



Evaluation of Mathematics, ICT and Technology (EVALMIT) 2023-2024

Self-assessment for research groups

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Introduction

1. Organization and strategy

1.1 Research group's organization

With a staff of more than 400, The UiO Department of Informatics (IFI) is a “powerhouse” for informatics training and research in Northern Europe. It is the largest such unit in Norway and the one with the strongest international rankings. Around a comprehensive core in computer science, IFI interprets informatics in substantial breadth: from microelectronics or signal processing, to participatory design or digital innovation. In 2023, IFI hosts five BSc and eight MSc study programs, with close to 2500 students. The department is organized in four thematic sections, each of which comprising 2–5 research groups. Our group, Programming Technology (PT), is part of the section for Programming (PROG).

The group was established as per January 1st, 2020, when a new structure for the entire department was implemented.

Historically, going back several decades, the origin of the group goes back to Kristian Nygaard Object Oriented group, which until 2014 was the Objekt, Modellering og Språk group / Objects, Modelling and Languages Group. OMS was integrated into the Programming and Software Engineering group in 2014, and split out again in 2020 as a separate group.

During the period 2014 – 2020 almost all of the Professors/Associate Professor/Lecturers in the original OMS group retired. In 2016, a new Professor was hired to continue the research in the areas of the original OMS group. When the department did a major reorganization of the structure of the research groups, including introducing the concept of five Sections that each had on the order of three to five research groups, the Programming Technology group was split off from the PSE group – essentially the “P” of PSE (and also a new Software Engineering group “SE”).

Since the establishment of the PT group, the group has grown by a full professor and an Associate Professor and now consists of two professor, one Associate Professor, and two Lecturers.

Currently, the group has five Ph.D. students and is pursuing further young.

As a young group, in the rest of this document, the descriptions for the GROUP will be for the period from primo 2020; for the individual researchers, the period will include their contributions while part of the old PSE group.

The group is headed by a group manager, but with a significant degree of self-rule for every group member

Concerning funding, the group is funded by IFI/MN/UiO as a research group.

Table 1. List of number of personnel by categories

	Position by category	No. of researcher per category	Share of women per category (%)	No. of researchers who are part of multiple (other) research groups at the admin unit	No. of temporary positions
No. of Personnel by position	Professor	2	0	0	0
	Associate Professor	1	0	0	0
	PhD fellowships	5	60	0	0
	Lectures	2	0	0	0
	Adjunct professors	1	0	0	0

1.2 Research group's strategy

The group grew out of the Programming and Software Engineering Group in 2020.

The group has established a new research goal: *Research in Energy Aware Computing*.

Common research objectives of the PT group:

- Gain a better understanding of energy consumption of computing.

- Ensure that tools and programs become energy aware and thus energy efficient.

Much research has focused on *efficient* computing, where efficient traditionally means using a metric of TIME and SPACE. For energy efficiency, we need to use the metric of ENERGY USED instead. This opens up a number of new research areas.

Multiple Approaches for Energy Awareness:

- Modify algorithms, both sequential and parallel, to use less energy
 - Influence of cache and execution time
- Improve Garbage Collectors and Virtual Machines
- Modify optimizing Compilers for fast and energy efficient code
- Support programmers in energy-aware programming languages

Developing energy-aware programming techniques will enable programmers to write more energy efficient program; however, it is worth noting that providing tools, *e.g.*, a compiler that generates more energy efficient code, can improve thousands of programs merely by recompilation.

The group is actively recruiting internationally and is reaching out to contacts internationally with a view to apply for multilateral funding. At the same time, we are planning several national grant applications in the Sustainability areas.

The group is quite new and is in the process of establishing its new research strategy. Because of this, a benchmark has, as yet, not been established.

The group has significant contributions to both the Bachelor's and Master's and PhD education at IFI. In the past two years, we have had a total of 14 Master's students and four PhD students.

We have significant teaching contribution in bachelor's courses and independently run four different Master's courses, three of which have been developed in the group over the past few years.

Furthermore, we are developing an entirely new course that includes novel on-line tools in cooperation with the University of Košice.

For 2023, one of the professors in the group has been named "Teacher of the year".

The department provides a fairly standard support setup, including extensive access to non-open-access articles at major publishers, good IT-support, and good admin support.

