

Tarkvarateaduse instituut, 2019. aasta uurimisrühmade teadus- ja arendustegevuse ülevaade

TARKVARATEADUSE INSTITUUT

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DEPARTMENT OF SOFTWARE SCIENCE

Director: Jaan Penjam, jaan.penjam@ttu.ee

Instituudis tegutsevad järgmised uurimisrühmad:

- Andmeteaduse töörühm. Juht: professor SADOK BEN YAHIA, sadok.ben@taltech.ee
- Infosüsteemide töörühm. Juht: professor DIRK DRAHEIM, dirk.draheim@taltech.ee
- Keeletehnoloogia laboratoorium. Juht: sihtrahastusega vanemteadur TANEL ALUMÄE, tanel.alumae@taltech.ee
- Kompositsiooniliste süsteemide ja meetodite labor. Juht: professor PAWEŁ SOBOCIŃSKI, pawel.sobocinski@taltech.ee
- Küberkriminalistika ja küberjulgeoleku keskus. Juht: sihtrahastusega professor RAIN OTTIS, rain.ottis@taltech.ee
- Mittelineaarsete juhtimissüsteemide töörühm. Juht: juhtivateadur ÜLLE KOTTA, ulle.kotta@taltech.ee
- Plokiahelate tehnikate töörühm. Juht: dotsent ALEXANDER HORST NORTA, alexander.norta@taltech.ee
- Proaktiivtehnoloogiate laboratoorium. Juht: professor LEO MÖTUS, leo.motus@taltech.ee
- Rakendusliku tehismõistuse töörühm. Juht: arendusspetsialist VAHUR KOTKAS, vahur.kotkas@taltech.ee
- Tugevalt tagatud tarkvara laboratoorium. Juht: juhtivateadur TARMO UUSTALU, tarmo.uustalu@taltech.ee

The department conducts research within 10 research units:

- Blockchain Technologies Group. Head Alexander Norta
- Centre for Digital Forensics and Cyber Security. Head Rain Ottis
- Data Science Group. Head Sadok Ben Yahia
- High-assurance Software Laboratory. Head Tarmo Uustalu
- Information Systems Group. Head Dirk Draheim
- Laboratory of Language Technology. Head Tanel Alumäe
- Laboratory of Proactive Technologies. Head Leo Mötus
- Laboratory of Lab for Compositional Systems and Methods. Head Pawel Sabocinski
- Model-Based Software Engineering Group. Head Vahur Kotkas
- Nonlinear Control Systems Group. Head Ülle Kotta

Andmeteaduse töörühm / Data science group

1. The research group leader: Sadok Ben Yahia, professor, tel. 53 653258, sadok.ben@taltech.ee, 0000-0001-8939-8948

2. Academic members of the research group:

Imen Ben Sassi, järeldoktor-teadur

Jaak Henno, vanemteadur

Innar Liiv, dotsent, 0000-0001-5236-0145

Grete Lind, spetsialist

Ahti Lohk, lektor, 0000-0003-0751-6715

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Chahinez Ounoughi, doktorant

Ashiq Ahmed, doktorant





3. Keywords: Data Science, Combinatorial optimisation, smart cities

4. Overview:

The Data Science Group is carrying out research activities towards extracting value from information standing at the crossroads of some of priority areas, e.g.,

- Cyber security : Intrusion /outlier detection
- Digital transformation of the society; healthcare information systems (Adverse events in hospitals, mining of patient trajectory)
- Smart-environment : IOT : Intelligent transportation system, smart city, smart home

Selected publications 2019:

- Taoufik Yeferny , Sofian Hamad, Sadok Ben Yahia: Query Learning-Based Scheme for Pertinent Resource Lookup in Mobile P2P Networks. *IEEE Access*, 7: 49059-49068 (2019)
- Syed Attique Shah , Dursun Zafer Seker, M. Mazhar Rathore , Sufian Hameed, Sadok Ben Yahia, Dirk Draheim: Towards Disaster Resilient Smart Cities: Can Internet of Things and Big Data Analytics Be the Game Changers? *IEEE Access*, 7: 91885-91903 (2019)
- Amira Mouakher, Oumaima Ktayfi, Sadok Ben Yahia : Scalable computation of the extensional and intensional stability of formal concepts. *Int. J. General Systems* 48(1): 1-32 (2019)

5. Outstanding results: --

6. Affiliation to the TalTech Academic Development Plan priority areas:

- Dependable IT solutions
- Future governance

7. Field(s) of research activity according to the Frascati:

1.2 Arvutiteadus ja informaatika / Computer and information sciences

8. Honours/awards: --

9. Participation in the activities of international R&D organizations:

- Keynote speakers
 - Innar LIIV, Oxford Internet Institute, London, UK (2019)
 - Innar LIIV, Data for Policy Conference 2019, London, UK (06/2019)
 - Leo VOHANDU, CLA2020, Tallinn, Estonia (6/2020)
 - Sadok BEN YAHIA, FDSE2019, Ho Chi Minh City, Vietnam (11,2019)
- Organization of International conferences

- 12th Concept Lattice and Applications (CLA2020), June 30th-July 1th 2020, Tallinn, Estonia
- 10th International Conference on Model & Data Engineering (MEDI2020), November 4th-6th 2020, Tallinn, Estonia
- Program-chairing
 - Co-program chair of ICBI2020 *International Conference on Big data, IoT, and Cloud Computing*, in Tokyo (Japan) on October 9-11, 2020

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) : --

11. Where the results of ongoing R&D can be applied? : --

Infosüsteemide töörühm / Information systems group

1. The research group leader: Prof. Dr. Dirk Draheim, full professor, Software Science Department, Information Systems Group, Akadeemia tee 15a, 12169 Tallinn, Room no. 641, +372 5884 6997, dirk.draheim@taltech.ee

2. Academic members of the research group:

Sidra Azmat Butt, doktorant-nooremteadur
 Erki Eessaar, dotsent
 Regina Erlenheim, lektor
 Kristiina Hiie, lektor
 Liisa Jõgiste, lektor
 Minakshi Kaushik, doktorant-nooremteadur
 Markko Liutkevicius, peaanalüütik, doktorant
 Silvia Lips, doktorant-nooremteadur
 Keegan David Braun McBride, doktorant-nooremteadur
 Kristina Murtazin, lektor
 Ingrid Pappel, dotsent
 Karl Ivory Pappel, analüütik
 Vishwajeet Pattanaik, doktorant-nooremteadur
 Sijo Arakkal Peious, doktorant-nooremteadur
 Gunnar Piho, dotsent
 Viljam Puusep, lektor
 Rahul Sharma, doktorant-nooremteadur
 Suran, Shweta, doktorant-nooremteadur
 Tõnn Talpsepp, vanemteadur
 Jaak Tepandi, professor
 Valentyna Tsap, doktorant-nooremteadur
 Enn Õunapuu, dotsent

3. Keywords:

information systems, e-government, e-governance, e-health, data science, system architecture, system design, databases, large-scale systems

4. Overview:

The Tallinn Tech Information Systems Group conducts research in large- and ultra-large-scale IT systems. We investigate the architecture, design, realization and management of IT system landscapes, high-volume data-intensive systems, high-volume workflow-intensive systems, massively resource-intensive systems, highly distributed systems.

