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Digital First: The Ontological Reversal and New Challenges for IS Research

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Abstract

The classical view of an information system is that it represents and reflects physical reality. We suggest this classical view is increasingly obsolete: digital technologies are now creating and shaping physical reality. We call this phenomenon the ontological reversal. The ontological reversal is where the digital version is created first, and the physical version second (if needed). This ontological reversal challenges us to think about the role of humans and technology in society. It also challenges us to think about our role as IS scholars in this digital world and what it means for our research agendas.

Keywords: Digital, digital ecosystems, ontology, ontological reversal, human experience, human values

Introduction

As information systems (IS) academics, we have traditionally viewed the purpose of an information system as being to model and reflect reality. The information system is a reflection of reality and the information it contains is a purposeful representation of the real world (Dourish 2001; Ihde 1990). In this classical view of an information system, data models provide a formal means of representing information about the world (Wand et al. 1999; Wand and Weber 1995); database systems capture information about customers and their purchases (Ryals and Payne 2001); workflow systems reflect the routines in organizations (Lee et al. 2008); and decision support systems rely on the correct representation and validation of knowledge in a particular knowledge domain in order to help managers make decisions (Sprague 1980). By definition, information systems do not make the world – they simply provide information that might be useful to humans in shaping the world.

We believe that this classical view of an information system is increasingly obsolete. In this paper, we explain how an ontological reversal is underway. In this reversal, the real world becomes a purposeful product of the digital world. Reality becomes a reflection of our models in the digital world. This reversal has profound implications for the IS field.

This ontological reversal and its obsolescing of the classical view of IS has been an ongoing process. Like the landscape left behind by a receding glacier, the world around IS has been changing so gradually, yet so steadily, that it has been difficult to notice the dramatic transformation of our world. In Williams' terms (1977), the residual structure of the classical view of IS has tended to obscure the emergent structure of the digital world.

In 1974 Gordon Davis, one of the founders of the field of information systems, provided this definition of an information system:

> *[An] integrated, man-machine system for providing information to support the operations, management, and decision-making functions in an organization. The system utilizes computer hardware and software, manual procedures, management and decision models, and a database* (Davis 1974, p. 5).

Such an early classical view presented an information system as a support function that used various resources to mainly deliver information to managers and decision-makers. By 2000, Davis had elaborated this definition as follows:

> *The information system or management information system of an organization consists of the information technology infrastructure, application systems, and personnel that employ information technology to deliver information and communications services for transaction processing/operations and administration/management of an organization. The system utilizes computer and communications hardware and software, manual procedures, and internal and*

external repositories of data. The systems apply a combination of automation, human actions, and user-machine interaction (Davis 2000, p. 67).

In this later definition, Davis made some important adjustments. Among the adjustments: IS and MIS become synonyms; there is an underlying IT infrastructure delivering communications services, not just information services; and resources now include external data sources. Notably, not all of an information systems' resources are internal and the system delivers more services than just information.

Since Davis, however, the IS world has changed considerably. Major parts of the IT infrastructure have been recast as non-strategic, but still "must-have", utilities (Carr 2003; Tilson et al. 2010), other parts are now consigned to the cloud or software platforms (Jain et al. 2017), and still others are now comprised of everyday objects (Harris et al. 2012 69; Yoo 2010). These kinds of evolutions in our infrastructure have enabled other revolutions; revolutions in organizational supply chains, markets, and sales channels. These revolutions have brought once distant technologies into our infrastructure as key elements. Powerful digital platform ecosystems now shape everyday lives, algorithmically curating and delivering highly personalized and contextualized services (Parker et al. 2017). Artificial intelligence is augmenting and, sometimes, substituting human decision-making; robotics and 3D printing means that the outputs of an information system include *things* as well as information and communications.

Although the evolution of these digital infrastructures has occurred gradually, it has been inexorable. When computers were first introduced into organizations, the technology was separate from the business and work. Early data processing systems were only *connected* when users deliberately captured data and entered it into the system (Davis 1974). With the introduction of network technology and its convergence with computers, however, technology began to be *immersed* into people's work and life, particularly in the realm of communication and coordination (Malone and Rockart 1993). With the rise of mobile phones and social media, such convergence of computing and communications took the entire world by storm, creating unprecedented waves of social and economic changes (Oh et al. 2015). Today, with 5G mobile networks, sensors, 3D printing, and blockchain, we now see the digital and the physical worlds *fused*, where digital technology actively shapes the physical world. Digital technology now *creates* (or help to create) the physical environments in which we live.

Moreover, information and communications services are now in the hands of most people worldwide with a myriad of smart and connected devices such as smartphones, refrigerators, thermostats, light bulbs, speakers, and automobiles (Yoo 2010). Activities arising from this ubiquitous interconnection have spawned value co-creation, yielding vast ecosystems of digital services that harness user-created content and other forms of digital trace data (Henfridsson et al. 2018). Notably, information is not just flowing inside, or even just into, the organization. Interconnections mean information is created everywhere and is now flowing in all directions. Information services are often not just reporting about an organization's transactions and products; information services *are* an organization's transactions or products in many important ways.

As well as changes in the nature of information systems, the scope of IS scholarship has broadened. From a narrow focus on corporate IT use for task performance in the early days, IS research today includes broader societal issues as well as non-task related IT use, reflecting the increasingly pervasive role of information technology in society. Digital transformation is top of the agenda for many IS scholars, as it is for many organizations (Chanias et al. 2019).

