The Research Council of Norway

Evaluation of Mathematics, ICT and Technology 2023-2024

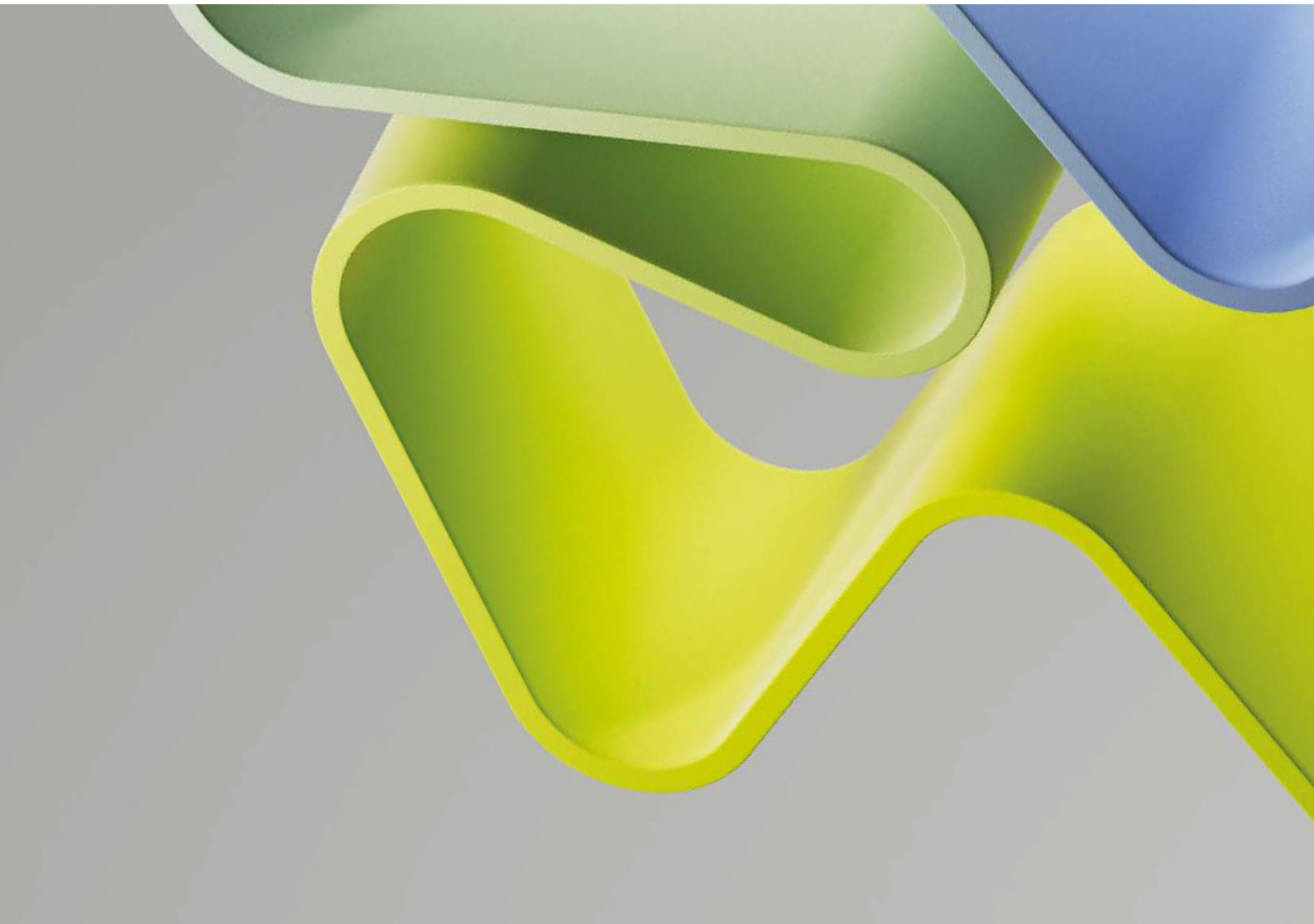
Evaluation Report for Administrative Unit

Administrative Unit: **Department of Computer Science (IDI)**

Institution: **Norwegian University of Science and Technology (NTNU)**

Evaluation Committee Higher Education Institutions 1

December 2024



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Statement from Evaluation Committee Higher Education Institutions 1

The members of this Evaluation Committee have evaluated the following administrative units at the higher education institutions within Mathematics, ICT and Technology 2023-2024 and has submitted a report for each administrative units:

- Department of Informatics, University of Bergen (UiB)
- Department of Mathematics, University of Bergen (UiB)
- Department of Informatics, University of Oslo (UiO)
- Department of Mathematics, University of Oslo (UiO)
- Department of Computer Science (IFI), UiT The Arctic University of Norway
- Department for Mathematics and Statistics (IMS), UiT The Arctic University of Norway
- Department of Mathematical Sciences (IMF), Norwegian University of Science and Technology (NTNU)
- Department of Computer Science (IDI), Norwegian University of Science and Technology (NTNU)
- Department of Mathematics and Physics (IMF), University of Stavanger (UiS)
- Faculty of Engineering and Science (TekReal), University of Agder (UiA)
- Department of Electrical Engineering and Computer Science (IDE), University of Stavanger (UiS)

The conclusions and recommendations in this report are based on information from the administrative units (self-assessment), digital meetings with representatives from the administrative units, bibliometric analysis and personnel statistics from the Nordic Institute for Studies of Innovation, Research, and Education (NIFU) and Statistics Norway (SSB), and selected data from the National survey for academic staff in Norwegian higher education and the National student survey (NOKUT). The digital interviews took place in the autumn 2024.

The members of the Evaluation Committee are in collective agreement with the assessments, conclusions and recommendations presented in this report. None of the committee members has declared any conflict of interest.