We are engaged into education with the International Study Programme on e-Governance Technologies and Services with Assoc.-Prof. Dr. Ingrid Pappel as Head of Study Programme and the Study Programme Business Information Technology with Assoc.-Prof. Gunnar Piho as Head of Study Programme.

Together with our partners from industry, academia and the public sector we strive for excellent solutions for non-standard, mission-critical IT system problems.

- Ingrid Pappel, Valentyna Tsap, and Dirk Draheim. The e-LocGov Model for Introducing e-Governance in Local Governments – an Estonian Case Study. IEEE Transactions on Emerging Topics in Computing, 2019.
- J. Tepandi, J. Verhoosel, P.C. Jack, D. Zeginis, G. Wettergren, J. Dimitriou, C. Rotuna, C. Carabat, Ö. Albayrak, E. Yilmaz, T. Lampoltshammer, E. Täks, A. Prentza, P. Brandt, P. Kavassalis, L. Leontaridis, J.W. Streefkerk, Generic Federated OOP Architecture (1st version). European Commission, 2017.
- Dirk Draheim. Generalized Jeffrey Conditionalization - A Frequentist Semantics of Partial Conditionalization. Springer, 2017.

5. Outstanding results: --

6. Affiliation to the TalTech Academic Development Plan priority areas:

- Future governance
- Dependable IT solutions

7. Field(s) of research activity according to the Frascati:

1.2 Arvutiteadus ja informaatika / Computer and information sciences

8. Honours/awards: --

9. Participation in the activities of international R&D organizations: --

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) : --

11. Where the results of ongoing R&D can be applied? : --

Keeletehnoloogia laboratoorium / Laboratory of language technology

1. The research group leader: Tanel Alumäe, vanemteadur, tel 6204201, tanel.alumae@taltech.ee

2. Academic members of the research group:

- Einar Meister, vanemteadur
- Lya Meister, teadur
- Rainer Metsvahi, programmeerija
- Jörgen Valk, tarkvaraarendaja
- Asad Ullah, doktorant

3. Keywords:

kõnetehnoloogia, foneetika, kõnekorpused / speech technology, phonetics, speech corpora

4. Overview:

Kompetentsid:

- Kõnetuvastus
- Kõneleja, kõneldava keele ja aktsendi identifitseerimine
- Kõnekorpused
- Foneetika (eesti keele prosoodia, L2 kõne)
- Mimesugused loomuliku keele töötamise alamteemad

Labori üheks väljapaistvamaks tegevuseks on eesti keele kõnetuvastuse arendus ning avalikult kättesaadavate kõnetuvastusteenuste loomine. Kuigi me keskendume arendustöös eesti keelele, on enamik laboris loodud meetodeid ja tehnoloogiaid keelest sõltumatud. Laboris välja töötatud tarkvara on saadaval vaba tarkvara litsentsi alusel.

The lab focuses on the following topics:

- Speech Recognition
- Speaker, spoken language and accent identification
- Speech corpora
- Phonetics (Estonian language prosody and vocal system, L2 speech)
- Various sub-topics of natural language processing

One of the important activities is the creation of speech technology applications targeted at society as a whole. This includes applications of end-user speech recognition as well as the key integration components that are easy to integrate. Although the focus is on speech recognition in Estonian, most of the software created in the laboratory is not specific to Estonian. The laboratory is a solid open source free software supporter.

Valitud viimase kolme aasta teadusartiklid / Selected papers:

- Paats, A.; Alumäe, T.; Meister, E.; Fridolin, I. (2018). Retrospective analysis of clinical performance of an Estonian speech recognition system for radiology: effects of different acoustic and language models. *Journal of Digital Imaging*, 31 (5), 615–621
- Alumäe, Tanel (2018). Training speaker recognition models with recording-level labels. 2018 IEEE Workshop on Spoken Language Technology, SLT 2018 : Proceedings, December 18-21, 2018, Athens, Greece.
- Chorowski, Jan K.; Laurent, Antoine; Chen, Nanxin; Dolfing, Hans J.G.A.; Łańcucki, Adrian; Sanchez, Guillaume; Khurana, Sameer; Alumäe, Tanel; Laurent, Antoine (2019). Unsupervised neural segmentation and clustering for unit discovery in sequential data. Perception as generative reasoning : Structure, Causality, Probability, NeurIPS 2019 workshop, Friday Dec.13, Vancouver. 1–7.

5. Outstanding results: --

6. Affiliation to the TalTech Academic Development Plan priority areas:

- Dependable IT solutions
- Future governance

7. Field(s) of research activity according to the Frascati:

1.2 Arvutiteadus ja informaatika / Computer and information sciences

8. Honours/awards: --

9. Participation in the activities of international R&D organizations: --

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) : --

11. Where the results of ongoing R&D can be applied? : --

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Kompositsiooniliste süsteemide ja meetodite labor / Lab for Compositional Systems and Methods

1. The research group leader: Paweł Sobociński (name, position and phone, e-mail)
2. Academic members of the research group: --
 - Prof Paweł Sobociński (group leader), Dr Edward Morehouse (postdoc), Dr Fosco Loregian (postdoc), Elena Di Lavore (PhD student), Nathan Haydon (PhD student), Chad Nester (PhD student), Mario Román (PhD student)
3. Keywords:
 - compositionality, open games, open systems, applied category theory, programming languages, diagrammatic reasoning, string diagrams, logic in computer science, relational methods
4. Overview: --

Research topics: The group's goal is to study compositional techniques in the context of models of computation, understood broadly. Compositionality means that syntactic descriptions for (open) systems are designed to be compatible with their semantics. While the examples motivating the research come from a broad section of scientific disciplines (logic, control theory, formal language theory, control theory, business processes, game theory, economics, machine learning), we have identified common principles for reasoning about open systems, guided by category theory. These including a semantic universe based on relations rather than functions, and the use of the diagrammatic syntax of string diagrams. String diagrams provide an intuitive calculus for computations via diagrammatic reasoning, and fine-grained control over resources, which is important for faithful descriptions of open systems. Our big questions/challenges are

 - 1) design a next generation of programming/specification languages that will be more suited for compositional (and therefore, more trustworthy and reliable) descriptions of systems,
 - 2) use compositionality to improve the analysis of systems, including the design of new techniques and algorithms, and
 - 3) design and implement tools for working with string diagrams, fast-tracking the passage from theory to practice.