Although the complex relationship between the intelligible and the real has been discussed extensively in the IS research literature, as it has in many other fields, we suggest that at the core of this digital transformation of our world is an ontological reversal. Previously, information systems were seen as only reflecting reality; they represented an existing or an expected reality. But increasingly digital technologies *shape* reality. In observing the ontological reversal between signs and reality, Jean

Baudrillard (1994) notes “a liquidation of all referential” as the key characteristic of our contemporary technological society. He notes, “Simulation is no longer that of a territory, a referential being or a substance. It is the generation by models of a real without origin or reality… It is no longer a question of imitation, nor of reduplication, nor even of parody. It is rather a question of substituting signs of the real for the real itself” (pp. 1-2).

With the ontological reversal, the non-physical digital version of the reality is not just as real as the physical version, it is more so. Just consider a business trip. On June 1, 2008 the airline industry moved to 100% electronic ticketing. From this time onwards, physical airplane tickets were no longer produced by airlines for travel. Passengers can print out a hardcopy if they want, but the real e-ticket is a reservation in the form of bits in an airline’s computer system. This means that a delayed flight arrival may trigger airline computers to automatically follow algorithms to reorganize onward connections. The reality of the trip is first recreated digitally; physical reality follows accordingly. Moreover, the airline’s policies and conventions regarding rebooking practices become digitally enacted. It is up to the digital algorithms to follow or ignore any social conventions (e.g., booting out a standby passenger or relegating a first-class passenger to a coach seat) or institutions (e.g., putting the boss in coach and her subordinate in business). The real ticket is thus digital; any physical ticket printed onto a piece of paper or on a smartphone screen is simply a temporary, possibly obsolete version of the non-material and digitally-created e-ticket. It is the digital version that is real; only the digital version in the airline’s reservation system gives a passenger the right to travel.

With this ontological reversal, there is also a temporal reversal in the way that products are manufactured. The digital version is created first, the physical representation second. In many industries such as the aerospace, construction and motor vehicle industries, products such as aircraft, buildings and cars are designed and created on the computer in the first instance (Leonardi 2012; Yoo et al. 2006). Before the product is manufactured, every detail is carefully planned and built using computer-aided design (CAD) software. Increasingly, robotics or 3-D printers produce the product itself. To reiterate: the digital version is produced first; the physical version second.

As an example of this temporal reversal, the America's Cup is regarded as the most prestigious sailing competition in the world. The America's Cup combines the world's best sailors with leading edge technology. The next America's Cup competition is to be held in Auckland, New Zealand, in 2021. The class rule specifying the design for new foiling monohulls was released in March 2018, despite the fact that foiling monohulls have never been used in sailing before (foiling enables the hull of a boat to "fly" above the water and hence travel at a much higher speed). In other words, the designers are so confident in their computer-aided design, that no on-water testing was deemed necessary to confirm that their design was viable. The challengers and defenders now have to spend millions of dollars building their boats while ensuring that they conform to a digital design that has never been tested physically.

The rise of the ontological reversal is an inevitable progression from the previous conditions under which information systems have been related to reality. For example, Borgmann (1999) postulated three such relationships: "information about reality", in which information described the nature of reality (e.g., reports and records); "information for reality", in which information prescribed the nature of reality (e.g., recipes, plans and constitutions); and "information as reality", in which information rivals reality (e.g., virtual reality, recordings). We recognize a progression to a fourth relationship: "information makes reality", in which information exceeds virtuality and takes us instead to material and physical reality.[1]

[1] Borgmann (1999) recognizes this boundary to his concept of information-as-reality, "taking vividness and interactivity to their extremes does not lead us to the heart of virtual but rather back to actual reality" (p. 179). It is timely to pick up where he left off.

In a similar way, the ontological reversal is also a natural progression from El Sawy's (2003) three views of information technology from within information systems: the connection view, in which technology is a tool conceptually separable from work and people; the immersion view, in which technology is integrated into the business environment in which people work; and the fused view, in which technology cannot be conceptually separated from the business or from people's work life or from their personal life. El Sawy, et al. (2010) further develop these three views by formulating "Digital Ecodynamics" in which information technology is an essential third element that interacts with Dynamic Capabilities and Environmental Turbulence to keep a business organization in tune with its environment.

This ontological reversal of information, from reflecting reality to creating and shaping reality, has a dramatic impact on the scope of information systems. Since almost everything people do is now mediated by digital technologies (Yoo 2010), an information system captures innumerable kinds of information, and this information produces innumerable kinds of services and products. Given our digital world, defining the scope of IS as something "totally devoted to processing information" (Alter 2008, p. 451) excludes little in the human enterprise. Because information systems increasingly shape reality, we can no longer govern, educate, enrich, prevent starvation or make war without digital technologies.

There is a corresponding shift in the ethical framing of IS. When an information system reflected reality, simple utilitarian ethical reasoning sufficed. If an IS delivered utility to its client (its primary stakeholder), we could reason its social and cultural value. But when an information system is determining reality, there can be myriad stakeholders. A prominent example is the way in which an IS can affect the privacy of people. Depending on how an IS retains or transfers information (either intentionally or unintentionally), it can nurture or ruin individual privacy. Consequently, the ethical framing of information systems is broadening to include more and more deontological reasoning.

Increasingly stronger laws and regulations, such as the European General Data Protection Regulation (GDPR 2016), are governing how information systems are developed and managed.

Given the scope and scale of this shift in the relationship between information and people, we believe there are profound implications for the context and research agenda of the field of information systems. Hence, the purpose of this paper is to open up a discussion about the ontological reversal and its implications for IS research. We suggest how we need to change and adapt our research agendas so that IS scholarship remains relevant in today's digital first world.