1.3 Relevance to the institutions

The research groups new research emphasis is on sustainability, specifically how changes in programming models, compiler, and tools can improve the energy awareness and efficiency of programming languages and their implementations.

As yet, we still need to establish suitable benchmarks; however, the area of energy aware computing is still a very new field and there is no consensus on whether or not there are significant improvement to be achieved; thus it is an active, but also open, research field.

1.4 Research group's resources

The group's main source of funding is the basic funding by the department along with a total of four Ph.D. stipends from KD funds.

Table 2. Describe the sources of R&D funding for the research group in the period 2018-2022.

	2018 (kNOK)	2019(kNOK)	2020 (kNOK)	2021(kNOK)	2022(kNOK)
Basic funding	2157	2781	3486	3315	4020
Funding from industry and other private sector sources					
Commissioned research for public sector					
Research Council of Norway					
Grant funding from other national sources					
International funding e.g. NIH, NSF, EU framework programmes				100	120
Other					

1.5 Research group's infrastructures

The group has established an open source version of CapillaryNet, which is maintained in cooperation with a researcher at USN Kongsberg.

The group continues to maintain the Emerald System, available at <https://www.emeraldprogramminglanguage.org/>

The group is currently establishing an EnergyLab with capacity to measure energy consumption of different computers and machines. This includes dedicated laptops, RaspberryPi and power meters.

The group has been using the international experimental, world-wide testbed Planetlab, which being shut down

1.6 Research group's cooperations

Table 3. Reflect on the current interactions of the research group with other disciplines, non-academic stakeholders and the potential importance of these for the research (e.g. informing research questions, access to competence, data and infrastructure, broadening the perspectives, short/long-term relations).

Collaboration with other research sectors e.g. higher education, research institutes, health trusts and industry.	Tobias Wrigstad (tobias.wrigstad@it.uu.se) from Uppsala University, Uppsala, Sweden. The PT group had a collaboration with the people from Uppsala Univ. in Sweden, in adjusting the Heap Size used in GC with CPU Control resulting in a paper (Heap Size Adjustment with CPU Control. Sanaz Tavakolisomeh, Marina Shimchenko (Uppsala University), Erik Osterlund (Oracle Sweden), Rodrigo Bruno (INESC-ID / Department of Informatics, University of Lisbon), Paulo Ferreira, Tobias Wrigstad (Uppsala University). In 20th International Conference on Managed Programming Languages & Runtimes (MPLR 2023). The group has a long running collaboration with Trinity College Dublin that has resulted in an (unsuccessful) EU application and two co-supervised, completed Ph.D.s. The group has a long running collaboration with Bell Labs (previously Alcatel-Lucent Bell Labs, now Nokia Bell Labs) that has resulted in two industrial Ph.D.s, six co-authored papers and 18 patent applications of which, so far, nine have been granted (see list in section 2.2).
<u>Transdisciplinary</u> (including non-academic stakeholders) <i>Transdisciplinary research involves the integration of knowledge from different science disciplines and (non-academic) stakeholder communities with the aim to help address complex societal challenges.</i>	Maged Helmy, UiO, ODI Medical, USN Kongsberg and NewCode.ai: cooperation concerning CapillaryNet, resulting in one industrial Ph.D. and four co-authored papers. The group collaborates with other international research institutions, companies, governmental organizations to improve communications systems in the maritime sector. This involves development inputs and standards to international organizations.

2. Research quality

2.1 Research group's scientific quality

The activities that have contributed to the scientific quality are described below. These are on-going and completed activities, and in general does not include new activities that have, as yet, not yielded significant contributions.

Google Indexes (as of January 2024)

Prof A	8274	h22
Prof B	2573	h26
Associate Prof	570	h14
New Ph.D. hire	34	h3

Activities

Automatic human activity detection.

Automatic human activity detection, mainly transport-wise, has been gaining interest not only because it allows better planning of our cities but also because new approaches have been made possible with the widespread use of smartphones carrying several different sensors. The automatic transport mode detection (TMD), instead of using paper-based surveys, is of utmost relevance for architects and urban planners (among many others) when designing cities, roads, public transportation systems, etc. In addition, the information obtained by TMD systems is essential for providing mobile users with various value-added services. TMD can facilitate services for transportation, navigation, health, and entertainment.

