

Tarkvarateaduse instituut, 2018. aasta uurimisrühmade teadus- ja arendustegevuse ülevaade

TARKVARATEADUSE INSTITUUT

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

DEPARTMENT OF SOFTWARE SCIENCE

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

Instituut koosneb järgmistest tööryhmadest:

- Andmeteaduse tööryhm. Juht: professor SADOK BEN YAHIA, sadok.ben@taltech.ee
- Infosüsteemide tööryhm. Juht: professor DIRK DRAHEIM, dirk.draheim@taltech.ee
- Keeletehnoloogia laboratoorium. Juht: sihtrahastusega vanemteadur TANEL ALUMÄE, tanel.alumae@phon.ioc.ee
- Küberkriminalistika ja küberjulgeoleku keskus. Juht: sihtrahastusega professor RAIN OTTIS, rain.ottis@taltech.ee
- Mittelineaarsete juhtimissüsteemide tööryhm. Juht: juhtivteadur ÜLLE KOTTA, ulle.kotta@taltech.ee
- Mudelpõhise tarkvaratehnika tööryhm. Juht: arendusspetsialist VAHUR KOTKAS, vahur.kotkas@taltech.ee
- Plokiahelate tehnikate tööryhm. Juht: dotsent ALEXANDER HORST NORTA, alexander.norta@taltech.ee
- Proaktiivtehnoloogiate laboratoorium. Juht: professor LEO MÕTUS, leo.motus@taltech.ee
- Sotsiotehniliste süsteemide laboratoorium. Juht: vanemteadur KULDAR TAVETER, kuldar.taveter@taltech.ee
- Tugevalt tagatud tarkvara laboratoorium. Juht: juhtivteadur 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 Mõtus
- Laboratory of Socio-Technical Systems Head Kuldar Taveter
- Model-Based Software Engineering Group Head Vahur Kotkas
- Nonlinear Control Systems Group Head Ülle Kotta

Tarkvarateaduse instituut loodi 1. jaanuaril 2017 TTÜ struktuurireformi raames TTÜ asutuse [Küberneetika Instituut foneetika ja kõnetehnoloogia](#), [juhtimissüsteemide](#), ja [tarkvarateaduse](#) laboratooriumi, TTÜ [arvutiteaduse](#) ja informaatika instituudi inimestest, kellele lisandusid ka mõned tööryhmad automaatika, raadio- ja sidetehnika ning tööstuspsühholoogia instituutidest. Tarkvarateaduse instituudi põhisuundadeks on informaatika, äriinfotehnoloogia, e-riigi tehnoloogiad ja teenused ning küberkaitse. Instituudi uurimisgrupid osalevad Eesti teaduse tippkeskuste EXCITE (IT Tippkeskus) ja CEES (Eesti-uuringute Tippkeskus) töös.

Tarkvarateaduse instituut on ka partner H2020 projektides TOOP, C3S BARON.

The Department of Software Science (DSS) is a newly established department of the School of Information Technologies that was formed in 2017 on the basis of the research groups of the former Department of Computer Science, Department of Computer Control, Department of Informatics and the Institute of Cybernetics. The research fields of DSS include logic, data analysis, programming languages, high-assurance software, model based software engineering, large-scale systems, digital forensics and cyber security, socio-technical systems, proactive technologies, nonlinear control systems, and human language technology. The research groups of DSS participate in the Estonian Centre of Excellence in ICT Research EXCITE and in the Centre of Excellence in Estonian Studies CEES. DSS is also partner in H2020 projects TOOP, C3S BARON.

UURIMISRÜHMAD

ANDMETEADUSE TÖÖRÜHM

Töörühma juhataja: Professor Sadok BEN YAHIA, sadok.ben@taltech.ee

Liikmed: Innar Liiv, Ants Torim, Grete Lind, Leo Vöhandu, Jaak Henno, Tarmo Vesikioja, Tarvo Treier, Ahti Lohk

Doktorandid: Martin Rebane

Võtmesõnad: andmekaevandamine, suurandmed, analüütika, visualiseerimine, ontoloogia joondamine, juhuslike andmete modelleerimine

Andmeteaduse uurimisrühm tegeleb uurimistööga, mille eesmärk on andmete väärimine, olles mitmete prioriteetsete valdkondade ristteel, nagu

- Küberkaitse: Sissemurdmise / anomaaliate tuvastus
- Ühiskonna digitaalne transformatsioon; tervishoiu infosüsteemid (ebatavaliste sündmuste tuvastamine, patsientide ravitrajektooride kaevandamine)
- Targad keskkonnad: asjade internet, intelligentne transpordisüsteem, tark linn, tark kodu

Valitud publikatsioonid:

Opik, Rain; Kirt, Toomas; Liiv, Innar (2018). Megatrend and intervention impact analyzer for jobs: a visualization method for labor market intelligence. *Journal of Official Statistics*, 34 (4), 961–979. 10.2478/jos-2018-0047.

Henno, J.; Jaakkola, H.; Mäkelä, J. (2018). Adjusting university education with workspace training and self-education. 2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO 2018) : May 21-25 2018, Opatija, Croatia, Proceedings. Ed. Skala, Karolj, [et al..]. Opatija, Croatia: IEEE Xplore, 701–708. 10.23919/MIPRO.2018.8400131.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika
2. Tehnika ja tehnoloogia 2.2 Elektrotehnika, elektroonika, infotehnika

DATA SCIENCE GROUP

Head of the research group: Professor Sadok BEN YAHIA, Department of Software Science, Email: sadok.ben@taltech.ee

Members: Innar Liiv, Ants Torim, Grete Lind, Leo Vöhandu, Jaak Henno, , Tarmo Vesikioja, Tarvo Treier, Ahti Lohk

Doctoral students: Martin Rebane

Key words: data mining, big data, analytics, visualization, ontology alignment, random data modeling

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:

Opik, Rain; Kirt, Toomas; Liiv, Innar (2018). Megatrend and intervention impact analyzer for jobs: a visualization method for labor market intelligence. Journal of Official Statistics, 34 (4), 961–979. 10.2478/jos-2018-0047.

Kachroudi, Marouen; Ben Yahia, Sadok (2018). Dealing with direct and indirect ontology alignment. Journal on Data Semantics, 7 (4), 237–252. 10.1007/s13740-018-0098-y.

Henno, J.; Jaakkola, H.; Mäkelä, J. (2018). Adjusting university education with workspace training and self-education. 2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO 2018) : May 21-25 2018, Opatija, Croatia, Proceedings. Ed. Skala, Karolj, [et al..]. Opatija, Croatia: IEEE Xplore, 701–708. 10.23919/MIPRO.2018.8400131.