The outline of the paper is as follows. In Section 2 we outline our core argument by describing the ontological reversal in our digital world. In Section 3 we theorize human experience in our digital world based on this ontological reversal. In Section 4 we draw out the implications of these ideas, suggesting new challenges for information systems research. The final section is the conclusion.

The Ontological Reversal in a Digital First World

Ontology is the philosophical study of reality. It is concerned with the nature or essence of being or existence (Oxford English Dictionary 2019). The ontological reversal - of digital technologies creating and shaping physical reality, not just reflecting it - occurs in a *digital world*. In this digital world, our surroundings and everything that makes up our surroundings is shaped by digital technologies. Digital technologies are not just used for business activities, as they were in the past, but are now used for everyday activities (Yoo 2010). These technologies are used for both personal and professional purposes in both organizational and non-organizational contexts. Digital technologies have become a part and parcel of our personal and professional lives.

The phrase *digital world* captures the idea that our surroundings, our economy, and the way we live our lives is digital in important ways. This digital world is in effect a new *digital culture*, one where everyone simply takes for granted that almost everything we do is shaped by digital technologies. With mobile devices linked to ubiquitous information systems in the cloud, the Internet of Things (IoT), and digital sensors monitoring virtually all movements we make, there is no longer any hard and fast distinction between the digital and the physical world. The expression, “there must be an app for it” captures the essence of this new digital culture. With the digital world becoming integrated into the physical world, our world is increasingly *computed* (Alaimo and Kallinikos 2017). Every digital object that comes into being requires some form of computation. A digital photo on a computer screen, a musical piece played on an MP3 player, or a quiet vibration on a wearable device – all of these are the outcomes of computations. Our human experiences are shaped by this computational world and the digital objects it produces. But importantly, the digital world shapes our experiences by seamlessly and inseparably interweaving the digital with the physical.

Digital Objects

This digital world is filled with heterogeneous *digital objects* (Hui 2016; Yoo 2010). Digital objects are “objects that take shape on a screen or hide in the back end of a computer program, composed of data and metadata regulated by structures or schemas” (Hui 2016, p. 1). While some objects are purely digital (e.g. digital media such as photos and videos), the Internet of Things means that even mundane everyday objects (such as a microwave and a thermostat) have embedded computing capabilities (Yoo et al. 2010). These digital objects acquire new affordances that were not previously available, changing user experiences and traditional industry boundaries (Yoo et al. 2012). As they sense, interact with and record their surroundings, these digital objects actively shape their physical environments and our experiences in such environments (Dourish 2001; McCullough 2004). The ontological reversal is a direct consequence of the two essential properties of digital objects. The two essential properties of digital objects are their non-materiality and computed nature.

Non-materiality of Digital Objects. Fundamentally, digital objects are non-material bitstrings (Faulkner and Runde 2013). They exist in the form of sequences of bits (0 and 1), regardless of its contents. They are produced by software that executes a set of coded instructions on hardware, whether they are computers, smartphones or an embedded sensor in another device[2]. Due to its non-material nature, corporeal human agents can come into contact with non-material digital objects only through their physical "bearers" like CD-ROMs, flash drives, LCD screens, or pieces of paper (Faulkner and Runde 2013). Digital objects are created from inputs that come from a human user (physical action of typing on a keyboard) or another machine (a device that generates data stream). The input process itself is governed by lower level machine-readable instructions that transform the input into bitstrings. Once transformed into non-material bitstrings, they can be either stored in another material bearer (for future use) or can be loaded into the central processing unit to be manipulated by a set of instructions. Once processed, digital objects can be "printed" onto physical objects such as LCD screens, pieces of paper, speakers, 3D printers, or physical actuators to move other objects. Such action also requires a set of low-level machine-readable instructions to be executed.

Computed Nature of Digital Objects. The second essential characteristic of digital objects is that they are always computed. All digital objects—no matter how simple they might be—require the execution of a set of instructions to come into being. By necessity, they are always computed. The computed nature of digital objects has two important implications.

First, this means that they are reprogrammable. Digital objects are produced by software that performs instructions. Software can create, replace, or erase digital objects. It does not matter whether the underlying computer architecture is a reduction machine, dataflow machine, neural network, or a von

[2] Under the Von-Neumann computing architecture, the software application itself must be stored in the form of bitstrings. Therefore, the production of digital objects cannot be done without digital objects, which we refer to as the "self-referentiality"of digital objects (Yoo 2010).

Neumann machine. Ultimately declarative, dynamic learning, or imperative instructions produce and manipulate digital objects.

Second, digital objects result from pre-formatted, automated, and contingent, “live actions” performed by software (Kitchin and Dodge 2011, p.27). As such, digital actions and digital objects can be indistinguishable. For example, an account balance is often computed when needed rather than stored in a record. Because it is the outcome of carrying out a set of instructions, it is created as a digital object to display to humans, but then erased. Ontologically, the account balance is a temporary assemblage of material and non-material objects brought about by an algorithm at the moment of run-time. It is not real in the naïve realist sense, yet at the same time, it is real as an emergent being (Delanda 2006) and can have real consequences. Similarly, each time a user displays the same photo on her smartphone, she is looking at the result of a new execution of the same set of the instructions. Each time a user runs a query on Google, the answer is the result of a complex web of instructions that are executed by a network of routers, servers and databases that are distributed around the globe. All human interactions with digital objects are the result of a temporary assemblage of material and non-material objects brought together by a set of algorithms that executes live actions of pre-specified instructions[3].