The Evaluation Committee consisted of the following members:

Professor Rebecka Jörnsten (Chair),

Univ. Gothenborg/Chalmers

Professor Matthias Schütt,
Leibniz Universität Hannover

Professor Jan Hesthaven,
École Polytechnique Fédérale de Lausanne

Professor Mads Nielsen,
University of Copenhagen

Professor Tiziana Margaria,
University of Limerick

Dr. Joanna Staneva,
Helmholtz Zentrum Hereon

Professor Björn Engquist,
University of Texas at Austin

Professor Plamen Angelov,
Lancaster University

Description of the Administrative Unit

The department operates in Trondheim and Gjøvik, consisting of six organizational units responsible for various administrative functions, including personnel, teaching activities, and research management. It has three deputy heads focusing on education, sustainability, and research, with a leadership group that includes these deputy heads, unit leaders, and administrative representatives. The research committee, which oversees research strategies and PhD programs, consists of members from each organizational unit and PhD candidates.

Most permanent research staff are engaged in a balanced mix of teaching, research, and administration, with a total of 44 professors and 51 associate professors across the campuses. However, the department faces challenges with gender balance, having a low representation of women in senior positions, which it is actively addressing through targeted recruitment initiatives. Temporary staff primarily consists of PhD candidates and postdocs, with additional smaller positions held by professors and associate professors.

The research is organised in the following research groups:

- Algorithms, HPC and Systems
- Applied Artificial Intelligence
- Artificial Intelligence Foundations (AIFO)
- Colourlab (Colourlab)
- Visual Computing Group
- Computing Education Research Group
- Software Engineering and Learning Technology (SE-LT)
- Computer Architecture Lab (CAL)
- Intelligent Systems and Analytics (ISA)
- Information Systems

The department's strategic goal is to comprehensively address all layers of the computing stack, from hardware to sociotechnical aspects, through focused research on long-term thematic topics. This includes integrating sustainability strategies that emphasize responsible resource use and minimizing environmental impact within research and education. The department aims to foster innovation and industry collaboration by coordinating initiatives and seeking funding through Norway's Centres for Research-based Innovation (SFI). Additionally, the unit is committed to enhancing public knowledge of ICT and increasing its social impact by engaging in outreach activities, such as public debates and hosting events through the Norwegian Open AI Lab.

The department engages in a wide range of collaborations across industry, public health, research units, and policy-making, both nationally and internationally. These partnerships are crucial for achieving the unit's strategic goal of producing research that spans the entire computing stack, from hardware to sociotechnical aspects, thus significantly contributing to the Norwegian research landscape and society. The department maintains a robust network with various universities and industries through national centers, linking its research to broader academic and industrial contexts. Internationally, the department participates in European Union Horizon 2020 and Horizon Europe projects, with about 70% of its research outputs co-authored with international partners.

Overall Assessment

The Terms of Reference letter has asked the Evaluation Committee to take especial notice to that NTNU has a national role and responsibility as the major university for technology education and research; the department, as part of a national strategy, is located at two geographical locations; the department aims to cover research areas presently in demand by the Norwegian society (including public sector and industry) whilst building knowledge and expertiseas a foundation for future science and technology breakthroughs; and the strategy in relation to resources and competences.

The department is distributed over two physical locations in Trindheim and Gjøvik, with the latter being the smaller.

The strategy of the AU may be interpreted defined from a computer science logic and not from a logic of computer science in relation to society as it aims at covering all layers of the computing stack, from the low levels of computing substrates and hardware to the higher levels of applications, users and sociotechnical aspects.It is however also mentioned that it must serve the Norwegian needs meaning that the AU must provide knowledge readiness for the future. This latter aspect could be better developed to include processes to make sure to be ahead of development in society as building competences in academia takes time.

The organisation seems very well aligned to achieve the goals and is appropriate and balanced with an appropriate management structure.

Faculty hasn’t increased proportionally to the student numbers. The AU has a well structured process to manage the overall teaching load, but does not monitor the individual teaching load making it possible that informal management plays a role in load distribution.

It is not described if junior staff receives training in responsible conduct of research or university pedagogics. It is not described how competences and tasks are aligned, and how quality is ensured.

The AU has an excellent track record of obtaining competitive grants but has yet to obtain the most prestigious individual excellence grants such as ERC. The AU has a strong track record in obtaining other European grants not from the excellence pillar.

The AU has an excellent track record for engaging in cross disciplinary effort within the institution and nationally and have substantial national and international collaborations with 60% of papers being internationally co-authored.

The AU has had an increased number of full-time research staff growing from 86 in 2013 to 222 full-time research staff members in 2021 distributed as 38% professors, 13% researchers and postdocs, and 49% PhD-students. Hence the ratio of postdocs and PhDs to professors is 1:0.34 and 1:1.30 respectively. This is an appropriate ratio of PhD students whereas post docs for many disciplines would have a higher ratio optimally.

The share of women is 29% of women with lower numbers in higher seniority. All personnel groups show an increasing trend in gender equality.

The number of full-time researchers in the AU have grown 45% since 2013. The number of publications has in the same period grown 60% and author shares grown 64%. There seems to have been a slight stagnation in both over the last 4 years. The citation score has increased 40% in the period 2013 (which was a high outlier) to 2022 and has 22% among the 10% most cited in 2019-2021.

The Terms of Reference for the administrative unit is attached to the report.

Recommendations

1. It is recommended to continue the focus on integration of the physical locations.
2. It is well appreciated that the AU aligns the strategy with both internal CS logic and the external needs of the Norwegian society, and it is recommended to further refine this in srtategic processes to make sure that new scientifically or societally important areas like AI and Quantum (and new to come) are addressed timely.
3. It is recommended that the AU and faculty seeks to maintain a reasonable student to professor ratio to have a balanced teaching load and research-based teaching.
4. It is encouraged that younger professors are receiving proper training and mentoring in teaching, in grant writing, and potentially disproportionally more often sabbaticals and relative less teaching.
5. It is recommended have special focus on obtaining prestigious excellence grants and potentially seek advice from successful organisations.
6. It is recommended to continue the strong international collaborations and with international funding.
7. It is recommended that the AU makes sure to engage in national and international infrastructures and invest in the GPU resources as machine learning and simulations will be used by researchers also from other areas of informatics.
8. It is recommended that the faculty/AU continues to grow the number of professors to maintain a reasonable teaching load and quality.
9. It is recommended that the department continues its positive development of gender balance and strives toward more than 40% of both genders.

