applications.
- Since 2013: Member of euRobotics Topic Group on Software Engineering, System Integration, System Engineering.
- Since 2011: Member of IEEE TC on Software Engineering for Robotics and Automation.- Conference chair duties, spans robotics and programming language communities: Workshop co-chair IEEE Robotic Computing 2019-2021; Program co-chair for IEEE Robotic Computing 2018; Program co-chair for ACM PEPM 2017; Co-chair for ACM PLMW SPLASH 2016; General chair for ACM GPCE 2014; Workshop co-chair for ACM SPLASH 2011-2013; Program chair for ACM GPCE 2011; Local chair for Robocomm 2009; Tutorial/workshop chair for ACM GPCE 2007.
- Program committee member (selected), spans robotics and programming language communities: IEEE RC, RoSE, ACM RC, ICRAS, IEEE ETFA, SIMPAR, ACM GPCE, ECOOP, RC, ACM SAC, ACM VEE, ESOP, CyPhy, ACM PEPM, TFP.
- Currently guest editor for yearly special issues in Elsevier COLA (previously COMLAN) since 2015 (computer science) and was guest editor for JOSER 2015-2016 (robotics) and ACM TAAS 2009-2010.
- Co-organizer of DSLRob workshop 2010-2016.
- Regular reviewer for conferences and journals in computer science and robotics.

Grants, project management, and participation

Grants and project management:

· 2021-2024 “GENIUS”: technology development for 5G control of drones in U-space, Innovation Fund Denmark, 24M DKK. Role: co-applicant and PI.

· 2021 “CleaningDrones”: initial experiments with the use of drones for indoor cleaning in hospitals, EnergiFyn, 230k DKK. Role: co-applicant.

· 2019-2022 “HealthDrone”: technology development for drone logistics in the health sector, Innovation Fund Denmark, 14M DKK. Role: co-applicant and lead on scientific management.

· 2018-2019 “X-Drive”: drone-based monitoring of horse arena surfaces, InnoBooster, 110K DKK. Role: PI for SDU, lead on scientific management.

· 2018-2021 “TeamPlay”: low-power computing applied to drones, H2020 ICT, 5M EUR. Role: partner in the application process, lead on scientific management for aerial robotics for SDU.

· 2017-2020 “Freezing Future Unit”: low-temperature robotic storage unit for medical samples, Innovation Fund Denmark, 16M DKK. Role: main applicant and co-PI (2017-2018)/member (2019-2020).

· 2015 “Exploratory study of healthcare innovation with application to domestic rehabilitative robotics”: research and innovation around low-cost rehabilitative robotics, International Network Programme, 278K DKK. Role: main applicant and PI.

· 2007-2010 “Morphing Production Lines": software for modular robots, Independent Research Fund Denmark: Technology and Production, 6.5M DKK. Role: co-applicant and co-PI, co-manager of the SDU Modular Robotics Lab centered around this project.

· 2003-2005 “B&O+OO”: pervasive computing for home entertainment, ISIS Katrinebjerg, 5M DKK. Role: main applicant and PI.

Project participation, including grant application phase:

· 2016-2020 “FreeD”: BVLOS for UAS, Innovation Fund Denmark.

· 2014-2018 “SAFE”: safety in agricultural robots, Innovation Fund Denmark.

· 2012-2016 “CARMEN”: software platform for industrial robots, Innovation Fund Denmark.

· 2009-2013 “Locomorph”: building kit for energy-efficient robots, H2020 FET.

· 2012-2016 “Patient@Home”: end-user programming and robotic training, Danish Strategic Research Council and the Danish Council for Technology and Innovation.
· 2004-2007 “PalCom”: pervasive computing runtime execution environment, EU FP6.

Grant proposal reviewing for Israeli Ministry of Science and Technology (2020), South African National Research Foundation (2020, 2017), Estonian Research Council (2017). Regular internal reviewer for TEK Innovation IFD rehearsal sessions.

Supervision of students (post docs, PhD students, MSc students)

Supervisor of 3 post-docs (1 ongoing).
1. Miguel Enrique Campusano Araya (2020-), post-doc at SDU UAS working on HealthDrone
2. Jacob Nielsen (2013-2014), now Associate Professor at University of Southern Denmark
3. Mirko Bordignon (2010-2011), now Engineer at Google X, previously ROS-Industrial Consortium Europe Program Manager and Group Manager at Frauenhofer IPA

