Augmented Intelligence: An Actor-Network Theory Perspective

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AUGMENTED INTELLIGENCE: AN ACTOR-NETWORK THEORY PERSPECTIVE

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Abstract

Augmented intelligence is an alternative conceptualisation of artificial intelligence (AI). Augmented intelligence focuses on AI’s assistive role in advancing human capabilities. Augmented intelligence reflects the ongoing socio-technical contribution of AI in amplifying human intelligence. However, within the field of Information Systems (IS) there are a lack of theoretical developments which examines the socio-technical assemblage of augmented intelligence. This article applies actor-network theory (ANT) and presents a model on Augmented Intelligence Moments of Translation to guide how researchers conceptualise the socio-technical intricacies of augmented intelligence. The contributions of this article are threefold. First, this article presents a review of the emergent literature on augmented intelligence. Second, this article argues that ANT and the ‘Moments of Translation’ is suitable to theorise about augmented intelligence. Third, the article presents avenues on future research for the IS community on socio-technical factors of augmented intelligence.

Keywords: Augmented Intelligence, Artificial Intelligence, Actor-Network Theory

1 Introduction

Since the time of the ancient Greek philosophers and rhetoricians, there has been a growing curiosity and debate to examine human intelligence and reasoning to support arguments and decision-making. Nowadays, we continue to search for techniques to mimic human intelligence (Mittal et al. 2017) and the relation between computation and cognition (Pylyshyn, 1984). Specifically, the advancements of artificial intelligence (AI) technology (Marr, 1977; Russell and Norvig, 2016) has profoundly altered our view of relationships between humans and technology across society (McCarthy and Hayes, 1987; Huang and Rust, 2018).

There is a growing body of knowledge on AI research efforts across several disciplines with various attempts to model humans as cognitive machines (Konar, 2018) and initiatives to build human-like AI systems (Jain et al. 2018). More recently, there has been growing interest in augmented intelligence which uses machine learning and deep learning to provide humans with actionable insights. It achieves this by offering a pattern for a human-centered partnership model of human intelligence and AI (Figure 1). Augmented intelligence can therefore enhance cognitive performance, including learning, decision making and new experiences (Jain et al. 2018; Myer et al. 2014; Zheng et al. 2017). Augmented intelligence is particularly suitable given the growth of large-scale computational problems which cannot be solved by either computer or humans alone, i.e., human computation problems (Von Ahn and Dabbish 2008) which can offer solutions across the business domain.

Against this background, there have been growing calls for new theoretical developments and empirical studies on the key challenges associated with the implications of AI systems (Gomes et al. 2019; Guzman and Lewis 2020; Makridakis, 2017). Yet, in practice, the adoption of AI continues to grow across industries ranging from finance, healthcare and logistics, all of which will be disrupted by the onset of new AI technologies (Dwivedi et al. 2019). However, as AI advancements alter relationships between humans and ‘machines’, we need to unravel the complexity of such relationships in amplifying human cognitive abilities, interaction with humans, and the digital embodiment of human skills and capabilities. The information systems (IS) discipline is especially well positioned to better explain the merging of humans and machines (Ågerfalk, 2020; Cecez-Kecmanovic et al. 2014; Hanseth et al. 2004; Makridakis, 2017; Walsham, 1997).
1.1 Motivation for Research

Since its origin in 1956, AI has been a growing area of research which is now been established worldwide (Dautenhahn, 2007). In the 1950s, pioneering research predicted that AI would become essential for management (Newell and Simon, 1956; Newell et al. 1960). However, research efforts on AI are often focused on mirroring human intelligence (Simon, 1981) and thereby placing more emphasis on the machine becoming human-like (Dautenhahn, 2007). Human-like intelligence can refer to agent’s knowledge gained from experiences during task performance, whose tasks and environment approximates humans over a specific timeframe with varying temporal and computational resource constraints in a complex dynamic environment (Dimoka et al., 2011; Donahoe, 2010; Engelbart, 1962; McClelland, 2009). From an IS perspective, human-like intelligence presents extremely complex environments to design and manage AI solutions. Alternatively, augmented intelligence presents another conceptualisation of AI that focuses on AI’s assistive role, emphasising the fact that cognitive technology is designed to enhance human intelligence rather than replace it (Cerf, 2013; Jain et al. 2018; Winograd, 2006). This is not to detract from research efforts against intellect, but rather an acknowledgment of the limitations in capturing the certain nuances and complexities of the real human world (Winograd, 2006) which AI researchers hope to achieve.

