Artificial Intelligence Enhanced By Modelling

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One of the biggest hypes in current research is Artificial Intelligence. Similar to the AI 1.0, 2.0, and 3.0 hypes, the claim is that AI will help to solve all problems everywhere and anytime, will replace almost all human activities by greater machinery, will be far more intelligent than humans, will be far more reliable than humans, and will be the basis for greater wealth.

We briefly investigate whether it is possible and figure out that these and other promises are not realistic. A silver bullet is, however, modelling since it is more concerned with human intelligence.

Keywords: artificial intelligence, human intelligence, modelling, AI models.

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1. Is AI 4.0 Mainly Money-Gathering Research?

AI 4.0 is Another Hype. Artificial Intelligence became again a hype in Computer Science. Researchers claim that this new wave of AI is going to solve all mankind problems and being the starting point of best intelligence. It seems that AI will cover any human activity and allows to proceed in a far better way. Weak AI solutions are reality. Strong AI is still a dream and might be achievable within this century. The claim that AI will lead to systems that think alike humans is completely infeasible. So far, AI is nothing else than another instrument for our life and practice.

A Reservation. The superiority of AI is based on its ability to handle big amounts of data mined from a variety of distributed sources. This superiority is based on "brute force" controlled by algorithms. In a way, even HI is based on algorithms – in most cases far more advanced. Researchers have tried to adopt these algorithms to be applied in AI. Learning is the key element in the current wave of AI. This is good start towards HI, but still a lot is missing: human sense, human kind of criticism, emotions and human ethics are examples of the missing elements. Current AI (weak, narrow) is still context dependent and not transferrable to new application areas.

Therefore, we present some doubts on the success of such promises. Whether AI will cover all human abilities and will replace humans in

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everyday life is not an open issue. It is in this direction an overstatement and misleading.

Human intelligence (HI) is oriented on the needs and challenges a human face. It also supports human societies. There are many tasks that are handled by humans and living beings. AI might be able to cover a good number of tasks -– at least in the form of strong AI. So far, we are covering a small porting of HI tasks as weak AI. Coverage of the other kinds of HI is currently infeasible.

Realism Lost in Computer Science. Computer realisation are based on the Turing machine approach to computation. This computation paradigm is the basis for digitalisation of processes, for support of stereotyped and normalised handling by data and algorithms, and for AI as well.

There are, however, other human abilities beyond digital computation such as analog computation, approximate and plausible reasoning, and non-rational problem solving. Additionally, digital computing on the Turing machine paradigm is restricted. In a nutshell, the second Rice theorem says that anything what is computable is trivial in the sense that either the solution or the counter-solution is finitely enumerable. There are already proposals for novel computation paradigms.

State-Of-The-Art So Far. Our artificial systems do not really produce anything new in reality. They bring, however, another kind of toolbox and instrument a great purely practical improvement in life. They increase speed, effectivity, and performance for everybody who has access to them. They enable a comfortable life for many people. Whether we call them 'intelligent' is a definition matter for intelligence.

What we achieved so far is the development of yet another tool and instrument for more convenient life, e.g. for support of industry, science, and technology.

Our Agenda: Towards Support of Human Intelligence. After a brief analysis of the potential and capacity of current AI, we introduce in this short paper a new discipline: systematic studies of models and modelling. Models are a universal instrument in science, technology, and daily life. They function as instruments in almost every scenario. This paper is a short note and a review based on our papers [1, 2, 3].

2. The Horizon of Possibilities

Human Intelligence is Far Broader. One reason for the AI-HI mismatch is the variety of human reasoning mechanisms. Weak AI has

assumed that these mechanisms are algorithm-based and supported by first-order logical calculi. A second reason is the ability of humans to non-rational reasoning. A third mechanism is human reasoning in general that is not only deductive or calculus-based. A fourth reason is that humans can survive with incomplete data. Moreover, cognitive systems are energy-minimal, interactive in a wide variation, evolutionary, and potentially unbounded. The cognition goes far beyond machine learning, neural networks, databases that are called knowledge bases, and linguistic systems.

