Current perspectives on the development of the philosophy of informatics (with a special regard to some Polish philosophers)

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Abstract
This article is an overview of the philosophy of informatics with a special regard to some Polish philosophers. It juxtaposes the informationistic worldview with the long-prevailing mechanical conceptualization of nature before introducing the metaphysical perspective of the information revolution in sciences. The article shows also how ontic pancomputationalism – regarded as an update to structural realism – could enrich the philosophical research in some classical topics. The paper concludes with a discussion of the philosophy of Jan Salamucha, a philosopher from the Cracow Circle (1903–1944) whose ideas could be inspiring for today's philosophy of informatics in Cracow.

Keywords
philosophy of informatics; pancomputationalism; methodology of informatics; informationistic worldview; mathematical computability of the world

1. Important questions

During the transition from the 20th to the 21st century, informatics indisputably played an important role in society. However, it presents somewhat of a mixed bag. On one hand, information technology solves many practical problems and makes our lives easier and more productive, but it also raises many controversies. Sometimes it is even perceived as a fresh threat to individuals and civilization. What is particularly interesting for us, though, is the role that informatics can play in philosophical reflection. In general terms, this problem has already been analyzed (Bolter, 1984; Goban-Klas, 1990; Stacewicz and Marciszewski, 2011; Polak, 2015). In this paper, we focus on the specific question of whether informatics can contribute to substantive changes in philosophy. In other words, we ask what role can informatics play in creating a new philosophy for the 21st century?

This article attempts to form a unified philosophical perspective on the field of informatics. It seems that many strands of research about the philosophy of informatics may be combined into a single, broader philosophical vision at a fundamental level. However, a unified picture of this science has yet to be created. For practical reasons, we will focus here on the aspects of the philosophy of informatics that are represented in the Polish philosophical tradition and especially represented in scientific milieu publishing in *Philosophical Problems in Science* (Zagadnienia Filozoficzne w Nauce). In this tradition, which was always open to foreign influences, one can find a wide variety of intriguing perspectives inspired by diverse views from other philosophical schools. In consequence we need also some confrontation of these ideas with mainstream of philosophy of informatics.

Informatics is understood in this paper in a broad sense, meaning that it is not limited to information technology and the digital processing of information but instead covers the general processing of information in all its diverse forms and aspects[1].

[1] The term "informatics" is used here in a broad sense that reflects the standard English usage as defined in (for example) http://www.ed.ac.uk/informatics/about/what-is-informatics or https://en.wikipedia.org/wiki/Informatics [accessed on 1.07.2017]. Traditionally the term "computer science" is used, but the scope of described reflection goes beyond the boundaries of classical paradigm, therefore change in the terminology is needed for showing much broader attempt (see paragraph "An update to mathematical structuralism – a concept of the computing Universe" below). We could use as well the term "computing" in a meaning given by Tedre and Dennig (2017) (N.B. in this publication it is a synonym for "informatics"). Nevertheless, a semantic field of the chosen term "informatics" is closer to Polish "informatyka" and is focused on the notion of information (crucial in mentioned paragraph).

2. Methodological uncertainty of modern informatics

The important role that informatics plays in a modern society, resulted from their practical successes. Without information technology in its various forms, it seems unlikely that modern societies could function as they do now. One could venture to state that information technologies, on both regional and global scales, create a new information "environment" for human activity. Paradoxically, the more critical thinkers in this field (e.g., Denning, 2005; Cerf, 2012) point out how the methodological foundations of informatics are unclear and very questionable[2], and they lack clarity as to what informatics actually is and what it should be.

Informatics has in practice ceased to be, at least in recent decades, confined to the science of principles and practices for constructing computing machines, developing algorithms and programs, and testing and deploying them. Today, elements of informatics are found in a variety of very remote methodological areas, such as formal and empirical sciences, engineering and humanities.