Information, entropy, and energy in computations

Computation model and their inherent implantation in programming languages are often designed with practical and concrete measures in mind. For general purpose models and programming languages that is often speed, while domain specific programming languages are trying to implement a limited domain. There are, however, more abstract properties that has a fundament impact, but are much harder to quantify. These include information preservation, aspects of entropy and energy usage. There is a theoretical relation between these that are not well understood. The group pursues different research directions under this umbrella. This includes *Reversible Computations*, where information preservation is a key bridge to energy preservation; *Reliable Decentral Systems*, where information flow in key to achieve reliability across nodes; *Quantum Computations*, where information progression is a fundamental property that must be kept until correct measurement; and latest *Energy-Aware Programming*, where we try to understand sources of energy-loss from empirical studies.

Decentralized reliable systems with a focus on the maritime sector

Founded in several international project, the group is an active participant in the international Maritime Connectivity Platform Consortium. In collaboration with international research

institutions, companies, organizations, and maritime governmental authorities, we design decentralized reliable systems to improve communication in the maritime sector. This includes development of standards, guidelines and influencing large international organizations, such as IALA, IHO, etc.

Fast and Efficient Parallel Computing on Multi-Core Computers

Efficient utilization of modern multi-core computers often requires traditional sequential algorithms to be reworked into parallel threads as to achieve the full speed-up potential of the multi-core hardware. We have been transforming a number of traditional algorithms into highly efficient parallel programs. Several of these transformations have been published.

Language Constructs for Distributed Computing

With the advent of powerful and inexpensive internet connections, distributed computing has become pervasive. Traditionally, programming language do not have language constructs for supporting distributed – rather they rely on library routine that access the underlying operating system and its network stack. We have proposed and researched a number of language constructs as to efficiently and smoothly support distributed programming in a OS-transparent manner.

Live Migration of Virtual Machines

Migration of data – and of threads, processes, and even full Virtual Machines – has become mainstream in Cloud Computing – especially at Cloud Computing Centers where the live migration of virtual machines enables 24/7/365 operations in response to hardware replacement and user compute demands. Over several decades, we have done research into live migration at many different levels and modes of granularity from migration a small object with a single variable up to live migration of entire actively running Linux operating systems.

Please add a link to the research group's publication list at the research group's website:

https://www.mn.uio.no/ifi/english/about/strategy/evalmit/pt.html

Table 4. List of projects

Project 1: <i>Project title/Project period (year from – year to)</i>	Project owner(s) (project leaders organisation)	UiO and ODI Medical
	Total budget and share allocated to research group	One half of an industrial Ph.D. provided by the Norwegian Research Council, the other half by ODI Medical in an Industrial Ph.D. project nr: 305716 and BIA project nr: 282213.
	Objectives and outcomes (planned or actual) and link to website	Produce real-time, bed-side analysis of blood movement in surface capillaries using a small, hand-held microscope. The system uses AI running on a off-the-shelf laptop and an inexpensive microscope. The system provides real-time analysis in about 1 second replacing a cumbersome procedure involving a stationary microscope in a hospital lab that produces analog pictures requiring manual evaluation by a clinic technician, an analysis that often takes 20 minutes. https://github.com/magedhelmy1/capillarydetection
Project 2: <i>EfficienSea2 (2015 – 2018)</i>	Project owner(s) (project leaders organisation)	Coordinated by the Danish Maritime Authority
	Total budget and share allocated to research group	0.5 M EUR. Allocated to current group member at the time at University of Copenhagen
	Objectives and outcomes (planned or actual) and link to website	• Improve navigational safety and efficiency • Improve Arctic navigation and emergency response • Decrease administrative burdens • Improve environmental monitoring & enforcement https://cordis.europa.eu/project/id/636329