Supervisor of 10 Ph.D. students (4 ongoing).
1. José de la Rosa (ongoing, started 2021, co-supervisor), “Programming of bodily human/robot interaction”
2. Kristian Husum Terkildsen (ongoing, started 2020, co-supervisor), “Autonomous Service Drones for Safety-Compliant European Operations”
3. Adam Seewald (ongoing, started 2018, main supervisor), “Low-Energy Computer Vision for Drones”
4. Martin Skriver (ongoing, started 2018, co-supervisor), “Modular Hardware for Continuous Testing of Robot Controllers”
5. Johann Ingibergsson Mogensen (2015-2018, main supervisor, industrial Ph.D. with CLAAS Agrosystems), “Generative Architecture for Functional Safety in Computer Vision”
6. Johan Sund Laursen (2014-2017, co-supervisor), “A Software Structure for Control and Monitoring of Flexible Automation”
7. Sorin Adam (2013-2016, main supervisor, industrial Ph.D. with Conpleks ApS and AgroIntelli), “Generative Programming for Functional Safety in Mobile Robots”
8. Wei Guan (2009-2010, co-supervisor after main supervisor left SDU), “A software Development Platform for Mechatronic Systems”
9. Theis Hjorth (2009-2011, co-supervisor after main supervisor left SDU), “Security in Embedded Home Automation Systems”
10. Mirko Bordignon (2007-2010, main supervisor), “Elements of a Software Development Ecosystem for Modular Robotics”

In addition supervisor of 63 MSc students (Robotics, Software Engineering, Computer Science) at University of Southern Denmark, University of Aarhus, and University of Rennes.

Teaching

Currently member of the Education Committee at University of Southern Denmark for Robotics (since 2007). Currently co-lead on the development of a Master-level version of the SDU Experts in Team Innovation interdisciplinary course. Lead the reform of the Unmanned Aerial Systems specialization of the Robotics education program now named Drones and Autonomous Systems. Developed several new courses with a significant impact on the current Robotics MSc education, and was central to the initial development and continued evolution of the Software Engineering education at University of Southern Denmark, and a member of the Education Committee 2014-2019. Course evaluations have reflected a high level of learning and a high degree of satisfaction from the students. For details see Teaching Portfolio below.

Invited talks and awards

Master’s Thesis awarded “Best Danish Master’s Thesis in Computer Science” by Dansk Datalogiselskab (Danish Society for Computer Science).
Invited talks given at Construction and Analysis of Safe, Secure and Interoperable Smartcard Devices (CASSIS) 2004, Java Object-Oriented Conference (JAOO) 2005, Øresund Developer Conference (ØREDEV) 2005, Dagstuhl Seminar on Domain-Specific Languages 2015, Trusworthy Computing Seminar at University of Bristol (2021).

Main international relations

École Polytechnique Fédérale de Lausanne (EPFL, Switzerland), Halmstad University (Sweden), Harvard (USA), INRIA

(France), Technical University of Delft (The Netherlands), Technical University of Ulm (Germany), University of Bergamo (Italy), University of Bordeaux (France), University of St. Andrews (UK).

Publikationer

Experimental Investigation of EMC Weaknesses in UAVs During Power-line Inspection
Skriver, M., Stengaard, A., Schultz, U. P. & Ebeid, E., 2022, (Accepteret/In press) *Proceedings of 2022 International Conference on Unmanned Aircraft Systems (ICUAS)..* IEEE, 10 s.

Reversible Computing in Debugging of Erlang Programs
Lanese, I., Schultz, U. P. & Ulidowski, I., 2022, I: IT Professional. 24, 1, s. 74-80

What Makes Agile Software Development Agile
Kuhrmann, M., Tell, P., Hebig, R., Klunder, J. A. C., Munch, J., Linssen, O., Pfahl, D., Felderer, M., Prause, C., Macdonell, S., Nakatumba-Nabende, J., Raffo, D., Beecham, S., Tuzun, E., Lopez, G., Paez, N., Fontdevila, D., Licorish, S., Kupper, S., Ruhe, G. & 27 flere, Knauss, E., Ozcan-Top, O., Clarke, P., Mc Caffery, F. H., Genero, M., Vizcaino, A., Piattini, M., Kalinowski, M., Conte, T., Prikladnicki, R., Krusche, S., Coskuncay, A., Scott, E., Calefato, F., Pimonova, S., Pfeiffer, R. H. , Pagh Schultz, U., Heldal, R., Fazal-Baqaie, M., Anslow, C., Nayebi, M., Schneider, K., Sauer, S., Winkler, D., Biffl, S., Bastarrica, C. & Richardson, I., 26. jul. 2021, (E-pub ahead of print) I: IEEE Transactions on Software Engineering. 16 s.

Safely Flying BVLOS in the EU with an Unreliable UAS
Terkildsen, K. H., Schultz, U. P. & Jensen, K., 19. jul. 2021, *Proceedings of the 2021 International Conference on Unmanned Aircraft Systems (ICUAS).* IEEE, s. 591-601 9476834

Towards SORA-Compliant BVLOS Communication
Andersen, F. M., Terkildsen, K. H., Schultz, U. P. & Jensen, K., 19. jul. 2021, *Proceedings of the 2021 International Conference on Unmanned Aircraft Systems (ICUAS).* IEEE, s. 1509-1519 9476768

UAVAT Framework: UAV Auto Test Framework for Experimental Validation of Multirotor sUAS Using a Motion Capture System
Jepsen, J. H., Terkildsen, K. H., Hasan, A., Jensen, K. & Schultz, U. P., 19. jul. 2021, *Proceedings of the 2021 International Conference on Unmanned Aircraft Systems, ICUAS 2021.* IEEE, s. 619-629 9476699