Valitud teadusartiklid / Selected papers (since September 2019 - date of group formation):

 - Nathan Haydon, Paweł Sobociński, “Compositional Diagrammatic First-Order Logic”. In preparation.
 - Elena Di Lavore, Jules Hedges, Paweł Sobociński, “Open games on Open Graphs”. In preparation. Chad Nester, “A Foundation for Ledger Structures”. In peer review.
 - Bryce Clarke, Derek Elkins, Jeremy Gibbons, Fosco Loregian, Bartosz Milewski, Emily Pillmore and Mario Román, “Profunctor optics, a categorical update”. In peer review.
 - Filippo Bonchi, Robin Piedeleu, Paweł Sobociński and Fabio Zanasi, “Contextual Equivalence for Signal Flow Graphs”. FoSSaCS 2020, to appear.
 - Nicolas Behr and Paweł Sobociński, “Rule Algebras for Adhesive Categories”. In peer review.
5. Outstanding results: --
6. Affiliation to the TalTech Academic Development Plan priority areas:
 - Dependable IT solutions
7. Field(s) of research activity according to the Frascati:
 - 1.2 Arvutiteadus ja informaatika / Computer and information sciences

8. Honours/awards:

Recognition:

The group has already hosted international academic visitors from leading research universities and institutions in France, Germany, UK and Brazil. Sobocinski is serving on the programme committees of several prestigious conferences in 2020, including the 25th Annual ACM/IEEE Symposium on Logic in Computer Science (LICS 2020) and the 17th International Conference on Quantum and Physics Logic (QPL 2020). He is an associate editor of journals Compositionality and Mathematical Structures in Computer Science.

Events:

* The group will host a meetup/hackathon February 17-21 attended by the entire development team (~10 people) of the Dutch startup Statebox, as well as developers from the UK and Italy. Estonian startups have also been invited and representatives from Guardtime and Multics will attend.

* The group will host SYCO 7 <http://events.cs.bham.ac.uk/syco/7/>, the Seventh Symposium on Compositional Structures on March 30-31, held at the Estonian Academy of Science.

9. Participation in the activities of international R&D organizations: --

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) : --

11. Where the results of ongoing R&D can be applied? : --

Küberkriminalistika ja küberjulgeoleku keskus / Centre for digital forensics and cyber security

1. The research group leader: Rain Ottis, sihtkohastusega professor / research professor, +372 620 2328, rain.ottis@taltech.ee

2. Academic members of the research group:

- a. Akadeemilised ametikohad: Olaf Manuel Maennel, Ahto Buldas, Hayretdin Bahsi, Stefan Sütterlin, Matthew Sorell, Adrian Venables, Risto Vaarandi, Birgy Lorenz, Eneken Tikk, Mika Juha Kerttunen, Anna-Maria Osula, Andro Kull, Aleksandr Lenin, Toomas Lepik
- b. järeldoktorid: [hetkel ei ole](#)
- c. doktorandid: Dan Heering, Alejandro Guerra Manzanares, Kaie Maennel, Sten Mäses, Jaan Priisalu, Tiia Sömer, Pavel Tšikul
- d. Mitteamakadeemilised ametikohad, kellel on oluline panus teadusuuringutesse: Kristine Hovhannisyan, Andrew Roberts, Anu Baum, Martha Jung, Kristi Ainen, Kieren Lovell

3. Keywords:

küberturvalisus, digitaalne ekspertiis, krüptograafia / cybersecurity, digital forensics, cryptography

4. Overview:

Küberkriminalistika ja küberjulgeoleku keskus tõstab Eesti küberturvalisuse kompetentsi läbi hariduse, teaduse ja teadmussiidre. Keskuse eksperdid esindavad erinevaid teadusvaldkondi nagu arvutiteadus, õigusteadus ja psühholoogia. See võimaldab uurimiserühmal ette võtta tänapäeva keerulisi küberturvalisuse probleeme, mis vajavad interdistsiplinaarset lähenemist.

Keskuse peamised uurimissuunad on: elutähtsa infotaristu kaitse (fookusega e-valitsemise ja transpordisektoritel), krüptograafia, võrgumonitoring, digitaalne ekspertiis, haridusteadus ning küberjulgeoleku strateegilised küsimused.

TalTech Centre for Digital Forensics and Cyber Security works towards raising Estonian cyber security competence and capacity through education, research and knowledge transfer. The research team includes experts from various scientific disciplines, including computer science, law and psychology. Such a team can take on today's complex cyber security issues that require an interdisciplinary approach.

The main research directions of the Centre are: Critical Information Infrastructure Protection (focus on eGovernance and transportation sectors), cryptography, network monitoring, digital forensics, education research, and cyber security strategy and policy.

Valitud teadusartiklid / Selected papers

- Firsov, Denis; Buldas, Ahto; Truu, Ahto; Laanoja, Risto (2020). **Verified security of BLT signature scheme**. CPP '20 : Proceedings of the 9th ACM SIGPLAN International Conference on Certified Programs and Proofs : January 20-21, 2020, New Orleans, LA, US. Ed. Blanchette, Jasmin; Hrițcu, Cătălin. New York, NY: ACM, 244–257.
- Blumbergs, Bernhards; Ottis, Rain; Vaarandi, Risto (2019). **Crossed Swords: a cyber red team oriented technical exercise**. Proceedings of the 18th European Conference on Cyber Warfare and Security, ECCWS 2019 : University of Coimbra, Portugal, 4-5 July 2019.
- Guerra-Manzanares, Alejandro; Nömm, Sven; Bahsi, Hayretin (2019). **In-depth feature selection and ranking for automated detection of mobile malware**. Proceedings of the 5th International Conference on Information Systems Security and Privacy, ICISPP 2019, February 23-25, 2019, Prague, Czech Republic, Vol. 1. Ed. Mori, Paolo; Furnell, Steven; Camp, Oliver. Prague: SciTePress, 274–283.

5. Outstanding results: --

6. Affiliation to the TalTech Academic Development Plan priority areas:

- Keskuse peamine fookus langeb täielikult kokku AAK prioriteediga „usaldusväärsed IT lahendused“.
- Lisaks sellele on küberturvalisus oluline vundament ka „tulevikku vaatava riigivalitsemise“ ja „tarkade ja energiatõhusate keskkondade“ jaoks.

7. Field(s) of research activity according to the Frascati:

- 1.2 Arvutiteadus ja informaatika / Computer and information sciences
- 5.3 haridusteadused

8. Honours/awards: --

9. Participation in the activities of international R&D organizations: --

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) :

- Küberkaitse õppuste, läbistustestimise ja kriisijuhtimise alane teadmussiire:
 - VA17103 - koostööprojekt Korea Riikliku Julgeolekuuuringute Instituudiga nende riikliku küberkaitseõppuse arendamiseks (2017-2019).
 - Küberintsidentide haldamise lauaõppused erasektorile 2019: PipeDrive, Elektrilevi, SK ID Solutions.