The long-term goal of AI is to make machines demonstrate intelligence at a similar level to natural intelligence displayed by humans, for example, within a business or healthcare context. Yet, due to the complexity, uncertainty, and vulnerability experienced in human life and problem-solving, it is unlikely that AI technology will completely replace humans (Jarrahi, 2018). Rather, there is significant scope to adopt a hybrid approach to enhance human cognitive capabilities through AI systems – something referred to as augmented intelligence. Therefore, it is important to develop a socio-technical perspective as organisations need to structure how they adopt augmented intelligence into organisations. However, little is understood about augmented intelligence within an IS context. There are two key objectives of this article. First, this article presents a review of the emergent literature on augmented intelligence. This research sets out to examine the socio-technical assemblage of augmented intelligence within an IS context and beyond. Second, this article argues that actor-network theory (ANT) is suitable to theorise about augmented intelligence and how it can become adopted within a contemporary business context.

2 Socio-technical Developments in IS

We have been relatively confident that humans were aware of the strengths and weaknesses of technology and humans, yet computers have made significant inroads in some unexpected areas which impact on society and work practices (Brynjolfsson and McAfee, 2011). Over the past few decades, we have witnessed growing efforts to learn how technology intertwines with human factors, moving from “things that serve human purposes” (March and Smith, 1995), to the “cultural properties packed into socially recognizable from such
hardware and/or software” (Orlikowski and Iacono, 2001). This had created a growing need to theorise about the socio-technical nuanced relational structures and their interconnections (Carroll, 2016). For example, Orlikowski and Iacono (2001) explain how articulation of the nature and role of technology, and theories of its interdependence with social contexts were missing or treated as being “black-boxed” (Latour, 1987) with little regard for social constructions.

Socio-technical systems (STS) offers an alternative view on interactions between people and technology which accounts for society’s complex infrastructures, organisations environments, and human behaviour. STS theory (Bostrom and Heinen, 1977) provides a reference framework to identify how IS relate to organisational systems. STS theory builds upon Leavitt’s (1965) socio-technical model that views four interacting and aligned components: (i) task, (ii) structure, (iii) people, and (iv) technology as the important dimensions of organisations as work systems (Alter, 2013). Therefore, augmented intelligence may be viewed as a combination of social and technical systems. Specifically, Bostrom and Heinen (1977; p.17) explains that a technical system is “concerned with the processes, tasks, and technology needed to transform inputs to outputs” while the social system is “concerned with the attributes of people (e.g., attitudes, skills, values), the relationships among people, reward systems, and authority structures”. IS relies on the interaction between these two systems to perform processes and activities, whereby “the system” is a computerised artifact that is used by users (Alter, 2013).

While many research contributions consider a myriad of social entities, individuals, groups, or organisations, play a key role in informing the implications of systems. Schmid et al. (2017) describes how IS studies tend to focus on how a tool or technology (i.e., material artefact) is used by social actors rather than how they become embedded systems (Orlikowski and Iacono 2001) and many studies do not attribute any material agency to information technology. There is a need for more balance between the social perspectives and technical perspectives and how they interconnected and interface in society. For example, Doherty et al. (2006; p. 569) explains: “...recent contributions to this debate have tended to be rather one-sided, focussing almost solely upon the role of the human agent in shaping the technical artefact, and in so doing either downplaying or ignoring the artefact’s shaping potential”. While scholars are recognising how humans enact agency (Leonardi, 2010) in response to technology’s material agency (Volkoff et al. 2007), we need to further understand the capacity for nonhuman entities to act on their own, outside of human intervention, i.e., the performativity perspective (Barad, 2003; Callon, 1998). Indeed, there have been recent calls to shift our attention from actors to the flows of action to uncover the trajectories of socio-technical transformation (Mousavi et al. 2020).

Most authors have treated human and material agencies as having a unidirectional relationship. Yet, in the enactment of their goals, humans must contend with the material agency of the technology which can also shape outcomes (Orlikowski 2000). In an effort to theorise about more stability across organisations, Feldman and Pentland (2003) present theoretical developments on organizational routines to understand how stability and change in organisational routines are related through a “repetitive, recognisable pattern of interdependent actions, involving multiple actors” (p. 96). Though this, they argue that routines have two aspects: ostensive (ideal or schematic form of a routine) and performative (specific actions by specific people at a given time and place). While organisational routines are a central feature of human organisations and much of the research has led to valuable insights on the human factors of routines, it “overlooks the ubiquitous involvement of artifacts” (Pentland et al. 2011; p. 1374) such as information and communication technologies, in every real routine (Orlikowski, 2007). Feldman and Pentland (2003) explain that we need to examine how routines, changes, and transformations become embedded into organisations. More fundamentally, we need to revisit what Boudreau and Robey (2005) once described from a human agency position that “humans are relatively free to enact technologies in multiple ways” and whether advances in technology have now eroded some levels of human agency and action. For example, through structuration theory, Giddens (1984) defines agency as the “capacity for action” whereby all actions involve some level of motivation, rationalisation, and reflexive monitoring. However, research indicates that structuration theory may be unable to fully account for the fluid
and flexible interchange between the material agency of technologies and the human agency (Orlikowski 2005; Leonard, 2011).