Reversible Execution for Robustness in Embodied AI and Industrial Robots
Lanese, I., Schultz, U. & Ulidowski, I., 1. maj 2021, I: IT Professional. 23, 3, s. 12-17

Coarse-Grained Computation-Oriented Energy Modeling for Heterogeneous Parallel Embedded Systems
Seewald, A., Schultz, U. P., Ebeid, E. & Midtiby, H. S., apr. 2021, I: International Journal of Parallel Programming. 49, 2, s. 136-157

HEIST: A Hardware Signal Fault Injection Methodology Enabling Feasible Software Robustness Testing
Skriver, M., Stengaard, A. & Schultz, U. P., 2021, *2021 24th International Symposium on Design and Diagnostics of Electronic Circuits and Systems (DDECS).* Shafique, M., Steininger, A., Sekanina, L., Krstic, M., Stojanovic, G. & Mrazek, V. (red.). IEEE, s. 123-126

Towards a Service-Oriented U-Space Architecture for Autonomous Drone Operations
Campusano, M., Jensen, K. & Schultz, U. P., 2021, *2021 IEEE/ACM 3rd International Workshop on Robotics Software Engineering (RoSE).* IEEE, s. 63-66

PReGO: A generative methodology for satisfying real-time requirements on COTS-based systems: Definition and experience report
Rouxel, B., Schultz, U. P., Akesson, B., Holst, J., Jørgensen, O. & Grelck, C., 16. nov. 2020, *GPCE 2020 - Proceedings of the 19th ACM SIGPLAN International Conference on Generative Programming: Concepts and Experiences, Co-located with SPLASH 2020.* Erwig, M. & Gray, J. (red.). Association for Computing Machinery, s. 70-83

Towards Declarative Specification of Multi-Drone BVLOS Missions for UTM
Campusano, M., Heltner, N., Molby, N., Jensen, K. & Schultz, U. P., nov. 2020, *2020 Fourth IEEE International Conference on Robotic Computing (IRC).* IEEE, s. 430-431

Editorial for GPCE&SLE2018 Special Issue
Pearce, D. & Schultz, U. P., aug. 2020, I: Journal of Computer Languages. 59, 100988.

Reversible control of robots
Schultz, U. P., maj 2020, *Reversible Computation: Extending Horizons of Computing - Selected Results of the COST Action IC1405.* Ulidowski, I., Lanese, I., Schultz, U. P. & Ferreira, C. (red.). Springer, s. 177-186 (Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), Bind 12070 LNCS).

Energy-Aware Design of Vision-Based Autonomous Tracking and Landing of a UAV
Zamanakos, G., Seewald, A., Midtiby, H. S. & Schultz, U. P., 2020, *2020 Fourth IEEE International Conference on Robotic Computing (IRC).* IEEE, s. 294-297

Mechanical and Computational Energy Estimation of a Fixed-Wing Drone
Seewald, A., Garcia de Marina, H., Midtiby, H. S. & Schultz, U. P., 2020, *2020 Fourth IEEE International Conference on Robotic Computing (IRC).* IEEE, s. 135-142

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Schultz, U. P., 2020, *Encyclopedia of Robotics.* Ang, M. H., Khatib, O. & Siciliano, B. (red.). Springer

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Mezzina, C. A., Schlatte, R., Glück, R., Haulund, T., Hoey, J., Holm Cservenka, M., Lanese, I., Mogensen, T., Siljak, H., Schultz, U. P. & Ulidowski, I., 2020, *Reversible Computation: Extending Horizons of Computing - Selected Results of the COST Action IC1405.* Ulidowski, I., Lanese, I., Schultz, U. P. & Ferreira, C. (red.). Springer, s. 41-59 (Lecture Notes in Computer Science, Bind 12070).

Component-based computation-energy modeling for embedded systems
Seewald, A., Schultz, U. P., Roeder, J., Rouxel, B. & Grelck, C., 20. okt. 2019, *Proceedings Companion of the 2019 ACM SIGPLAN International Conference on Systems, Programming, Languages, and Applications: Software for Humanity.* Smaragdakis, Y. (red.). New York, NY, USA: Association for Computing Machinery, s. 5-6

Increasing safety by combining multiple declarative rules in robotic perception systems
Ingibergsson, J. T. M., Kraft, D. & Schultz, U. P., 13. apr. 2019, *Cyber Physical Systems. Design, Modeling, and Evaluation: 7th International Workshop, CyPhy 2017, Revised Selected Papers.* Chamberlain, R., Taha, W. & Törngren, M. (red.). Springer VS, s. 43-60 (Lecture Notes in Computer Science, Bind 11267).