Fields of activity by Frascati manual

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

INFOSÜSTEEMIDE TÖÖRÜHM

Töörühma juhataja: Professor Dirk Draheim, dirk.draheim@taltech.ee

Liikmed: Erki Eessaar, Ingrid Pappel, Gunnar Piho, Jaak Tepandi, Enn Õunapuu

Doktorandid: Silvi Lips, Vishwajeet Pattanaik, Shweta Suran, Valentyna Tsap, Rozha Ahmed

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

INFORMATION SYSTEMS GROUP

Head of the research group: Professor Dirk Draheim, dirk.draheim@taltech.ee

Members: Erki Eessaar, Ingrid Pappel, Gunnar Piho, Jaak Tepandi, Enn Õunapuu

Doctoral students: Silvi Lips, Vishwajeet Pattanaik, Shweta Suran, Valentyna Tsap, Rozha Ahmed

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

Introduction of the research group

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.

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

Valitud publikatsioonid

Selected publications

- 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.
- Syed Attique Shah, Dursun Zafer Seker, Sufian Hameed, and Dirk Draheim. The Rising Role of Big Data Analytics and IoT in Disaster Management: Recent Advances, Taxonomy and Prospects, IEEE Access, 2019
- Tepandi, Jaak; Verhoosel, Jack P.C.; Zeginis, Dimitrios; Wettergren, Gunnar; Dimitriou, Jerry; Rotuna, Carmen; Carabat, Cagatay; Albayrak, Özlem; Yilmaz, Erol; Lampoltshammer, Thomas; Täks, Ermo; Prentza, Andriana; Brandt, Paul; Kavassalis, Petros; Leontaridis, Lefteris; Streefkerk, Jan Willem (2017). Generic Federated OOP Architecture (1st version). European Commission.
- Draheim, Dirk (2017). Generalized Jeffrey Conditionalization : A Frequentist Semantics of Partial Conditionalization. Cham: Springer.10.1007/978-3-319-69868-7.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika
2. Tehnika ja tehnoloogia 2.2 Elektrotehnika, elektroonika, infotehnika
2. Tehnika ja tehnoloogia 2.11 Teised tehnika- ja tehnoloogiateadused

KEELETEHNOLOOGIA LABORATOORIUM

Labori juhataja: sihtrahastusega vanemteadur Tanel Alumäe, tanel.alumae@phon.ioc.ee

Liikmed: Lya Meister, Einar Meister

Doktorandid: Asadullah

Võtmesõnad: Kõnetehnoloogia, loomuliku keele töötlus, foneetika

Keeletehnoloogia laboratoorium keskendub järgmistele teemadele:

- * Kõnetuvastus
- * Kõneleja identifitseerimine
- * Kõneldava keele ja aktsendi identifitseerimine
- * Kõnekorpused
- * Foneetika (eesti keele prosoodia ja häälikusüsteem, L2 kõne)
- * Mitmesugused loomuliku keele töötamise alamteemad

Üheks meie oluliseks tegevuseks on kogu ühiskonnale suunatud kõnetehnoloogia rakenduste loomine. Sinna hulka kuuluvad nii kõnetuvastuse lõppkasutaja-rakendused kui ka lihtsalt integreeritavad kõnetuvastuse tuumikkomponendid. Kuigi meie fookuses on eesti keele kõnetuvastus, ei ole enamik

meie loodud tarkvarast eesti keele spetsiifiline. Me oleme kindlad avatud lähtekoodiga vaba tarkvara toetajad.

Valitud publikatsioonid:

Karu, Martin; Alumäe, Tanel (2018). Weakly supervised training of speaker identification models. Odyssey 2018 The Speaker and Language Recognition Workshop : 26-29 June 2018, Les Sables d'Olonne, France, Proceedings. International Speech Communication Association, 24–30. 10.21437/Odyssey.2018-4.

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. 10.1007/s10278-018-0085-8.

Asadullah; Alumäe, Tanel (2018). Data augmentation and teacher-student training for LF-MMI based robust speech recognition. Text, Speech, and Dialogue : 21st International Conference, TSD 2018, Brno, Czech Republic, September 11-14, 2018, Proceedings. Ed. Sojka, Petr; Horák, Aleš; Kopeček, Ivan; Pala, Karel. Cham: Springer, 403–410. (Lecture Notes in Artificial Intelligence; 11107). 10.1007/978-3-030-00794-2_43.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika

Uurimisrühma liikmete riiklikul ja rahvusvahelisel tasemel olulised tunnustused 2018. aastal

Best Student Paper Award konverentsil TSD 2018 artiklile:

Data augmentation and teacher-student training for LF-MMI based robust speech recognition. Text, Speech, and Dialogue : 21st International Conference, TSD 2018, Brno, Czech Republic, September 11-14, 2018, Proceedings. Ed. Sojka, Petr; Horák, Aleš; Kopeček, Ivan; Pala, Karel. Cham: Springer, 403–410. (Lecture Notes in Artificial Intelligence; 11107). 10.1007/978-3-030-00794-2_43.

Uurimisrühma liikmete osalus välisriikide akadeemiate ja/või muude oluliste TA&I-ga seotud välisorganisatsioonide töös 2018. aastal

Einar Meister, professor Ida-Sooime Ülikoolis

LABORATORY OF LANGUAGE TECHNOLOGY

Head of the laboratory: senior research scientist Tanel Alumäe, tanel.alumae@phon.ioc.ee

Members: Lya Meister, Einar Meister

Doctoral Students: Asad Ullah

Key words: speech processing, natural language processing, phonetics

The Laboratory of Language Technology focuses on the following topics:

- Speech recognition
- Speaker recognition
- Language and accent identification
- Speech corpora
- Phonetics (Estonian prosody and sound system, L2 speech)
- Various subtopics in natural language processing

In addition, we also work on making speech technology more accessible to the general public, by creating end-user oriented speech recognition applications and packaging speech recognition related

software components in more accessible form. Our main focus is on Estonian speech recognition, but most of the components are not specific to Estonian. We are firm supporters of open source.

Selected publications

Karu, Martin; Alumäe, Tanel (2018). Weakly supervised training of speaker identification models. Odyssey 2018 The Speaker and Language Recognition Workshop : 26-29 June 2018, Les Sables d'Olonne, France, Proceedings. International Speech Communication Association, 24–30. 10.21437/Odyssey.2018-4.

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. 10.1007/s10278-018-0085-8.

Asadullah; Alumäe, Tanel (2018). Data augmentation and teacher-student training for LF-MMI based robust speech recognition. Text, Speech, and Dialogue : 21st International Conference, TSD 2018, Brno, Czech Republic, September 11-14, 2018, Proceedings. Ed. Sojka, Petr; Horák, Aleš; Kopeček, Ivan; Pala, Karel. Cham: Springer, 403–410. (Lecture Notes in Artificial Intelligence; 11107). 10.1007/978-3-030-00794-2_43.

Fields of activity by Frascati manual

1. Natural Sciences 1.2 Computer and information sciences

Significant recognition of the members of the study group at national and international level in 2018

Best Student Paper Award at the TSD 2018 conference to the paper:

Data augmentation and teacher-student training for LF-MMI based robust speech recognition. Text, Speech, and Dialogue : 21st International Conference, TSD 2018, Brno, Czech Republic, September 11-14, 2018, Proceedings. Ed. Sojka, Petr; Horák, Aleš; Kopeček, Ivan; Pala, Karel. Cham: Springer, 403–410. (Lecture Notes in Artificial Intelligence; 11107).10.1007/978-3-030-00794-2_43.