While digital innovation continues to transform how we work and live (Carroll and Conboy, 2020), Mousavi et al. (2020) explain that these transformations are characterised by mobility, interconnectivity, virtuality, complexity, hybridity, and fluidity. While digital transformations are typically in flux and flowing and rendering boundaries, we need to understand how we can embed transformations at any given time to ensure business continuity also (Carroll, 2020). Yet, insights into the material and human agency as we adopt more ubiquitous digital and AI-related technologies are limited. Mousavi et al. (2020) summarise the nature and role of human and technological actors and/or entities ranging from entity-oriented to process-oriented. This research is positioned on relational enactment which sets out to understand the enacted entities within relational fields of practices. By doing so, this research allows us to understand transformation of boundaries in sociomaterial practices and the configuration of boundaries in sociomaterial practices associated with augmented intelligence.

3 Augmented Intelligence

Human intelligence is amplified by organising intellectual capabilities into higher levels of synergistic structuring with the assistance of technology (Engelbart, 1962). In opposition, artificial intelligence refers to the capability of a machine to imitate intelligent human behaviour. While AI, machine learning, and other automatic process technologies are usually in the spotlight, Jain et al. (2018; p. 557) reports that “many important problems are often solved through human beings and computers working cooperatively”. Augmented intelligence elevates human intelligence and aids them to work faster and smarter through decision-making processes (Cerf, 2013) and “seeks to empower and amplify human capability to solve complex problems” (Crowe et al. 2017; p. 494). For example, augmented intelligence plays a key role in critical evolving systems such as within the aviation sector to enhance pilot performance by evaluating system limitations and flight precision and performance (Naranji et al. 2015). Indeed, the literature indicates that augmented intelligence tools are created to help rather than replace humans. Augmented intelligence technologies are not novel per se as they emerged over several decades, but its advancements have enabled global connectivity and the ubiquitous nature of technology, for example, an assistive bot which processes information and performs actions that benefit humans.

Within the IS community, additional research needs to bring about more balance on the technical and social factors which influences human decision-making for example, understanding, interpretation, reasoning, learning, and assurance. Augmented intelligence requires a focus on design that optimally combines the abilities of human and AI technologies and the interactions, control, and interface of technological innovations (Jain et al. 2018). Pavlou (2018) draws our attention to ‘human-computer symbiosis’ which denotes the collaborative interaction between human beings and computers, i.e., computers and humans have complementary strengths and problem-solving capabilities. Indeed, augment intelligence involves several actors and based on interactions with touchpoints that may be categorised as actions or interactions. Therefore, we need to examine what supports augmented intelligence to assemble and sustain relations and value networks between human and non-human interactions. Jylkäs et al. (2018) explain that before defining a non-human actor such as an AI assistant, we must question whether it has agency and how should we determine agency using other characteristics. For example, Latour (2005; p. 46) describes how “an actor is what is made to act by many others”. Therefore, we can view agency within augmented intelligence through the use and actions of, for example, natural language communicating with users and software, such as voice recognition, text, etc. without the involvement of human actors from the service provider. As the availability and sophistication of connected digital solutions increase and form new service ecosystems, the actor-network perspective becomes important to explain how socio-technical artefacts are initially developed, modified and applied to networks of alliances between both human and non-human actors. Therefore, understanding processes around implementing, embedding, integrating, and evaluating technologies which transform business operations and business models are of critical importance to exploit augmented intelligence.
Specifically, this article examines the role of augmented intelligence in IS and presents the suitability of ANT as a theoretical lens to conceptualise how augmented intelligence technologies create and assemble knowledge and networks which become embedded in practice.