Adapting Parameterized Motions using Iterative Learning and Online Collision Detection
Laursen, J. S., Sørensen, L. C., Schultz, U. P., Ellekilde, L-P. & Kraft, D., 13. sep. 2018, *Proceeding of the 2018 IEEE International Conference on Robotics and Automation.* IEEE, s. 7587-7594

A Survey of Open-Source UAV Flight Controllers and Flight Simulators
Ebeid, E. S. M., Skriver, M., Terkildsen, K. H., Jensen, K. & Schultz, U. P., 1. sep. 2018, I: Microprocessors and Microsystems. 61, s. 11-20

Message from the IRC 2018 program co-chairs
Chang, C. M., MacDonald, B., Matson, E. & Schultz, U. P., 2. apr. 2018, I: Proceedings - 2nd IEEE International Conference on Robotic Computing, IRC 2018. 2018-January, s. xv

Reversible object-oriented programming with region-based memory management: Work-in-progress report
Schultz, U. P., jan. 2018, *Proceedings of the 10th International Conference on Reversible Computation.* Kari, J. & Ulidowski, I. (red.). Springer VS, s. 322-328 (Lecture Notes in Computer Science, Bind 11106).

Experience report: Studying the readability of a domain specific language
Ingibergsson, J. T. M., Hanenberg, S., Sunshine, J. & Schultz, U. P., 2018, *Proceedings of the 33rd Annual ACM Symposium on Applied Computing.* Association for Computing Machinery, Bind Part F137816. s. 2030-2033

Modelling reversible execution of robotic assembly
Laursen, J. S., Ellekilde, L. P. & Schultz, U. P., 2018, I: Robotica. 36, 5, s. 625-654

Safety Computer Vision Rules for Improved Sensor Certification
Mogensen, J. T. I., Kraft, D. & Schultz, U. P., 11. maj 2017, *Proceedings of the First IEEE International Conference on Robotic Computing (IRC).* IEEE, s. 89-92

Declarative Rule-based Safety for Robotic Perception Systems
Mogensen, J. T. I., Kraft, D. & Schultz, U. P., 2017, I: Journal of Software Engineering for Robotics. 8, 1, s. 17-31

DSLs in robotics: A case study in programming self-reconfigurable robots
Schultz, U. P., Bordignon, M., Stoy, K., Nordmann, A., Hochgeschwender, N. & Wrede, S., 2017, *Grand Timely Topics in Software Engineering: International Summer School GTTSE 2015, Tutorial Lectures.* Cunha, J., Fernandes, J. P., Lämmel, R., Saraiva, J. & Zaytsev, V. (red.). Springer, s. 98-123 (Lecture Notes in Computer Science, Bind 10223).

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Mogensen, J. T. I., Kraft, D. & Schultz, U. P., 2017, *Proceedings of the 12th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications.* Braz, J., Tremeau, A. & Imai, F. (red.). Institute for Systems and Technologies of Information, Control and Communication, Bind 6. s. 433-444

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Tell, P., Pfeiffer, R. H. & Schultz, U. P., 2017, *Product-Focused Software Process Improvement: 18th International Conference, PROFES 2017, Innsbruck, Austria, November 29–December 1, 2017, Proceedings.* Felderer, M., Méndez Fernández, D., Turhan, B., Kalinowski, M., Sarro, F. & Winkler, D. (red.). Springer, s. 420-427 (Lecture Notes in Computer Science, Bind 10611).

Message from the workshop chairs
Yallop, J. & Schultz, U. P., 2017, *Proceedings of the 2017 ACM SIGPLAN Workshop on Partial Evaluation and Program Manipulation.* Schultz, U. & Yallop, J. (red.). Association for Computing Machinery, s. iii 1 s.

Special Issue on the 2015 International Conference on Generative Programming: Concepts & Experiences (GPCE)
Gokhale, A., Asai, K. & Schultz, U. P., 2017, I: Computer Languages, Systems and Structures. 48, s. 1-2

Towards a Virtual Machine Approach to Resilient and Safe Mobile Robots
Adam, M. S., Kuhrmann, M. & Schultz, U. P., 3. nov. 2016, *Proceedings of the 21st IEEE International Conference on Emerging Technology and Factory Automation.* IEEE Press, 8 s. (I E E E International Conference on Emerging Technologies and Factory Automation. Proceedings).

Automatic code generation in practice: experiences with embedded robot controllers
Adam, M. S., Kuhrmann, M. & Schultz, U. P., 20. okt. 2016, *Proceedings of the ACM SIGPLAN International Conference on Generative Programming: Concepts and Experiences.* Schaefer, I. & Fischer, B. (red.). Association for Computing Machinery, s. 104-108

Rule-based Dynamic Safety Monitoring for Mobile Robots
Adam, M. S., Larsen, M., Jensen, K. & Schultz, U. P., jul. 2016, I: Journal of Software Engineering for Robotics. 7, 1, s. 120-141

Low-cost modular robotic system for neurological rehabilitative training
Sørensen, A. S., Nielsen, J., Maagaard, J., Skriver, M., Lin, C-C. & Schultz, U. P., 19. maj 2016, *Proceedings - 2016 IEEE International Conference on Industrial Technology, ICIT 2016.* IEEE Press, s. 1585-1591

Drone Identification and Tracking in Denmark
Jensen, K., Skriver, M. & Schultz, U. P., 2016, Syddansk Universitet. Mærsk Mc-Kinney Møller Instituttet. 56 s.

