Exploring the Role of Adaptive Hybrid Intelligent Systems on Competitive Advantage: The Case of the STM Publishing Industry

Semester Paper

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Abstract: @todo: write the abstract once the paper is ready…

Contents

1 Introduction

As enterprises face universally accelerating change (Eliazar & Shlesinger, 2018), it is crucial for their artificial intelligence (AI) systems to be dynamic and adaptable. Hybrid intelligent (HI) systems that learn from both new data and the interaction with human agents can provide a competitive advantage to enterprises. This study explored the competitive advantage for enterprises adopting adaptive hybrid intelligent systems using the case of the scientific, medical and technical (STM) publishing industry. The study answers the following research question: *How can AI systems learn from and adapt to humans and their environment for the competitive advantage of enterprises?*

A mixed-methods approach was used, consisting of a literature review and qualitative data collection from a focus group of graduate students in information systems ($n = 25$). The literature review identified factors contributing to competitive advantage and was used to derive hypotheses using the case of the scientific, medical and technical (STM) publishing industry. The hypotheses were tested through qualitative feedback from the focus group.

@todo: add a short summary of the findings and discussion...

The remainder of the paper is structured as follows. Section 2 presents a literature review on hybrid intelligent systems and their competitive advantage for enterprises. Section 3 describes the methodological approach of the study. Section 4 presents the findings. The paper concludes in Section 5 with a discussion of the findings and limitations of the study.

2 Literature Review

In this section we inform a background on different types of artificial intelligence, hybrid intelligence, design patterns and principles for hybrid intelligent systems, and the competitive advantage arising from the use of such systems in enterprises.

According to Russell and Norvig (2010) artificial intelligence is the creation of computer programs and algorithms that allow machines to replicate human cognition and behavior, which includes the capabilities of learning, perception, reasoning, solving problems, and making decisions. Artificial intelligence can be broadly subdivided into symbolic and sub-symbolic approaches, see e.g., Eliasmith and Bechtel (2006). Symbolic approaches involve the use of explicit symbols and rules to represent knowledge and reason in a way that is easily understood and explainable by humans, while sub-symbolic approaches aim to learn complex patterns from vast amounts of data using neural networks (Ilkou & Koutraki, 2020).

Hybrid artificial intelligence refers to systems involving symbolic and sub-symbolic approaches. Hybrid AI systems can be anywhere from loosely coupled to tightly integrated (d'Avila Garcez & Lamb, 2020). Loosely coupled hybrid AI systems typically involve a human, which is also known as *human in the loop* (HITL) computing. Within tightly integrated hybrid AI approaches, neurosymbolic AI has recently earned a particular research interest as a way to overcome the limitations of deep learning, such as lack of explainability, susceptibility to adversarial attacks (data poisoning) and high computational cost (d'Avila Garcez & Lamb, 2020).

Hybrid intelligence (HI) refers to systems where humans and AI systems work together towards common goals, augmenting the human intellect and overcoming human limitations and cognitive biases (Akata et al., 2020). Such HI systems show the potential for improving the outcomes of AI systems, hence augmenting rather than replacing human intelligence (Akata et al., 2020, p. 19). HI systems can be represented by a boxology notation with certain design patterns describing the commonalities of such systems that emerge (van Bekkum, de Boer, van Harmelen, Meyer-Vitali, & ten Teije, 2021; van Harmelen & ten Teije, 2019; Witschel, Pande, Martin, Laurenzi, & Hinkelmann, 2021). HI has recently received attention from the leaders in the field: in his presidential address to the AAAI community, Kambhampati (2020) demanded that AI researchers build human-aware AI systems that consider the human mental model. In particular, AI systems should show the capabilities of explicability (AI agents should show behavior that is expected by humans) and explainability (AI agents – if behaving unexpectedly – should be able to provide an explanation) (Kambhampati, 2020).

2.1 Design Principles Hybrid Intelligent Systems

Ostheimer, Chowdhury, and Iqbal (2021) developed a framework of eight principles for the design of human-in-the-loop (HITL) computing. They argue that such hybrid systems achieve higher accuracy and reliability of machine learning algorithms. Using a case in the manufacturing industry, they showed that the efficiency of operational processes could be increased by applying an algorithm that followed these design principles (Ostheimer et al., 2021).

Box 1. HITL Computing Design principles (Ostheimer et al., 2021).