4 Actor-Network Theory

Adopting a socio-technical lens to theorise on augmented intelligence plays an important role in IS theoretical developments. Rather than primarily focusing on the technical system or the social system, or the two within a single case, we need to investigate “the phenomena that emerge when the two interact” (Lee, 2001, p. iii). ANT describes a social world that is built upon a relational network of actors, that can be either human or non-human. In the words of Latour (2005) “we should not limit in advance the sort of being populating the social world.” Specifically, ANT adopts the principle of generalised symmetry which equally treats the capacity of human and non-human actors (i.e. actants) to equally participate in systems and networks or both and therefore should be described in equal terms. ANT provides us with a lens to explore questions about how networks are assembled or established and maintained through ‘Moments of Translation’ (Callon, 1986; Doolin and Lowe, 2002; Cecez-Kecmanovic et al., 2014). This work leads to the identification of four Moments of Translation for augmented intelligence: (i) problematisation, (ii) interessement, (iii) enrolment, and (iv) mobilisation. The Moments of Translation framework has tended to be more unilinear at least in its application to IS analysis (Heeks and Stanforth, 2007) which provides a suitable theoretical lens to conceptualise the role of augmented intelligence. Empirical studies using ANT typically describe social activity and social forces. Table 1 explains the four core concepts of Callon’s (1986) Moments of Translation in an IS context.

<table>
<thead>
<tr>
<th>ANT Concept</th>
<th>Explanation of Concept</th>
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<tr>
<td>Problematisation</td>
<td>Problematisation examines the identities and interests of other actors that align with the initiator’s interests. Here, researchers can begin to identify intelligence associated with the emergence of key interests, new ideas, and drivers behind new initiatives to meet the objectives set out by stakeholder interests, i.e. to clarify what is the problem that needs to be solved? Solution for specific problems become an obligatory passage point which is a path from problem to a single solution or goal. The obligatory passage point describes a key situation that must occur in order to satisfy the interests of all actors associated with the problem.</td>
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<tr>
<td>Interessement</td>
<td>Interessement focuses on efforts to secure actors’ interest in a proposed change and negotiating the terms of their involvement. This concept is concerned with the process of convincing other actors to agree on and accept the proposed change. The primary actor works to convince other actors that the redefined roles are acceptable. These actions may include the attempt to break away from norms and attempts to reorganise other actors into the roles to resolve the problem described in problematisation. ANT refers to immutable mobiles as strong properties or interactions which establishes its irreversibility, i.e. the point to which it is impossible to return to a point where alternative opportunities may exist.</td>
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<tr>
<td>Enrolment</td>
<td>Actors accept the roles that have been defined for them during interessement. Through this concept, we learn why actors accept the interests defined by the focal actor and set out to achieve them through other allies that align with the actor network. Enrolment is reflected by the active support to solve the problem: do the delegate actors adequately represent the masses? This describes the physical actions and negotiations to define and coordinate the roles of other actors.</td>
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<tr>
<td>Mobilisation</td>
<td>Mobilisation focuses on the process of ensuring actors represent actors’ interests. Mobilisation ensures that supposed spokespersons for relevant collective entities are properly representative of all members of the network that are acting as a single agent. Here researchers can identify how the solution is defined to achieve specific objectives through a new process and which actor speaks on behalf of all actors in the network.</td>
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Table 1. Moments of Translation (adapted from Callon, 1986; Carroll et al. 2012)
In addition to the Moments of Translation model, there are three additional concepts that are used across ANT literature to describe the assemblage of actor networks. Firstly, ‘irreversibility’ describes the point to which it is impossible to return to a point where alternative opportunities may exist (Callon, 1990; Walsham and Sahay, 1999). Secondly, ‘immutable mobiles’ refers to strong properties or interactions within a network that establishes its irreversibility (Walsham, 1997) for example, new policies or standards. These may be described as immutable mobile as they let the information flow from one actor-network to another. Finally, ‘performativity’ explains how entities achieve their form as a consequence of the relations in which they are located. They are performed in, by and through those relations (Law and Hassard, 1999). Here researchers can explore, for example, how key relations between people and technology generate value through the reconfiguration of specific relationships.

The ANT concepts presented in Table 1 supports IS researchers to describe how networks assemble or dissolve (Hanseth et al., 2004; Czarniawska and Hernes, 2005), for example, ANT can be employed to examine socialisation within augmented intelligence. ANT presents a suitable socio-technical theoretical lens for augmented intelligence for several core reasons. Firstly, the fundamental aim of ANT is to explore how socio-technical environments are built, unfold, and evolve to achieve a specific objective. In addition, Latour (2005) argues that ANT is first and foremost a call for the close empirical study of associations. Secondly, ANT offers a rich vocabulary (Table 1) to explore the infrastructure that supports the entanglement of social and technical environments. Thirdly, ANT provides a guideline to investigate augmented intelligence with particular attention on examining the socio-technical assessable of human and machine intelligence.