Elements of a Reversible Object-Oriented Language: Work-in-Progress Report
Schultz, U. P. & Axelsen, H. B., 2016, *Reversible Computation: Proceedings of the 8th Conference on Reversible Computation.* Devitt, S. & Lanese, I. (red.). Springer, s. 153-159 (Lecture Notes in Computer Science, Bind 9720).

On the Use of Safety Certification Practices in Autonomous Field Robot Software Development: A Systematic Mapping Study
Mogensen, J. T. I., Schultz, U. P. & Kuhrmann, M., 1. dec. 2015, *Product-Focused Software Process Improvement: Proceedings of the 16th International Conference on Product-Focused Software Process Improvement.* Abrahamsson, P., Corral, L., Oivo, M. & Russo, B. (red.). Springer, s. 335-352 (Lecture Notes in Computer Science, Bind 9459).

Towards tool support for spreadsheet-based domain-specific languages
Adam, M. S. & Schultz, U. P., 26. okt. 2015, *Proceedings of the 2015 ACM SIGPLAN International Conference on Generative Programming: Concepts and Experiences.* Kastner, C. & Gokhale, A. (red.). Association for Computing Machinery, s. 95-98

Automatic Error Recovery in Robot Assembly Operations Using Reverse Execution
Laursen, J. S., Schultz, U. P. & Ellekilde, L-P., 29. sep. 2015, *Proceedings of the 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems.* IEEE, s. 1785-1792

Towards a DSL for Perception-Based Safety Systems
Mogensen, J. T. I., Suvei, S-D., Hansen, M. K., Christiansen, M. P. & Schultz, U. P., 28. sep. 2015. 2 s.

Towards Declarative Safety Rules for Perception Specification Architectures
Mogensen, J. T. I., Schultz, U. P. & Kraft, D., 28. sep. 2015, *Proceedings of 6th International Workshop on Domain-Specific Languages and models for Robotic systems (DSLRob-15).* 4 s.

Information and communication technology (ICT) assisted intervention at home for patients with Cervical Radiculopathy: MAST evaluation of a pilot study
Rasmussen, H., Kjaer, P., Schultz, U. P. & Bondy, J., 31. aug. 2015, 8 s.

Towards a Domain-Specific Language for Reversible Assembly Sequences
Schultz, U. P., Laursen, J. S., Ellekilde, L-P. & Axelsen, H. B., 2015, *Reversible Computation: 7th International Conference, RC 2015, Grenoble, France, July 16-17, 2015, Proceedings.* Krivine, J. & Stefani, J-B. (red.). Springer, s. 111-126 (Lecture Notes in Computer Science, Bind 9138).

Applying Simulation and a Domain-Specific Language for an Adaptive Action Library
Buch, J. P., Laursen, J. S., Sørensen, L. C., Ellekilde, L-P., Kraft, D., Schultz, U. P. & Petersen, H. G., 20. okt. 2014, *Simulation, Modeling, and Programming for Autonomous Robots.* Brugali, D., Broenink, J. F., Kroeger, T. & MacDonald, B. A. (red.). Springer, Bind 8810. s. 86-97 (Lecture Notes in Computer Science, Bind 8810).

Towards Rule-Based Dynamic Safety Monitoring for Mobile Robots
Adam, M. S., Larsen, M., Jensen, K. & Schultz, U. P., 20. okt. 2014, *Simulation, Modeling, and Programming for Autonomous Robots: 4th International Conference, SIMPAR 2014, Bergamo, Italy, October 20-23, 2014. Proceedings.* Brugali, D., Broenink, J. F., Kroeger, T. & MacDonald, B. A. (red.). Springer, s. 207-218 (Lecture Notes in Computer Science, Bind 8810).

Towards Interactive, Incremental Programming of ROS Nodes
Adam, M. S. & Schultz, U. P., okt. 2014. 5 s.

Towards automatic consistency checking of software components in field robotics
Larsen, M., Adam, M. S., Schultz, U. P. & Jørgensen, R., 21. maj 2014, *Proceedings of the Second International Conference on Robotics, Associated High-Technologies and Equipment for Agriculture and Forestry: New trends in mobile robotics, perception and actuation for agriculture and forestry.* Gonzalez-de-Santos, P. & Ribeiro, A. (red.). s. 409-418 10 s.

Towards Error Handling in a DSL for Robot Assembly Tasks
Laursen, J. S., Buch, J. P., Sørensen, L. C., Kraft, D., Petersen, H. G., Ellekilde, L-P. & Schultz, U. P., 2014. 5 s.