Participation of the members of the study group in the work of foreign academies and / or other relevant RD&I related organizations in 2018

Einar Meister, Professor in University of Eastern Finland

KÜBERKRIMINALISTIKA JA KÜBERJULGEOLEKU KESKUS

Keskuse juhataja: professor Rain Ottis, rain.ottis@taltech.ee

Liikmed: Hayretdin Bahsi, Ahto Buldas, Mika Juha Kerttunen, Andro Kull, Birgy Lorenz, Olaf Manuel Maennel, Anna-Maria Osula, Risto Vaarandi, Adrian Nicholas Venables, Matthew James Sorell, Eneken Tikk, Stefan Sütterlin

Doktorandid: Alejandro Guerra Manzanares, Toomas Lepik, Kaie Maennel, Sten Mäses, Jaan Priisalu, Tiia Sõmer, Dan Heering

Võtmesõnad: küberkaitse; digitaalne ekspertiis, krüptograafia

TalTechi küberkriminalistika ja küberjulgeoleku keskus töötab Eesti küberturvalisuse tõstmise nimel. Keskus kuulub TalTechi tarkvarateaduse instituudi koosseisu. Uurimismeeskonnas on erinevate teadusvaldkondade eksperte, sh arvutiteadus, õigusteadus ja psühholoogia. Selline meeskond saab ette võtta keerukaid küberturvalisusega seotud probleeme, mis vajavad interdistsiplinaarset lähenemist.

Valitud publikatsioonid

Buldas, Ahto; Laanoja, Risto; Truu, Ahto (2018). A blockchain-assisted hash-based signature scheme. Secure IT Systems: 23rd Nordic Conference, NordSec 2018, Oslo, Norway, November 28-30, 2018, Proceedings. Ed. Gruschka, Nils. Cham: Springer, 138–153. (Lecture Notes in Computer Science; 11252).10.1007%2F978-3-030-03638-6_9.

Mäses, Sten; Randmann, Liina; Maennel, Olaf; Lorenz, Birgy (2018). Stenmap: framework for evaluating cybersecurity-related skills based on computer simulations. Learning and Collaboration Technologies. Learning and Teaching : 5th International Conference, LCT 2018, held as Part of HCI International 2018, Las Vegas, NV, USA, July 15-20, 2018, Proceedings, Part II. Ed. Zaphiris, Panayiotis; Ioannou, Andri. Cham: Springer, 492–504. (Lecture Notes in Computer Science; 10925).10.1007/978-3-319-91152-6_38.

Vaarandi, Risto; Blumbergs, Bernhards; Kont, Markus (2018). An unsupervised framework for detecting anomalous messages from syslog log files. NOMS 2018 IEEE/IFIP Network Operations and Management Symposium, Cognitive Management in a Cyber World : 23-27 April 2018, Taipei, Taiwan. IEEE, 1–6.10.1109/NOMS.2018.8406283.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika

CENTRE FOR DIGITAL FORENSICS AND CYBER SECURITY

Head of the centre: Professor Rain Ottis, rain.ottis@taltech.ee

Members: Hayretdin Bahsi, Ahto Buldas, Mika Juha Kerttunen, Andro Kull, Birgy Lorenz, Olaf Manuel Maennel, Anna-Maria Osula, Risto Vaarandi, Adrian Nicholas Venables, Matthew James Sorell, Eneken Tikk, Stefan Sütterlin

Doctoral Students: Alejandro Guerra Manzanares, Toomas Lepik, Kaie Maennel, Sten Mäses, Jaan Priisalu, Tiia Sömer, Dan Heering

Key words: cyber security, digital forensics, cryptography

TalTech Centre for Digital Forensics and Cyber Security works towards improving cyber security of Estonia through education and research. The Centre is a part of TalTech Department of Software Science. The research team contains experts from different fields, including computer science, law and psychology. This breadth of expertise allows us to tackle complex cyber security problems with an interdisciplinary approach.

Selected Publications:

Buldas, Ahto; Laanoja, Risto; Truu, Ahto (2018). A blockchain-assisted hash-based signature scheme. Secure IT Systems: 23rd Nordic Conference, NordSec 2018, Oslo, Norway, November 28-30, 2018, Proceedings. Ed. Gruschka, Nils. Cham: Springer, 138–153. (Lecture Notes in Computer Science; 11252). 10.1007%2F978-3-030-03638-6_9.

Mäses, Sten; Randmann, Liina; Maennel, Olaf; Lorenz, Birgy (2018). Stenmap: framework for evaluating cybersecurity-related skills based on computer simulations. Learning and Collaboration Technologies. Learning and Teaching : 5th International Conference, LCT 2018, held as Part of HCI International 2018, Las Vegas, NV, USA, July 15-20, 2018, Proceedings, Part II. Ed. Zaphiris, Panayiotis; Ioannou, Andri. Cham: Springer, 492–504. (Lecture Notes in Computer Science; 10925). 10.1007/978-3-319-91152-6_38.

Vaarandi, Risto; Blumbergs, Bernhards; Kont, Markus (2018). An unsupervised framework for detecting anomalous messages from syslog log files. NOMS 2018 IEEE/IFIP Network Operations and Management Symposium, Cognitive Management in a Cyber World : 23-27 April 2018, Taipei, Taiwan. IEEE, 1–6. 10.1109/NOMS.2018.8406283.

Fields of activity by Frascati manual

1. Natural Sciences 1.2 Computer and information sciences

MITTELINEARSETE JUHTIMISSÜSTEEMIDE TÖÖRÜHM

Töögrupi juhataja: juhtivteadur Ülle Kotta, kotta@ioc.ee

Liikmed: Juri Belikov, Arvo Kaldmäe, Vadim Kaparin

Järeldoktorid: Ashutosh Simha

Doktorandid: Christian Meurer (kaasjuhendamisel)

Võtmesõnad: mittelineaarsed juhtimissüsteemid, algebralised meetodid, autonoomsed allveerobotid

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 väljatöötamisse, mis toetab teadusuuringuid, õpetamist ja rakendusi. On välja arendatud universaalne algebraline meetodika, mis lihtsustab mittelineaarsete juhtimissüsteemide erinevate probleemide uurimist. Põhiidee on konstrueerida juhtimissüsteemiga defineeritud diferentsiaalsete 1-vormide alamruumide (või alammodulite) jadad, mis pakuvad informatsiooni süsteemi struktuursete omaduste kohta. Antud lähenemine võimaldab juhtimissüsteeme uurida ühildatud vaatenurgast, s.o nii, et erinevatesse klassidesse kuuluvaid süsteeme (pidevad/diskreetsed, siledad/mittesiledad, jne) on võimalik iseloomustada samade meetodite, teoreemide ja algoritmide abil.

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 ionjuhitavate elektroaktiivsete polümeertäiturmehhanismide juhtimisega. Lisaks oleme välja töötanud lihtsad ja optimaalsed kontrollid kütte-, ventilatsiooni- ja kliimaseadmetele, ning kontrollinud eksperimentaalselt (meie poolt välja töötatud) olekutaastajaid ja kontrollereid aktiivse magnetlaagersüsteemi jaoks.