Kinds of Human Intelligence. HI is far more advanced and broader. We claim that most of HI cannot be covered by current programming approaches. Let us consider some kinds of human intelligence:

Creative or success intelligence such as:

- Linguistic, narrative or verbal intelligence
  - · metaphorical intelligence
- Musical intelligence
- Abstract intelligence
  - · analytical intelligence
  - · logical-mathematical intelligence
  - · numerical intelligence
- Intuitive intelligence
  - · crystallized intelligence
- Practical intelligence
  - · application intelligence
  - · practical wisdom
- Imaginative intelligence
- Physical-kinesthetic intelligence
- Spatial intelligence
- Visual intelligence

Emotional or social intelligence such as:

- Perception of emotions
- Use and understanding of emotions (to facilitate thinking)
- Intra- and interpersonal intelligence
- Machiavellian intelligence
- Ability to manipulate
- Ability to deceive
- Ability to make assessments
- Disposal of second-order mental representation
- Pedagogical intelligence
- Regulation of emotions

Spiritual or existential intelligence such as:

- Moral and ethical intelligence including appreciation
- Ability to achieve extraordinary states of consciousness, spiritual abilities to solve

Body intelligence (our second HI reasoning system) such as:

- Perception of emotions
- Vegetative nerve system as part of body intelligence
  almost autonomous; heavily interacting and optimising
- As symbiotic system with bacteria (and may be viruses) that properly support.

Survival intelligence for the species (as third HI system) such as:

- Sexual sustainability; selection of an appropriate partner; activation as a main driving force for certain moments with overruling all other organs;
- Group and society compromising including social interaction;
- Fear and other functions of the limbic system with autotimer functionality for other two intelligent systems.

If we deliberate this small list and compare it with recent achievements then we discover how far we are at present from real AI-backed HI. Strong AI might cover the first kinds. Currently, weak AI covers a small portion of the first kind. For instance, neural networks follow the old-fashioned 70-years-old understanding of neurons. They can mimic normalised and average behaviour in simple approximation at the level of a house pet if highest quality data are available. They can be used for approximation by polynoms (degree +2 of the layers of the network; e.g. one layer = splines). Whenever the full picture or the non-average case or changing data must be considered this approach is out of any chance. The rest of intelligence seems to be infeasible. Infeasibility is also caused by the believe that solutions can be entirely based on programs within current computer approaches.

3. Modelling for Overcoming the Mismatch

Modelling – The Denouement. The main reason for the AI-HI mismatch is, however, that humans often use models for any kind of activity including reasoning. Rational reasoning is partially based on plausible and approximative techniques beyond induction and abduction. Non-rational reasoning on the basis of models has already found some theoretical basis.

Models are a universal instrument in science, technology, and daily life [4, 5]. They function as instruments in almost every scenario. Any human activity can be (and is) supported by models, e.g. reason, explain, design,

act, predict, explore, communicate, collaborate, interact, orient, direct, guide, socialises, perceive, reflect, develop, making sense, teach, learn, imagine, etc. This universal suitability is also the basis for a wide use of models and modelling in Computer Science and Engineering. A claim often met is that model theory in classical logics has a different treatment of models. Our general notion covers this specific case as well:
A **model** is a well-formed, adequate, and dependable instrument that represents 'something' (called origin as a source, archetype, starting point) and functions in scenarios of use.

The criteria of well-formedness are often considered a specific requirement of the modelling language or more generally of the model formation. The criteria for *adequacy* are (1) analogy (as a generalisation of the mapping property, which forms a rather narrow kind of analogy), (2) focussedness (as a generalisation of reduction to central properties or abstraction), and (3) usefulness (or purposiveness) (as a generalisation of classical pragmatics or substitution properties). *Dependability* is often concealed, implicit, and yet central part of the model-being of objects and ideas. A model has to be *justified* or viable and has to be of a sufficient quality. *Well-formedness* is a specific modelling language requirement for model's convenience and ease of use and understandability. It enables an instrument to be justified by an empirical corroboration according to its objectives, by rational coherence and conformity explicitly stated through conformity formulas or statements, by falsifiability or validation, and by stability and plasticity within a collection of origins. The instrument is *sufficient by its quality* characterisation for internal quality, external quality and quality in use or through quality characteristics. A well-formed instrument is called *dependable* if it is sufficient and is justified for some of the justification properties and some of the sufficiency characteristics.