Towards Using a Generic Robot as Training Partner: Off-the-shelf robots as a platform for flexible and affordable rehabilitation
Sørensen, A. S., Savarimuthu, T. R., Nielsen, J. & Schultz, U. P., 2014, *Proceedings of the 9th ACM/IEEE International Conference on Human-Robot Interaction.* Association for Computing Machinery, s. 294-295

Towards Automatic Migration of ROS Components from Software to Hardware
Lange, A. B., Schultz, U. P. & Sørensen, A. S., 8. nov. 2013, *Proceedings of the Fourth International Workshop on Domain-Specific Languages and Models for Robotic Systems.* 4 s.

Unity-Link: A Software-Gateware Interface for Rapid Prototyping of Experimental Robot Controllers on FPGAs
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Teaching Portfolio
Fundamental pedagogical view

My approach to and motivation for teaching is captured by the following quote: “Always be a first-rate version of yourself, instead of a second-rate version of somebody else. —Judy Garland” I always strive to communicate the subject being taught in a personal and lively way, based on my own interpretation and in combination with selected material grounded in relevant scientific literature. I carefully motivate why each topic is included, and I have high expectations for how much the students learn. Although I strive for friendly interactions with students, I generally adhere to an underlying principle of “tough love” where students are given difficult challenges and praise must be earned.

I believe the key to good teaching lies in effective two-way communication. As a teacher I must adapt my communication to the specific topic, the specific students, and the specific interaction we are having at a given point in time. Interactivity is key to this communication, to lift students I must meet them where they are, and this is only possible if I communicate effectively with them.

I embrace the use of new technologies, new techniques, and the inclusion of new subject matters in the courses that I teach. New technologies often provide opportunities for enhancing various aspects of the way I teach, although they never change the fundamental principles. New techniques provide opportunities for new forms of interaction and for new ways of structuring the learning process, which can serve to complement the basic communication with the students. I enjoy discussing teaching issues with my colleagues, both issues specific to selected courses and general pedagogical issues. I see good teaching as a continuous evolution over the years, both in terms of content and form.
I view my teaching in the context of the curriculum as a whole, and just as I strive to continuously improve my own teaching and my own courses, I strive for continuous improvement of the curriculum as a whole. True excellence of a curriculum requires a synergy of the individual components that takes time to develop and is difficult to achieve in practice.

Teaching experience

I have taught one Software Engineering bachelor course, 18 Master courses in Computer Science, Robotics and Software Engineering, and I am currently teaching a special Robotics MSc version of the interdisciplinary Experts in Team Innovation course. I have defined the course contents and learning goals for most of the courses that I have taught. Without any exceptions, I have always defined the specific contents and the curriculum, and I have always created my

own teaching materials (e.g., slides and exercises).

I have played a major role in the continuous evolution and development of educations at the Technical Faculty, University of Southern Denmark:

•I motivated the need for and lead the development of the Scientific Methods master-level course, which initially was designed for the Robotics education, but now also is present on Software Engineering, Welfare Technology, Energy Technology, and Game Development and Learning Technology.

•Based on interaction with researchers at MIT, I motivated the need for and helped to develop the first version of the Robot Systems Development course, now a key element of the Robotics Master education, and the foundation for the newly developed Experts in Team Innovation Robotics MSc course.

•As part of teaching the ESD and DES courses in the Mechatronics education (see below), I lead the development of the two-way remote-teaching system that connects the engineering educations at Odense and Sønderborg campus.

•I played a key role throughout the development and implementation of the highly successful Software Engineering and Software Technology educations, strongly influencing the overall vision of the program, the composition of the curriculum, the specific course descriptions, and the teaching practice employed at Bachelor and Master levels of the education.

•I lead the newly completed revision of the Robotics Master profile in Drones and Autonomous Systems (previously Unmanned Aerial Systems), for the first time providing a complete program that not only covers relevant areas in aerial robotics, but also provides a strong synergy with the robotics research at the Mærsk Institute in general.

•I am currently co-teaching and co-developing the new Experts in Team Innovation Robotics MSc course, which builds on the ideas and concepts of the existing Experts in Team Innovation Bachelor course taught to all students at the Technical Faculty of SDU, and significantly enriches the project-based learning to match the abilities of Master-level students in Robotics.

I continue to be involved in the development of our education, and I am a member of the Education Committee at University of Southern Denmark for Robotics since 2007 (and was a member of the Software Engineering Education Committee 2014-2019).

The courses that I have taught are the following

1.Experts in Team Innovation MSc for Robotics, taught fall 2020, interdisciplinary course at the Technical Faculty, University of Southern Denmark. Evolution of the existing Bachelor-level Experts in Team Innovation course to accommodate project-based learning at the Master level for robotics students.

2.Model-Driven Software Development Project (MDSD-P), taught spring 2019-2021, Software Engineering MSc course at MMMI, University of Southern Denmark. Evolution of the Model-Driven Software Development (MDSD) course (described below) to better accommodate individual, project-oriented development. Material covered: see MDSD.

3.Model-Driven Software Development (MDSD), taught spring 2017-2018, Software Engineering MSc course at MMMI, University of Southern Denmark. Material covered: metamodeling, domain-specific languages, automatic program generation, parsing, model-driven software development.