Ontological Reversal

With digitization, digital objects are not simply a representation of the physical activities by firms and users; rather, digital objects are created first and these objects prompt physical activities and production of physical objects (Baudrillard 2006). With the ontological reversal, physical objects are the outcome of “printing” digital objects onto physical bearers.

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[3] In the case of artificial intelligence, the pre-specified nature of the live action will be diminished, as the computers are likely to execute actions that were not pre-mediated by the human designer.

Let’s consider a car with the Google Maps navigation service. As we drive, the location information of the car is extracted and digitized through a GPS sensor. This digital object (the digitized location information along with other information about the car) is then transmitted to Google. The digital object of the car’s location is manipulated by Google and beamed back to the car as a blue dot on the bitmap image of Google Maps. Each time the physical car moves, the blue dot follows. The blue dot would not come into existence without the real car in the world. The relationship between the physical vehicle and the blue dot is that of a digital object that represents the vehicle.

Now let’s consider an autonomous vehicle. The idea of an autonomous vehicle begins by creating a blue dot and associating it with a real object (a physical car). The goal of the AI is to “drive” the blue dot from point A to point B on the map. As long as the movement of the blue dot in the non-material Google Cloud triggers the movement of the “real” car in the physical world, the autonomous vehicle works. Here, the non-material digital object—namely the blue dot—comes before the material “real” object—namely the car. The digital reality takes precedence over the physical reality. The ontology is reversed.

Of course, there are many complexities: the system needs to analyze surrounding traffic conditions and make sure the physical vehicle in the real world correctly follows the blue dot with a minimum latency in communication and feedback, etc. But since the blue dot came into being first, the physical vehicle can be brought in only as a temporary bearer of the blue dot as a non-material digital object. If necessary, one can always change the binding between a blue dot and a physical vehicle as a bearer with another physical vehicle. In other words, the blue dot is “printed” onto a physical vehicle.

Human Experience in a Digital First World

Given the significant changes that have occurred and are occurring in the relationship between digital and physical reality, how can we theorize human experience in a digital first world? As digital technology mediates virtually all aspects of human activities, and digital is increasingly shaping physical reality, our human experiences become *computed*. People now live in a world in which digital tools and their effects become taken for granted. Figure 1 below shows a proposed descriptive framework of human experience in a digital first world.

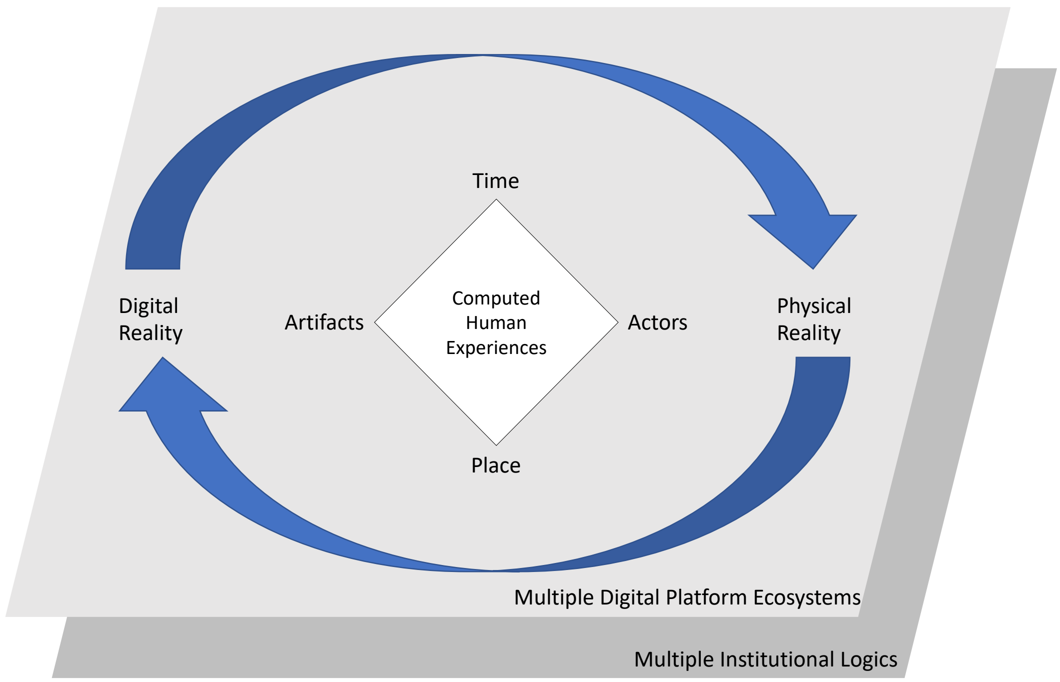

Figure 1. Computed Human Experiences in a Digital First World

Computed Human Experiences in a Digital First World

Computed human experiences are at the center of Figure 1. Computed human experiences in a digital first world rest on "the possibility of complete or partial mediation of the four dimensions of lived human experiences by digital technology" – time, place, artifacts, and actors (Yoo 2010, p. 219). Surrounding our computed human experiences are physical and digital reality. With the increasing penetration of digital technology into all dimensions of our lives, our experiences in a world of digital first are shaping and shaped by both physical and digital realities. A digital world that surrounds us consists of the enmeshing of material atoms and immaterial bits, some directly interacting with users, while others are invisible to them. For information systems, this notion implies dual realities, one embodied by the physical world in which we live, and the other embodied by digital codes and signals in networks and computer processing devices. Human experience is shaped in the intertwined duality of both realities. Historically, the principle aspect of this duality was the reality of the physical world. The codes and signals that make up the reality in the digital world represented or reflected the physical world. But the relationship between these realities is changing. The reality of the digital world is becoming the principle aspect because it defines and creates the physical world. What's more, there are elements of growing importance present in the reality of the digital world that cannot exist in the physical world. The changing relationship between digital and physical realities that surround and shape human experience involves emerging digital platforms on one hand, and multiple institutional forces on the other hand; and, these two macro-level forces shape each other.