We notice that all properties are parametric and can be refined in dependence of their envisioned function in scenarios of use. Configuration is a typical refinement in modelling. Configuration directly leads to special disciplinary notions. For instance, a *conceptual model* is a concise and purposeful consolidation of a set of concepts that are presented by means of terms in a predefined linguistic format. As such it establishes a view of a given notion space.

Model-based Reasoning and Activities Let us now briefly discuss how powerful is model-based reasoning and model usage [8] beside the initiative Models-as-Program or at least Modelling-as-Programming [6]. We realise that model-based human reasoning and human activities are far more advanced than supportable at present. Figure 1 depicts the variety of model-based support for HI.

Other typical HI techniques are enhancements similar to conceptualisation, model inheritance from generic or reference models, parameter hardening used for inverse modelling in physics, model-based checking and control for systems, and simulation of behaviour for some of the parameters. Cognitive modelling is another important HI technique. Shallow and deep reasoning techniques are another lacuna for the study of models.

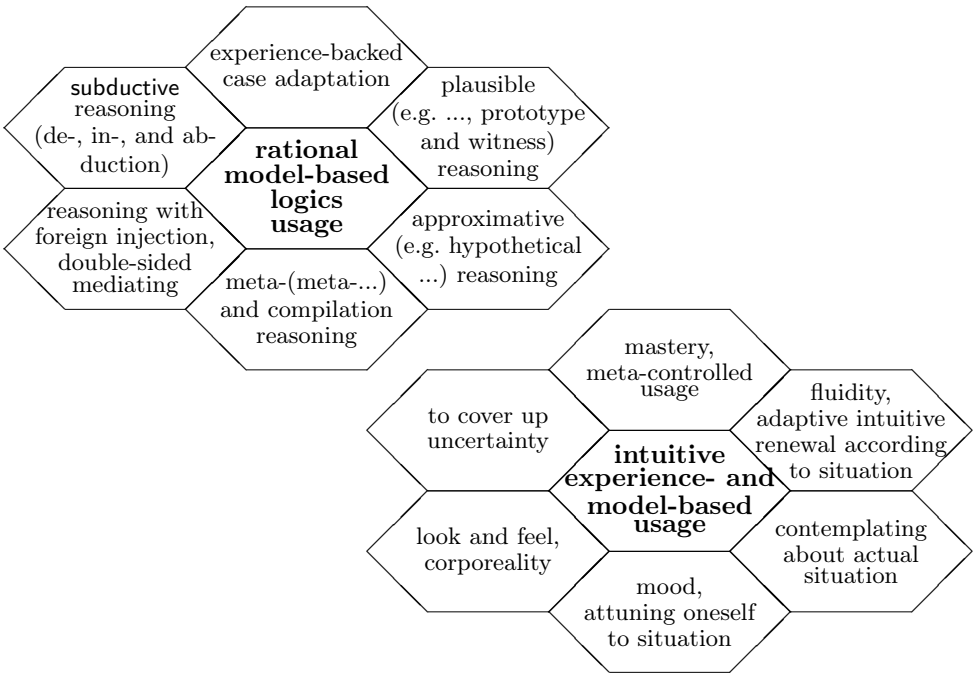

Fig. 1. Rational and intuitive model-based reasoning and activities (revised from [8])

4. Finally

Our reservation is based on the wide range of human intelligence that cannot be easily covered and on the limited computer science that is based on a too simple computation paradigm. Human intelligence is far broader than covered so. AI provides only some solutions to some of the kinds of one of the five dimensions. Problem-solving intelligence might be partially covered by algorithmics and somehow "intelligent" machines.

Instead, we consider models and modelling as one of the loopholes, back doors, or first and certainly powerful resource to develop support for human

intelligence. Model-based reasoning is the real kind of human reasoning [7]. Models are universal instruments for humans. So, we might ask whether we should develop AI models as an alternative. What is meant for models is not so much aesthetics but parsimony, understandability, believability, harmony, and balance, that the chosen concepts fit together and appropriate compromises are reached.

Remark: The full version of the talk given at the 12^{th} International Conference "Artificial Intelligence and Computer Science" has been recorded and can be viewed and downloaded from the YouTube channel "Bernhard Thalheim": https://youtu.be/TAc3S7bCli8.

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