1. Strategy, Resources, and Organisation of Research

NTNU merged with University Colleges in 2016 resulting in IDI to becoming a multi campus department where former IDI at NTNU was co-located with UC Sør-Trøndelag in Trondheim, IDI Gjøvik was established at campus Gjøvik.

The overall Scientific strategical goal of the department is to cover all layers of the computing stack, from the low levels of computing substrates and hardware to the higher levels of applications, users and sociotechnical aspects. The AU's strategy is to enable and facilitate for research groups to deliver excellent research and impact. NTNU has a national role and responsibility, and the AU aims to cover research areas presently in demand by the Norwegian society.

Formally, the AU has a head of department, deputy heads of department and six organisational units with unit leaders; two at campus Gjøvik four at the campus in Trondheim. The organisational units have responsibility including personnel, organisation of teaching activities, economy, equipment and labs. All members of the research staff formally belong in an organisational unit.

The AU consists of 10 research groups evaluated taking part in the evaluation: Algorithms, HPC and System, Applied Artificial Intelligence, Artificial Intelligence Foundations, Colourlab, Visual Computing Group, Computing Education Research Group, Software Engineering and Learning Technology, Computer Architecture Lab, Intelligent Systems and Analytics, Information Systems.

The organisation into 6 organisational units containing the researchers of the 10 research groups is not clearly described in the self-assessment. Whereas all managerial structures are tied to the organisation units all research is described in terms of research group. It is not described how these layers play together to constitute a cohesive and adequate

management structure. Hopefully, the management structure appears clear for those working in the system.

1.1 Research Strategy

The NTNU has an overall strategy including thematic research areas. The overall scientific strategical goal of the department is to cover all layers of the computing stack, whereas NTNU has a national role and responsibility and the AU aims to cover research areas presently in demand by the Norwegian society. This creates a natural tension between the internal logic of computer science and societal needs that the AU is well aware about. It is not described how this healthy tension is used for managing a dynamic department where new areas are put into focus and other scientific areas fade over time as the result of an analytic process.

The strategy of the AU is aligned with the NTNU thematic research areas and contribute to all of these and the Enabling Technologies Initiatives at NTNU, as well as all the faculties strategic areas: Artificial Intelligence, Digital Enterprise and Energy Efficient Computing Systems.

The AU has a strategy towards sustainability and is incorporated in the overall strategy of the AU. The strategies toward innovation and industry collaboration at the department level is to facilitate for initiatives emerging from the thematic research topics to be part of, or coordinate, and seek funding in NFR's Centres for Research-based Innovation (SFI). At present time the AU leads the The Norwegian Research Center for AI Innovation and the Excited Centre of Excellent IT Education (SFU), and is partner in the Centre for Geophysical Forcasting (CGF).

The AU take responsibility regarding outreach and social impact, for the general public, policy makers, academia students to increase the public knowledge of ICT. The AU seeks to enable staff to take part in public debates and write popular science books. The AU has towards industry and public sector e.g. establish the Norwegian Conference for eGovernment (NOCOUS) now with 800 participants.

The above clearly describes an AU aware of its responsibility to the society and contributing to the Norwegian society through the instrument made available by institutional strategies and national instruments, and also actively seeking outreach.

Recommendations

- It is recommended that the AU makes it clear in actions how to unfold the tension between the computer science logic of covering all elements of the computing stack, and the at the same time serve the Norwegian society.
- It is recommended that the AU verbalises a policy for how to start new research areas and close existing areas. This may be both argued scientifically where new areas appear and create new research opportunities as we have seen in blockchain, AI and quantum recently, but may also be from society where sustainability, resource management and security may pose new challenges.
- It is recommended to build a strategy to improve the gender balance.
- It is recommended that written output from the department is checked for spelling and grammar.

1.2 Organisation of Research

The AU has a head of department, deputy heads of department and organisational units with unit leaders. The AU has three deputy head of department within distinct delegated

responsibilities: education, sustainability and research. Deputy head for education leads the Teaching committee. The deputy head for research has responsibility for the departments PhD program, leads the research committee, research project portfolio, and work with research strategies for the department, faculty and at the NTNU level. Whereas the deputy head of education and research are commonly seen, a deputy head of sustainability is not commonly seen. This role is described as to ensure the sustainability aspect in all of IDI's activities.

The research committee consists of deputy head of research, deputy head of sustainability, one member for each organisational unit and two PhD candidates. It runs the PhD program in computer science, advice and operative work in research strategies, coordination of larger research initiatives, and works on strategies at department, faculty and at NTNU level.

The AU is organized into six Organisational units two at campus Gjøvik four at the campus in Trondheim: Applied Information Technology (AIT), Colourlab (CL), Computing (COMP), Data and Artificial Intelligence (DART), Information Systems and Software Engineering (ISSE), Intelligent Systems and Analytics (ISA). All researchers are allocated to one organisational unit. The organisational units are represented in the management of the AU.

The AU consists of 10 research groups evaluated taking part in the evaluation: Algorithms, HPC and System, Applied Artificial Intelligence, Artificial Intelligence Foundations, Colourlab, Visual Computing Group, Computing Education Research Group, Software Engineering and Learning Technology, Computer Architecture Lab, Intelligent Systems and Analytics, Information Systems.

It is unclear how the interplay between research groups and organisational units play together to constitute a cohesive and adequate management structure.

Communication and dissemination resources are at the NTNU level. The PhD programme in computer science is run by the AU through the research committee. The research groups are responsible for the research part of PhD projects. A PhD coordinator's responsibilities include recruitment work, on-boarding, psycho-social issues, arranging PhD seminars, and internal processes toward finalisation.

