

Novel Applications of Artificial Intelligence in Physical Sciences and Engineering Research (AIPSE)

Academy Programme 2018–2021

Programme memorandum



1 Background

Different types of data-driven methods are continuing to gain in importance in research, administration and industry. One area of recent focus and interest is artificial intelligence (AI), which in the past ten years has seen major advances in the practical applicability of its methods and techniques. This development owes much to progress in such areas as machine learning, pattern recognition, statistics, data mining and computational and software-based database technology; the much-expanded availability of training materials; and the rapid growth of computing power. AI is growing in importance throughout society, and data-driven methods in particular are set to achieve an increasingly prominent role in both business and public administration.

Promoting the practical application of AI is listed among the Finnish Government's key objectives. In spring 2017, the Minister of Economic Affairs appointed a steering group to prepare a proposal for a programme on AI application and developing new ways of working in Finland.

Methods developed in AI research also have broad potential application in the science context, and particularly in new lines of multidisciplinary research. The main goal and ambition of the Academy Programme for Novel Applications of Artificial Intelligence in Physical Sciences and Engineering Research (AIPSE) is to deepen and broaden AI research expertise within these disciplines. Physical sciences comprise the natural sciences disciplines with the exception of biosciences. AI research can therefore be concerned, for instance, with physics, chemistry, geosciences, mechanical engineering and ICT. A more detailed discussion of the research fields coming under the scope of this Academy Programme is presented in Chapter 2 below.

2 AI research

2.1. AI research: scope and purpose

All AI research is aimed at automating tasks and functions of such complexity that the methods applied must demonstrate some form of intelligent behaviour. The field of AI comprises a diverse range of methods that usually stem from computer science or statistics and that address problems related to reasoning, knowledge presentation, search and optimisation, planning, pattern recognition, learning, creativity or interaction. Some of the most prominent commercial successes today combine several different types of AI techniques: AI assistants (Siri, Alexa, Google Assistant, Cortana, Bixby, etc.), for example, combine several natural language processing techniques with intelligent information retrieval algorithms, and self-driving cars, robots, drones and other autonomous devices and systems also combine several AI techniques associated with learning, pattern recognition and planning.

The ongoing AI boom is largely driven by recent advances in machine learning, a subfield of AI concerned with algorithms that learn from data or experience. The combination of massive datasets, improved computation resources and more advanced core learning algorithms has brought dramatic improvements in many tasks that were previously considered too complex for AI to master. We now have deep learning models that can classify natural images as well as humans, or translate speech from one language to another in real time, and we can perform accurate statistical reasoning using much more complicated models than before. Often these powerful machine learning algorithms are combined with more symbolic reasoning to solve practical AI problems. For example, beating the best human in the game of Go required a combination of deep learning models to understand the board and traditional game-playing AI algorithms to plan and decide on the moves.



In the context of the AIPSE programme, an important determinant of AI is how the methods applied in the project relate to the broader field of scientific computation as part of AI research. AI methods often involve creating data-based approximative models that replace exact physical models and that can be used for reasoning purposes. Machine learning, therefore, lies at the very heart of AI. By contrast, numerical analysis, optimisation, the solution of differential equations and iteration methods, all of which are central to scientific computation, are not artificial intelligence per se, and the same goes for the modelling and simulation of a complex physical system based on the laws of physics. For this reason, it is important that applications submitted clearly detail the AI methods and other methods of scientific computation that will be used in the project, and that they describe how the AI methods relate to the broader field of AI research. Furthermore, applications must describe the relevance of these methods not only to the project concerned, but to AI research in general.

2.2. AI in physical sciences and engineering research

There is substantial untapped potential in the practical application of AI in physical sciences and engineering research. In this Academy Programme, physical sciences and engineering comprise the following research fields (and their subfields) as listed in the classification used by the Academy of Finland (see [Research field classification](#)): food engineering, energy engineering, physics, geosciences, chemistry, mechanical engineering and manufacturing technology, medical engineering, materials science and technology, nanoscience and nanotechnology, process technology, electrical engineering and electronics, industrial biotechnology, astronomy and environmental engineering. In addition, computational science, computer science, statistics and mathematics can on certain conditions be regarded as research fields applying AI (see the programme review criteria in Chapter 6). Among the fields not included in the programme's application areas are architecture, construction and municipal engineering, and industrial management. Biochemistry and biophysics are also specifically excluded from the scope of this programme.

Finland has outstanding expertise in physical sciences research. One notable example is the field of materials research, where determining materials properties used to be a time-consuming exercise – until the realisation that AI techniques could be used for mining materials libraries. Today, AI algorithms are used to quickly analyse large amounts of materials and so to predict materials properties such as electrical conductivity.

In chemistry research, AI can be applied to discover different reaction pathways in the development of a specific end product. High-level research is also conducted in several engineering fields and in several universities across Finland. Since AI is well-suited to rapidly process large datasets, it is expected that AI-based techniques will facilitate the analysis of satellite data, for example. In smart factories of the future, new automation and information system architectures will also make it possible to flexibly process data across the whole production chain using new AI methods at both device, unit process and factory and group level, including global stakeholder groups.