We can illustrate the notion of computed human experience with the use of Google Maps. It begins with digital objects, Google Maps "printed" onto our physical device, a smartphone that is always connected to Google's cloud infrastructure. As we drive through a street, our smartphone interacts with many digital assets embedded in the physical environments such as cell phone towers, satellites and so forth so that, using GPS technology and the telecommunications network, it can correctly determine our location. Based on where we are, Google's cloud can combine vast amounts of data - the user's location, the user's calendar events, current traffic and weather conditions, the user's past driving patterns, etc - to inform when the user when they should leave for the next appointment and which route to take. Every instruction from the Google Maps app on the device – including the contents and the voice itself – is computed. The net result is that our driving experience with the Google Maps service is computed. What we see and where we go depends upon where Google Maps takes us. With emerging technologies like augmented reality through a heads-up display which can be "printed" onto a windshield, we see the world through computed reality. After using Google Maps for a while, we simply take the app for granted and maps on paper become redundant. The human driver thus becomes integrated into digital assets, algorithms and analytic capabilities that are outside of his or her control (Orlikowski and Scott 2014). With the emergence of autonomous vehicles, as we noted above, the vehicle itself, as well as the driving experience of the vehicle, is computed first and then "printed" second.

As another example, when we use a wearable device like an Apple Watch or Fitbit, the haptic experience by which we interact with the device is computed and algorithmic. As we experience the world, these algorithms provide a translation. Likewise, when we read news feeds from Facebook or the *New York Times* website, all the contents and our reading experiences are the outcomes of a vast amount of computation through a large and complex web of servers and digital contents. The algorithms of these digital services condition, translate, and edit what we see. Every time we look at the Facebook feed on our mobile phone, the digital content is computed.

People now take such computed experiences for granted. Whether we dine (Blue Apron), listen to music (Spotify), take a walk (Map My Walk), or read a book (Amazon), people readily use the services curated by algorithms owned by digital platforms. Our choices of restaurants, hotels, doctors and which university to attend are driven by the computed score of rankings and reputations. Behind all of these are the vast arrays of complex computer algorithms that process big data. The capability to manipulate these algorithms implies a capability to manipulate the world that we see (Mackenzie 2006). At the same time, we feed data into the digital world. The recommendations of services like Netflix, Yelp, Amazon, LinkedIn and Spotify are based on what people who are similar to us do or do not do. Our "likes" and comments are fed into the algorithm and used to compute the next notification to us or notifications to other users (Orlikowski and Scott 2014).

Digital Platform Ecosystems and Computed Human Experiences

As shown in Figure 1, multiple digital platform ecosystems enable our computed human experiences. In a world of digital first, digital platform ecosystems that are enabled by large-scale cloud-based infrastructures supported by big data analytics and artificial intelligence are competing to offer services to users. They deliver services to users by delivering digital objects that are combined with physical resources, some of which are owned by the platform owner while others are by complementors (Van Alstyne et al. 2016). Some platform ecosystems - such as Facebook, YouTube or Spotify - are driven primarily by digital objects which remain in non-material digital forms until they are used by users through users' own devices. Other platform ecosystems - such as Uber, AirBnB, and additive manufacturing platforms like 3D Hubs or Shapeways - orchestrate the mobilization of physical resources to "print" digital objects onto the physical reality to render service to users. In both cases, however, digital objects are created first, then "printed" onto the physical reality by mobilizing physical resources. In so doing, these platform ecosystems compete for users' attention and users' activities feed into their algorithms. These platforms then ask these users to subscribe to their services so that they can envelop more users with their version of reality (Van Alstyne et al. 2016). Traditional firms which produce and deliver physical goods, although not born digital, can become a part of a larger digital platform ecosystem.

Some digital objects are created on their own by human designers as in the case of 3D digital models of new buildings or products (Bailey et al. 2011; Leonardi 2012; Yoo et al. 2006). However, most digital objects are created by analyzing and recombining existing digital objects produced from physical reality. With wearable, mobile, and smart devices that are always on and connected, human actions in physical reality are monitored, recorded, and encoded into digital objects. The vast array of these digital devices are connected to a cloud-based digital infrastructure, forming ubiquitous and embedded computing capabilities in the physical world (Dourish 2001; Lyytinen and Yoo 2002; McCullough 2004). The digital objects captured from physical reality are analyzed and recombined in order to generate new digital objects, which in turn are used to shape physical reality. Therefore, even with the ontological reversal, we do not imply the disappearance of traditional information processing that produces digital representations of physical reality. As we show in the bottom arrow of Figure 1, physical reality is still captured by and represented in digital reality.

However, with the ontological reversal, not only do we have the traditional relationship from physical reality to digital reality, we also have a new relationship from digital reality to physical reality (represented in the upper arrow in Figure 1). The relationship from digital reality to physical reality is not merely an output of traditional information processing where an output of computation is used to assist human decision making or communication. Instead, this relationship represents the reversal of the principle aspect of the relationship, an ontological and temporal reversal of the relationship between physical and digital realities. As digitalization continues, we expect the trend of ontological reversal will become even stronger, as more powerful algorithms continue to process ever-growing data that are coming from all aspects of our lived experiences.

