Learning $\in$ Artificial Intelligence $\cap$ Cognitive Technologies $\cap$ Neural Computation $\cap$...

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Dear reader,

We strive for computer systems that can deal autonomously and flexibly with our needs. Such systems must work in situations that have not been fully specified a priori. Incomplete descriptions of application scenarios are inevitable because we need software for domains where the designer's knowledge is not perfect, the solutions to particular problems are simply unknown, and/or the sheer complexity and variability of the task and the environment precludes a sufficiently accurate description of the domain. Although such systems are in general too complex to be designed manually, large amounts of data describing the task and the environment are often available or can be easily obtained. To take proper advantage of this available information, we need to develop systems that self-adapt and automatically improve based on sample data—systems that learn.

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One may well argue that the ability to adapt is a decisive property of any technical system that deserves the attribute “cognitive” or “intelligent”. Technical learning systems are studied in many research fields and under many labels, for instance, in artificial intelligence, in statistical pattern recognition, and in neural computation. I like to use the currently popular term *machine learning* for research devoted to answering the fundamental, cross-disciplinary questions of how to “build computer systems that automatically improve with experience, and what are the fundamental laws that govern all learning processes” (T. M. Mitchell: The discipline of machine learning, Machine Learning Department technical report CMU-ML-06-108, Carnegie Mellon University, 2006).

Machine learning algorithms are already an integral part of today's computing systems. Highly specialized technical solutions for restricted task domains exist that have reached superhuman performance, usually for problems that require extensive computation or handling large datasets. State-of-the-art real-world applications of systems relying on machine learning include pattern recognition in biometrics, text and speech recognition, Internet search engines, and data mining in bioinformatics.

Despite these successes, there are fundamental challenges that must be met if we are to develop more general learning systems. Current adaptive systems succumb to *scalability* problems. The ever growing databases and learning from streaming data require highly efficient large-scale learning algorithms. Efficient algorithms exploiting modern hardware architectures and distributed computing are required to meet the “big data challenge”. Furthermore, present adaptive systems lack *autonomy* (Douglas, Sejnowski, et al.: Future challenges for the science and engineering of learning, Final NSF Workshop Report, 2008). For example, they usually require a human expert to se-

lect the training examples, the learning algorithm and its parameters, and an appropriate representation or structure of the learning system. This dependence on expert supervision is hindering the ubiquitous deployment of adaptive software systems. We need robust systems that can handle large multimodal datasets, that actively select training patterns, and that autonomously build appropriate internal representations based on data from different sources. These representations should foster learning, generalization, and communication. The new DFG Priority Programme “Autonomous Learning” (<http://autonomous-learning.org>) aims at developing and analyzing autonomously learning systems, and we are eagerly awaiting to report on its results in the KI journal.

I am looking forward to the forthcoming KI journal issue on “Neural Learning Paradigms” edited by Barbara Hammer, the first issue where I have the pleasure to act as a new editorial board member. In order to build powerful learning machines, an interdisciplinary approach is needed. Machine learning is clearly rooted in computer science as well as in statistics and optimization theory. Nonetheless, I regard the understanding of the principles of how humans learn as the royal road to creating flexible, autonomous machines. It goes without saying that machine learning need—and should—not work exactly like the learning in biological neural systems. Different constraints require and allow for different implementations of the same fundamental principles.

The current issue on “Spatiotemporal Modeling and Analysis” edited by Christine Körner, Stefan Wrobel, and Michael May brings us to a domain posing many highly interesting “big data” challenges. More and more measurements of processes embedded in time and space are becoming available and are awaiting intelligent data analysis. Enjoy reading!

Best wishes,

Christian Igel

Forthcoming special topics

1 Neural Learning Paradigms

The capability of the human brain constitutes an ever fascinating topic, and a major goal of Artificial Intelligence

is to mimic these capabilities. Unlike ‘classical AI’, Neural Computation directly uses learning paradigms inspired by human brains to arrive at intelligent behavior. Its great success story dates back more than 20 years with the introduction of efficient brain-inspired learning algorithms such as back-propagation, Hopfield-networks, or self-organizing principles. Since then, Neural Computation became a well established research area, and numerous brain-inspired techniques offer standard learning algorithms in today’s digital data processing. In parts, Neural Learning Paradigms are already so commonplace that they are considered just another method of statistical data analysis. Modern information science is about to change this situation: an ever increasing complexity of data and learning tasks poses new challenges on the learning paradigms such as efficiency, flexibility, and robustness, when dealing with large data volumes, and scaffolding, self-organization, and emergence of structures when dealing with complex learning scenarios.