4.Distribution and Integration Technologies (TEC), taught spring 2016, Software Engineering MSc course at MMMI, University of Southern Denmark. Material covered: web-based systems, scalability, virtualization.

5.Software Customization (SWC), taught spring 2014-2016, Software Engineering MSc course at MMMI, University of Southern Denmark. Material covered: domain-specific languages, automatic program generation, parsing, model-driven software development.

6.Operating Systems and Networks (OPN), taught fall 2013-2017, Software Engineering BSc course at MMMI, University of Southern Denmark. Material covered: operating systems, virtual machines, networks, socket- and object-based communication.

7.Programming languages, description and execution (SSE02), taught spring 2012-2013, Robotics MSc course at MMMI, University of Southern Denmark. Material covered: general programming languages principles, domain-specific languages, automatic program generation, agile software development.

8.Embedded Software Design (ESD), taught spring 2011, Mechatronics and Robotics MSc course taught remote in parallel at MCI and MMMI, University of Southern Denmark. Material covered: hierarchical state machines, automatic code generation, domain-specific languages.

9.Scientific Methods (SCM), taught fall 2009, 2010, Robotics MSc course at MMMI, University of Southern Denmark. Material covered: empirical science, scientific methods, statistics, reading and writing academic papers.

10.Software Aspects of Embedded Systems (EMB4) / Distributed Embedded Systems (DES), co-taught fall 2010-2011, taught fall 2012, Mechatronics and MSc course taught remote in parallel at MCI and MMMI, University of Southern Denmark. Material covered: operating systems, device drivers, real-time programming, distributed embedded systems, automatic program generation.

11.Advanced Topics in Software Engineering (SSE05), taught spring 2008, Robotics MSc course at MMMI, University of Southern Denmark. Material covered: advanced topics in programming languages and frameworks, empirical methods.

12.Model-based Processes and Systems (SSE04), taught spring 2006-2009 (fourth quarter), Computer Systems Engineering MSc course at MMMI, University of Southern Denmark. Material covered: model-driven software development, agile development processes, domain-specific languages, code generation.

13.Introduction to Software Systems Engineering (SSE01), taught fall 2005-2008 (first quarter), Computer Systems Engineering MSc course at MMMI, University of Southern Denmark. Material covered: object-oriented programming, unified process, unified modelling language, mobile agents.

14.Aspects of Object-Oriented Programming (dAOOP), co-taught fall 2001 and 2004 (second quarter), Computer Science MSc course at CS, University of Aarhus, Denmark. Material covered: virtual machines, static and dynamic optimizations.

15.Software Patterns, taught fall 2004 (first quarter), Computer Science MSc course at CS, University of Aarhus, Denmark. Material covered: design patterns, architectural patterns, frameworks, antipatterns, and various other kinds of patterns. (At the time the largest elective graduate course to date at the Computer Science Department, with over 100 students.)

16.Partial Evaluation for Imperative and Object-Oriented Languages, taught spring 2004 (fourth quarter), Computer Science MSc course at CS, University of Aarhus, Denmark. Material covered: generative programming, two-level languages, binding-time analysis, applications of partial evaluation.

17.Pervasive Computing (PvC), co-taught fall semester 2003, Computer Science MSc course at CS, University of Aarhus, Denmark. Material covered: technologies and issues in pervasive computing, context awareness, software mobility, embedded systems.

18.Patterns and Software Architecture (PASA), taught spring 2001, co-taught spring 2002-2003, Computer Science MSc course at CS, University of Aarhus, Denmark. Material covered: general introduction to software patterns, design patterns, frameworks, and software components.

19.Distributed Objects and Pervasive Computing (DOPC), co-taught fall 2002, Computer Science MSc course at CS, University of Aarhus, Denmark. Material covered: Java RMI, CORBA, J2EE, overview of topics in pervasive computing.

20.Design and Implementation of Object-Oriented Virtual Machines (OOVM), co-taught spring 2002, Computer Science MSc course at CS, University of Aarhus, Denmark. Material covered: virtual machines, advanced dynamic optimizations.

In addition, I have taught adapted versions of the SWC/MDSD courses as advanced Ph.D. courses; supervised 18 semester project groups on the third semester of the Software Engineering BSc/Software Technology BEng education in the years 2013-2019; served as semester coordinator of this semester 2015-2016; supervised 63 MSc students, 10 Ph.D. students, and 3 post-docs; and co-supervised the Lecturer Training Program of Assist.Prof. Agus Hassan (SDU UAS). Course evaluations have reflected a high level of learning and a high degree of satisfaction from the students.

Formal pedagogical education

I have followed the two-day course in university pedagogy for assistant professors (adjunktpædagogisk kursus) offered by the University of Aarhus, summer 2001.