	Objectives and outcomes (planned or actual) and link to website	

Table 5. Research group's contribution to publications

Publication 1:	Authors (Please highlight group members)	Maged Helmy , Trung Tuyen Truong (University of Oslo), Anastasiya Dykky (ODI Medical AS), Paulo Ferreira , Eric Jul
<i>Project title/Journal/Year/DOI/URL</i>	Short description	Capillaries are the smallest vessels in the body which are responsible for delivering oxygen and nutrients to surrounding cells. Various life-threatening diseases are known to alter the density of healthy capillaries and the flow velocity of erythrocytes within the capillaries. In previous studies, capillary density and flow velocity were manually assessed by trained specialists. However, manual analysis of a standard 20-s microvascular video requires 20 min on average and necessitates extensive training. Thus, manual analysis has been reported to hinder the application of microvascular microscopy in a clinical environment. To address this problem, this paper presents a fully automated state-of-the-art system to quantify skin nutritive capillary density and red blood cell velocity captured by handheld-based microscopy videos. The proposed method combines the speed of traditional computer vision algorithms with the accuracy of convolutional neural networks to enable clinical capillary analysis. The results show that the proposed system fully automates capillary detection with an accuracy exceeding that of trained analysts and measures several novel microvascular parameters that had eluded quantification thus far, namely, capillary haematocrit and intracapillary flow velocity heterogeneity. The proposed end-to-end system, named CapillaryNet, can detect capillaries at ~0.9 s per frame with ~93% accuracy. The system is currently used as a clinical research product in a larger e-health application to analyse capillary data captured from patients suffering from COVID-19, pancreatitis, and acute heart diseases. CapillaryNet narrows the gap between the analysis of microcirculation images in a clinical environment and state-of-the-art systems.

	Research group's contribution	Main authors and sole software developers. CapillaryNet: An automated system to quantify skin capillary density and red blood cell velocity from handheld vital microscopy. Maged Helmy (University of Oslo), Trung Tuyen Truong (University of Oslo), Anastasiya Dykky (ODI Medical AS), Paulo Ferreira (University of Oslo), Eric Jul (University of Oslo). Artificial Intelligence in Medicine (2022).
Publication 2: <i>Project title/Journal/Year/DOI/URL</i>	Authors (Please highlight group members)	Paulo Ferreira , Constantin Zavgorodnii, Luis Veiga
	Short description	edgeTrans - Edge transport mode detection. Paulo Ferreira (University of Oslo), Constantin Zavgorodnii (INESC-ID / University of Lisbon), Luis Veiga (INESC-ID / University of Lisbon). Elsevier Journal on Pervasive and Mobile Computing (2020). volume 69, issn 15741192.
	Research group's contribution	Main author.
Publication 3: <i>Project title/Journal/Year/DOI/URL</i>	Authors (Please highlight group members)	Markus Schordan, Tomas Oppelstrup, Michael Kirkedal Thomsen & Robert Glück
	Short description	Optimistic parallel discrete event simulation (PDES) requires doing a distributed rollback if conflicts are detected during a simulation due to the massively parallel optimistic execution approach. When a rollback of a simulation is performed each node that is determined to be in a wrong state must be restored to one of its previous states. This can be achieved through reverse computation or by restoring a previous checkpoint. In this paper we investigate and compare both approaches, reverse computation, and a variant of checkpointing, incremental state saving (also called incremental checkpointing), to restore a previous program state as part of an optimistic parallel discrete event simulation. We present a benchmark model that is specifically designed for evaluating the performance of approaches to reversibility in PDES.

	Research group's contribution	Fundament knowledge on design and implementation of domain-specific programming languages.
Publication 4: <i>Project title/Journal/Year/DOI/URL</i>	Authors (Please highlight group members)	Mahdieh Kamalian, Paulo Ferreira, and Eric Jul (all UiO)
	Short description	A Survey on Local Transport Mode Detection on the Edge of the Network. Springer Journal on Applied Intelligence (The International Journal of Research on Intelligent Systems for Real Life Complex Problems). ISSN 0924-669X. doi: 10.1007/s10489-022-03214-y. As the title suggests, the paper present a survey of Transport Mode Detection on the Edge of the Network.
	Research group's contribution	All the survey was done in-house as well as the paper writing. Thus, the Group contribution is 100%.
Publication 5: <i>Project title/Journal/Year/DOI/URL</i>	Authors (Please highlight group members)	Arne Maus, Thomas Gulli, Eric B Jul (all UiO)
	Short description	A novel set of improvement to efficiently find Large Prime Gaps on Multi-core computers.
	Research group's contribution	Group contribution is 100%. Some Faster Algorithms for Finding Large Prime Gaps Arne Maus, Thomas Gulli, Eric B Jul - Norsk IKT-konferanse for forskning og utdanning, 2020