Uurimisrühma viimaste aastate rahvusvahelisel tasemel väljapaistvad teadustulemused.

Tõestati, et suvaline autonoomne süsteem on põhimõtteliselt vaadeldav vaid üheainsa sensori ja juhitav vaid üheainsa täiturmehhanismi abil. Tulemus on uudne isegi lineaarsete süsteemide jaoks, kus oli võimalik loobuda süsteemi tsüklilisuse eeldusest [1].

Lahendati realisatsioonülesanne ajas hilistuvate mittelineaarsete süsteemide jaoks [2].

Valitud publikatsioonid:

- [1] Y. Kawano, Ü. Kotta, C. H. Moog. Any dynamical system is fully accessible through one single actuator and related problems. *International Journal of Robust and Nonlinear Control*, 26 (8), pp. 1748–1754, 2016.
- [2] A. Kaldmäe, Ü. Kotta. Realization of time-delay systems. *Automatica*, 90, pp. 317–320, 2018.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.1 Matemaatika (Põhisuund: juhtimisteooria matemaatilised meetodid)

Uurimisrühma liikmete riiklikul ja rahvusvahelisel tasemel olulised tunnustused 2018. aastal:

Ülle Kotta, Eesti vabariigi teaduspreemia (täppisteaduste aastapreemia), “Algebralised meetodid matemaatilises juhtimisteoorias”

Uurimisrühma liikmete osalus välisriikide akadeemiate ja/või muude oluliste TA&I-ga seotud välisorganisatsioonide töös 2018. aastal.

Ülle Kotta

2011 – 2018 IEEE TC-CACS Action Group on Polynomial Methods for Control System Design, esimees

2019 – ... IEEE robustsete ja keerukate süsteemide töörühma liige

1995 – ... IFAC'i mittelineaarsete juhtimissüsteemide töörühma liige

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

NONLINEAR CONTROL SYSTEMS GROUP

Head of the research group: lead research scientist Ülle Kotta, kotta@ioc.ee

Members: Juri Belikov, Arvo Kaldmäe, Vadim Kaparin

Postdoctoral researcher: Ashutosh Simha

Doctoral student: Christian Meurer (under co-supervision)

Key words: nonlinear control systems, algebraic methods, autonomous underwater vehicles

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 significant contributions in developing constructive algebraic methods and the related symbolic software package NLControl, supporting research, teaching and applications. A universal algebraic formalism has been developed that simplifies the study of very different problems for nonlinear control systems. In this formalism, sequences of subspaces (or submodules) of differential 1-forms, associated with the control system, are defined that provide a lot of information about the system structural properties. The approach allows to study control systems from unified perspective. In such unification, different system classes (continuous/discrete, smooth/non-smooth, etc.) can be studied and characterized by the same techniques, theorems, and algorithms.

Though we mostly develop generic tools, independent of application domain, with applicability 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. Additionally, we have developed simple-yet-optimal controllers for heating, ventilation and air-conditioning systems and verified experimentally the (developed by us) observers and controllers for active magnetic bearing systems.

Latest results

- It has been proven that an autonomous system can be rendered fully controllable though a single actuator and single sensor can guarantee system observability. The solution is innovative for linear systems as well and relaxes the well-known cyclicity conditions [1].
- The solution of the realization problem for nonlinear time-delay systems is found [2].

Selected publications:

- [3] Y. Kawano, Ü. Kotta, C. H. Moog. Any dynamical system is fully accessible through one single actuator and related problems. *International Journal of Robust and Nonlinear Control*, 26 (8), pp. 1748–1754, 2016.
- [4] A. Kaldmäe, Ü. Kotta. Realization of time-delay systems. *Automatica*, 90, pp. 317–320, 2018.

3.7 1. Natural Sciences; 1.1 Mathematics; (We are **not sure** how define the correct classificatory: Main research direction: mathematical methods for control systems)

Significant recognition of the members of the study group at national and international level in 2018:

Ülle Kotta, Estonian science award (exact sciences), “Algebraic methods in mathematical control theory”

Participation of the members of the study group in the work of foreign academies and / or other relevant RD&I related organizations in 2018

Ülle Kotta

2011 – 2018 IEEE TC-CACS Action Group on Polynomial Methods for Control System Design, chairman

2019 – ... Member of the IEEE TC on Robust and Complex Systems

1995 – ... Member of the IFAC Technical Committee on Non-Linear Control Systems

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

MUDEL-PÕHISE TARKVARATEHNIKA TÖÖRÜHM

Töörühma juhataja: Vahur Kotkas, vahur.kotkas@taltech.ee

Liikmed: Irina Astrova, Hele-Mai Haav, Mait Harf, Kristiina Kindel, Ago Luberg, Riina Maigre, Jaan Penjam, Margarita Spitšakova, Tanel Tammet, Martin Verrev

Doktorandid: Priit Järv

Võtmesõnad: mudelipõhine tarkvaratehnika, loogikal põhinevad tarkvarasüsteemid, DSL metamudeli ontoloogiad, hüdraulikasüsteemide modelleerimine ja simuleerimine

Teemad ja kompetents

Töörühma uurimistöö on suunatud arendusvahendite loomisele, mis võimaldavad keeruliste süsteemide modelleerimist, arendamist ja simulatsioone, teadmiste kaevandamist, haldamist ja arutlemist ning loogikapõhist tarkvara sünteesi.

Uuringutes on keskendunud järgmistele valdkondadele:

mudelipõhine tarkvaratehnika; loogikal põhinevad tarkvarasüsteemid; ontoloogiapõhine tarkvaraarendus; DSL metamudeli ontoloogiad; struktuurne programmisüntees - tõestusotsingul põhinev programmisüntees; teadmiste kogumine, haldamine ja suurtel teadmistebaasidel loogikavahendite kasutamine; visuaalsed spetsifikatsioonikeeled; jne.

Loodud arendusvahendid

Mitmete aastakümnete jooksul on välja töötatud arendusvahendeid, mis hõlbustavad teadmiste kogumist, haldamist ja loogikapõhise programmisünteesi viljelemist:

- PRIZ - suurarvutite IBM 370, ES jaoks;
- ExpertPRIZ - PRIZ versioon arvutile koos sisseehitatud ekspertsüsteemiga;
- c-Priz - PRIZ versioon PC arvutitele. Esimene arendusvahend, milles on kasutatav graafiline kasutajaliides;
- NUT - X11-l põhinev arendusvahend tehniliseks modelleerimiseks Sun Solaris ja Linux tüüpi arvutitel (toetus katkestatud);
- Gandalf - teoreemitõestaja
- CoCoViLa - praegune Java-põhine arendusvahend mudelipõhiseks visuaalseks programmide koostamiseks.