Eight PhD students work out of Ålesund and are not employed by the AU. Most of the permanent staff have a split 45/45/10% on teaching/research/administration. It is not clear whom and how many does not have this split. It is mentioned how this split is implemented down to the individual researcher.

IDI is responsible for 14 bachelor programs, 8 master programmes and one 5-year master programme. A total of 2876 students are IDI students. In addition, IDI provide a rather large portion of basic courses in ICT to all study programs at NTNU including programming for all NTNU's students.

<u>Recommendations</u>

- It is encouraged that the deputy head of sustainability is given a clearly defined position with real managerial power to intervene and handle resource allocation, or if this is not judged expedient to cancel the position. It is not recommended to have managerial positions without execution power.
- It is encouraged to make the management structure and interplay between organisational units and research groups very clear making sure that there is no disconnect in the managerial communication, especially the upwards communication tends to suffer when structures are not clear.

- It is recommended that the quality of the PhD program is surveyed thoroughly being spread over 10 research groups and the activities in Ålesund when the whole research part organisationally is left to the research groups. It is recommended to have focus on whether all research environments are well represented in the PhD programme council.
- It is recommended to survey the teaching/research/administration split of the individual researcher and especially to make sure that earlier carrier researchers have sufficient time to build their research carriers.
- It is recommended that the teaching portfolio is structured such that all students receive high quality research-based teaching while maintaining teaching duties manageable within the 45% of permanent staff time.
- It is recommended that gender biases in the organisation is becoming part of the work on developing the organisation.

1.3 Research Funding

The AU has had an increasing income from both national and international grants, where national grants is roughly 80% of the overall 177 MNOK reached in 2022. The international grants are from the European Union.

The AU has obtained awards in all NFR's portfolios with majority of projects within Fundamental Research (44 projects) and Enabling Technologies (36 projects).

In the period 2018 - 2022 the activities include projects within the Horizon 2020 and Horizon Europe programs. This includes research training and mobility projects, high RTL level research projects like RIA projects to more fundamental FET Open projects. The European grants does not include personal projects in the excellence pillar from ERC.

The AU takes part in programmes for research mobility like ERCIM, MSCA, and Innovative Training Networks (ITNs). The AU has supported and hosted 15 ERCIM Postdoc projects over the reporting period.

Recommendations

- It is recommended to continue the strong record of being awarded competitive grants both nationally and internationally and build strategies for how to multiply this.
- It is recommended to work structurally towards obtaining ERC grants at any level including training for and allowing time for making excellent applications. Advice from more successful AUs can be sought.
- It is recommended to work strategically with younger researchers to build their research funding portfolios.
- It is recommended to work strategically with female researchers and early stage to build their research funding portfolios.

1.4 Research Infrastructures

The AU takes part in computing facilities: it is the main shareholder and part of the coordination of NTNU IDUN GPU cluster. It depends on the UNINET Sigma2 E-Infrastructure. These are essential for carrying out research in several research groups.

On top of compute infrastructure, some research groups also participate in biotechnology and nanotechnology infrastructures. Here also computational infrastructure is available.

Recommendations

- It is recommended that the AU seeks a structural approach to access to modern HPC facilities including GPU facilities. These enables research and it is the Evaluation Committees opinion that access is a major component of modern informatics research including recruitment, retention, and development of research talent.

1.5 National and international collaboration

The AU takes part, and have initiated, many intra-university, national and international collaborations of both mono-disciplinary and interdisciplinary nature.

At university level the AU take part in projects in NTNUs three Enabling Technologies in interdisciplinary projects.

At national level it takes part in industry collaboration in NorwAI, Centre for Geophysical Forecasting, Research Centre on Zero Emission Neighbourhoods in Smart Cities, as well as collaboration headed by the individual research groups. The AU thereby has a profound interaction with industry with substantial scientific inspiration and knowledge transfer.

Internationally, two ITNs are mentioned along with a large number of international collaborations of the individual research groups. This show a high degree of internationalisation of the research with other international academic institutions.

Recommendations

- It is recommended that the strong international collaborations and publication tradition is transferred into even more funded international projects.

1.6 Research staff

The research staff has grown to 44 full professors and 51 associate professors in 2022 from 25/34 full/associate professors in 2017 and 26/19 in 2013. This is a doubling in 10 years with a 60% increase in the period 2017-22.

This has not been followed by a positive trend in gender equality as it would have been possible during a phase of expansion. Only 16% of full professors are female whereas the largest growing group of associate professors with 25 new hires 2017-2026, has decreased to 13% women. This seems to be a missed opportunity.

From 2017 to 2021 the number of PhD students have grown from 52 to 109 with a share of women slightly decreasing from 44% to 38%.

For permanent research staff the possibility for sabbatical leave with financial support and time for project development is available. Strategical funding to support strategical important research area or projects is available. For new permanent staff the AU provides a start-up package for including funding of travel and networking and for one PhD project for associate professors.

During the process of merging with two university colleges, funds where available for competence development to reach the associate professor level for less qualified staff. Teaching staff may in a similar scheme apply for research time.

Recommendations

- It is recommended that a strategy and plan to meet gender balance is introduced, and that this is followed in detail and the outcome and contingency plans are made. The AU has really missed an opportunity in this area and must improve.

- The mobility programMEs seem well developed. It is encouraged to follow up on statistics of utilization and to see if any hidden gender biases are becoming apparent.

1.7 Open Science

NTNU has introduced Guidelines “Policy for Open Science”. Research data management and data management plans (also covered by the Guidelines) ARE an essential part of the department’s handling of scientific publications with associated data.

70% of the publications are open science, and this has been stable in the period 2018-22. The AU has a strategy for developing open source software. NTNU has developed standards for openness in research and they have been implemented by the department.

Recommendations

- It is recommended to introduce regular follow up on the openness in publications as 30% are still not archive or “gold OA”.