5 Applying ANT to Augmented Intelligence

As is often the case with new and emerging phenomena in IS, research on AI-related topics is beginning to gain momentum, as is evident from the increasing number of dedicated journal special issues, conferences, conference tracks, and workshops. This section summarises key research on augmented intelligence (a key part of narrow AI) which are categorised into four broad themes: (i) problematisation can examine the system purpose and describe the rationale for developing a cognitive system; (ii) interessement can establish the key values and priorities for the reasoning process; (iii) enrolment can describe the general functions of a system to execute the work to the required level of satisfaction and the physical functions to deliver on the functional requirements, and (iv) mobilisation can ensure all actors are represented by validating the source objects that will perform the work (Figure 2).

5.1 Problematisation of Augmented Intelligence

Intelligence, in the human context, is defined as a person’s ability to learn, to deal with new situations, to understand abstract concepts, and use knowledge to manipulate or advance one’s environment (Legg and Hutter, 2007; Sternberg, 2017). In more general terms, intelligence is defined as the ability to perceive and process data, transform data into information and ultimately knowledge, and use this knowledge towards goal-directed behaviour. Within an ANT context, problematisation examines the identities and interests of other actors that align with the initiator’s interests to solve a particular problem. It can better guide us to examine and describe a system’s purpose and describe the rationale for developing this specific cognitive system. Therefore, the effective adaptation of intelligence draws upon the selective combination of a number of processes, including perceiving one’s environment, problem solving, reasoning, learning, memory and acting to achieve goals. This creates new challenges with the advancements of technology and availability of big data, with growing socio-technical complexities of AI solutions which mimic human intelligence (Bassano et al. 2020). As a result, we are witnessing a continued blurring of boundaries between the physical, digital, and human factors (Newell and Simon, 1976; Syam and Sharma, 2018). ANT can therefore guide us in examining identities and interests of AI’s “computational agents that act intelligently” (Poole and Mackworth, 2010, p. 3). Yet, there is no agreed path towards artificially intelligent artifacts, but rather they take the form of software agents, robots, or other characterisations of IS (Dautenhahn, 2007; Rust and Huang 2014). As noted with the
AI definition from Poole and Mackworth (2010), the focus has shifted from AI being solely about machines that can display human-like intelligence.

Figure 2. Augmented Intelligence Moments of Translation

Understanding how identities and interests of other actors align with the initiator’s interests is important since more emphasis is placed upon performance. For example, we can explore AI system’s rationality (Russell and Norvig, 2016), i.e., doing the “right thing”, given what it knows in an attempt to achieve the best possible outcome and achieve an obligatory passage point. This does not divorce the relationships between humans and machines but rather reinforces the need to compensate for some human flaws such as irrational behaviours (Kahnemann and Tversky, 1979), often due to limited information, cognitive abilities, emotions or intuition. In addition, Poole and Mackworth’s (2010) definition of AI also points to the importance of “computational agents” and how agents perceive and act within a specific environment (Russell and Norvig, 2016). As humans, we heavily rely on our senses (sights, sound, and touch) to make sense of the world and establish norms based on experiences. Within an IS context, computer agents use sensors to perceive inputs and generate outputs to solve problems by searching, querying and presenting data. Advancements in AI has become an enabling technology which leads to disruptive changes in many fields (Minsky, 1961; Stone et al., 2016) to enhance the cooperation in both humans and machines – as if a part of the human evolutionary process. However, little research focused on the intersection of technology and human components in augmented intelligence and the identities and interests of other actors which ANT can achieve.

5.2 Interessement of Augmented Intelligence

The history of “general AI” research can be represented as a series of explosions or waves of invention expectations and inflated expectations for emerging technology innovations. General AI is viewed as a broad area of computer science that makes machines seem like they have human intelligence, yet the majority of AI innovation may be categorised as “narrow AI”, i.e., systems programmed to perform a single task to improve human decision-making and performance (as opposed to be conscious, sentient, or driven by emotion). Within an ANT context, interessement can establish the key values and priorities for the reasoning process. Interessement focuses on the intricacies around specific efforts to secure actors’ interest in a proposed change.
and negotiating the terms of their involvement. This requires us to focus on the immutable mobiles which represent the strong properties or interactions within a network that later supports to establish its irreversibility, for example by establishing and executing suitable training sets. Augmented intelligence technologies help shape and reshape new roles of humans and technology. For example, we have become accustomed to everyday examples of narrow AI include Google Assistant, Google Translate, Siri and other natural language processing tools which can also present a number of recommendations based on requests for information. Yet, across the IS community, there are calls for more research clarity and depth on AI, rather than simply relabelling IS as AI or confusing analytics with AI (Ågerfalk, 2020). Augmented intelligence seeks practical applications which are likely to become implemented, embedded, and integrated in conditions marked by complexity and emergence within a contemporary business context yet we need to apply ANT to understand how to secure actors’ interest in a proposed change in augmented intelligence solutions.