- WhiteDB - <http://whitedb.org/>
- GKC - arutlusvahend suurtel teadmusbaasidel - <https://github.com/tammet/gkc>

Rakendused ja tegevused

Oleme arvamusel, et arendusvahendite loomisel ilma tegeliku väljundita pole mõtet. Enamik ideid, eesmärke ja realiseerimisviise on tekkinud reaalse elu ülesannetest. Järgnevalt on esitatud valik inspiratsiooni pakkunud rakendustest ja tegevustest:

- käigukasti planeerija;
- Eesti radarkatte mudel;
- vedelike vooluomaduste simulaator;
- turvalahenduste valikute optimeerija;
- graafikul põhinev automatiseeritud DDoS-rünnaku vastumeetmete valija;
- MB-JSDT - projekt, kus keskenduti mudelipõhisele Java-tarkvara arendamisele;
- VisitEstonia reisi planeerija;
- Vaatamisväärsuste külastatavuse kaart - <http://sightsmap.com/>

Uurimistulemused

Kõige olulisemad uurimistulemused on seotud uuringutega ontoloogiatega seotud tehnoloogiates ja mudelipõhise tarkvaraarenduse põhimõtete kasutuselevõtul. Meie lähenemise uudsus, võrreldes teiste ontoloogiapõhiste tarkvaraarendamise meetodikatega, seisneb formaalsete domeeni ontoloogiatega kasutamises spetsifikatsioonimalli automatiseeritud genereerimisel. Selleks kasutatakse DSL-metamudeleid, mis on kooskõlalised antud domeeni ontoloogiaga.

On loodud suurtel teadmisbaasidel kasutatavad loogikapõhised arutlusmeetodid.

Pidevalt arendatakse modelleerimisel ja intelligentsel simulatsioonil põhinevaid lähenemisi vedelike pneumohüdrauliliste sõlmede projekteerimiseks.

Valitud publikatsioonid

Grossschmidt, Gunnar; Harf, Mait (2018). Model-based simulation of hydraulic hoses in an intelligent environment. *International Journal of Fluid Power*, 19 (1), 27–41. 10.1080/14399776.2017.1374140.

Järv, Priit; Tammet, Tanel; Tall, Marten (2018). Hierarchical regions of interest. In: Bilof, Randall (Ed.). 2018 IEEE 19th International Conference on Mobile Data Management - MDM 2018 : 26-28 June 2018, Aalborg University, Denmark, Proceedings (86–95). Institute of Electrical and Electronics Engineers (IEEE).10.1109/MDM.2018.00025.

Haav, Hele-Mai; Ojamaa, Andres (2017). Semi-automated integration of domain ontologies to DSL meta-models. *International Journal of Intelligent Information and Database Systems*, 10 (1/2), 94–116. 10.1504/IJIDS.2017.10007349.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika

MODEL-BASED SOFTWARE ENGINEERING GROUP

Head of the research group: Vahur Kotkas, vahur.kotkas@taltech.ee

Members: Irina Astrova, Hele-Mai Haav, Mait Harf, Kristiina Kindel, Ago Luberg, Riina Maigre, Jaan Penjam, Margarita Spitšakova, Tanel Tammet, Martin Verrev

Doctoral Students: Priit Järv

Key words: DSL meta-model ontology, modeling and simulation of fluid dynamics, knowledge engineering

Topics and Competences

The research of the group is aiming at a tool development that enables modeling, development and simulation of complex systems, knowledge acquisition and management and logic-base software composition. The research is concentrated on the following fields: model-based software engineering; logic-based software systems; ontology-driven software development; DSL meta-model ontology; structural program synthesis – a proof search based program synthesis paradigm; knowledge acquisition; reasoning on large knowledge bases; visual specification languages; etc.

Tool history

During a number of decades several software tools that facilitate knowledge management, logic usage and program synthesis features have been developed:

- PRIZ – for mainframes IBM 370, ES;
- ExpertPRIZ – a PRIZ version for PC with a built-in expert system engine;
- c-Priz - a PRIZ version for PC implemented in C; the first tool in the line that facilitated a graphical user interface;
- NUT – an X11 based tool for engineering modeling running on Sun Solaris and Linux (support discontinued);
- Gandalf - a theorem prover
- CoCoViLa – the current Java-based tool for model based visual program composition. -
- WhiteDB - <http://whitedb.org/>
- GKC - a tool for reasoning on large knowledge basis - <https://github.com/tammet/gkc>

Applications and Activities

We consider building just the tools without any applications not fun. Most of the ideas and realization approaches are there due to the tasks from the real life. The following is a limited list of applications made:

- Gearbox planner;
- Model of Estonian Radar Coverage;
- Fluid Power Systems' Simulator;
- Graded Security Optimizer;
- Graph-Based Automated DDoS Attack Response;
- MB-JSDT - a project on model based Java software development.
- Visit Estonia trip planner
- Sights Map - <http://sightsmap.com/>

Research results

The most significant research results were related to the research on the development of ontology technology and on model-based software deployment.

A precise implementation for execution of mapping rules from OWL to the CoCoViLa modelling language and for semi-automated generation of a DSL meta-model is realized.

The novelty of our approach comparing to other ontology-driven software development methodologies lies in using formal domain ontologies as a basis for automated generation of concept specification templates of a DSL meta-model that are consistent with the given domain ontology.

A method for reasoning on large knowledge basis is introduced.

An approach based on multi-pole modelling and intelligent simulation is further developed for design of fluid power feeding systems with pneumo-hydraulic accumulators.

Selected publications

Grossschmidt, Gunnar; Harf, Mait (2018). Model-based simulation of hydraulic hoses in an intelligent environment. International Journal of Fluid Power, 19 (1), 27–41. 10.1080/14399776.2017.1374140.

Järv, Priit; Tammet, Tanel; Tall, Marten (2018). Hierarchical regions of interest. In: Bilof, Randall (Ed.). 2018 IEEE 19th International Conference on Mobile Data Management - MDM 2018 : 26-28 June 2018, Aalborg University, Denmark, Proceedings (86–95). Institute of Electrical and Electronics Engineers (IEEE). 10.1109/MDM.2018.00025.

Haav, Hele-Mai; Ojamaa, Andres (2017). Semi-automated integration of domain ontologies to DSL meta-models. International Journal of Intelligent Information and Database Systems, 10 (1/2), 94–116. 10.1504/IJIDS.2017.10007349.

Fields of activity by Frascati manual

1. Natural Sciences 1.2 Computer and information sciences

PLOKIAHELA TEHNIKATE TÖÖRÜHM

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Doktorandid: Vipin Deval, Abhishek Dixit, Vimal Kumar Dwivedi

Võtmesõnad: blockchain, smart contracts, proof of stake (PoS), decentralized autonomous organization (DAO)

BLOCKCHAIN TECHNOLOGIES GROUP

Head of the research group: Associated Professor Alexander Norta, alexander.norta@taltech.ee

Doctoral students: Vipin Deval, Abhishek Dixit, Vimal Kumar Dwivedi

Key words: blockchain, smart contracts, proof of stake (PoS), decentralized autonomous organization (DAO)

Blockchain technology and smart contracts are a key interdisciplinary, new research area that has the potential to profoundly change industry and society at large. The first prominent use case of blockchain technology is crypto-currencies as a decentralized form of payment that promises to deeply affect the currently existing central-banking systems with the introduction of triple-entry accounting ledgers. However, the spectrum of blockchain use cases has increased dramatically with the inception of so-called smart-contract systems where quasi Turing-complete programming languages are placed into the protocol layer on top of blockchain systems. That way, a new generation of distributed applications emerges that promises to de-hierarchify industry and government that allows to distributed, decentralize, disintermediate and deeply disrupt established inefficient business- and government structures. Blockchain technology serves as a truth engine for peer-to-peer, sociotechnical collaboration in trustless environments. That way, the BTG unit affects other interdisciplinary research domains such as information systems, software development, IoT, e-healthcare, e-learning, e-governance, logistics, legal research, multi-agent systems, cryptography, big-data management, cyber-physical systems, and so on.