2.2 Research group's societal contribution

The group's research is in many ways at the "heart" of Computer Science – *i.e.*, deep down in the "engine", so therefore it is harder for our research have visible impact to the general public. We do have some areas where our research is more "visible". One project concerns analysis of transport patterns – this has been described in an interview in Titan: *"Vil bruke KI til å analysere transportdata fra smarttelefoner – kan føre til nye billettsystemer."*

We have also engaged in cross-disciplinary research, successful example has been a recent Industrial Ph.D. (defended in 2022) concerning the design of a system to evaluate the health of a patient by inspecting blood flow in the capillaries in the skin of patients. The Ph.D. work resulted in a system, CapillaryNet: An automated system to quantify skin capillary density and red blood cell velocity from handheld vital microscopy.

This project combined systems architecture, machine learning and clinical diagnosis. The resulting, patented, system, resulted in significantly better results than a clinical technician and within a time frame of seconds rather than hours, thus enabling inexpensive, real-time bedside analysis of microcirculation in a clinical environment.

Contributions besides publications are an Open Source Software depository and a Patent Application, listed below.

Patent in cooperation with ODI Medical

[Capillary analysis](#)

WO EP GB [WO2022184943A1](#) Maged HELMY Odi Medical As

Priority 2021-03-05 • Filed 2022-03-07 • Published 2022-09-09

An automated method for analysing capillaries in a plurality of images acquired from a subject. The method comprising the steps of: a) acquiring the plurality of images; b) generating a plurality of capillary candidate maps for each of said images, each capillary candidate map comprising one or ...

Running the NIKT organization

For the past years, the group has provide both the Head and Vice-Head of the NIKT organization that is responsible for the annual [Norsk IKT-konferanse for forskning og utdanning](#).

President of AITO

A group member has been the President of the non-profit, international AITO organization that arranges the annual European Conference on Object Oriented Programming.

Bell Labs

In our cooperation with Bell Labs (Previously Alcatel-Lucent Bell Labs, now Nokia Bell Labs), we have filed 18 patent applications of which, so far, nine have been granted. Two industrial Ph.D.'s have completed.

List of Granted Patents in cooperation with Bell Labs

[Method for balancing a load, a system, an elasticity manager and a computer ...](#)

EP US [US9891941B2](#) Eric JUL Alcatel Lucent

Priority 2014-08-20 • Filed 2015-08-06 • Granted 2018-02-13 • Published 2018-02-13

A method, in a virtualized system, for balancing a load across multiple virtual machines instantiated over physical hardware of the system, including vertically scaling the capacity of respective ones of the VMs up to a physical capacity limit, L PHY , from an initially allocated physical capacity, ...

[Network nodes and methods](#)

WO EP US CN JP KR PL [US9894530B2](#) Eric B. Jul Alcatel Lucent

Priority 2010-11-05 • Filed 2011-11-02 • Granted 2018-02-13 • Published 2018-02-13

Methods and network nodes of a wireless telecommunications system are disclosed. One method of controlling transmissions with a base station of a wireless telecommunications system comprises the steps of: determining a set of neighboring base stations, each base station in the set of neighboring ...

[Secure data processing](#)

WO EP US CN [US9674153B2](#) Eric B. Jul Alcatel Lucent

Priority 2012-06-07 • Filed 2013-05-31 • Granted 2017-06-06 • Published 2017-06-06

A secure data processing apparatus and method are disclosed. The secure data processing apparatus is operable to securely process user data provided by a user and includes a trusted domain having a trusted bus; a trusted domain controller coupling the trusted bus with an untrusted bus of an ...

[A method and system for scaling and a telecommunications network](#)

EP [EP3035619B1](#) Eric Jul Alcatel Lucent

Priority 2014-12-15 • Filed 2014-12-15 • Granted 2019-02-13 • Published 2019-02-13

A computer-implemented method, in a virtualized system (400) comprising multiple virtual machine, VM, instances (403) executing over physical hardware (405), for scaling one or more of the VM instances, the method comprising: collecting data representing one or more interactions between VM ...

[A femtocell base station, and a method of selecting carrier frequency band of a ...](#)

WO EP US CN [EP2426974B1](#) Eric B Jul Alcatel Lucent

Priority 2010-09-03 • Filed 2010-09-03 • Granted 2017-03-01 • Published 2017-03-01

A method of selecting carrier frequency band of a femtocell base station (30,55) that provides a femtocell and resides within a macrocell (24) provided by a macrocell base station (22), the method comprising: the femtocell base station operating initially at the carrier frequency band (50) of the ...