As informatics has been applied in so many diverse research areas, with no firm methodological basis for it being established, many have been tempted to question its future and its

[2] Comprehensive outline of views on methodology of informatics could be found in: (Tedre and Denning, 2017). Three different paradigms of informatics were analyzed by Eden (2007). See also (Tedre, 2011).

status as a science in its own right. This question, from a historical perspective, is of fundamental significance when we recall how several autonomous disciplines have been expected to bring on a new worldview only to recede into the backwaters of science over the course of history. A good example of this is the old science of microscopy. Robert Hook's famous *Micrographia* (Hook, 1665) was perceived as the beginning of a new chapter in the history of science, opening up a previously unknown world. The science of microscopy itself was to play a fundamental role in science. Today, microscopy is regarded as no more than a collection of useful techniques that can be applied in many scientific domains.

The status of informatics shows some similarities with the historical development of microscopy: Informatics takes on diverse roles among most scientific disciplines (as microscopy did in the past), ranging from basic sciences through to technical sciences and on to applied sciences like forestry and even modern humanities. Many scientists perform *de facto* tasks typical to informatics. However, there is a significant distinction between the history of microscopy and informatics, because informatics has already had fundamental and widespread effects throughout science. For example, compare a textbook from the early 20th century with its modern-day counterpart. One can easily see conceptual changes with, for example, frequent references to concepts such as information and algorithms. One can witnesses the application of computational methods and information technology in almost every area of modern research. This has led to substantial methodological changes, such as the use of simulation (Kleiber, 1999; Winsberg, 2010, 2014; Boyer-Kassem, 2014), computer-controlled experimental systems (Leciejewski, 2013), computer-aided discovery of scientific knowledge (e.g., Żytkow, 2000; Giza, 2002, 2006), data mining (e.g., Critchlow and van Dam, 2013; Bell, Hey and Szalay, 2009; Callebaut, 2012; Kelling et al., 2009; Trumbull, Bonney, Bascom and Cabral, 2000), the application of computational methods in humanities[3], and the use of information technologies in legal practice and research (e.g. Mamak, 2017). The methodological changes observed in informatics itself, such as empirical

[3] The literature for the application of computer technologies in humanities (i.e., Digital Humanities) is quite substantial, but it is worth mentioning at least the pioneers of these applications in philosophy, such as Roberto Busa, who was the first to use computer technology for linguistic and literary analysis and built the *Index Thomisticum*: (Busa, 2004; Janusz, 2012). To learn more about the sources and history of the creation and application of computational methodologies in humanities, see the work of Dalbello (2011). Digital Humanities have not just opened up new areas of research but also precipitated revolutionary changes in traditional research methods. One could mention here the highly significant initiative to develop the Polish Federation of Digital Libraries (a part of Europeana Collection), which radically changed the way research could be conducted using old publications and manuscripts by offering unprecedented access to dispersed, difficult-to-obtain, and unique sources. A short characterization of the methodological changes brought around by computer technologies to the philosophical workshop can be found in the textbook of Polak, Michalczyk and Stawarz (2012).To learn about new research areas created by the digital humanities, one may consult a number publications on the topic (e.g. Berry, 2011).

informatics, clearly indicate that the relationship between information and the natural sciences is becoming increasingly intimate. As well, our perception of what computation is changes significantly (Polak, 2016).

Some researchers, such as Gordana Dodig-Crnkovic and Rafaela Giovagnoli, emphasize the extraordinary breadth of the methodological changes brought about by informatics, postulating that a paradigm shift beyond the boundaries of the record previously set by Newton has already taken place in science (Dodig-Crnkovic and Giovagnoli, 2012, p. 18). Certainly, without informatics, our progress in understanding the complex phenomena in physics, chemistry, biology, environmental sciences, and climatology – as well as in social sciences like anthropology, psychology, medicine, technology, military sciences and economics (e.g. Urchs, 2016; Hooker, 2011b) – would have been hindered. These changes are so far-reaching that some researchers, such as Clifford Hooker, talk about a revolution in science precipitated by computer-aided research into complex phenomena (*complex system revolution*)[4].