Goals

- The development of a novel smart contract language that is legally recognized and formally verifiable before enactment.
- The adoption of multi-agent systems to solve the so-called oracle problem for smart-contract enactment, i.e., delivering trusted information to enacting smart contracts.
- The prevention of oligopoly formation for proof-of-stake consensus algorithms with means of mobile devices applications.

- The improvement of e-healthcare management processes with means of smart-contract Dapps.
- Blockchain-secured big data management systems research and development.

Valitud publikatsioonid:

Norta, Alex (2018). Self-aware smart contracts with legal relevance. 2018 International Joint Conference on Neural Networks (IJCNN) : Rio de Janeiro, Brazil, 8-13 July, Proceedings. Rio de Janeiro: IEEE, 1–8. 10.1109/IJCNN.2018.8489235.

Norta, Alex; Hawthorne, Daniel; Engel, Serafin L. (2018). A privacy-protecting data-exchange wallet with ownership- and monetization capabilities. 2018 International Joint Conference on Neural Networks (IJCNN) : Rio de Janeiro, Brazil, 8-13 July, Proceedings. Rio de Janeiro: IEEE, 1–8. 10.1109/IJCNN.2018.8489551.

Udokwu, Chibuzor; Kormiltsyn, Alexandr; Thangalimodzi, Kondwani; Norta, Alex (2018). The state of the art for blockchain-enabled smart-contract applications in the organization. Proceedings 2018 Ivannikov Isp Ras Open Conference, Dedicated to the 70th Anniversary of Computer Science in Russia, ISPRAS 2018 : 22-23 November 2018, Moscow, Russia Federation. Los Alamitos, Calif.: IEEE, 137–144. 10.1109/ISPRAS.2018.00029.

Leiding, Benjamin; Norta, Alex (2017). Mapping requirements specifications into a formalized blockchain-enabled authentication protocol for secured personal identity assurance. Future Data and Security Engineering : 4th International Conference, FDSE 2017, Ho Chi Minh City, Vietnam, November 29 - December 1, 2017, Proceedings. Ed. Dang, T. K.; et al. Cham: Springer, 181–196. (Lecture Notes in Computer Science; 10646). 10.1007/978-3-319-70004-5_13.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika
5. Sotsiaalteadused 5.2 Majandusteadus ja ärimus

PROAKTIIVTEHNOLOOGIATE LABORATOORIUM

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

Võtmesõnad: küber-füüsikaliste-süsteemid, spontaansed sensorvõrgud, uduarvutus, riigiülese tervikliku olukorrateadlikkuse võimekus

Proaktiivtehnoloogiade 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 spontaanseid sensorvõrke, teoreetiliselt uuritakse uduarvutust ja selleks kasutatavat proaktiivset vahevara (ProWare) ja osaletakse riigiülese tervikliku olukorrateadlikkuse võimekuse loomisel riigikaitse rakendustele.

Valitud projektid:

Manticus Apollo (01.09.2018 - 01.10.2020) Riigiülene olukorra teadlikkuse (OT) süsteem abistab erinevates kohtades ja erinevatel organisatsioonitasanditel olevaid otsustajaid – valitsus, KOV,

ettevõtjad, jt. – teabega riigi toimimise parandamiseks. Projekt on orienteeritud vahetult riigi sise- ja välisjulgeoleku vajadustele, ning toetab ka looduslike ja tehniliste õnnetuste/kriiside lahendamist. SmeNeTe (01.07.2017 - 01.12.2019) Projekti eesmärkideks on valideerida Thinnect OÜ poolt patenteeritud "mesh" võrgukihi rakendatavus, ProWare vahevara laiendamine vastavalt targa keskkonna rakenduste nõuetele ja pilverakenduse toetusega lokaalse diagnostika funktsionaalsuse välja arendamine juhtmevaba võrgu tarbeks.

EITSA18008 (1.04.2018 - 31.03.2019) IT-Akadeemia programm "Kvaliteedi tõstmine IKT õppekavadel" toetab küberfüüsikaliste süsteemide magistrkursuse uute materjalide loomist ja õppelabori sisustamist uute seadmetega. Projekti tulemusel tekib muuhulgas kaasaegne õppelabor traadita sensortehnoloogia õpetamiseks ja arenduseks.

LEP18032 (1.04.2018 - 30.09.2018) Projekti sisuks oli välja töötada metoodika fotodelt teekatte defektide automaatseks tuvastamiseks. Projekti tulem on suunatud kuluefektiivse teeholduse planeerimiseks.

Valitud publikatsioonid

Kaugerand, Jaanus; Ehala, Johannes; Mõtus, Leo; Preden, Jürjo-Sören (2018). Time-selective data fusion for in-network processing in ad hoc wireless sensor networks. *International Journal of Distributed Sensor Networks*, 14 (11), 1–17. 0.1177/1550147718811302.

Ehala, J.; Kaugerand, J.; Pahtma, R.; Astapov, S.; Riid, A.; Tomson, T.; Preden, J.-S.; Mõtus, L. (2017). Situation awareness via Internet of things and in-network data processing. *International Journal of Distributed Sensor Networks*, 13 (1), 1–21. 10.1177/1550147716686578.

Riid, A.; Preden, J.-S. (2017). Design of fuzzy rule-based classifiers through granulation and consolidation. *Journal of Artificial Intelligence and Soft Computing Research*, 7 (2), 137–147. 10.1515/jaiscr-2017-0010.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika

LABORATORY OF PROACTIVE TECHNOLOGIES

Head of the laboratory: professor Leo Mõtus, leo.motus@ttu.ee, tel: +372 5049 717

Members: Taivo Kangilaski, Mart Murdvee, Tõnu Näks, Andri Riid, Raul Savimaa, Andres Udal

Doctoral students: Johannes Ehala, Jaanus Kaugerand

Key words: cyber-physical-systems (CPS), ad hoc sensor networks, fog computing, comprehensive situation awareness capability

Introduction of the research group

The lab for Proactive technologies (<https://www.ttu.ee/institutes/proactivity-lab/>) focuses on teaching, theoretical and practical study of networked **cyber-physical-systems** (CPS) – for instance, developing a master level course on CPS, industrial contracts on building and applying **ad hoc sensor networks**, theoretical study of **fog computing** based on proactive middleware (ProWare), participating in building a nation-wide **comprehensive situation awareness capability**.

