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Artificial General Intelligence - a systematic mapping study

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Abstract: In this thesis, a systematic mapping study is performed on the field of artificial general intelligence. The goal of the study is to gain insight about the recent developments in the study field. This includes the focus points of the current reserch, possible research gaps, and how the research itself is conducted. TODO: more accurate, proper abstract

Keywords: Master's Theses, AGI, AI, artificial intelligence, systematic literature mapping, mapping study

Suomenkielinen tiivistelmä:

Tässä suunnitelmassa käydään läpi pro gradu -tutkielman mahdollista aihetta ja tutkimustapaa. TODO: translate when abstract done

Avainsanat: Pro Gradu,tutkielma, AI, tekoäly

Contents

1 Introduction

The thesis will be a systematic research mapping on the field of Artificial General Intelligence (AGI). The goal of the thesis is to identify the themes and subfields of AGI research in recent years, what is being researched recently, and what kind of gaps exist on the field. For a while the AGI field was not so active and the more specific approaches, 'narrow AI', grew in popularity. Recently, however, the wider, more general artificial intelligence has been regaining interest. This kind of mapping study would be needed as the research field is complex and there is no clear presentation of the current trends and focal points. Creating this king of overview would be a valuable asset for future research, as it would enable focusing the research on areas less ventured. Furthermore, if an interesting subtopic comes up during the process of mapping, more focus may be directed towards that in form of more traditional systematic literature review. This option is left for further consideration.

2 Artificial General Intelligence

2.1 Definition

In order to be able to define AGI, or artificial intelligence in general, one must first consider the definitions of intelligence in general. The exists many different definitions, in many different branches of science. Legg and Hutter (2007) list over 60 definitions collected from various academic sources. These include, for example, *"the general mental ability involved in calculating, reasoning, perceiving relationships and analogies, learning quickly, storing and retrieving information,using language fluently, classifying, generalizing, and adjusting to new situations."* (Columbia Encyclopedia, sixth edition, 2006), *"that facet of mind underlying our capacity to think, to solve novel problems, to reason and to have knowledge of the world"* (Anderson 2006), and *"Intelligence is the ability for an information processing system to adapt to its environment with insufficient knowledge and resources."* (Wang 1995). Based on the aforementioned collection of definitions, Legg and Hutter (2007) have formed the following definition: *"Intelligence measures an agent's ability to achieve goals in a wide range of environments"*. This gives us a single definition which encompasses the common traits in intelligence definitions.

Artificial General Intelligence, sometimes referred as "strong ai", according to Goertzel and Pennachin (2007) means *"AI systems that possess a reasonable degree of self-understanding and autonomous self-control, and have the ability to solve a variety of complex problems in a variety of contexts, and to learn to solve new problems that they didn't know about at the time of their creation."*. It is abbreviated as AGI. The reason general intelligence is specified instead of plain intelligence is that there is a need to differentiate it from the domain specific artificial intelligence, also known as "narrow AI" or "weak AI". Terms strong AI and weak AI were coined by John Searle in 1980 (John et al. 1980). Narrow AI means smart solutions that may learn and improve their performance through training, but they are only focused on specific type of problems in a specific context. Examples of such AI include chess engines, autonomous vehicles, and natural language processing. These solutions may outperform human capabilities, but only in their limited tasks. As above definition by Goertzel and

Pennachin describe, AGI is able to function on different context and tasks without separate human intervention and reconfiguration.

2.2 History of Artificial Intelligence

Even though the idea of autonomous machinery has been around since the ancient Greek (), AI's origins are set around in the 1940s. At the time, American science fiction author Isaac Asimov wrote numerous novels and short stories about conscious robots and technology's relation to humankind. His work has inspired countless people in the field's of AI and computer science since then (Haenlein and Kaplan July 2019). Also in the 1940s, mathematician Alan Turing's work on Britain's code breaking efforts lead to the creation of first electromechanical computer, The Bombe (Haenlein and Kaplan July 2019). Turing later gave lectures and wrote an article titled *"Computing Machinery and Intelligence"* (1950), in which he presented several ideas later prevalent in AI field, including the "Imitation game", a test to measure the intelligence of a machine (Russell and Norvig 2009). This later became well known as the Turing test. The term Artificial Intelligence was coined in 1956 during a two-month workshop *Darthmouth Summer Research Project on Artificial Intelligence*, organized by John McCarthy and Marvin Minsky (Haenlein and Kaplan July 2019). The participants of the workshop later became the most prominent figures of AI research. During DSRPAI two researchers, Allen Newell and Herbert Simon presented Logic Theorist, their existing reasoning program, capable of proving multiple mathematical theorems (Russell and Norvig 2009).