- Osalemine NATO CCDCOE õppuste arendamisel ja läbiviimisel (Locked Shields ja Crossed Swords õppusteseeriad)
- LEP17045 - Nutika spetsialiseerumise projekt Guardtime'ga (2017-2019): BLT signatuuriskeemi arendamine.
- LEP17064 – Nutika spetsialiseerumise projekt CybExer Technologies'ga (2017-2019): küberhügieen.
- LMIN18052 – Eesti küberjulgeoleku võime analüüs MKM-le (2019).
- LKM17052 – Küberolümpia projekt (peamiselt KMin ja Eesti Interneti SA rahastatud), sh Kübernaaskli ja Küberpähkli võistlused ning Eesti esindamine rahvusvaheliselt
- LEP18079 – MANTICUS APOLLO projekt (kriisijuhtimine, situatsiooniteadlikkus)
- VFP19005 – ECHO projekt (sh 2019 detsembris korraldatud õppus)

11. Where the results of ongoing R&D can be applied? :

- Kriisijuhtimisõppuste korraldamine
- Tehniliste ja kompleksõppuste konsultatsioon, korraldamine ja disain
- Koolitused
- Riiklike poliitikate ja strateegiate nõustamine Eestis ja väljaspool

Mittelineaarsete juhtimissüsteemide töörühm /Nonlinear control systems group

1. The research group leader: Ülle Kotta, juhtivteadur, Akadeemia tee 21/1, 12618 Tallinn, e-mail: kotta@cc.ioc.ee, tel: (+372) 620 4153

2. Academic members of the research group:

- a) Juri Belikov, Arvo Kaldmäe, Vadim Kaparin
- b) postdocs: Ashutosh Simha
- c) PhD students: Christian Meurer(kaasjuhendamisel), Vjatšeslav Škiparev (kaasjuhendamisel), Tuuli Uudeberg (kaasjuhendamisel)

3. Keywords:

Mittelineaarsed juhtimissüsteemid, algebralised meetodid, autonoomsed sõidukid, energiasüsteemid /
Nonlinear control systems; algebraic methods; autonomous vehicles; power systems

4. Overview:

Koduleht: <https://cc.ioc.ee/dokuwiki/doku.php?id=en:start>

Töörühm on Eesti juhtiv uurimisüksus automaatjuhtimise valdkonnas, keskendudes mittelineaarsetele juhtimissüsteemidele sh mittesiledatele, hübriidsetele ja ajas hilistuvatele süsteemidele. Rühm on oluliselt panustanud konstruktiivsete algebraliste meetodite ja nendega seotud sümboltarkvarapaketi NLControl väljatöötamise, mis toetab teadusuuringuid, õpetamist ja rakendusi.

Välja on arendatud universaalne algebraline meetodika, mis lihtsustab erinevate mittelineaarsete juhtimissüsteemidega seotud probleemide uurimist ühildatud vaatenurgast. Põhiidee on konstrueerida juhtimissüsteemiga defineeritud diferentsiaalsete 1-vormide alamruumide (või alammodulite) jadad, mis sisaldavad informatsiooni süsteemi struktuursete omaduste kohta. Antud meetodika põhjal on välja töötatud ressursisäästlik sündmuspõhine juhtimismeetod, mis põhineb süsteemide lameduse omadusel.

Kuigi me arendame valdavalt rakendustest sõltumatuid üldisi meetodeid, mille rakendatavus sõltub pigem matemaatiliste mudelite dünaamilistest omadustest, oleme hiljuti keskendunud mõnele hoolikalt valitud rakendusele, millest osa on määratud Eesti teaduse tippkeskuse EXCITE (kuhu meie töörühm kuulub) ühisteemade poolt. Nimelt, tegeleme autonoomsete allveerobotite ja ioonjuhitavate elektroaktiivsete polümeertäiturmehhanismide juhtimisega. Viimaste aastate jooksul on erilist tähelepanu pööratud energiasüsteemidega seotud praktilistele probleemidele, mis on modelleeritud mittelineaarsete juhtimissüsteemidena. Täpsemalt, me uurime taastuvenergiaallikate võrku integreerimise fundamentaalseid piire ning, kasutades meetodeid optimaaljuhtimisteooriast, madala inertsienergia süsteemides asuvate jaotatud energiasalvestusseadmete võimalikke kitsendusi.

Homepage: <https://cc.ioc.ee/dokuwiki/doku.php?id=en:start>

The group is a leading Estonian research unit in automatic control, focusing on nonlinear control systems, including non-smooth, hybrid and time-delay systems. The group has made a significant contributions to the development of constructive algebraic methods and the associated symbolic software package NLControl, which supports research, teaching and applications.

A universal algebraic methodology has been developed that simplifies the study of very different problems for nonlinear control systems from unified perspective. The main idea is to construct sequences of subspaces (or submodules) of differential 1-forms that provide a lot of information about the structural properties of the system. For instance, an event-based resource-aware control method based on the concept of differential flatness has been developed.

Although the group is developing predominantly application-independent general methods determined by the dynamic properties of the mathematical models, we have been recently focused on a few carefully chosen applications, some of them addressed within the joint topics in the Estonian Centre of Excellence on IT, our group is part of. These include control of autonomous underwater vehicles and ionic polymer-metal composite actuators. Within the last few years, special attention has been paid to the study of practical problems arising in limits of renewable energy integration, and determine the possible limitations of distributed energy storage devices in low inertia power systems utilizing methods from optimal control theory.

Viimaste aastate artiklid / selected papers:

- [1] A. Kaldmä, Ü. Kotta. Realization of time-delay systems. *Automatica*, 90, pp. 317–320, 2018.
- [2] Z. Bartosiewicz, J. Belikov, Ü. Kotta, and M. Wyrwas. State feedback linearization of nonlinear control systems on homogeneous time scales. *Nonlinear Analysis: Hybrid Systems*, 31, 69–85, pp. 2019.
- [3] A. Tepljakov, V. Vunder, E. Petlenkov, S. S. Nakshatharan, A. Punning, V. Kaparin, J. Belikov, and A. Aabloo. Fractional-order modeling and control of ionic polymer-metal composite actuator. *Smart Materials and Structures*, 28 (8), 084008, pp. 1–12, 2019.

5. Outstanding results:

Lahendati realisatsioonülesanne ajas hilistuvate mittelineaarsete süsteemide jaoks Kalast inspireeritud roboti suuna juhtimisseaduse konstrueerimine ja implementeerimine, mis põhineb asümmeetrilistel signaalidel

- The solution of the realization problem for nonlinear time-delay systems is found
- Design and implementation of nonlinear control law for orientation control, based on asymmetric actuation signals of the fish-inspired robot.