Selected projects:

Manticus Apollo (01.09.2018 - 01.10.2020). A nation-level situation awareness (SA) system supports the decision-makers at the various locations and levels of the government, local authorities, and entrepreneurs, providing them with the information that enables them to improve the overall functioning of the country. This project supports directly defence related activities, but also the

activities aimed to prevent and manage natural or other man-caused disasters, and/or transforming one into another.

SMeNeTe (01.07.2017 - 01.12.2019). The project goal is to validate the applicability of Thinnect patented mesh networking layer, to extend the existing middleware solution (ProWare) to offer the functionality required for Smart Environment applications and to develop functionality for in situ diagnostics of wireless network with cloud based support.

EITSA18008 (1.04.2018 - 31.03.2019). A grant from IT Academy development program "Enhancing the quality of curricula in ICT" supporting the development of new study materials for the graduate level course "Cyber-Physical Systems" and the procurement of new equipment to facilitate wireless sensor technology based study-projects and labwork.

LEP18032 (1.04.2018 - 30.09.2018). The project was about developing a methodology for the automated detection of cracks and other road defects using the high-resolution orthophotos of road surfaces. The outcome is applicable for assessing the state of roads in urban environment.

Selected publications

- Kaugerand, Jaanus; Ehala, Johannes; Mõtus, Leo; Preden, Jürjo-Sören (2018). Time-selective data fusion for in-network processing in ad hoc wireless sensor networks. *International Journal of Distributed Sensor Networks*, 14 (11), 1–17. 10.1177/1550147718811302.
- Ehala, J.; Kaugerand, J.; Pahtma, R.; Astapov, S.; Riid, A.; Tomson, T.; Preden, J.-S.; Mõtus, L. (2017). Situation awareness via Internet of things and in-network data processing. *International Journal of Distributed Sensor Networks*, 13 (1), 1–21. 10.1177/1550147716686578.
- Riid, A.; Preden, J.-S. (2017). Design of fuzzy rule-based classifiers through granulation and consolidation. *Journal of Artificial Intelligence and Soft Computing Research*, 7 (2), 137–147. 10.1515/jaiscr-2017-0010.

Fields of activity by Frascati manual

1. Natural Sciences 1.2 Computer and information sciences

SOTSIOTEHNILISTE SÜSTEEMIDE LABORATOORIUM

Labori juhataja: professor Kuldar Taveter, kuldar.taveter@taltech.ee

Liikmed: Hannes Keernik, Deniss Kumlander, Kristina Murtazin, Kalev Rannat, Mart Roost, Regina Sirendi, Jekaterina Tšukrejeva, Ermo Täks, Inna Švartsman

Doktorandid: Msury Rogasian Mahunnah, Regeina Sirendi, Inna Švartsman, Tanel Tenso

Võtmesõnad: sotsiotehniliste süsteemide nõuete analüüs, sotsiotehniliste süsteemide prototüüpimine, proaktiivsed avalikud teenused, sotsiotehnilise süsteemid olukorrateadlikkuseks laiapindses rahvuslikus riigikaitstes

Teemad ja kompetentsid

Uurimisrühm tegeleb interdistsiplinaarse uurimistööga tarkvaratehnika, kontseptuaalse modelleerimise, infosüsteemide ning sotsiaalteaduste ja psühholoogia piirimal. Rakendame motivatsioonilise modelleerimise (AOM) meetodikat keerukate sotsiotehniliste süsteemide modelleerimiseks, simulatsiooniks ja prototüüpimiseks nagu näiteks e-valitsemise, tarkade linnade ja kogukondade, kriisihalduse ja kerkuse, infosulandamise ning sotsiaalsete nähtuste simulatsiooni süsteemid.

Aastal 2018 olid kõige olulisemad uurimistulemused järgmised: agiilse tarkvaratehnika põhimõtete edasiarendamine sotsiotehniliste süsteemide jaoks, kombineerides AOM-i eesmärgimudeleid

kasutajalugudega, veebipõhise tööriista arendamine ja hindamine sotsiotehniliste süsteemide graafiliste mudelite loomiseks ja valideerimiseks, põhimõtete väljatöötamine elusündmustel põhinevate proaktiivsete avalike teenuste kavandamiseks ning olukorrateadlikkuse otsustusprotsesside määratlemine.

Valitud publikatsioonid

- Mahunnah, Msury; Taveter, Kuldar; Matulevičius, Raimundas (2018). An Empirical Evaluation of the Requirements Engineering Tool for Socio-Technical Systems. Proceedings 2018 7th Workshop on Empirical Requirements Engineering, EmpiRE 2018 : 21 August 2018, Banff, Alberta, Canada. Los Alamitos, Calif.: IEEE, 8–15. 10.1109/EmpiRE.2018.00012.
- Mahunnah, Msury; Taveter, Kuldar; Wai Shiang, Cheah; Yee Wai, Sim (2018). Empirical Evaluation of Guidelines for Prototyping Sociotechnical Systems in JADE Framework. 2018 International Symposium on Agents, Multi-Agent Systems and Robotics 2018 (ISAMSR 2018) : Putrajaya, Malaysia, 27 August 2018. IEEE, [1–6]. 10.1109/ISAMSR.2018.8540558.
- Sirendi, Regina; Mendoza, Antonette; Barrier, Mariane; Taveter, Kuldar; Sterling, Leon (2018). A conceptual framework for effective appropriation of proactive public e-services. Proceedings of the 18th European Conference on Digital Government, ECDG 2018 : University of Santiago de Compostela, Spain, 25-26 October 2018. Ed. Bouzas-Lorenzo, Ramon; Cernadas Ramos, Andres. Reading, UK: Academic Conferences and Publishing International Limited , 213–221.
- Rosquist, T.; Havlik, D.; Meriste, M. (2017). A reference decision model of first responders' decision-making. International Journal of Emergency Management, 13 (3), 193–209. 10.1504/IJEM.2017.10005414.

Uurimisrühma tegevusvaldkond Frascati Manuali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika
5. Sotsiaalteadused 5.1. Psühholoogia ja tunnetusteadused
5. Sotsiaalteadused 5.8 Meedia ja kommunikatsioon

LABORATORY OF SOCIO-TECHNICAL SYSTEMS

Head of the laboratory: Professor Kuldar Taveter, kuldar.taveter@ttu.ee

Members: Hannes Keernik, Deniss Kumlander, Kristina Murtazin, Kalev Rannat, Mart Roost, Regina Sirendi, Jekaterina Tšukrejeva, Ermo Täks, Inna Švartsman

Doctoral Students: Msury Rogasian Mahunnah, Regeina Sirendi, Inna Švartsman, Tanel Tenso

Key words: analysis of socio-technical systems requirements, prototyping of socio-technical systems, proactive public services, socio-technical systems for situational awareness in broad national defense

Topics and Competences

The research group carries out interdisciplinary research work at the intersection of software engineering, conceptual modelling, information systems, social sciences, and psychology. In particular, we apply the methodology called motivational modelling (AOM) to the modeling, simulation, and prototyping of complex socio-technical systems, such as systems for e-governance, smart cities and smart communities, crisis management and resilience, information fusion, as well as to the simulation of social phenomena.