Description of practice

Key elements of my teaching practice can be outlined through selected examples from the two courses that I currently teach, namely Model-Driven Software Development Project (MDSDP) and Experts in Team Innovation MSc (EiT-MSc):
•Teaching content and learning objectives. One of the main goals of the MDSDP course is to provide basic compiler knowledge to Software Engineering students. Unlike a traditional compiler course for computer scientists, the content and learning objectives however emphasize topics immediately perceived as relevant to Software Engineering students. This includes internal domain-specific languages, model-driven development, and automated code generation. Moreover, the focus on domain-specific languages gives the course an application-oriented angle that motivates the students and makes it easy to link MDSDP to other courses on the same semester, as outlined below.

•Teaching and evaluation methods. Both MDSDP and EiT-MSc are advanced courses emphasizing project-based learning with open-ended selection of topics. In both cases the students are free to choose what challenges to address with their project. This creates more room for the stronger students to learn and to demonstrate the full extent of their abilities but can be challenging for the weaker students. I use a combination of project group supervision and class-level guidance towards the use of specific solution approaches to support the weaker students. The evaluation according to specific technical learning goals is challenging in such open-ended courses, but this issue can be countered by explicitly separating the project-based learning from the more concrete technical learning goals. In MDSDP this is done by using two separate exams: a take-home exam focusing on a concrete development task and a project exam focusing on the open-ended project and the associated learning.

•External influencing factors. Both MDSDP and EiT-MSc have been designed for compatibility with the rest of the education program. I actively encourage the MDSDP students to use challenges identified in other courses on the same semester as topics for their projects, and I work with the teachers of these courses to define useful starting points for the students, in order to facilitate such inter-course projects. EiT-MSc requires a significant amount of coordination, since it is co-taught with Prof. Schlette (SDU Robotics) and Assoc.Prof. Johansen (SDU Global Sustainable Production), makes uses of Ph.D. students and scientific assistants for group supervision, and requires use of the SDU UAS lab facilities at the HCA Airport. Significant preparation and planning prior to the start of the semester was required to ensure that the teaching of EiT-MSc could be done according to the needs of the Robotics MSc students, be compatible with the Bachelor-level EiT course taught by Assoc.Prof. Johansen, and make use of a newly developed experimental drone platform (see below) and the lab facilities at HCA Airport.

•Examples of produced teaching resources. The experimental drone platform and accompanying documentation made available to the EiT-MSc students is derived from the HealthDrone project and based on earlier courses taught by Assoc.Prof. Jensen (SDU UAS). The updated version of the material however increases the focus on supporting open-ended projects and emphasizes the use of simulation in prototyping. The goal is to develop this material into an open experimental platform for teaching aerial robotics, including guides for both educators and students in usage of the platform. This material would be unique due to the ability of the drone to safely and legally perform flights beyond visual line of sight (BVLOS, based on the addition of the safety module developed by Assoc.Prof. Jensen in the context of HealthDrone).

•Results of student evaluations and follow-up. The MDSDP course has been continuously evolved based on interactive mid-way evaluations and written end-of-semester evaluations. Student evaluations for example indicated a wish to change the balance between my use of slides and the blackboard, depending on the type of material. The students felt that while the blackboard worked well for some kinds of material, it was too slow and not well suited for other kinds of material. Based om this feedback I immediately adjusted to increase the use of slides to provide an overview of topics and to recap material presented on blackboard in earlier lectures. Through this process my use of the blackboard became more focused on difficult technical material and on delivering interactive teaching where the examples used on the blackboard are generated interactively with the students during class.

•How my fundamental pedagogical view influences my teaching. Teaching the MDSDP course required significant adaptation in spring 2020 due to the COVID-19 pandemic and the resulting requirement to teach remotely. In my pedagogical view (above) I emphasize “effective two-way communication”, and I felt that switching to “videos of slides” would not be an appropriate way to communicate the material. Rather, I made extensive use of home-recorded videos presenting the material by writing and drawing on paper in the same way as I would have presented the material on the blackboard. This was complemented by use of discussion forums and adoption of the “discord” online platform for project supervision. The use of discord in particular proved efficient to support interaction with students in a way that emulated the interactions I would normally have with them in class. My investment into this form of online, interactive communication was successful, and I was able to achieve the same level of learning and student satisfaction for the course as seen in previous years.

Knowledge basis

My research and teaching activities provides direct connections with relevant companies in areas such as aerial robotics (Sky-Watch, Lorenz Technology, Avy, Naviair); industrial and mobile robotics (Universal Robots, Mobile Industrial Robots, AgroIntelli); communications infrastructure (Ericsson, TDC); and software engineering (Google, Hesehus, Systematic). These connections naturally serve to keep me up to date with central tendencies within the employment areas of the Robotics and Software Engineering programs. The technology development work that is part of my current research projects such as GENIUS and HealthDrone gives me a high level of awareness of technological innovation and provides a testbed for evaluation of new technological developments.
My continuous interaction with the academic communities in both Robotics and Software Engineering provides a solid basis for research-based teaching in both areas. As a concrete example, I am a member (previously Chair) of IFIP Working Group 2.11 on Program Generation, where I regularly meet with world-leading researchers in program generation. Teaching is regularly discussed at our meetings, providing a unique opportunity for both improving and communicating the way I teach advanced topics in software engineering.