6. Affiliation to the TalTech Academic Development Plan priority areas: --

- Dependable IT solutions
- Smart and energy efficient environments

7. Field(s) of research activity according to the Frascati:

1. Natural Sciences; 1.2. Computer and information sciences
2. Engineering and technology; 2.2 Electrical engineering, electronic engineering, information engineering

8. Honours/awards:

Juri Belikov, Vabariigi Presidendi Kultuurirahastu, Noore IT-teadlase preemia / Estonian Cultural Foundation of the President, Young IT-scientist award

9. Participation in the activities of international R&D organizations:

Ülle Kotta

- IEEE robustsete ja keerukate süsteemide töörühma liige / Member of the IEEE TC on Robust and Complex Systems
- IFAC'i mittelineaarsete juhtimissüsteemide töörühma liige / Member of the IFAC Technical Committee on Non-Linear Control Systems

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) :

LEP18083 "Alexela Energia AS rakendusuuring klientide elektritarbimise prognoosimudeli väljatöötamiseks"

Viited:

[Uudised] <https://www.alexela.ee/et/alexela-ja-taltech>

<https://sciencebusiness.net/creating-digital-crystal-ball>

[Aruanne]

https://www.ttu.ee/public/u/ulikool/Oigusaktid_ja_dokumendid/Eelarved_ja_aruanded/taltech_2018_majandusaasta%20aruanne.pdf

- - - - -

LEP18083 "Alexela Energy AS applied research for development of electricity consumption prediction model"

Links:

[News] <https://www.alexela.ee/et/alexela-ja-taltech>

<https://sciencebusiness.net/creating-digital-crystal-ball>

[Report]

https://www.ttu.ee/public/u/ulikool/Oigusaktid_ja_dokumendid/Eelarved_ja_aruanded/taltech_2018_majandusaasta%20aruanne.pdf

11. Where the results of ongoing R&D can be applied? :

Rühma unikaalset pädevust ning teoreetilisi tulemusi on võimalik rakendada erinevates valdkondades, sealhulgas (a) robotikas, (b) tööstusprotsesside juhtimises, (c) elektrotehnikas ja energeetikas.

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The unique competence and theoretical results of the research group can be applied in several areas, including: (a) robotics, (b) process control, (c) electrical engineering and energy management.

Plokiahelate tehnikate tööruhm / Blockchain technology group

1. The research group leader: Alex Norta, associate professor, 56294420, alexander.norta@taltech.ee

2. Academic members of the research group:

- Abhishek Dixit
- Vipin Deval
- Vimal Dwivedi

3. Keywords:

Blockchains, smart contracts, consensus algorithms, decentralized autonomous organizations (DAO), distributed applications (Dapp), e-governance, identity authentication, machine-to-anything economy, e-healthcare, legal relevance of smart contracts, oracle problem

4. Overview:

Competencies

- Smart contract language development with legal relevance,
- Improved consensus algorithms such as incentiviced proof-of-stake algorithms,
- Methods for the development of blockchain-based distributed applications-specific,
- Novel e-governance frameworks that are blockchain based for achieving total distribution, disintermediation, decentralization and disruption,
- secure data management using blockchains,
- non-governmental multi-factor authentication on blockchains for machine-to-anything e-governance,
- cross-organizational business-process automation with blockchains,
- multi-agent systems for addressing the oracle problem in smart-contract systems,
- personalized e-healthcare management with wearables using blockchains for secure data exchange,
- e-learning and AI with blockchain support to achieve immutable traceability

Publications:

Publications BTG relevant

1. Akaba, Temofe; Norta, Alex; Udokwu, Chibuzor; Draheim, Dirk (2020). A framework for the adoption of blockchain-based e-procurement systems in the public sector. *19th IFIP Conference on e-Business, e-Services, and e-Society, I3E 2020, Skukuza, South Africa, 6-8 April 2020, 2019, Proceedings*. Springer, x. (Lecture Notes in Computer Science) [forthcoming].
2. Norta, Alex; Matulevičius, Raimundas; Leiding, Benjamin (2019). Safeguarding a formalized blockchain-enabled identity-authentication protocol by applying security risk-oriented patterns. *Computers & Security*, 86, 253–269.10.1016/j.cose.2019.05.017.
3. Norta, Alex; Dai, Patrick; Mahi, Neil; Earls, Jordan (2019). A public, blockchain-based distributed smart-contract platform enabling mobile lite wallets using a proof-of-stake consensus algorithm. *Business Information Systems Workshops : BIS 2018 International Workshops, Berlin, Germany, July 18-20, 2018, Revised Papers*. Ed. Abramowicz, Witold; Paschke, Adrian. Cham: Springer, 368–380. (Lecture Notes in Business Information Processing; 229).10.1007/978-3-030-04849-5_33.

4. Deval, Vipin; Norta, Alex (2019). Mobile smart-contract lifecycle governance with incentivized proof-of-stake for oligopoly-formation prevention. *Proceedings 19th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, CCGrid2019, Cyprus*. Piscataway, NJ: IEEE, 165–168.10.1109/CCGRID.2019.00029.
5. Dwivedi, Vimal; Deval, Vipin; Dixit, Abhishek; Norta, Alex (2019). Formal-verification of smart-contract languages: A survey. In: Singh, Mayank; Gupta, P.K.; Tyagi, Vipin; et al. (Ed.). *Advances in Computing and Data Sciences : Third International Conference, ICACDS 2019, Ghaziabad, India, April 12-13, 2019, Revised Selected Papers, Part II (738–747)*. Singapore: Springer. (Communications in Computer and Information Science; 1046).10.1007/978-981-13-9942-8_68.
6. Lazuashvili, Nino; Norta, Alex; Draheim, Dirk (2019). Integration of blockchain technology into a land registration system for immutable traceability: A casestudy of Georgia. *Business Process Management: Blockchain and Central and Eastern Europe Forum : BPM 2019 Blockchain and CEE Forum, Vienna, Austria, September 1-6, 2019, Proceedings*. Ed. Di Ciccio, Claudia; Gabryelczyk, Renata; García-Bañuelos, Luciano; et al. Cham: Springer, 219–233. (Lecture Notes in Business Information Processing; 361).10.1007/978-3-030-30429-4_15.
7. Azogu, Irene; Norta, Alex; Papper, Ingrid; Longo, Justin; Draheim, Dirk (2019). A framework for the adoption of blockchain technology in healthcare information management systems: A case study of Nigeria. *Proceedings of the 12th International Conference on Theory and Practice of Electronic Governance, ICEGOV2019 : 3-5 April 2019 Melbourne, Australia*. Ed. Ben Dhaou, Soumaya; Carter, Lemuria; Gregory, Mark. New York, NY: ACM Press, 310–316. (ACM International Conference Proceedings Series).10.1145/3326365.3326405.
8. Abodei, Ebizimoh; Norta, Alex; Azogu, Irene; Udokwu, Chibuzor; Draheim, Dirk (2019). Blockchain technology for enabling transparent and traceable government collaboration in public project processes of developing economies. *Digital Transformation for a Sustainable Society in the 21st Century : 18th IFIP WG 6.11 Conference on e-Business, e-Services, and e-Society, I3E 2019, Trondheim, Norway, September 18-20, 2019, Proceedings*. Ed. Pappas, Ilias O.; et al. Cham: Springer, 464–475. (Lecture Notes in Computer Science; 11701).10.1007/978-3-030-29374-1_38.
9. Norta, Alex; Rossar, Risto; Parve, Mart; Laas-Billson, Liina (2019). Achieving a high level of open market-information symmetry with decentralised insurance marketplaces on blockchains. *Intelligent Computing : Proceedings of the 2019 Computing Conference, Volume 1, [July 16-17, 2019, London, UK]*. Ed. Arai, Kohei; Bhatia, Rahul; Kapoor, Supriya. Cham: Springer, 299–318. (Advances in Intelligent Systems and Computing; 997).10.1007/978-3-030-22871-2_22.
10. Norta, Alex; Leiding, Benjamin; Lane, Alexi (2019). Lowering financial inclusion barriers with a blockchain-based capital transfer system. *IEEE INFOCOM 2019 - IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS) : 29 April-2 May 2019, Paris, France*. IEEE, 319–324.10.1109/INFOCOMW.2019.8845177.
11. Kormiltsyn, Aleksandr; Udokwu, Chibuzor; Karu, Kalev; Thangalimodzi, Kondwani; Norta, Alex (2019). Improving Healthcare Processes with Smart Contracts. *Business Information Systems : 22nd International Conference, BIS 2019, Seville, Spain, June 26-28, 2019, Proceedings, Part I*. Ed. Abramowicz, Witold; Corchuelo, Rafael. Cham: Springer, 500–513. (Lecture Notes in Business Information Processing; 353).10.1007/978-3-030-20485-3_39.