In fact, the unprecedented amount of digital data, combined with increasingly powerful artificial intelligence, allows algorithms to create new digital objects that do not have their counterparts in the physical world. Digital objects can be produced from the recombination of existing digital objects; and they might not be mere reproductions of existing physical or digital objects. Just as the thought processes and memory of any two people will be different, the data and algorithms of any digital reality will be different from the details and behaviors in any physical reality. It follows that digitally created objects (and events) might fit perfectly in the digital version of reality, but imperfectly in the physical version of reality. The results from privileging digital reality can be a surprising improvement or a surprising deterioration. For example, DeepMind's AlphaGo (Silver et al. 2016) beat the world's best human champion by studying human play, but used a move that no human has ever made[4]. As another example, Google's Duplex performed surprising actions in unexpected situations that were not

[4] https://www.huffingtonpost.com/entry/move-37-or-how-ai-can-change-the-world_us_58399703e4b0a79f7433b675

anticipated by its developers[5]. In some cases, artificial intelligence can create its own big data and learn from them without any input or data from human users in the physical world. For example, DeepMind's AlphaGo Zero, the successor to their previous version of AlphaGo, learned the game of Go by playing by itself - without ever looking at human play. This later version exceeded the capability of the previous one (Silver 2017). In other cases, however, privileging digital reality can be disastrous. For example, the digital reality of certain models of the Boeing 737 MAX sometimes detected a stall condition when the physical reality was that the plane that was climbing normally. In the digital reality, it was critical to push the plane's nose down. In the physical reality, it was critical to pull the nose up. The data and the behavior in the two realities were different. But in this case, the software determined that digital reality should take precedence. The airplane refused to obey the pilots, leading to two fatal airline crashes.[6]

Although firms with their own digital platform ecosystem try to envelop human experiences with the version of reality they construct, individual users tend to constantly move in and out of different ecosystems. As they go on their lives, people tend to shift through multiple platform ecosystems which offer sometimes competing and at other times complementary services. Having human experiences computed requires a person to constantly navigate between these platforms and the intertwined duality of physical and digital reality.

Multiple Institutional Logics and Computed Human Experiences in a World of Digital First

As shown in Figure 1, computed human experiences curated by digital platform ecosystems are shaped by multiple institutional logics. Various institutional contexts and social practices shape our experience. The precise manner by which our experiences are shaped by time, place, artifacts and other social actors is subject to professional and less formal social roles, contractual and casual relationships, strict legal

[5] https://ai.googleblog.com/2018/05/duplex-ai-system-for-natural-conversation.html
[6] https://www.wsj.com/articles/testing-the-fix-for-the-troubled-737-max-11559772634

and business rules, and less strict, yet nevertheless important, informal norms in which we are embedded. All human actions articulated in social practices take place at the junction where macro-level institutional and organizational arrangements and micro-level social fabric local practices meet. In this paper, we use the theoretical device of institutional logics to span multiple levels of analysis, connecting individual users actions and their experiences in the context of institutions and social practices (Berente and Yoo 2012; Friedland and Alford 1991). Institutional logics are "the symbolically grounded organizing principles or "rationalities" that underpin individual practices in a manner consistent with a given institution (Friedland and Alford 1991). More specifically, we argue that how individuals orient themselves toward particular actors and artifacts in a particular time at a particular place is determined by the particular institutional logics that they enact at a particular moment (Berente and Yoo 2012; Lamb and Kling 2003). As our social lives are shaped by multiple, often conflicting, institutional logics, we constantly and skillfully negotiate with our surroundings, shifting through multiple roles, expectations, and rules, trying to make sense of who we are and what we do by enacting different institutional logics (Giddens 1984; Weick 1995). In this sense, a complex overlapping array of various institutional forces are mediated through institutional logics that we enact (Thornton 2002). It is in this context of multiple institutional logics that users take their actions, influenced by digital platforms, or delegate their actions altogether to the platforms.

As digital technology has become increasingly pervasive and ubiquitous over the last half century, institutional logics themselves have started to become represented in the form of technology. Information technology represents institutional logics that enable and constrain human actions in all social settings (Orlikowski 1992). Furthermore, information technology over time has automated and infomated human actions in different institutional contexts (Kallinikos 2011; Zuboff 1988). In recent years, the scope and the extent of information technology substituting or augmenting human actions has vastly expanded.

However, with the ontological reversal in a digital world, we see a more fundamental change at work. That is, institutional logics themselves are becoming computational and algorithmic. Mackenzie (2006) provides an extensive discussion on how the stock market has become a complex web of algorithms that automatically execute trading orders. Markus (2017) discusses how the institutional practices of mortgage underwriting have become completely automated by artificial intelligence over the last 10 years. With the increasing power of distributed computing such as blockchain technology, some technology visionaries argue that personal identity in the future will be *computed* using the vast amount of data about the person[7].

The extent to which institutional forces are enmeshed with the ontological reversal can be illustrated if we consider an international traveler checking in at the airport. At check-in, airline staff are required by many governments to check the computer reservation system to ensure that the traveler has a valid visa. Without that online approval, the traveler in not allowed to board the plane. Governments might also require various taxes to be paid before check-in. All these various charges and approvals on behalf of the airline, the airport company and governments are checked electronically by the airline reservation system. There are many other examples. The enactment of the General Data Protection Regulation by the European Union has meant that many organizations around the world have had to update their privacy policies and systems (GDPR 2016). Uber has had to adopt its business practice and operation model according to local regulations in different cities (Cramer 2016).