3 Aims

The Academy Programme for Novel Applications of Artificial Intelligence in Physical Sciences and Engineering Research (AIPSE) is aimed at integrating AI research expertise with high-level research in the physical sciences and engineering fields with a view to promoting the renewal of science. The scope of the programme is limited to research fields that apply AI as listed under section 2.2 above. The programme's primary aim is to deepen and expand AI research expertise and to put this expertise to the best possible use in physical sciences and engineering

research to achieve new scientific breakthroughs. Figure 1 uses a four-field matrix to illustrate the preferred type of projects that will be funded under the programme.

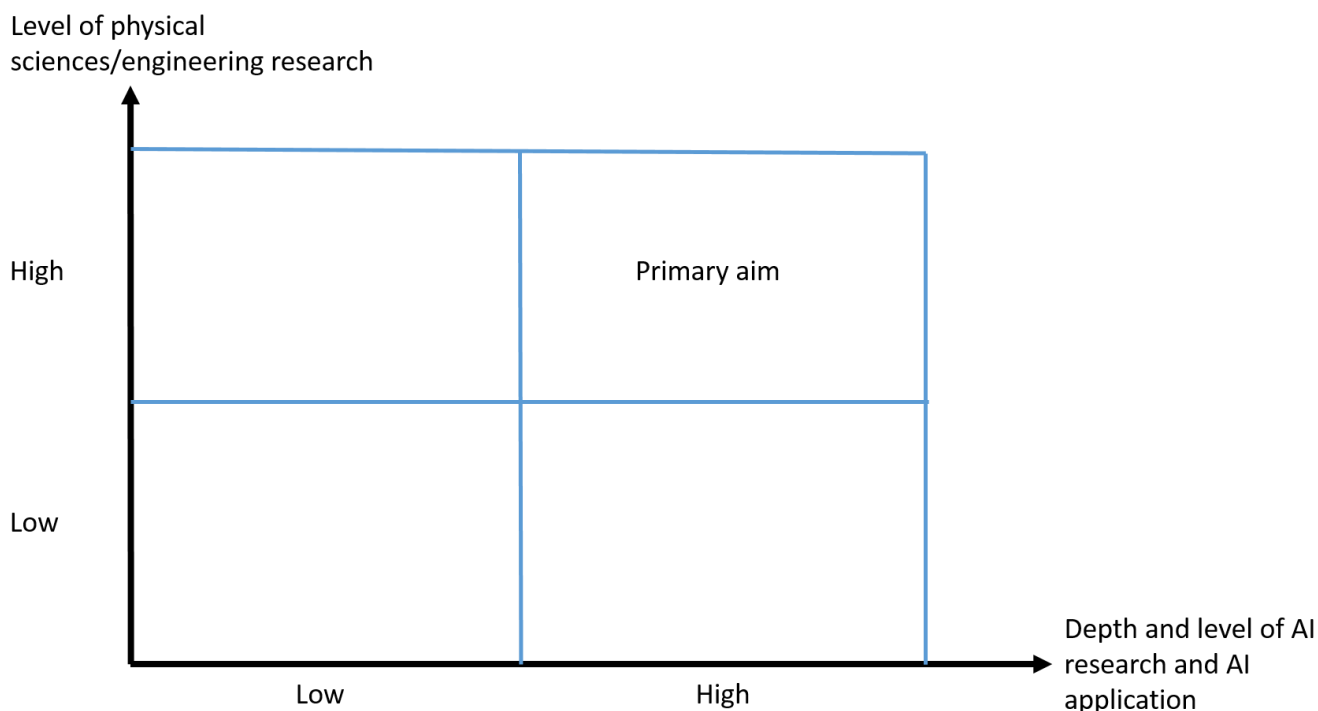


Figure 1. Primary aim of projects funded under the AIPSE programme in a four-field matrix: vertical axis illustrates the level of physical sciences or engineering research (field of research applying AI) and the horizontal axis the depth and level of AI research and AI application.

The programme's primary objective is to

- produce scientific breakthroughs in projects that combine high-level AI research with high-level physical sciences or engineering research and in which AI plays a central role in facilitating the breakthrough either in AI research or in physical sciences or engineering research.

Other aims of the programme are to

- identify new areas of application and opportunities for research collaboration in physical sciences and engineering
- promote new kinds of research collaboration and so to regenerate research
- harness data for productive use and actively utilise open data in the projects funded.

4 Scientific and societal impact of the programme

The programme will contribute to establishing a skills and knowledge base in a field of great future importance. It will add to existing applied skills and expertise in machine learning and create new lines of research in the fields of AI and machine learning. In applied fields of research, the programme will increase understanding of the opportunities offered by AI and open new avenues for science renewal and new potential for breakthroughs.