1. Principle of client-designer relationship: designers should aim for mutual knowledge exchange with clients to foster the understanding of which aspects of a system are influenced by human or artificial intelligence.
2. Principle of sustainable design: designers should keep up to date with the latest progress in the field of AI and apply the latest and lasting AI techniques.
3. Principle of extended vision
4. Principle of AI-readiness
5. Principle of hybrid intelligence
6. Principle of use-case marketing
7. Principle of power relationship
8. Principle of human-AI trust

2.2 Narrow versus Broad AI

2.3 Artificial General Intelligence (AGI)

2.4 Types of Hybrid Intelligent Systems

- Expert systems
- Decision support systems
- Recommender algorithms with human decision-making
- Case-based reason systems

2.5 Foundation Models

- Language Models (LMs)
- neural networks trained of vast amounts of data, including on multimodal data (text, images, speech, video)
- Good at a variety of tasks, often the performance of LMs is closed to that of specialized model
- However, they show several limitations in their capabilities in reasoning and information retrieval.
- Thus the terms "Foundation Model" was proposed by researchers at the Human-centered AI (HAI) institute of Stanford University
- Foundation models represent a paradigm shift in AI
- ChatGPT as a chatbot is highly interactive: user has to prompt AI (althoug it is an unexplainable black box)
- Emerging capability in foundation models: in-context learning
- In-context learning is highly adaptable: AI can learn from examples in the prompt

2.5.1 Limitations of Foundation Models

2.5.2 Hybrid Intelligent Approaches Involving Foundation Models

- Agents
- Mixed architecture, e.g., MRKL
- Using the model as IR agent

2.6 Enterprise Competitiveness

@todo: what are the aspects of and factors increasing the competitiveness of enterprises?

2.7 Competitive Advantage Through Adaptive Hybrid Intelligent Systems

Xu, Guo, and Huang (2021) found that post COVID-19 companies using AI in their products grew faster than their peers. However, they could not observe evidence of the same effect before COVID-19, indicating that this development is either very recent or was fueled by the COVID crisis. More recently Ho, Gan, Jin, and Le (2022) reviewed the potential benefits of AI for enterprises as reported by selected previous studies published between 2016 and 2021:

- reduced costs
- improved performance
- better decision-making
- higher customer satisfaction
- better customer segmentation
- improved customer experience
- better products & services
- business innovation

Further, Ho et al. (2022) identified several empirical studies that reported a positive, neutral or negative effect of AI on enterprise performance. In particular one study by ...liu et al. (2022)... and cited in Ho et al. (2022) reported negative performance of AI-related adoption announcements on firm market value for 62 listed US companies between 2015-2019.

3 Methodology

The study aimed to investigate the competitive advantage that can arise for an enterprise through the adoption of hybrid intelligent systems. Specifically, the study explored the aspect of adaptability of such hybrid intelligent systems. The study used a mixed-methods approach consisting of a literature review (secondary data) and qualitative data collection from a focus group of 25 graduate students in the FHNW Business Information Systems master program (primary data).

The literature review was conducted to identify factors that contribute to the competitive advantage of enterprises using AI systems in general, and adaptable hybrid intelligent systems in particular. The literature search was mainly conducted on Elicit [1] and Google Scholar [2] using different query terms, including “competitive advantage of AI”, “hybrid intelligent system”, “expert system”, “decision support system”, “human-in-the-loop”, “competitive advantage and AI”, etc. Additionally, a forward and backward search was applied on relevant papers that were identified from the initial literature searches.

The findings from the literature review were used to establish hypotheses on the competitive advantage of adaptable hybrid intelligent systems for enterprises using the example of one industry.

[1] elicit.org
[2] scholar.google.com

Given the background knowledge of the author, the hypotheses were applied to the scientific, technical and medical (STM) publishing industry. To test the derived hypotheses, a focus group of students ($n = 25$) was selected based on their educational background in business information systems. As part of a workshop the focus group was presented with the hypotheses and asked to discuss and provided qualitative feedback for each hypothesis. Participants were encouraged to provide detailed feedback on their experiences and perceptions related to the application of the hypotheses in the industry case. The qualitative data was analyzed using thematic analysis and common themes identified.

4 Results

4.1 Hypotheses

Hypotheses from the literature:

- *"[Humans] overestimate the range of expertise of an automated system and deploy it for tasks at which it is not competent"* (Akata et al., 2020, p. 19)
- *"AI systems [...] were not designed with societal values such as fairness, accountability, and transparency in mind"* (Akata et al., 2020, p. 19)

5 Discussion

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Appendix

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