However, not only formal legal regulations influence how digital platforms operate, but users' general perception on what is appropriate and what are acceptable for different social settings also influence the way users use different platforms. In many cases, these institutional and social influences will result

[7] https://techcrunch.com/2017/09/10/the-promise-of-managing-identity-on-the-blockchain/.

in concrete material implementations in the way digital objects are created, stored, shared, and used (Kallinikos 2011; Lessig 2006).

In summary, digital technology is now directly shaping our world and our physical and existential experiences in it (Dourish 2001; McCullough 2004; Yoo 2010). Our digital world is one in which these digital tools and their effects become taken for granted. Computed human experience today is one where the digital and the physical are seamlessly and inseparably interwoven. The deeply and inseparably fused nature of the digital world can make it overwhelmingly complex to carry out IS research. We suggest that our framework of computed human experiences in a world of digital first as shown in Figure 1 can be used to identify key constructs and research questions.

New Challenges for IS research

Given the ontological reversal in our digital world, we suggest a set of emerging research themes that IS researchers could study (see Table 1). These research themes build on a rich legacy of previous IS research but require a different focus.

Table 1. Legacy and emerging research themes in IS

Legacy research themes in the IS scope	**Emerging research themes in the IS scope**
Information/Users	Computed human experiences
Information systems as a representation of the world	Digital technologies shaping our world

Information Systems at the individual/organization/firm level	Digital platforms and digital platform ecosystems
Adapting information systems to society	Adapting society to information systems
Efficiency and effectiveness	Human values

Computed human experiences

With the ontological reversal in our digital world, the focus shifts from users who consume information to the co-creation of computed human experiences. For digital natives especially, the use of technology is not a passive experience, as it was for digital immigrants, but an active experience by which they live their lives as social actors (Emanuel 2013; Lamb and Kling 2003). People are now active creators of digital content, digital conversations and digital objects. Paradoxically, however, if the digital content they create is seen as valuable by the system and others, then the users of systems also become the *used by systems*. Often it is the algorithms within the system that decide what is valuable and what is not.

Hence IS researchers could study the co-creation of computed human experiences and how these experiences are curated by firms within multiple platforms. We could also study how these platforms continue to adapt both to people's changing preferences and norms and to multiple institutional logics (e.g. new regulations).

IS researchers should also explore how the sense of individual and collective identities are *computed* and *experienced*. As users leave the digital trace of their activities on multiple platforms, the sense of who they are and where they belong can be profoundly shaped by what is computed by these platforms. Users' gender, ethnicity, and affiliations to various social groups are constantly computed, often beyond the control of individuals. What does this mean for our own sense of identity and agency?

What are the economic, social, and ethical implications of algorithms that compute our identity? These are some of important issues that IS scholars could explore.

Digital technologies shaping our world

There is a rich legacy of IS research that assumes information systems are a representation of the world. However, given the ontological reversal in our digital world, digital technologies are increasingly creating, shaping and controlling our world. Hence, we need to focus on the implications of this shaping of our world.

The fact that digital technologies are increasingly shaping our world suggests that IS scholars could study questions surrounding the nature of this shaping. For example, what is the impact of this digital shaping on firms and entire industries? How are digital technologies changing the nature of competition? How are people and organizations adapting to the increasing automation of work?

Previous IS research has drawn attention to the intended and unintended consequences of using information technology (Berthon et al. 2008). We need to continue studying these consequences for individuals, groups, organizations and society (Orlikowski and Iacono 2001). However, with digital first, the unintended consequences are likely to be much more serious than previously (e.g. affecting human safety, as we discuss in more detail below). We need to study the difficulties and challenges that individuals, organizations and society as a whole might face with the ontological reversal, and with digital innovation and transformation (Majchrzak et al. 2016).

How does the ontological reversal affect the way we think about value creation? The existing model of value creation whether they are following a goods-dominant logic (Porter and Millar 1985) or a service-dominant logic (Lusch and Nambisan 2015; Vargo and Lusch 2004) assumes the “physical first” mindset as a departure point. IS scholars must develop new frameworks of value co-creation based on the ontological reversal. The traditional theories of IT business value and competitive use of IT draw heavily on the theories of industrial economics theories that take physical objects and their attributes for granted such as asset specificity and transaction opportunism (Williamson 1985). How will the theories on the nature of firms, their boundaries, and behaviors change (Jacobides and Billinger 2006; Santos and Eisenhardt 2005) if some of these core assumptions about assets can be challenged due to ontological reversal? The theory of complementarities (Teece 1986) plays an important role in analyzing the competitive use of IT and increasingly in digital platform and ecosystem research (Jacobides et al. 2018; Teece 2018). Yet most existing theories on complementariness do not consider the unique properties of digital objects, let alone the implications of the ontological reversal. IS scholars could explore the implications of the ontological reversal on these issues.