In 2018, the most significant research results were: enhancing the practices of agile software engineering of socio-technical systems by combining goal models of AOM with user stories, development and evaluation of a tool for creating and validating graphical models of socio-technical systems, working out principles for designing proactive public services based on life events, and defining decision-making processes concerned with situation awareness.

Selected publications

- Mahunnah, Msury; Taveter, Kuldar; Matulevičius, Raimundas (2018). An Empirical Evaluation of the Requirements Engineering Tool for Socio-Technical Systems. Proceedings 2018 7th Workshop on Empirical Requirements Engineering, EmpiRE 2018: 21 August 2018, Banff, Alberta, Canada. Los Alamitos, Calif.: IEEE, 8–15. 10.1109/EmpiRE.2018.00012.
- Mahunnah, Msury; Taveter, Kuldar; Wai Shiang, Cheah; Yee Wai, Sim (2018). Empirical Evaluation of Guidelines for Prototyping Sociotechnical Systems in JADE Framework. 2018 International Symposium on Agents, Multi-Agent Systems and Robotics 2018 (ISAMSR 2018) : Putrajaya, Malaysia, 27 August 2018. IEEE, [1–6]. 10.1109/ISAMSR.2018.8540558.
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Fields of activity by Frascati manual

1. Natural Sciences 1.2 Computer and information sciences
5. Social Sciences 5.1. Psychology and cognitive sciences
5. Social Sciences 5.8 Media and communications

TUGEVALT TAGATUD TARKVARA LABORATOORIUM

Labori juht: juhtivateadur Tarmo Uustalu, tarmo.uustalu@ttu.ee

Liikmed Jüri Vain, Silvio Capobianco, Juhan-Peep Ernits, Marko Kääramees, Sven Nõmm, Hellis Tamm, Leonidas Tsiopoulos, Gert Kanter

Doktorandid: Evelin Halling, Hendrik Maarand, Deepak Pal

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

Teemad ja kompetents

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

Viimaseid uurimistulemusi

Näidati, et kahe funktori vaheliste interaktsiooniseaduste kategooria moodustab Day konvolutsiooni monoidilise struktuuri suhtes Chu ruumi; funktorite kompositsioon annab sellele kategooriale monoidilise struktuuri; monaadi ja komonaadi vahelised interaktsiooniseadused on monoidobjektid.

Brzozowski ja Antimirovi tuletiste konstruktsioonid üldistati regulaarsetelt sõnade keeltelt nende jälgsulunditele; tõestati Antimirovi automaadi lõplikkus juhul, kui sulundatud regulaarsel sõnade keelel on lõplik ühtlane laotusastak.

Sümboolsete automaatide teooria jaoks defineeriti sümboolse automaadi poolt aktsepteeritud keele mintermid ning näidati, kuidas neid saab kasutada mõnede tuntud klassikaliste automaatide sümboolsete versioonide defineerimiseks.

Töötati välja arhitektuur asjade interneti arhitektuur ja mudelipõhise tarkvaratehnika lähenemine tööstusprotsesside juhtimiskonstruktsioonide disainiks, verifitseerimiseks ja automaatseks koodigeneerimiseks.

Valitud publikatsioonid

- H. Maarand, T. Uustalu (2018). Certified Foata normalization for generalized traces. In A. Dutle, C. Muñoz, A. Narkawicz, eds., Proc. of 10th NASA Formal Methods Symp., NFM 2018 (Newport News, VA, Apr. 2018), v. 10811 of Lect. Notes in Comput. Sci., Springer, pp. 299-314. https://doi.org/10.1007/978-3-319-77935-5_21
- L. Pinto, T. Uustalu (2018). A proof-theoretic study of bi-intuitionistic propositional sequent calculus. J. Log. Comput., v. 28, n. 1, pp. 165-202. <https://doi.org/10.1093/logcom/exx044>.
- F. Siavashi, D. Truscan, J. Vain (2018). Vulnerability assessment of web services with model-based mutation testing. Proc. of 2018 IEEE Int. Conf. on Software Quality, Reliability and Security, QRS 2018 (Lisbon, July 2018), IEEE Comp. Soc., pp. 301-312. <https://doi.org/10.1109/qrs.2018.00043>.
- H. Tamm, M. Veanes (2018). Theoretical aspects of symbolic automata. In A. M. Tjoa, L. Bellatreche, S. Biffl, J. van Leeuwen, J. Wiedermann, eds., Proc. of 44th Int. Conf. on Current Trends in Theory and Practice of Computer Science, SOFSEM 2018 (Krems an der Donau, Jan./Feb. 2018), v. 10706 of Lect. Notes in Comput. Sci., Springer, pp. 428-441. https://doi.org/10.1007/978-3-319-73117-9_30

Uurimisrühma tegevusvaldkond Frascati Manuaali järgi

1. Loodusteadused 1.2 Arvutiteadus ja informaatika

HIGH-ASSURANCE SOFTWARE LABORATORY

Head of the laboratory: lead research scientist Tarmo Uustalu, tarmo.uustalu@ttu.ee

Members: Jüri Vain, Silvio Capobianco, Juhan-Peep Ernits, Marko Kääramees, Sven Nõmm, Hellis Tamm, Leonidas Tsiopoulos, Gert Kanter

Doctoral students: Evelin Halling, Hendrik Maarand, Deepak Pal

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

Topics and Competences

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

Recent research results

The category of functor-functor interaction laws was shown to be a Chu space wrt the Day convolution monoidal structure; functor composition endows this category with a monoidal structure; monad-comonad interaction laws are monoid objects.

The Brzozowski and Antimirov derivatives constructions were generalized from regular word languages to their trace closures; the Antimirov automaton was proved to be finite if the regular word language subjected to trace closure has finite uniform rank.

For the theory of symbolic automata, canonical minterms of a language accepted by a symbolic automaton were defined and shown to be useful for defining symbolic versions of some known classical automata.

An architecture for the Internet of Things (IoT) and a Model-Based Engineering (MBE) approach for design, verification, and auto-code generation of control applications in process industries were proposed.

Selected publications:

- H. Maarand, T. Uustalu (2018). Certified Foata normalization for generalized traces. In A. Dutle, C. Muñoz, A. Narkawicz, eds., Proc. of 10th NASA Formal Methods Symp., NFM 2018 (Newport News, VA, Apr. 2018), v. 10811 of Lect. Notes in Comput. Sci., Springer, pp. 299-314. https://doi.org/10.1007/978-3-319-77935-5_21
- L. Pinto, T. Uustalu (2018). A proof-theoretic study of bi-intuitionistic propositional sequent calculus. J. Log. Comput., v. 28, n. 1, pp. 165-202. <https://doi.org/10.1093/logcom/exx044>.
- F. Siavashi, D. Truscan, J. Vain (2018). Vulnerability assessment of web services with model-based mutation testing. Proc. of 2018 IEEE Int. Conf. on Software Quality, Reliability and Security, QRS 2018 (Lisbon, July 2018), IEEE Comp. Soc., pp. 301-312. <https://doi.org/10.1109/qrs.2018.00043>.
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1. Natural Sciences 1.2 Computer and information sciences