2. Research production, quality and integrity

The overall Scientific strategical goal of the department is to cover all layers of the computing stack, from the low levels of computing substrates and hardware to the higher levels of applications, users and sociotechnical aspects. The AU’s strategy is to enable and facilitate for research groups to deliver excellent research and impact. NTNU has a national role and responsibility, and the AU aims to cover research areas presently in demand by the Norwegian society.

The AU consists of 10 research groups evaluated taking part in the evaluation: Algorithms, HPC and System, Applied Artificial Intelligence, Artificial Intelligence Foundations, Colourlab, Visual Computing Group, Computing Education Research Group, Software Engineering and Learning Technology, Computer Architecture Lab, Intelligent Systems and Analytics, Information Systems. In general, they are very good to excellent with a couple of outstanding groups.

The AU reports to be understaffed in pure theoretical computer science. Even though the department cover all levels, the overarching theoretical aspect is more or less covered by a few people spread among other thematic research units.

The publications have shown an increasing trend in numbers and modified author shares over the period of 2013 to 2022 from respectively 226 to 362 (+60%) and 129.6 to 212.1 (+63%). Hence this is a very productive AU with a positive development. The publications have however not increased in numbers as much as the staff that has more than doubled in the same period. The overwhelming part of publications are informatics but with a small but steadily growing part in multidisciplinary sciences.

The publications are consistently well cited with more than 20% in the top 10% cited with a steady growth in mean normalised citation score and with an impressive average 2019-2021 of 223, the double of the Norwegian average.

The fraction of internationally co-authored publications have increased from 39% to 60% in the period 2013-2022.

Overall, this is a productive AU with well received publications and with strong research groups.

Recommendations

- It is recommended to keep focus on quality and productivity and let the weaker groups learn from the stronger groups.
- It is recommended that groups not achieving as high level in research quality as the best in the department are supported to achieve this or alternatively refocused.
- It is recommended to seek to have critical mass in more theoretical aspects of computer science, but it is not recommended to gather these in a single group, as interplay between purely theoretical and research including also applications is important.

2.1 Research quality and integrity

The EVALMIT includes assessment of 10 research groups in the AU.

The research groups have a very good to excellent organisation and research quality. Two of ten groups have an outstanding research quality and contribution, a single has a good research quality. Hence, overall quality is very good with a large spread in quality and contribution. The overall societal contribution is very good to excellent with a single outstanding group. The user involvement is a little weaker but similar. Hence, a summary is very good to excellent quality with a couple of outstanding groups, and with a large variation.

Research group Algorithms, HPC and Systems overall assessment

The research activities in the group does not appear to be the result of a deliberate hiring and research strategy but rather to opportunity driven. This limits the visibility and impact of the group, even if the individual researchers often produce research at a high level. This fragmentation also limits internal collaboration. The goals of the group are relatively modest and entirely aligned with traditional academic metrics – excellence in teaching, high quality of publications, and increased funding. These goals are sufficiently non-quantitative that they can be reached. One can reasonably question whether retaining the activities on bioinformatics within the group is meaningful. Overall, the team performs well, but is limited by its size, the breadth of activities and a lack of internal coordination and collaboration. Research funding is stable and even slightly increasing from national resources. There is a lack of industrial collaborations and general engagement with society.

Research group Artificial Intelligence Foundations (AIFO) overall assessment

The research group is integrated into an excellent environment, with access to a good compute infrastructure and low teaching-load. The group is doing well on most of the benchmark criteria, especially it significantly contributes to teaching and is regularly securing external funding. Members of the group are also supervising 1/ of IDI's total students at the Master and contribute to all but one of IDI's courses in the current AI study program. Thus, one can say that the group takes a premier role in the AI education within the Department of Computer Science at NTNU. The group's research profile is very broad and lacks a clear focus. It is part of the group's strategy that individual professors follow their own research interests. As a result, members cover a large range of diverse topics, with little overlap. The group has strong connections to several other NTNU departments, resulting in various interdisciplinary collaborations. In addition, the group also collaborates with partners from the industry on applications of their AI technology. Despite the group's name, the research of the group only minimally contributes to AI foundations. On the contrary, many publications are application-oriented and are a result of interdisciplinary collaborations (e.g., flood prediction, hate speech classification or social network analysis). The number of papers published at international AI conferences is low for a group focusing on AI foundations. The ratio of junior

researchers / faculty is also too low for a group with such a broad research focus. Overall, the level of research excellence is slightly below that of comparable international groups working in this research field.

Research group Applied Artificial Intelligence overall assessment

The research group is integrated into an excellent environment at NTNU, with access to a good compute infrastructure and a low teaching load. The group is doing well on the benchmark criteria, especially on acquisition of externally funded projects. Members of the group are also supervising 1/12 of IDI's total students at the Master, with each professor supervising 3-5 theses. The group members also contribute to courses in the department's AI study program. The group is well connected internationally and part of various collaborations and AI-related initiatives. Through these collaborations the group members were able to publish papers in high-impact journals (e.g., JAMA internal medicine). However, the number of papers published at top-tier international AI conferences (e.g., International Conference on Machine Learning (ICML), International Conference on Learning Representations (ICLR), Conference on Neural Information Processing Systems (NeurIPS), Computer Vision Foundation Conference (CVPR) , Association for the Advancement of Artificial Intelligence (AAAI)) is relatively low for a group of such and ambitions. The ratio of junior researchers / faculty is very good. Overall, the level of research excellence is comparable to international groups working in this research field.

Research group Colourlab (Colourlab) overall assessment

The group performs excellently in organisation and funding, although their low gender diversity is alarming. Given their great starting point, the quality of their listed publications is lower than expected. In particular, 4 out of the 15 listed papers are from Multidisciplinary Digital Publishing Institute (MDPI) journals, which are considered predatory. The group seems very well placed within the international coloUr imaging community; however, they do not seem to take their place within the larger and more impactful adjacent communities of computer vision, computer graphics and medical imaging. This is likely necessary to bring their research quality up to the expected level.