[Load-balancing and scaling of cloud resources by migrating a data session](#)

EP US [EP3046028B1](#) Eric Jul Alcatel Lucent

Priority 2015-01-15 • Filed 2015-01-15 • Granted 2020-02-19 • Published 2020-02-19

A method, in a virtualized system comprising first and second virtual machine, VM, instances executing over physical hardware, the first VM instance participating in multiple data sessions, wherein for the duration of each data session a communications channel is formed with a respective client ...

Secure data processing

EP [EP2827276B1](#) Eric Jul Alcatel Lucent

Priority 2013-07-19 • Filed 2013-07-19 • Granted 2019-07-03 • Published 2019-07-03

A secure data processing apparatus operable to securely process user data provided by a user, said secure data processing apparatus comprising: a trusted domain (20) comprising a trusted bus coupled with a trusted data processing apparatus operable to process incoming user data received over said ...

Content-centric networking

WO EP [EP2785017B1](#) Eric Jul Alcatel Lucent

Priority 2013-03-28 • Filed 2013-03-28 • Granted 2018-07-11 • Published 2018-07-11

A method for a network node (20, 21, 22) of a content-centric network the method, comprising: receiving an interest packet (60) over a link from a requesting network node requesting content be provided, said interest packet having a received charge value associated therewith, a magnitude of said ...

Content-centric networking

EP [EP2940967B1](#) Eric Jul Alcatel Lucent

Priority 2014-04-30 • Filed 2014-04-30 • Granted 2018-02-14 • Published 2018-02-14

A method for a pre-caching network node (130) of a content-centric network, the method comprising: when it is determined that selected content (150) is to be pre-cached by said pre-caching network node, setting a resistance value allocated to incoming links (184; 182) with other network nodes when ...

Table 7. The research group's societal contribution, including user-oriented publications, products (including patents, software or process innovations)

No.	Name of publication/product	Date of publication/product	Link to the document
1	Method for balancing a load, a system, an elasticity manager and a computer program product	US Patent S9891941 granted 2018-02-18 • Published: 2018-02-18	https://patentimages.storage.googleapis.com/28/49/41/0402e00b914c33/US9891941.pdf
2	Secure data processing	European patent EP2827276 granted 2019-07-03 • Published 2019-07-03	https://patentimages.storage.googleapis.com/4f/41/c8/71a1ca966ac855/EP2827276B1.pdf
3	Load-balancing and scaling of cloud resources by migrating a data session	European patent EP3046028 granted 2020-02-19 • Published 2020-02-19	https://patentimages.storage.googleapis.com/50/9c/70/ede0ce4d8676f5/EP3046028B1.pdf
4	Capillary analysis	European patent application: Application PCT/EP2022/055767, published: 2022-09-09	https://patentimages.storage.googleapis.com/b6/d6/94/4d59fcea0c2704/WO2022184943A1.pdf
5	Open Source Software: CapillaryNet	Software to do capillary flow analysis, 2022	https://github.com/magedhelmy1/capillarydetection
6	Open Source Software: Emerald	The Emerald Object Oriented Programming Language for Distributed Computing, since 1989 with many updates up until today.	https://www.emeraldprogramminglanguage.org/
7	Standardization of communication in the maritime sector under the MCP consortium	From 2019 and onwards	https://maritimeconnectivity.net/mcp-documents/

3. Challenges and opportunities

<i>Strengths</i> • High quality of researchers • Newly developed research vision • International connections and cooperation • International industrial contacts • High quality, active Ph.Ds. • Good gender balance amongst Ph.D. students	<i>Weaknesses</i> • Poor gender balance amongst tenured members • Limited NORWEGIAN industrial contacts
<i>Opportunities</i> • Leverage new hires and new department strategy to develop a strong strategy for the future • Follow up on research vision concerning energy aware computing realigning the group's research • Develop industrial contacts within Norway • Develop inter-group/-section contacts within IFI	<i>Threats</i> • Current hold on replacing retiring professor will soon impact group • Limited equipment for parallel programming and energy measurements to support research vision