12. 5. Outstanding results: --
6. Affiliation to the TalTech Academic Development Plan priority areas:
- Dependable IT solutions
 - Future governance
7. Field(s) of research activity according to the Frascati:
- 1.2 Arvutiteadus ja informaatika / Computer and information sciences
8. Honours/awards: --
9. Participation in the activities of international R&D organizations: --
10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) :
- Qtum.org, Everex.io, CEDEX.com, Agrello.io, Datawallet.com, Evareium.io, Black.insure, Admiralmarkets.com, Trustededucation.io
11. Where the results of ongoing R&D can be applied? :
- Non-governmental multi-factor authentication of identities
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Proaktiivtehnoloogiate laboratoorium / Laboratory of proactive technologies

1. The research group leader: Leo Mõtus, professor, e-mail
2. Academic members of the research group:
- Labori juhataja: professor Leo Mõtus, leo.motus@ttu.ee, tel: +372 5049 717
- Liikmed: Taivo Kangilaski, Mart Murdvee, Tõnu Näks, Andri Riid, Raul Savimaa, Andres Udal
- Doktorandid: Johannes Ehala, Jaanus Kaugerand
3. Keywords: -- küber-füüsikalised-süsteemid, spontaansed sensorvõrgud, uduarvutus, riigiülese tervikliku olukorrateadlikkuse võimekus
4. Overview:
- Proaktiivtehnoloogiate uurimislabori (<https://www.ttu.ee/institutes/proactivity-lab/>) põhitegevuseks on võrgustatud küber-füüsikaliste-süsteemide õpetamine üliõpilastele ning teoreetiliste ja praktiliste probleemide uurimine/lahendamine – näiteks arendatakse küberfüüsikaliste süsteemide magistrikursust, lepingute toetusel ehitatakse ja rakendatakse spontaansed sensorvõrke, teoreetiliselt uuritakse uduarvutust ja selleks kasutatavat proaktiivset vahevara (ProWare) ja osaletakse riigiülese tervikliku olukorrateadlikkuse võimekuse loomisel riigikaitse rakendustele.

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The laboratory (<http://www.proactivity-lab.ee>) focuses on theoretical and practical study of networked systems built from stationary and/or mobile software-intensive (proactive) components. Typical components are pervasive computing systems. The research is partitioned into three threads -- modelling and verification of situation-aware interaction-centred computation, methods and technologies for acquiring situational information, and methods for interpretation of situational information for (proactive) decision making. The long-term goal of the laboratory is the ability to detect and partially control the emergent behaviour in pervasive computing systems.

The laboratory was established in 2007 by a decree of Senate (Tallinn University of Technology), stems from the Real Time Systems group at the Department of Computer Control, Tallinn University of Technology, and has inherited its theoretical results and experience.

Publications:

- 1 P. Laud, L. Motus, ... (16 authors) 2019 "Mapping the information flows for the architecture of a nation-wide situation awareness system", Poster, DOI: 0.1109/COGSIMA.2019.8724167, Conference: 2019 IEEE Conference on Cognitive and Computational Aspects of Situation Management (CogSIMA)
- 2 Motus L., K.Taveter, V. Dieves (2019) "Speculations on Collaboration of Models" CogSIMA 2019 Conference, Poster, Poster, DOI: 0.1109/COGSIMA.2019.8724167, Conference: 2019 IEEE Conference on Cognitive and Computational Aspects of Situation Management (CogSIMA)
- 3 Motus, L., M. Teichmann, T. Kangilaski, J. Priisalu, J. Kaugerand (2019) „Some issues in modelling comprehensive Situation awareness“, IEEE International Conference on Systems, Man and Cybernetics, Bari, Italy, October 6-9 2019, 978-1-7281-4568-6/19/\$31.00 ©2019 IEEE, 550 – 555 p.
- 4 Riid, Andri; Lõuk, Roland; Pihlak, Rene; Tepljakov, Aleksei; Vassiljeva, Kristina (2019). Pavement distress detection with deep learning using the ortho-frames acquired by a mobile mapping system. Applied Sciences, 9 (22), 4829, 1–22.10.3390/app9224829.
- 5 Tepljakov, Aleksei; Riid, Andri; Pihlak, Rene; Vassiljeva, Kristina; Petlenkov, Eduard (2019). Deep learning for detection of pavement distress using non-ideal photographic images. 2019 42nd International Conference on Telecommunications and Signal Processing (TSP): July 1-3, 2019, Budapest, Hungary. Brno: IEEE, 195–200.10.1109/TSP.2019.8769086.
- 6 Pūkienė, S; Karaliūnas, M; Jasinskas, A; Dudutienė, E; Čechavičius, B; Devenson, J; Butkutė, R; Udal, A; Valušis, G (2019). Enhancement of photoluminescence of GaAsBi quantum wells by parabolic design of AlGaAs barriers. Nanotechnology, 30 (45), 455001 (11pp).10.1088/1361-6528/ab36f3.

5. Outstanding results: --

6. Affiliation to the TalTech Academic Development Plan priority areas:

- Dependable IT solutions
- Smart and energy efficient environments

7. Field(s) of research activity according to the Frascati:

1.2 Arvutiteadus ja informaatika / Computer and information sciences

8. Honours/awards: --

9. Participation in the activities of international R&D organizations

- Jaanus Kaugerand: Eesti esindaja NATO STO SCI paneelis
- Leo Mõtus, aseesimees IEEE Society for Systems, Man and Cybernetics, TC on Cognitive Situation Management

Ingl. k.:

- Jaanus Kaugerand: National representative in NATO STO SCI panel
- Leo Mõtus, vice-chairman: IEEE Society for Systems, Man and Cybernetics, TC on Cognitive Situation Management

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.)