Research group Visual Computing Group overall assessment

The VC group consistently attracts funding from national and international project partners in diverse areas of Visual Computing. They also provide a coherent VC curriculum to the computer science students at NTNU. It is a strong national research group that has international standing and is recognised also outside of Norway. Their publication record is good as well as their project participation. Given the publication authorships, it is not very clear how active societal partners are in the research process.

Research group Computing Education Research Group overall assessment

• Strength: The group has solid annual funding of about 13 Mio NOK (50% basic funding and 50% grants from other national sources). It is well structured in terms of full and associated professor positions in an overall balanced gender diversity. The group successfully launched channels to address the public with online courses.
• Weakness: The group misses a clear organisational structure surrounding the Excited Centre. The publication output is of lower quality as compared to other competing groups locally (e.g., the Software Engineering and Learning Technology (SE-LT) group at NTNU), nationally (e.g., the Uppsala CERG group), as well as internationally. The number of PhD positions is rather low, and the coaching of PhD candidates seems ad hoc and unsystematic.

• Overall performance: In the international context, the overall performance of the group is rather low.

Research group Software Engineering and Learning Technology (SE-LT) overall assessment

The SE-LT research group exhibits robust performance characterised by a well-defined focus and strategic alignment, impressive project acquisition capabilities, and an extensive network in academia and industry. These strengths collectively foster a strong publication track record and ensure a sustainable output, underscoring the group's prominent role within the international research community. One of the key strengths of the SE-LT research group is its clear focus and coherent strategy that spans both software engineering and learning technologies. This strategic clarity allows the group to effectively target and secure relevant projects, ensuring their research activities are both impactful and aligned with global technological trends. The group's ability to consistently secure substantial competitive funding, particularly from national and European sources, supports ambitious research endeavours and positions the group favourably for future success. Additionally, the extensive networks the group maintains in research and practice not only enhance the quality and relevance of their research but also ensure that findings are translated into practical applications, thereby increasing the group's visibility and influence within the field. Internationally, the SE-LT group is strong and particularly recognised for its contributions to educational technologies and software systems (e.g., the game-based learning platform Kahoot!). Their consistent output of high-quality research, as evidenced by regular publications in top-tier journals and conferences, positions the group competitively on a global scale. The group's research outputs are not only recognised within academic circles but also widely utilised in educational practices and industry, highlighting its broad impact. There are areas where improvements could further enhance the group's performance. The moderate gender imbalance within the group is a concern that could affect its diversity of perspectives and innovation. Addressing this imbalance by implementing targeted recruitment and retention strategies for female researchers could enrich the group's research environment and outputs. Additionally, while the group has been successful in securing substantial funding, there is potential to tackle more competitive funding schemes, which is already recognised by the group.

Research group Information Systems (IS) overall assessment

A significant strength lies in the group’s strategic focus, which is well-aligned with both national and international research priorities, enabling the group to secure substantial external funding and produce high-impact research outputs. The group’s extensive network of collaborations across academia, industry, and non-academic partners significantly enhances its research quality and societal impact. Overall, the IS research group performs exceptionally well across several evaluation criteria. It excels in integrating its research activities with societal needs, as evidenced by its contributions to educational programs, policy formulation, and the development of spin-off companies that translate research into practical applications. The group’s commitment to knowledge transfer and public dissemination further amplifies its societal impact, making significant contributions both within Norway and internationally. In terms of research quality, the group maintains a high standard, with regular publications in top-tier journals and influential projects that push the boundaries of the IS discipline. Its strategic use of resources, leveraging both national and international funding, along with excellent infrastructural support from NTNU, positions the group well to continue its trajectory of impactful research. Internationally, the IS research group stands strong and is notably recognised for its contributions to digital transformation

and the socio-technical aspects of IT deployment. The group faces some challenges, primarily the marked gender imbalance within its core faculty (particularly at the full professor level). This imbalance may limit the diversity of perspectives and expertise within the group, potentially affecting the innovation and comprehensiveness of its research outputs. Additionally, while the group has set ambitious benchmarks to become a leading IS research hub in Europe, achieving these goals will require expanding its visibility through increased publications in top-tier journals.

Research group Computer Architecture Lab (CAL) overall assessment

Strengths: The group is active with access to international resources and network for creating impact. The group is active in contributing to high quality research considering their involvement in conferences like ISCA, International Symposium on Field-Programmable Gate Arrays (FPGA), IEEE Symposium on High Performance Computer Architecture (HPCA)etc. The group members are young and active and they have a high potential for attracting more grants and growing the group further and creating more high impact outcome. The group has a good internal synergy between PIs which is a strong point although this should not stop them outreaching or collaborating with other research groups. Weaknesses: Publishing through high impact journals only when it comes to new computing paradigms like neuromorphic computing for example, this can be expanded to other fields. Involvement of industry is not profound. On the national level, the number of grants per PI is not high which can be due to the fields of research or other reasons which can be identified and addressed. The group is internationally competitive in some fields, but this can be strengthened even further for example by collaboration with leading institutes like the Federal Institute of Technology Zurich (ETH) within computer architecture to be in the forefront of the research.

Research group Intelligent Systems and Analytics (ISA) overall assessment

Although the ISA group consists of several long-standing department members, it is still a young research group, founded only in 2022. The group has a good balance between senior researchers and PhD students, as well as between permanent members and Postdocs and Professor II. The group has a shared leadership between two people, which could be an asset, but also a risk. Funding comes from various sources including RCN, EU and industry. Overall funding has been growing but could be further increased. The ISA group has made a good contribution to the state of the art within their respective fields. Selected publications are 3 levels 1 and 7 level 2 publications, together with monographs. However, no publications are mentioned from the most prestigious conferences in their fields. The research group has many and strong international project collaborations and is well anchored in teaching. They have a very good impact on society through its software tools, and its training of professionals as well as training of students and early-stage researchers. The group has a good position to achieve its goals of being an internationally attractive partner contributing directly to society with applications and publishing with high impact. The group is, in an international context performing very well across the evaluation criteria with direct impact on society.