Ever since the Artificial Intelligence research entered the academia, speculation about an AI that would reach the human level intelligence has been surfacing every few years. For example, American AI scientist Marvin Minsky suggested in 1970 that a machine with human level general intelligence could be developed in the next few years (Haenlein and Kaplan July 2019). This never happened, and soon after that whole AI research lost its interest in the eyes of the financial backers. The time period following this is known as the first "AI winter" (Haenlein and Kaplan July 2019).

3   Systematic literature mapping process

3.1   Research method and reasoning

The research method, systematic mapping, is a secondary study method that aims to create a general view of the studied area by a process of keywording, classification, and mapping. According to Peterson et al. (2008), it consist of the following phases:

1. Definition of research questions
2. Conducting search
3. Screening the papers for inclusion and exclusion
4. Keywording (abstracts, conclusions, introductions)
5. Data extraction and mapping

Each phase produces a subresult to be used in the next one. This process results in a systematic map of the area. This can and should be further visualized using for example bubble graphs (Mononen 2018 and Petersen et al. 2008). This helps to more easily spot the focus points and gaps in the research.

The material is to be gathered through databases and search engines via specified search terms. Databases and content libraries such as IEEE, ACM, and Google Scholar can be used. One possible option would be to focus on journals that specialize on the field, such as *Journal of Artificial General Intelligence, Journal of Artificial Intelligence Research*, and *Artificial Intelligence*, the first of which is highly focused on the area, but not well ranked based by Publication Forum.

There exists many good papers on the research method. There are some example theses using the approach, such as Niko Mononen's (Mononen 2018) and Sari Ryynänen's (Ryynänen 2017). Guidelines regarding the method itself can be found on article ny Petersen et al. 2008. There is an update on the topic as well (Petersen, Vakkalanka, and Kuzniarz 2015). Some sources about literature reviews such as Bereton et al. (2007) and Salminen (2011) might be useful as well.

3.2 Difference with other secondary studies

3.3 Mapping studies in field of IT

4 The literature mapping

4.1 Background/why this method and topic

The research questions are not too specific yet, but some ideas are:

- What is the current state of AGI?
- What are the current techniques used and researched?
- What have been the most successful attempts recent years?
- How has the generalization of specific techniques advanced recently?

4.2 Research questions

The following research questions...

1. How much, and what type of research is done in the field of AGI?
2. Where is the AGI research focused on?
3. Has there been any major breakthroughs?
4. Where and when were the studies published?

4.3 Sources and databases used

- Journal listing and their date ranges etc.

- search terms here or another section?

- table showing used search phrases?

4.4 conducting search

search phrases are used on different databases, limiting the papers to amount possible to handle

4.5 Criteria for inclusion, exclusion

papers from the

4.6 Keywording

papers are further analyzed, keywords are extracted from abstracts,

4.7 Data extraction and mapping

keywords are mapped using frequencies etc

4.8 Source material control

- How the papers were handled - How graphs etc. were made

5 Results and analysis

The results of the thesis will be a clear overview of the recent research in the field of artificial general intelligence in form of classification data, visual graphs and further synthesis. As mentioned earlier, if an interesting topic presents itself during the process of mapping, it may be further examined in a more focused way, such as literature review. This will be considered at that time.

5.1 Results of literature mapping

- Graphs and other visualization, bubble graphs are useful.

5.2 Possible continuation research

- List of most prominent topics for further research

6 Conclusion

In this thesis, a systematic literature mapping was conducted on the field of artificial general intelligence. Results of the study showed that ....

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