AIPSE will deepen understanding of the potential of AI and its uses in society, although the programme's main focus will be on scientific breakthroughs that do not necessarily have immediate and significant industrial application. It will also pave the way to more effective use of open data. Large parts of both the private business sector and the public sector do still not appreciate the full potential of AI, so the programme will provide an opportunity for businesses to recruit skilled staff. The programme will also generate further interest among international corporations in Finnish expertise in machine learning and AI.

The programme will expand Finnish researchers' skills and knowledge base into the area of international collaboration. Under Horizon 2020, for instance, the Future and Emerging Technologies (FET) Committee has identified six potential FET flagship projects, one of which is Interfaces, Robotics and Artificial Intelligence.

5 Programme implementation

5.1. Programme funding

AIPSE is an Academy Programme funded and coordinated by the Academy of Finland. The Academy Board has set the programme's funding budget at a maximum of 7 million euros.

5.2. National cooperation

AIPSE will work closely especially with the computation, machine learning and artificial intelligence projects funded through the Academy's ICT 2023 call in spring 2017, with other AI projects funded under the ICT 2023 programme, and with the Digital Humanities programme. It will also promote collaboration with the Team Finland Augmented Intelligence – Artificial Intelligence campaign.

5.3. International cooperation

AIPSE will aim to collaborate selectively with foreign research funding agencies that support high-level scientific research, insofar as this collaboration benefits Finnish research. Depending on emerging needs and opportunities the programme will also seek the collaboration of similar foreign programmes, projects and leading research institutes in the field.

5.4. Schedule

Funding will be made available to projects and consortiums scheduled to run for no more than four years. The funding period for the 2017 call starts on 1 January 2018 and ends no later than 31 December 2021. The timetable for the call and the review process is set out in more detail in Chapter 6 of this memorandum. The programme's kick-off seminar will be held in spring 2018. Separate information will be provided on the funding sources, research areas, timetables and application processes of any future supplementary calls.

5.5. Programme steering group and coordination

The programme is run by a steering group composed of members of the Academy's research councils and other expert members. The programme strives to support and promote the development of the selected projects into a coherent and cohesive structure through active cooperation and exchange of information. Programme



coordination rests with the programme managers and the project officer, whose role it is to facilitate achievement of the programme's objectives together with the steering group and the participating projects.

The PIs of the projects selected for funding under the programme will be required to

- assume responsibility for and report on the scientific progress of the project and on the use of the funds in accordance with the instructions of the programme manager and relevant funding bodies
- ensure that the whole research team attends all events organised by the programme coordinators, and facilitate exchange and cooperation between research teams in the programme
- take part in producing reviews, syntheses and information material around the programme, and actively disseminate information about the programme's progress and results on public and scientific forums.

During the programme, the research projects will participate in events arranged together with end-users of research results and in any other activities designed to disseminate information to stakeholders.

5.6. Final evaluation

The Academy Programme will be evaluated on its completion to assess implementation and outcomes. The scope and aims of the evaluation will be defined during the programme, but it may consider e.g. the

- attainment of the programme's aims
- programme implementation
- achievement of intended impacts
- national and international cooperation.

6 Application guidelines and review criteria

The call for applications to the AIPSE Academy Programme is a single-stage call. Applications shall be submitted via the Academy's online services no later than 27 September 2017 at 16.15 local Finnish time. The deadline is non-negotiable. Guidelines for preparing and submitting an application and for required appendices are given in the Academy's September 2017 call text. The cost estimate must be realistic. It must be justified by type of expenditure in the research plan.

Based on the scientific review process and bearing in mind the aims of the programme, the steering group will prepare a proposal on the projects recommended for funding and submit its proposal to the Research Council for Natural Sciences and Engineering, which will make the final funding decisions in December 2017. Any supplementary calls will be scheduled separately.

The applications will be reviewed by an international panel of experts. The review process will consider the standard of both the AI research and the research in the field of application. The aim will be to select projects that further the programme's primary objective. Applications must explain how artificial intelligence is understood in the project and how the project proposes to validate the performance and effectiveness of AI in a new area of application.

Applications must clearly identify the AI methods and other methods of scientific computation used in the project, describe how the AI methods relate to the broader field of AI research, and document their relevance not only to



the project but to AI research in general. This can be done in a separate section in the research plan to facilitate the review process.

Research in the project's area of application area is expected to extend beyond research and development on AI itself. Basic AI research is conducted among others in computational science, mathematics, computer science and statistics. If a new area of application for AI research is concerned with research in any of these fields, the research plan should make it explicit that the project is not just an AI development project, but a genuine new application for AI.

Applications will be reviewed following the general criteria applied to all Academy Programmes (see [Guides for reviewers](#) on our website). In addition, applications will be weighed against the aims specified for this programme as detailed under Chapter 3 of this programme memorandum, ensuring furthermore that the applications come under the specified fields of research applying AI, as described in section 2.2 above. This aspect will be considered on the review form under section "Relevance of the project to the Academy Programme".

7 Further information

This programme memorandum is available as a PDF download at www.aka.fi/AIPSE > EN.

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