1. IMO – AR17119 "Infotehnoloogiline mobiilsusobservatoorium 2017 – 2022
2. SmENeTe2 –Lep 17070 Targa Keskkonna Võrgutehnoloogiad 2017 – 2019
3. Lep 19022 „Kuluefektiivse ühildatava geodeetilise täpsusega 3D ruumiandmete taristu loomise rakendusuring“ 2019 – 2020
4. Lep 18079 „Riigiülese ja tervikliku olukorrateadlikkuse võimeloomine riigikaitse juhtimiseks ja koordineerimiseks
5. EITSA 18008 "Küberfüüsikalised süsteemid – uute õppevahendite ja –metoodika loomine" (Johannes Ehala leping)

1. IMO – AR 17119 „Info-technological Mobility Observatory“ 2017 – 2022
2. SmENeTe2 – Lep. 17070 „Smart Environment Networking Technologies“ 2017 – 2019
3. Lep. 19022 „Applied Research for creating a cost-effective interchangeable 3D spatial data infrastructure with survey-grade accuracy“,
4. Lep. 18079 „Creation of a transnational and comprehensive situation awareness capability for the management and coordination of national Defence“
5. EITSA 18008 “Revision of lecture notes and study methodology for Cyber–physical systems course“

11. Where the results of ongoing R&D can be applied? : --

Rakendusliku tehismõistuse grupp / Applied Artificial Intelligence group

1. The research group leader: Vahur Kotkas, Development Officer, vahur.kotkas@taltech.ee

2. Academic members of the research group:

- Irina Astrova,
- Hele-Mai Haav,
- Mait Harf,
- Priit Järv
- Kristiina Kindel,
- Ago Luberg,
- Riina Maigre,
- Margarita Spitšakova,
- Tanel Tammet,
- Martin Verrev

3. 3. Keywords:

machine learning, automated commonsense reasoning, ontology based reasoning, AI methods in spatial data analysis, recommender systems, logic-based software systems

Masinõpe, automatiseeritud inimlaadne arutus, ontoloogiapõhine arutus, tehismõistusel põhinevad ruumiandmete töötlemise meetodid, soovitusüsteemid, loogikapõhised tarkvarasüsteemid, keeruliste süsteemide modelleerimine ja simulatsioonid

4. Overview:

Research and Competencies / Teadussuunad ja kompetentsid

Rakendusliku tehismõistuse grupp keskendub oma uurimistöös tehismõistuse meetoditele, arendades ja rakendades neid erinevates valdkondades. 2019 aastal keskenduti peamiselt masinõppe, ontoloogiapõhise arutluse, automaatse teoreemitõestamise, teadmuse loomise jt tehismõistuse meetodite juurutamisele tööstuse ja avaliku sektori rakendustes.

Grupi eelnevates uurimisteedes on muuhulgas olnud tehismõistuse osi integreerivad tarkvaraarendusmeetodid ja rakendused (nt CoCoViLa), (visuaalsed) modelleerimiskeeled, programmide loogikapõhine kompositsioon ja ontoloogiatel põhinev teadmiste esitamine.

Uurimistöö mitmete dekaadide vältel on loodud mitmeid rakendusi, mis võimaldavad tehismõistuse tehnikaid rakendada. Praegusel ajal on neist veel kasutusel või arendusjärgus järgmised:

CoCoViLa – visuaalne mudelipõhine automaatset programmisünteesi pakkuv

tarkvaraarenduskeskkond - <http://cocovila.github.io/>

WhiteDB – kiire NoSQL andmebaasiohjur - <http://whitedb.org/>

GKC – arutlusvahend tööks (väga) suurte teadmusbasisidel – <https://github.com/tammet/gkc>

Käesoleval ajal on grupi keskseteks teemadeks tehismõistuse meetodite rakendamine ruumiandmeanalüüsil, masinõppe rakendamine e-kaubanduse ja avaliku sektori riskihalduses ning loomulikul keelel baseeruvate suhtlussüsteemide arendus. Nende teemadega on seotud järgmised projektid:

1. Applied research for creating a cost-effective interchangeable 3D spatial data infrastructure with survey-grade accuracy
2. Applied research for e-commerce EU VAT and duty declaration (as from 2021) digitalisation
3. Machine learning and AI powered public service delivery

The Applied AI Group conducts research in application of AI methods in various fields and systems. We investigate applicability of machine learning, ontology based reasoning, automated theorem provers, knowledge discovery and other AI methods for solving digitalisation problems of different industrial and governmental stakeholders.

Our previous research has been concentrated on building software development methods and tools (e.g. CoCoViLa) with AI components, basically with program synthesis and ontology based knowledge representation components.

During a number of decades several software tools that facilitate AI techniques have been developed by the group. The following is a list of tools that are still in use or under development:

CoCoViLa – visual model-based software development environment - <http://cocovila.github.io/>

WhiteDB – a lightweight NoSQL database library - <http://whitedb.org/>

GKC – discussion tool on large knowledgebases – <https://github.com/tammet/gkc>

Currently we work on topics like application of AI methods in spatial data analysis, using machine learning for risk management in e-commerce and for public service delivery. The corresponding projects are listed as follows:

1. Applied research for creating a cost-effective interchangeable 3D spatial data infrastructure with survey-grade accuracy
2. Applied research for e-commerce EU VAT and duty declaration (as from 2021) digitalisation
3. Machine learning and AI powered public service delivery

Selected publications in 2019

- Tammet, Tanel. GKC: A reasoning system for large knowledge bases. Automated Deduction - CADE 27 : 27th International Conference on Automated Deduction, Natal, Brazil, August 27-30, 2019, Proceedings, 11716. Ed. Fontaine, Pascal. Cham: Springer, 538–549. (Lecture Notes in Artificial Intelligence; 11716).10.1007/978-3-030-29436-6_32

- Spichakova, Margarita; Belikov, Juri; Nõu, Kalvi; Petlenkov, Eduard (2019). Feature engineering for short-term forecast of energy consumption. Proceedings of 2019 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe) : Bucharest, Romania, 29 September - 2 October 2019. IEEE, [1–5].10.1109/ISGTEurope.2019.8905698.
- Koschel, Arne; Heine, Felix; Astrova, Irina (2019). Harnessing cloud scalability to Hadoop clusters. Information Systems : 15th European, Mediterranean, and Middle Eastern Conference, EMCIS 2018, Limassol, Cyprus, October 4-5, 2018, Proceedings. Ed. Themistocleous, Marinos; Rupino da Cunha, Paulo. Cham: Springer, 59–71. (Lecture Notes in Business Information Processing; 341).10.1007/978-3-030-11395-7_6.

5. Outstanding results / Teadustulemused:

1. Loodi loogikapõhine, suurtel teadmusbaasidel arutlev, diskussioonimeetod. Töö kaugemaks eesmärgiks on hübriidse (masinõpet ja loogikat sisaldava) tuletusmootori loomine, mis võimaldab inimõttlemises tavapäraseid üldistusi kasutades teavet analüüsida ja soovitusi koostada või otsuseid vastu võtta.
2. Loodi uudne meetod energiatarbimise lühiajaliseks ennustamiseks kasutades masinõpet.
3. Loodi soovitusüsteem sobivate turismi sihtkohtade leidmiseks lähtudes avalikest, väga erinevat liiki, andmeallikatest, eraldades neist populaarsemad sihtkohad vastavalt turisti(de) käitumisele.
4. Pidevas arengus on erinevate hüdraulikasõlmede modelleerimise ja nende töö simuleerimise põhimõtted ja arendusvahendid.