5.3 Enrolment of Augmented Intelligence

Augmented intelligence is an example of narrow AI which can offer practical solutions to business. Augmented intelligence supports primitive cognitive sensory processes. Within a psychology context, cognitive sensory processes refer to knowing, attending, learning, remembering and reasoning to support human’s cognitive ability such as memory capacity, attention and judging. Engelbart (1995) also refers to augmenting humans’ intellect by organising their intellectual capabilities into higher levels of synergistic structuring. This suggests that within a broader intellect system, we need to learn why actors accept the interests defined by the focal actor and set out to achieve them through other allies that align with the actor network. Specifically, within an ANT context, enrolment can describe the general functions of a system to execute the work to the required level of satisfaction and the physical functions to deliver on the functional requirements. Uncovering the socio-technical actors within such systems is important since in more recent years there have been research efforts to explore ontological reasoning using semantic objects as the atomic level of knowledge representation of real-world concepts and phenomena (Fong et al. 2019). These efforts may be traced back viewpoints given by Ashby (1956), Licklider (1960) and Engelbart (1995) who emphasise humans’ essential role in problem solving. Therefore, developing a balanced view of human and machine is important since IS can deliver improved consistency and efficiencies. On the other hand, humans are flexible and capable of applying nonlinear approaches to identify questions, iteratively hypothesise, discover new patterns, and pose a trait of creativity, which are very difficult for computers to replicate. For example, Licklider (1960) states that humans are superior in setting goals, formulating hypotheses, determining criteria, performing evaluation, and handling uncertainties. However, humans’ capabilities are limited in coping with issues at scale, computation and volume. Hence in terms of efficiency, humans need computers to aid with the formulated and real-time thinking. Licklider (1960) suggests that computers do all the routine work to prepare humans for the insights to make a decision. Within a business context, augmented intelligence can play a key role in repetitive tasks that have to be completed in limited time and often containing some form of uncertainty (Dobrkovic et al. 2016), for example digital transformation to support task automation such as accounting (Marshall and Lambert, 2018). Augmented intelligence is described as a promising approach although there are no turn-key solutions for developing and implementing such systems, for example, Internet of Things (Pavlou, 2018), wearable devices (Krenzer et al., 2019) or via a semantic workspace (Fong and Hong, 2018) and we therefore to better understand how to enrol human and non-human actors.

5.4 Mobilisation of Augmented Intelligence

Mobilisation can ensure all actors are represented by validating the source objects that will perform the work. Therefore, mobilisation within augmented intelligence can represent a wide network of socio-technical actors. To ensure actors represent key interests as a representative of all actants in the network, it is important to develop models and identify patterns which represent actors’ interests and compliance within specific sectors. For example, research indicates that augmented intelligence is required to enable industry players and regulators to provide seamless regulation and stability, for example, in banking and financial technology (Lui
and Lamb, 2018). Other methods to align with actors’ interests include text mining and machine learning to facilitate augmented intelligence, for example IBM Watson. Kelly (2015) also describes how large-scale machine learning is the process by which cognitive systems improve with training and use which can combine five core capabilities: (i) creating deeper human engagement; (ii) scale and elevate expertise; (iii) infuse products and services with cognition; (iv) enable cognitive processes and operations, and (v) enhance exploration and discovery. As part of these mobilisation efforts, Zheng et al. (2017) explain that it is necessary to introduce human cognitive capabilities or human-like cognitive models into AI systems. This indicates that mobilisation can play a key role in developing hybrid-augmented intelligence, i.e. a combination of human-computer collaboration and the other is cognitive computing embedded in the machine learning system. Yet, less is understood regarding the IS context and how augmented intelligence can become implemented, embedded, and integrated in conditions marked by complexity and emergence within a contemporary business context. The majority of published research on augmented intelligence stems from disciplines such as computer science, law, and psychology. However, the IS community is well positioned to unravel the complexities since there is a solid understanding of both digital technology and social practice, and especially of the phenomena that emerge when the two interact (Lee, 2001). In addition, Davenport and Ronanki (2018) also describe the need to understand how AI technologies influences functions such project management approach which may be deemed more suitable for augmenting human capabilities. Uncovering the emergent relationship between human and machine, i.e. the socio-technical dynamics, encourages the IS community to examine how technological and human factors which mediate reasoning and symbolic action (Aakhus et al., 2014; Ågerfalk, 2020; Te’eni, 2001). Therefore, drawing more balance on how the socio-technical factors assemble knowledge for augmented intelligence is important.