This special issue includes technical papers, reports on current research projects, interviews, book reviews and others with focus on current developments and challenges in Neural Learning Paradigms.

Topics include:

- neural learning paradigms for complex data structures and structure inference
- self-organizing principles
- sparse coding and compressed sensing
- reservoir computing
- deep learning
- autonomous learning systems
- challenging applications of neural learning paradigms

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2 Social Media

Social Media has led to radical paradigm shifts in the ways we communicate, collaborate, consume, and create information. Technology allows virtually anyone to disseminate information to a global audience almost instantaneously. Information published by peers in the form of Tweets, blog posts, or Web documents through online social networking services has proliferated on an unprecedented scale, contributing to an exponentially growing data deluge. A new level of connectedness among peers adds new ways for the consumption of (traditional) media. We are witnessing

new forms of collaboration, including the phenomenon of an emergent ‘collective intelligence’. This intelligence of crowds can be harnessed in myriad ways, ranging from outsourcing simple, repetitive tasks on Amazon Mechanical Turk, to solving complex challenges such as proving a mathematical theorem creatively and collaboratively. This call for papers welcomes contributions showing: (1) How to make sense of Social Media data, i.e. how to condense, distill, or integrate highly decentralized and dispersed data resulting from human communication, including sensor-collected data to a meaningful entity or information service, or (2) How Social Media contributes to innovation, collaboration, and collective intelligence. We invite papers covering all aspects of Social Media analysis including Social Media in Business (especially for Marketing, Innovation, and Collaboration), Entertainment (especially Social News, Social Music Services, Social TV, and Social Network Games), as well as Art (e.g. City Installations).

Applications of Social Media in art may be understood as a playing field for translating highly decentralized ‘social data’ into centralized forms of artful expression, thus furthering our intuitive understanding of these complex emergent phenomena. The list of topics mentioned below is neither exhaustive nor exclusive. Insightful artifacts and methods as well as analytical, conceptual, empirical, and theoretical approaches (using any kind of research method, including experiments, primary data from social media logs, case studies, simulations, surveys, and so on) are within the scope.

- Information/Web mining (e.g. opinion mining)
- Prognosis (e.g. trend and hot topic identification)
- Collective Intelligence
- Crowdsourcing
- Swarm Creativity, Collaborative Innovation Networks
- (Dynamic) Social Media Monitoring
- Sentiment, Natural Language Processing
- Social Media within and for Smart Cities, Smart Traffic, Smart Energy
- Social Networks for the collaboration of large communities
- User behavior, social interaction
- Social Network Analysis (SNA), semantic network analysis
- Social search engines and aggregators
- Social network games
- Personalization and adaptation to user preference
- Trust, reputation, social control, privacy
- Information reliability, Web spam, content authenticity (e.g., detecting ‘astroturfing’)

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3 Symbol Grounding

In robotics and intelligent systems, there is a growing trend to include high level semantic knowledge for enabling better reasoning and increased functionality. One of the most important aspects in integrating is the problem of intrinsically linking the symbols used by a cognitive agent to their corresponding meanings through grounding language in perception and action. This is widely known as the “Symbol Grounding Problem (SGP)” defined by Harnad in 1990, where a linguistic symbol representing a meaning, needs to be grounded in the perceived world. For cognitive agents and robots, a subset of symbol grounding is the anchoring problem which focuses on the connection between symbols and physical object while interacting in the environment. In a multi-robot system, this problem is more challenging as symbols have not only to be grounded, but commonly shared in order to facilitate the exchange of information. This is called the social grounding problem. This also raises questions with respect to human-robot dialog modeling, where symbols and their references need to be communicated and how the social grounding between robots can be made transparent to a human interaction partner.

This special issue includes technical papers, reports on current research projects, interviews, book reviews and others with focus on current developments and challenges in Symbol Grounding in intelligent systems.

Topics of interest include but are not limited to:

- Symbol Grounding in intelligent systems
- Social Symbol grounding
- Anchoring symbols to sensor data from physical objects
- Symbol Grounding applied to language acquisition
- Symbol Grounding in robotics and intelligent systems
- AI applications of Symbol Grounding
- Knowledge representation and reasoning for robotics and intelligent systems
- Dialog modeling and Symbol Grounding

Interested authors should contact one of the guest editors to discuss a possible contribution:

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