1. Logical-based discussion methods used in large knowledge bases have been developed. The goal of ongoing experimental research and development of a commonsense reasoning system is to build a world leading hybrid (machine learning plus logical reasoning) commonsense reasoner, to be used as a commonsense reasoning tool in various AI toolchains.
2. A novel method has been developed for estimating short-term energy-consumption using machine learning techniques.
3. Approaches based on modeling and intelligent simulation for the design of pneumo-hydraulic systems for liquids are continuously developed.
4. Methods to extract data about tourist destinations and tourist behavior from public, heterogeneous data sources and to create knowledge bases for tourist recommender systems.

6. Affiliation to the TalTech Academic Development Plan priority areas:

- Dependable IT solutions
- Future Innovative SME-s and digital economy

7. Field(s) of research activity according to the Frascati:

1.2 Arvutiteadus ja informaatika / Computer and information sciences

8. Honours/awards: --

9. Participation in the activities of international R&D organizations: --

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) : --

11. Where the results of ongoing R&D can be applied? : --

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Tugevalt tagatud tarkvara laboratoorium / High-assurance software laboratory

1. The research group leader: Tarmo Uustalu, juhtivteadur, 620 4250, tarmo@cs.ioc.ee, 0000-0002-1297-0579

2. Academic members of the research group:

- Jüri Vain, kaasprofessor tenuuris, 0000-0002-0700-7972
- Maksym Bortin, teadur al 1.3.2019, 0000-0003-4749-4987
- Silvio Capobianco, vanemteadur, 0000-0002-2936-0419
- Juhan-Peep Ernits, dotsent
- Denis Firsov, teadur al 1.2.2019
- Evelin Halling, assistent
- Gert Kanter, lektor, 0000-0002-8201-8540
- Marko Kääramees, dotsent
- Sven Nõmm, vanemteadur, 0000-0001-5571-1692
- Hellis Tamm, vanemteadur, 0000-0001-5446-3762
- Leonidas Tsiopoulos, vanemteadur, 0000-0002-3994-3810
- Niccolò Veltri, teadur al 1.5.2019, 0000-0002-7230-3436
- Niels Voorneveld, järeldoktorant-teadur al 1.11.2019, 0000-0001-6650-3493
- Hendrik Maarand, nooremteadur (doktorant), 0000-0002-1967-4297

3. Keywords:

funktsionaalne ja sõltuvalt tüübitud programmeerimine, tarkvara verifitseerimine ja testimine, formaliseeritud programmeerimisteooria

functional and dependently-typed programming, software verification and testing, formalized programming theory

4. Overview:

Rühm uurib tugevalt tagatud tarkvara arendamise teooriaid, meetodeid ja tööriistu, spetsialiseerudes nii tõestustele (sertifitseeritud tarkvara) kui ka testimisele.

The group conducts research into theories, methods and tools for developing high-assurance software, specializing on both proofs (certified software) and testing.

5. Outstanding results:

Näidati, et küllalt üldiselt tingimustel morfism kahe komonaadi vahel tegurdub isomorfismi täpsusega unikaalselt kaheks komonaadimorfismiks, millest esimene on identsus kujudel teine on isomorfism kujudel ja teine isomorfism positsioonidel igas kujus.

Näidati, et iga normaalsuse tingimus kiivmonoidilistele kategooriatele vastab teatud lõdvendusele selliste kategooriate sekvensiarvutuse reeglites.

Loodi kõrgtaseme keel TDLP missioonikriitiliste süsteemide keerukate testistsenaariumide spetsifitseerimiseks mudelipõhises testimises.

Defineeriti TDLP keele operaatorite süntaks ja semantika ning reeglid nende teisendamiseks Uppaali ajaga automaatide käivitavasse formalismi.

It was proved that, under mild conditions, a map between two comonads factorizes uniquely up to isomorphism into two comonad maps where of the first is an isomorphism of shapes and the second is an isomorphism of positions in every shape.

Every normality condition on skew-monoidal categories was shown to correspond to some relaxation of the inference rules of the sequent calculus of such categories.

A high-level test scenario specification language TDLTP for specifying complex test scenarios that are relevant for model-based testing of mission critical systems was developed. The syntax and semantics of TDLTP operators were defined and the transformation rules that map TDLTP expressions to executable Uppaal timed automata test models were specified.

Selected publications 2019

- Buldas, D. Firsov, R. Laanoja, H. Lakk, A. Truu. A new approach to constructing digital signature schemes. In N. Attrapadung, T. Yagi, eds., Proc. of 14th Int. Wksh. on Security, IWSEC 2019 (Tokyo, Aug. 2019), v. 11689 of Lect. Notes in Comput. Sci., pp. 363-373. Springer, 2019. doi: 10.1007/978-3-030-26834-3_21
- J. Chapman, T. Uustalu, N. Veltri. Quotienting the delay monad by weak bisimilarity. Math. Struct. in Comput. Sci., v. 29, n. 1, pp. 67-92, 2019. doi: 10.1017/s0960129517000184
- H. Maarand, T. Uustalu. Reordering derivatives of trace closures of regular languages. In W. Fokkink, R. van Glabbeek, eds., Proc. of 30th Int. Conf. on Concurrency Theory, CONCUR 2019 (Amsterdam, Aug. 2019), v. 140 of Leibniz. Int. Proc. in Inf., article 40. Dagstuhl Publishing, 2019. doi: 10.4230/lipics.concur.2019.40
- Muthukumar N., S. Srinivasan, K. Ramkumar, D. Pal, J. Vain, S. Ramaswamy. A model-based approach for design and verification of industrial Internet of Things. Future Gener. Comput. Syst., v. 95, pp. 354-363, 2019. doi: 10.1016/j.future.2018.12.012

6. Affiliation to the TalTech Academic Development Plan priority areas:

- Dependable IT solutions
- Future governance

7. Field(s) of research activity according to the Frascati:

1.2 Arvutiteadus ja informaatika / Computer and information sciences

8. Honours/awards: :

Tarmo Uustalu pälvis Valgetähe III klassi ordeni.

9. Participation in the activities of international R&D organizations:

Tarmo Uustalu on IFIPi WG 2.1 liige al 2010 (liikmed kutsutakse, liikmesus on eluaegne).

10. Applied R&D activities of in business, economics, society (projects, contracts, news, etc.) :

Meie töö uuenduste monaadidest (D. Ahman, T. Uustalu, Proc. TYPES 2013, 2014) võeti kiiresti kasutusele professionaalsete Haskell'i ja F# programmeerijate hulgas; sarnane meetod on Reduxi nime all nüüd väga kuum JavaScripti maailmas.

11. Where the results of ongoing R&D can be applied? : --