6 Discussion

This article describes how ANT (specifically, the ‘Moments of Translation’) is suitable to theorise about augmented intelligence within organisational or societal contexts. The research presents four themes which describe how:

1. **Problematisation** can examine the system’s purpose and describe the rationale for developing a specific cognitive system which is framed as augmented intelligence.
2. **Interessement** can establish the key values and priorities for the reasoning process of augmented intelligence.
3. **Enrolment** can describe the general functions of a system to execute the work to the required level of satisfaction and the physical functions to deliver on the functional requirements for augmented intelligence.
4. **Mobilisation** can ensure all actors are represented by validating the source objects that will perform the work as instructed by augmented intelligence actors.

Despite the claim that AI can revolutionise the way organisations do business, to date organisations still face a number of obstacles in leveraging such technologies and realising performance gains (Mikalef et al. 2019). Specifically, augmented intelligence presents a complex interaction between AI technologies and human networks that more than amplify human capacities as it transforms cognitive capabilities. Therefore, augmented intelligence modifies the structure of cognitive processes and providing new tools to optimise interpretative schemas, useful to analyse the real world (Barile et al. 2018) – often suggesting there is a growing paradox between automation and augmentation. For example, Raisch and Krakowski (2020) describe the automation-augmentation paradox and that both perspectives are equally biased. They explain that augmentation cannot be neatly separated from automation in the management domain and that these dual AI applications are interdependent across time and space, which creates a paradoxical tension (Raisch and Krakowski, 2020). Failing to find a balance between augmentation or automation can fuel reinforcing cycles that negatively impacts on an organisation’s performance and has wider societal implications. Considering that the majority of AI-related research is conducted in scientific domains, human, organisational, and the wider
societal and behavioural implications are often not considered (Rahwan et al., 2020). Much of the theoretical development efforts on AI and augmented intelligence are outside of the IS domain. This article argues that the IS discipline is best positioned to theorise on the socio-technical complexities of augmented intelligence and how ANT is well-positioned to uncover these.

AI requires that organisations develop a plan that enables them to leverage the full potential of such technologies, yet there is still no theoretical framework to define the important dimensions and aspects that are critical to realise business value (Gregory et al. 2020; Mikalef et al. 2019). By focusing on an actor-network of augmented intelligence, it allows us to understand how actants (i.e. human and non-human actors) act and adopt activities to embed new social patterns of change which become generally accepted within a specific context or across the wider society. For example, recent developments in hardware, sensor, and networking technologies combined with significant growth in Internet of Things devices has increased interest in combining them with AI technologies to develop completely autonomous systems, such as driverless cars (Jain et al. 2018). Within the IS literature, there are examples of cases which focus on implementation, embedding, and integration of AI which can support theorising about augmented intelligence. For example, heuristic theorising has been considered to be a useful alternative to establish theorising approaches, such as reasoning-based approaches particularly around problem solving (Gregory and Muntermann, 2014). In addition, Bawack et al. (2019) presents and propose an AI adoption, use and impact classification framework for IS research and suggests that organisations need AI technologies to perform the tasks and solve the types of complex problems they face. However, many organisations lack a thorough understanding of AI as each of them develops, implements and markets AI according to their understanding and perception of it which ultimately becomes a barrier to sustain value creation (Bawack et al. 2019). Yet, such research developments also pose questions on ethical, societal, organisational, and technical issues (Dwivedi et al. 2019). In addition, there is still a lack of coherent discussion and an integrated body of literature on the direct implications of how augmented intelligence research can contribute to organisational and societal applications and to its impact on the socio-technical factors of transforming work, decision-making, and the future of work (Bawack et al. 2019; Brynjolfsson and McAfee, 2014). ANT presents us with a theoretical lens to describe the socio-technical complexities of augmented intelligence. However, one limitation to this research is that it provides a theoretical perspective which needs to be tested through a number of augmented intelligence case studies. To address this, the article outlines some useful avenues for future research.

6.1 Future Research

Organisations are continuously seeking innovation opportunities to align people, processes, and technology to achieve their organisations’ long-term transformation success (Kiron et al. 2016). Augmented intelligence presents significant promise for organisational transformation strategies. However, an implication for IS research is that there are insufficient theoretical contributions to investigate augmented intelligence and an apparent need for additional research efforts to focus on its socio-technical complexities. To expand on this rationale, four key research areas for augmented intelligence research guided by the ‘Moments of Translation’ from ANT will form part of a future research agenda:

1. **Problematisation of augmented intelligence**. Future research should support how we describe the purpose of augmented intelligence and categorise socio-technical processes which influences human decision-making, for example, understanding, interpretation, reasoning, learning, and assurance. From an IS perspective, further research is required to examine specific dimensions associated with sensemaking of augmented intelligence and begin to identify intelligence associated with the emergence of actors’ interests. These research efforts should complement and build on previous interdisciplinary research efforts with a view to identify the multifaceted layers associated with augmented intelligence. Specifically, additional research is required to describe how intelligence is enhanced as a result of new AI-related algorithms and stakeholder understanding on value co-creation as a result of a new set of practices.