3. Diversity and equality

NTNU has in a centralized effort to addresses research integrity and research ethics, and it has established The Research Ethics Committee to address complicated cases. PhD students must include in their project plans include a section on ethical reflections, including research integrity.

Clear instructions are in place to handle cases with possible misconduct.

The research staff has grown to 44 full professors and 51 associate professors in 2022 from 25/34 full/associate professors in 2017 and 26/19 in 2013. This is a doubling in 10 years with a 60% increase in the period 2017-22.

This has not been followed by a positive trend in gender equality as it would have been possible during a phase of expansion. Only 16% of full professors are female whereas the largest growing group of associate professors with 25 new hires 2017-2026, has decreased to 13% women. This seems to be a missed opportunity.

From 2017 to 2021 the number of PhD students have grown from 52 to 109 with a share of women slightly decreasing from 44% to 38%.

The AU has initiated the project ”Jenter og data” (Girls in computing) that has been followed up at the faculty level as the ongoing Ada_ project. IDUN - from PhD to professor is an initiative for career development for female in academia. The AU is ethnically diverse.

Recommendations

- It is recommended that a strategy and plan to meet gender balance is introduced, and that this is followed in detail and the outcome and contingency plans are made. The AU has really missed an opportunity in this area.

4. Relevance to institutional and sectorial purposes

An important component of impact includes student production. The AU is responsible for 14 bachelor programs, 8 master programs and one 5 year master program including 2876 students.

Innovation and commercialisation are considered in connection with participation to large research and innovation initiatives such as The Norwegian Open AI Lab including industry related projects in collaboration with partners. Research-based Innovation (SFI) initiatives with their industry partners include strategies and processes for innovation and commercialisation. The AU host one SFI, The Norwegian Research Centre for AI Innovation.

Clear politics for innovations and commercialisation are in place including guidelines for IPR and technology transfer. 10 innovation and commercialisations results are mentioned of which the four are the impact cases discussed below.

Recommendations

- It is encouraged that the educational programmes are followed closely on the degree to which the students meet the requirements of the surrounding society.

5. Relevance to society

The AU has a profound societal contribution through its massive student production including 14 BSc programmes and eight MSc programmes. The PhD production is also substantial with more than 100 enrolled PhD students currently.

The research covers the fields of informatics very broadly and thereby also makes a very broad societal impact possible.

The AU has created several spin offs. The AU participates in several industry collaborations. The four impact cases listed below show a profound societal footprint in terms of outreach in

conferences and organisation, entrepreneurship leading to publicly traded company, and research becoming products with largest international players. All of the above demonstrates efforts of outstanding impact.

The AU contributes to several of UN sustainable development goals and the AU has a specific deputy head of department for sustainability.

5.1 Impact cases

Comments to impact case 1: FINN

FINN was the first Field Programmable Gate Array (FPGA) accelerator for binarized convolutional neural networks and enables highly energy-efficient neural network inference.

It was designed by the research group Computer Architecture Lab (CAL) in collaboration with Xilinx, then a global leader in FPGA technology and is after acquisition a key product in AMD's portfolio.

The endeavour started in 2012 with hiring of a talented PhD student, Umuroglu, that in turn in 2017 presents FINN at an international conference. The collaboration with AMD is ongoing and the papers has been cited more than 1000 times.

The is an excellent showcase of academic research reaching the market through collaboration with market leading players, and where the PhD student continues his career in the industry. This happened in an excellent research environment.

The AMD products have been used by SICK for industrial automation in among others airport baggage handling.

Comments to impact case 2: NOKIOS

NOKIOS is an annual conference on eGovernment initiated by the Norwegian University of Science and Technology (NTNU) in 2006. It was started by Professor John Krogstie and collaborators. Krogstie has since been the leader of the program committee. The conference is now organized by NTNU in cooperation with a total of 25 vendors and governmental and local agencies and universities.

The target group for the event is decision makers from the Norwegian public sector.

It presents trends from research to the public sector.

In 2023 the conference had around 1000 participants.

The conference is an excellent example of directed dissemination of knowledge to the public sector, and can as such have profound impact on the public sector and its ability to identify collaboration partners and experts in academia.

Comments to impact case 3: Kahoot!

Kahoot! is a game-based learning platform. The technology is based on research conducted by Kahoot! co-founder Morten Versvik and Professor Alf Inge Wang. The work started from a game concept developed by Wang and then further developed Versvik's Master's at NTNU. Kahoot! has hosted over 9 billion participants in hundreds of millions of learning sessions since it is launched in 2013.

The underlying idea was to transform the classroom into a gameshow, where the teacher acted as the game show host, and the students were contenders, using their own mobile

devices. Studies have shown that it boost students' engagement, motivation, concentration, and learning after using it repeatedly for five months.

Kahoot! is used in many institutions of higher education around the world, including 97% of the global top 500 universities. Also, half of US teachers and students have hosted or played a Kahoot! in the last year. 97% of Fortune 500 companies are using Kahoot! for training, presentations, onboarding, events and more. Kahoot! offers a free version, and also has 1.37M paid subscribers.

This is an outstanding case of research driven innovation and entrepreneurship that has created an internationally known brand. The company is now publicly traded and has more than 500 employees. This is a truly amazing endeavour.

Comments to impact case 4: The Norwegian Open AI Lab (NAIL)

The Norwegian Open AI Lab is a collaboration and research initiative with partners in academia and industry. The underpinning research is all AI activities at NTNU. NAIL's ambition is to be the number one AI hub for cooperation between Norwegian universities, research institutes, private, and public sector within ethical, sustainable, and trustworthy AI. NAIL focuses on basic research topics with broad relevance, applied research and research driven innovation.

NAIL has accomplished many things in its so far short life including construction of 17 partnerships. In 2023, staff affiliated with NAIL were involved in 48 ongoing research projects, which marks an increase of net 13 new projects compared to 2022.

