Faculty of Science and Engineering

Profile report: Theory of computation (Theoretische Informatica)

- Discipline: Computer Science
- Level: tenure-track Assistant professor/Associate professor/Full professor
- Fte: Full time (1.0)

1. Scientific discipline
Theory of Computation is the foundation of computer science, covering subjects like models of computation (such as concurrency), design and analysis of algorithms, and verification. Here the focus is on novel cognitive computing architectures and algorithms.

2. Vacancy
This position is opened by the Board of the Faculty (PT/dja/18/00153) as part of the new Center "Groningen Cognitive Systems and Materials", which aims to develop systems and materials for cognitive computing. The position will be embedded in the Bernoulli Institute and falls within the framework of 'Career Paths in Science 3' ('Bèta's in Banen 3'). Please see link for criteria and conditions.

3. Selection committee (BAC)

Prof.dr. J.B.T.M. Roerdink	Scientific director Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence (Chair), and professor Scientific Visualization and Computer Graphics
Prof.dr. B. Noheda	Director Groningen Cognitive Systems and Materials and Professor Nanostructures of Functional Oxides
Prof.dr. A. Telea	Program director bachelor Computing Science and professor Visual Analytics
Prof.dr. G. Renardel de Lavalette	Professor Theoretical Computer Science
Prof.dr. L.C. Verbrugge	Professor Multi-Agent Systems
S. Houwink	Student member
Prof.dr. W. Fokkink	Professor Theoretical Computer Science, VU University

Advisors:

Prof.dr.ir. C.H. van der Wal	Scientific director Zernike Institute for Advanced Materials and professor Nanostructures of Functional Oxides
Dr. J.H.M. van der Velde	Scientific Coordinator Groningen Cognitive Systems and Materials and secretary of the selection committee

HR advisor:
L.A. Boomsma

4. Research area

Theory of Computation forms a fundamental ingredient of computer science. It covers models of computation (such as concurrency), semantics, logic and reasoning, formal languages and automata theory, computational complexity, design and analysis of algorithms, discrete structures, as well as theory and algorithms for application domains (ACM Computing Classification System, 2012 Revision).

For this position, the focus is on the Theory of Computation for novel cognitive computing architectures and algorithms. In general, the term neuromorphic or cognitive computing has been used to refer to new hardware and/or software that mimics the functioning of the human brain and helps to improve human decision-making. Within theory of computation, broadly construed, novel approaches and programming models are needed to design and program neuromorphic and cognitive systems but also to rigorously certify their reliability, correctness, and efficiency.

Examples of complementary areas in the scope of this position include: programming languages, logic, dependability, automated verification, design and analysis of algorithms, security and privacy, multi-agent systems.

5. Embedding: institute (and base unit)

The position will be embedded in the Fundamental Computing group of the Bernoulli Institute. This group already carries out research on Theory of Computation, with a focus on programming models and verification techniques for concurrent and communication-centric computing. There is a particular interest in strengthening and expanding the group's research activities. The position will play a crucial role within the Center "Groningen Cognitive Systems and Materials" (CogniGron).

The Groningen Cognitive Systems and Materials Center is a joint venture between FSE-institutes Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, and the Zernike Institute for Advanced Materials. It comprises researchers from materials science, physics, chemistry, mathematics, computer science and artificial intelligence. The center provides structure, coherence, and visibility for a joint research program in the direction of cognitive systems and materials. The main goal of the Groningen Cognitive Systems and Materials Center is to create self-learning materials that will perform the tasks that are now assigned to thousands of transistors and complex algorithms in a more efficient and straightforward manner, hence, forming the basis for a new generation of computer platforms for cognitive applications, such as pattern recognition and analysis of complex data.

The Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence is part of the Faculty of Science and Engineering (FSE). The profile of the institute centers around modelling, computation, and cognition with a focus on science and technology, keeping a balanced mix of fundamental and applied aspects. The Bernoulli Institute comprises five mathematics programmes, six computer science programmes, and four artificial intelligence programmes. The constituting programmes participate in various national research schools and most of the PhD

students are enrolled in an educational programme and take part in other activities offered by these schools. The Bernoulli Institute aims to strengthen the current research portfolio in Mathematics, Computer Science and Artificial Intelligence by expanding both in fundamental areas that have a prominent role in education as well as in directions that are essential for new technological and societal developments.

6. Local and (inter)national position

Locally, work on the Theory of Computation is carried out by the research groups Fundamental Computing and Multi-Agent Systems of the Bernoulli Institute. Examples of international strong research groups on Theory of Computation are Institut de Recherche en Informatique Fondamentale (IRIF, Paris), Laboratory for Foundations of Computer Science (LFCS, Edinburgh), University of Oxford, Department of Computer Science, and Institute of Science and Technology (IST, Vienna). Nationally, there are strong groups in theoretical computer science at the Free University (Amsterdam), Radboud University (Nijmegen) and Leiden University. In many research groups on Theory of Computation, there are connections with bioinformatics and artificial intelligence. However, the intended connection with cognitive engineering and neuromorphic computing is unique for Groningen.

At the national level the Bernoulli Institute participates in the Dutch computer science research schools Advanced School for Computing and Imaging (ASCI), Dutch Research School in Logic (OZSL), the Dutch Research School in Programming and Algorithmics (IPA), and the School for Information and Knowledge Systems (SIKS), the latter being the most relevant for the position.

At the international level the Bernoulli Institute is involved in several EU research projects (*e.g.*, Human Brain Project, Smart Homes, Visual Analytics), has established collaborations with major companies (Philips Research, IBM) and technological institutes (Astron, TNO, NLR, ECN), and has cooperation and exchange programmes with many universities (*e.g.*, Rome, Leipzig, Birmingham, Barcelona, Ghent, ESIEE-Paris, Tampere). In Computer Science, the Bernoulli Institute has a strong position (as evidenced by participation in NWO and EU projects, publications in renowned journals and conferences, memberships of editorial boards and program committees, conference chairing, *etc.*) in intelligent systems (biologically inspired computational modelling, machine learning, morphological image processing); pervasive middleware and energy distribution infrastructures; architecting of software-intensive systems and object-oriented software design; information systems; data and information visualization, and visual analytics.

7. Expected contributions to research

The candidate is expected to initiate and develop an internationally leading research program in the field of Theory of Computation, complementing existing research efforts at the Bernoulli Institute. The research should be visible on the national and international level and lead to publications in top journals and conferences. Furthermore, the new professor is expected to take a leading role in the field of

Computer Science within the Netherlands. Obtaining substantial external funding for PhD projects is crucial. Supervision of PhD students is an important part of the research activities. The research is expected to strengthen the existing efforts in the field of Computer Science within the Bernoulli Institute and the Groningen Cognitive Systems and Materials center, and should lead to a strengthening of the international reputation of the group, the research center and the institute.

8. Expected contributions to teaching

The candidate is expected to contribute to the teaching programs in the bachelor and master degree programs within the Undergraduate and Graduate Schools of Science and Engineering. She/he is expected to participate in the teaching program of specialized courses in relation to Theory of Computation and other related topics, *e.g.* Programming and Program Correctness, Formal Methods, Theory of Programming Languages, Logical Calculus, and Automata Theory. Furthermore, the candidate will be involved in supervising bachelor, master and PhD students. Upon appointment, depending on experience and formal qualifications to date, the candidate may be required to enter a nationally standardized tertiary teaching skills certification trajectory (BKO or Basis Kwalificatie Onderwijs), successful completion of which is a condition for extensions and tenure.

9. Expected contributions to the organization

The candidate is expected to have an active interest and to provide a positive contribution to the management and organizational tasks of the institute. At the level of the FSE, the candidate will contribute to the organization of the faculty, for example by participating in working groups and committees, in the fields of teaching, research and management. The candidate will participate in relevant national and international organizations.