2. **Interessement with augmented intelligence**. To understand the scope and complexity of augmented intelligence capabilities, interessement can be applied to multiple case studies to empirically validate how augmented intelligence initiatives are introduced and negotiated in terms of change. This will provide more
insight on how key values and priorities for the reasoning process are established and by what actants. Fundamentally, such research efforts will build a narrative on how augmented intelligence innovations are planned for, implemented, and sustained to co-create value and investigate new associations between social factors, cognitive processes, technological investments, and performance measures.

3. **Enrolment in augmented intelligence.** Future research on theorising about augmented intelligence will support the IS community to describe how augmented intelligence come into being, unfolds, and evolves to enhance human intelligence and decision-making capabilities. In addition, applying the core theoretical constructs of ANT to uncover factors of enrolling augment intelligence will further advance the IS community to deep dive into theoretical and empirical accounts of enhancing cognitive capabilities. Specifically, additional research must focus on the changes to the relational infrastructure of an organisation as a result of augmented intelligence and how this impact (positively and negatively) on growing expectations around new skillsets and altering the context and nature of work. Additional research efforts must also uncover how the rationale for augmented intelligence creates various new roles to implement initiatives around augmented intelligence.

4. **Mobilisation of augmented intelligence.** The promise of augmented intelligence is not simply to automate processes, but it does open up new routes to carry out business. To better understand the success and failures of augmented intelligence, additional research must investigate how organisations are exploiting augmented intelligence to alter, for example, the nature of work, cognitive processes, value creation, or decision-making processes. Such efforts should describe how practitioners attempt to ensure all actors are represented by validating the source objects to perform the work. Additional research must also uncover how intelligence is reconceptualised as a result of reconfigured processes and practices and how these developments influence novel socio-technical theoretical developments in the IS community.

7 Conclusion

The long-term goal of AI is to make machines demonstrate intelligence at a similar level to natural intelligence displayed by humans, for example, within a business or healthcare context. Yet, due to the complexity, uncertainty and vulnerability experienced in human life and problem-solving, it is unlikely that AI technology will completely replace humans. There is significant scope to adopt a hybrid approach to enhance human cognitive capabilities through AI systems – something referred to as augmented intelligence. However, little is understood about the socio-technical factors of augmented intelligence within an IS context. The contributions of this article are threefold. First, this article presents a review of the emergent literature on augmented intelligence. This research sets out to examine the socio-technical assemblage of augmented intelligence within an IS context. Second, this article argues that ANT and the ‘Moments of Translation’ model is suitable to theorise about augmented intelligence and how it can become adopted within a contemporary business context. The article presents a model for an *Augmented Intelligence Moments of Translation* serves as a guide for researchers in the IS community. Third, the article presents avenues for future research for the IS community on socio-technical factors with augmented intelligence and the opportunities which an ANT theoretical lens presents for researchers.

ANT is well-positioned to play a central theoretical role in identifying and guiding research exploration on augmented intelligence. In addition, ANT provides a unique theoretical lens to presents ‘the untold story’ and ideally provide a useful “resource that organisational actors themselves employ, going forward, in the design and construction of the socio-technical order” (Ramiller and Pentland, 2009; p. 489). This will enable researchers to highlight the undocumented intricacies of augmented intelligence and uncover the challenges that may be preventing the adoption of augmented intelligence in practice. Incremental technological improvements in AI, machine learning and natural language processing will in near future enable human-machine collaboration for diverse knowledge intensive work tasks (Poser and Bittner, 2020; Seeber et al. 2018; vom Brocke et al. 2018). Yet, given the IS community commitment to diversity and rally around a unified research paradigm (Robey, 1996; Hirschheim and Klein, 2012), there has been much hype about the disruption of AI. In an attempt to draw focus on these challenges and shortcomings throughout IS literature, this article describes the need to carry out research on the socio-technical factors augmented intelligence. From a research and practice perspective, this research outlines how ANT can be adopted to focus on the processes which
creates value and sustains developments in intelligence. Specifically, ANT is presented as a way to theorise about the augmented intelligence process and test guidelines for upholding and implementing augmented intelligence practices in designing and managing socio-technical factors of human-AI interactions.

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