NAIL contributes to the AI education through, among others, The Nordic Probabilistic AI School. In 2023 it had almost 700 applicants from all over the world, for the 160seats available.

Dissemination has been key in 2023 and Inga Strümke gave short intros to AI technologies and news and at the end of the year she was awarded the RCN prize "Communicator of the year". Inga also won a Brage prize in 2023 for her best-selling book: Maskiner som Tenker.

This impact case is an excellent example of bundling activities into a recognizable brand and thereby creating profound impact on the surrounding society. It is a very timely effort in much need.

Methods and limitations

Methods

The evaluation is based on documentary evidence and online interviews with the representatives of Administrative Unit.

The documentary inputs to the evaluation were:

- Evaluation Protocol that guided the process
- Terms of Reference
- Administrative Unit’s self-assessment report
- Administrative Unit’s impact cases
- Administrative Unit’s research groups evaluation reports
- Bibliometric data
- Personnel and funding data
- Data from Norwegian student and teacher surveys (only for HEI’s)

After the documentary review, the Committee held a meeting and discussed an initial assessment against the assessment criteria and defined questions for the interview with the Administrative Unit. The Committee shared the interview questions with the Administrative Unit at least two weeks before the interview.

Following the documentary review, the Committee interviewed the Administrative Unit in an hour-long virtual meeting to fact-check the Committee’s understanding and refine perceptions. The Administrative Unit presented answers to the Committee's questions and addressed other follow-up questions.

After the online interview, the Committee attended the final meeting to review the initial assessment in light of the interview and make any final adjustments.

A one-page summary of the Administrative Unit was developed based on the information from the self-assessment, the research group’s evaluation reports, and the interview. The Administrative Unit had the opportunity to fact-check this summary. The Administrative Unit approved the summary.

The Committee judged the information received through documentary inputs and the interview with the Administrative Unit sufficient to complete the evaluation.

List of administrative unit's research groups

Institution	Administrative Unit	Research Groups
Norwegian University of Science and Technology	Department of Computer Science	Algorithms, HPC and Systems
		Colourlab (Colourlab)
		Software Engineering and Learning Technology (SE-LT)
		Intelligent Systems and Analytics (ISA)
		Artificial Intelligence Foundations (AIFO)
		Visual Computing Group
		Information Systems (IS)
		Applied Artificial Intelligence
		Computing Education Research Group
		Computer Architecture Lab (CAL)

Terms of Reference (ToR) for the administrative unit

The board of Faculty of Information Technology and Electrical Engineering, NTNU (NTNU-IE), mandates the evaluation committee appointed by the Research Council of Norway (RCN) to assess the Department of Computer Science, NTNU (NTNU-IDI) based on the following Terms of Reference.

Assessment

You are asked to assess the organisation, quality and diversity of research conducted by NTNU-IDI as well as its relevance to institutional and sectoral purposes, and to society at large. You should do so by judging the unit's performance based on the following five assessment criteria (a. to e.). Be sure to take current international trends and developments in science and society into account in your analysis.

a) Strategy, resources and organisation

b) Research production, quality and integrity

c) Diversity and equality

d) Relevance to institutional and sectoral purposes

e) Relevance to society

For a description of these criteria, see Chapter 2 of the mathematics, ICT and technology evaluation protocol. Please provide a written assessment for each of the five criteria. Please also provide recommendations for improvement. We ask you to pay special attention to the following 3 aspects in your assessment:

1. NTNU has a national role and responsibility as the major university for technology education and research. To fulfill this role NTNU-IDI cover a broad range of research topics within computer science, information science, and didactics, including computer education and research education.
2. The department, as part of a national strategy, is located at two geographical locations with an aim of delivering quality research, within localized strategic research areas, whilst providing education quality that fulfill our responsibility as the national university of technology.
3. The department aim to cover research areas presently in demand by the Norwegian society (including public sector and industry) whilst building knowledge and expertise as a foundation for future science and technology breakthroughs.

In addition, we would like your report to provide a qualitative assessment of NTNU-IDI as a whole in relation to its strategic targets. The committee assesses the strategy that the administrative unit intends to pursue in the years ahead and the extent to which it will be capable of meeting its targets for research and society during this period based on available resources and competence. The committee is also invited to make recommendations concerning these two subjects.

Documentation

The necessary documentation will be made available by the mathematics, ICT and technology secretariat at Technopolis Group.

The documents will include the following:

- a report on research personnel and publications within mathematics, ICT and technology commissioned by RCN
- a self-assessment based on a template provided by the mathematics, ICT and technology secretariat

Interviews with representatives from the evaluated units

Interviews with NTNU-IDI will be organised by the evaluation secretariat. Such interviews can be organised as a site visit, in another specified location in Norway or as a video conference.

Statement on impartiality and confidence

The assessment should be carried out in accordance with the *Regulations on Impartiality and Confidence in the Research Council of Norway*. A statement on the impartiality of the committee members has been recorded by the RCN as a part of the appointment process. The impartiality and confidence of committee and panel members should be confirmed when evaluation data from NTNU-IDI are made available to the committee and the panels, and before any assessments are made based on these data. The RCN should be notified if questions concerning impartiality and confidence are raised by committee members during the evaluation process.

Assessment report

We ask you to report your findings in an assessment report drawn up in accordance with a format specified by the mathematics, ICT and technology secretariat. The committee may suggest adjustments to this format at its first meeting. A draft report should be sent to the NTNU-IDI and RCN. The NTNU-IDI should be allowed to check the report for factual inaccuracies; if such inaccuracies are found, they should be reported to the mathematics, ICT and technology secretariat within the deadline given by the secretariat. After the committee has made the amendments judged necessary, a corrected version of the assessment report should be sent to the board of NTNU-IE and the RCN no later than two weeks after all feedback on inaccuracies has been received from NTNU-IDI.

Appendices

1. Description of the evaluation of EVALMIT
2. Invitation letter to the administrative unit including address list
3. Evaluation protocol
4. Template of self-assessment for administrative unit (short-version)

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