Digital platform and digital platform ecosystems

The development, adoption and use of information systems at the individual, organizational and firm level is a longstanding topic in IS research. However, we suggest there needs to be increasing focus on digital platforms and the digital platform ecosystem (Parker et al. 2016; Tiwana 2014). Such a broad view regards a landscape of diverse, interconnected systems, platforms, and ecosystems. The need for such a scope is because individuals, organizations and firms no longer develop and implement their information systems in isolation. Rather, these systems are increasingly interconnected (Kallinikos et al. 2013). Such digital interconnected platforms attract heterogeneous complementors and users to form ecosystems (Eaton et al. 2015; Tiwana et al. 2010). These platforms and ecosystems operate within an institutional framework that enables or prevents various activities. Hence, instead of a focus on managers who decide what ICT to implement, the focus shifts to "complex systems, subsystems, networks, individuals, and actions within which ICT is embedded. Instead of terms from traditional organization theory such as structure, goals, task segmentation, hierarchies, and boundaries … (the focus shifts to) social theory, emergence, and complexity science. A focus on goals is replaced with an emphasis on managing tensions and adaptations… (and) reconceptualizing the organization as a complex and decentered network or system of actors has great potential utility for many traditional IS research domains" (Majchrzak et al. 2016, p. 273-274).

For example, Amadeus is a computer reservation system and global distribution systems connecting the entire travel ecosystem including airlines, hotels, car rental companies, and travel agencies. In 2016, Amadeus processed more than 595 million travel agency bookings and boarded over 1.3 billion passengers (MIT Technology Review Insights 2018). This digital ecosystem includes a multitude of individuals, firms and institutions such as national governments. In the latter case, a government might legislate a new or revised airport departure tax that needs to be accurately reflected in the price that Amadeus passes on to travel agents, travel apps and travelers.

Adapting society to information systems

The ontological reversal may also bring about a degree of reversal in the relationship between the social and the technical. In our digital world, we may need to complement this sociotechnical perspective with a technosocial perspective. A technosociety is one in which technological systems are indispensable mediators of reality. Human relations and actions are only feasible with this mediation (Echeverría and Tabarés 2017). Once thought to be an extreme conception, with digitalization and the ontological reversal the technosocial might be arriving. Such an idea may have been anathema in the early history of information systems, when such technological dominance was regarded as oppressive. But many people today are happily spending time online to create digitally-based social networks, communities, romances, and social movements.

The field of information systems thus needs to research the potential unfolding of a technosociety. Is this the grim arrival of a dreaded dystopia or the unfolding of a digitally-delivered utopia? We need to know how a society that is technically mediated changes the relations between people and technology. How does such mediation reshape social actions? What are the attractions that motivate people (or compel them) to choose one version of reality (a technologically mediated social world) over an alternative one?

Human values

Since most information systems scholars are based in business schools, it is perhaps to be expected that in the past we focused mostly on the efficiency and effectiveness of IT in an organizational context. However, the ontological reversal in a digital world raises many questions related to human values, ethics and safety. For example, if we value human freedom and autonomy, are there some decisions which should not be automated by AI and robots? Alternatively, can we better enable human freedom and autonomy using AI and robots? If our identity is computed, what happens if the datasets on which it is based and/or the algorithms are biased? Bias already taints the algorithms in many web-based applications (Baeza-yates 2018). If the algorithms reside behind a black box, with one proprietary algorithm feeding into another proprietary algorithm, it may make it impossible for someone to question a decision or a score. Alternatively, can algorithms better protect us against bias? AI can potentially improve productivity, decision-making and the customer experience, but AI can also be used to automate inequality in human society (Eubanks 2018).

Hence, we think that research needs to be conducted regarding the impact of the ontological reversal on people, organizations and society. For example, how can we make the decisions of digital systems transparent and explainable? Research also needs to be conducted into improving the transparency and accountability for algorithms that affect the wider public e.g. insurance algorithms assessing risk.

The emergence of a digital world can potentially improve human safety and has already done so in some industries (e.g. the airline industry). But it can also present many potential dangers. At the moment we can freely choose to disobey the suggestion from the Google Maps app to take a certain route. In future, however, when self-driving cars become mandatory, that free choice may disappear. The algorithm will determine which route we take and whether we can travel there at all. It is the designers of the system who will determine how the car operates and which rules it follows. When an autonomous vehicle has to choose between two inevitable fatal accidents, the designer must prescribe which pedestrian might get killed by the autonomous vehicle ahead of time (Bonnefon et al. 2016). When there is a choice between two routes that will take the same amount of time, will the vehicle choose the shortest (most efficient) route or the scenic (most pleasant) route? The values of the designers will be inscribed into the way the autonomous car operates.

Hence, we believe that IS scholars should be taking the lead in not only researching the effectiveness and efficiency of information systems, but also the relationship of information systems to human values. Given that the mission of AIS is to serve "society through the advancement of knowledge and the promotion of excellence in the practice and study of information systems…" this means that IS scholars have an obligation to inform society at large about these issues. Until now IS scholars have been relatively silent on these matters.

Conclusion

In this paper we have argued that information systems no longer just represent and reflect physical reality, but are now creating and shaping physical reality. This ontological reversal implies that, increasingly in our digital world, a digital version of reality is created first, and the physical version second (if needed). This ontological reversal has many implications for the role of humans and technology in society and for our role as IS scholars.

With digital first, we as IS scholars need to focus more holistically on the entire technosocial ecosystem. Just as users and their computed human experiences cannot be studied in isolation, neither can the information systems of individual firms. Computed human experiences are embedded with multiple platforms and multiple institutional logics, all of which are constantly evolving.

With digital first, we as IS scholars also need to engage with a broader group of stakeholders than the CIO and the IT department. New stakeholders such as marketing, design, entrepreneurship and innovation and the Chief Digital Officer become important to our success. And given the rise of a technosociety, do IS scholars have an obligation to become more active in informing public debate about the digital transformation of our world? We think so.

In conclusion, we suggest that the IS discipline needs to be broadly transformed into a field that studies the implications of the ontological reversal for individuals, organizations and society as a whole.

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