[4] The complex systems revolution is currently exploding through science, transforming its concepts, principles, methods and conclusions. It is also transforming its disciplinary structure, both creating new, distinctive "complexity" disciplines, such as climate science, systems and synthetic biology and self-maintaining and social robotics. It is also transforming older disciplinary relations, such as developmental biology, psychology and sociology. This revolution creates a plethora of new problems and challenges for the foundations and philosophy of science (Hooker, 2011a, p. 902).

Let us briefly try to characterize the uniqueness of these changes. We can begin with how it is hard to deny that the range of changes precipitated by informatics is even greater than those that resulted from the introduction of mathematical and empirical methods in the description of nature. Indeed, the changes introduced by informatics relate to the whole system of human knowledge, not just to natural sciences. What is more, while attempts by positivists to introduce scientific methods into humanities have not been successful, the application of information technology in a variety of liberal arts research is a fact that is neither astonishing nor objectionable. Even the informatization of various aspects of human life meets with scarce resistance from anthropologists and philosophers[5]. Sometimes, simple metaphors are rejected, like treating the brain as a digital computer comparable to a von Neumann machine, but this computer – brain analogy merely indicates that some metaphors are unsuitable for certain specific problems and does not refute the general current of informatization. Despite many examples for methodological changes, it is not yet possible to talk about a uniform "information methodology" that is common to all areas of knowledge acquisition. Instead, we see applications of information technologies to solve specific problems. On the other hand,

[5] The term "informatization" is defined in the OED as "the adoption of information technology; computerization." It has been used in literature on the subject having been coined similarly to the term "mechanization" (e.g., Mul, 1999).

however, the informational nature of reality seems even more evident today than its mathematical nature (Polak, 2010).

Certainly, the greatest symptom of these changes is the unification of scientific concepts (and partially methodology) under the umbrella of informatics. It has happened despite the proponents of inductive generalizations in philosophy[6] and against the fears of scientometrics adherents, who see the rapid progress of informatics more like a road to the Tower of Babel than an opportunity to develop some common and generally accepted language (Price, 1961, 1963). The restructuring of the conceptual foundations of science has occurred gradually, paralleling the development of informatics and being accepted without any major shocks. This may be interpreted as confirmation of David Bolter's thesis about the Turing man, who thinks about himself and about the world in new computational categories (Bolter, 1984; see also Goban-Klas, 1990; Polak, 2015).

3. Informationistic philosophy – a new mechanical philosophy?

From a historical perspective, there are numerous analogies between the role played by mechanical philosophy and (philosoph-

[6] In Polish philosophy, in the 19th century already, Fr. Stefan Z. Pawlicki realized how philosophy influences other sciences through their assumptions and fundamental concepts, not just through inductive generalizations (Pawlicki, 1878).

ical) evolutionism in the development of science and the role played today by informationistic philosophy. Informationistic philosophy is understood here (using the analogy with mechanical philosophy) as a set of philosophical ideas inspired by informatics, constituting the essential elements of the modern worldview[7].

From a historical perspective, mechanical philosophy has, since the 17th century, largely served as a philosophical basis for the development of modern natural science. Using the terminology coined by Marciszewski, it can be said that mechanical philosophy fulfilled the basic role of establishing a "worldview" and "compass of conduct" for scientific research (Stacewicz and Marciszewski, 2011). In the 19th century, mechanical philosophy was complemented significantly by evolutionism. It is worth noting how the crisis of the mechanistic worldview began in the same field that originally inspired it, namely physics (Mul, 1999). The development of physics in the late 19th century and the early 20th century precipitated the rejection of mechanical philosophy as a scientific worldview. (It was especially apparent in the controversies surrounding Einstein's theory of relativity.)[8]

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7 Informationistic philosophy in this sense is very close to the concept of the informational worldview formulated by W. Marciszewski and P. Stacewicz (Stacewicz and Marciszewski, 2011; Stacewicz, 2015, 2016). See also (Mul, 1999).

8 The rejection of mechanical philosophy as the philosophical environment for the development of physics did not take place rapidly or without tension. It is also worth noting that despite this rejection, elements of mechanical philosophy have survived in the popular view of science.

Previous studies into the relation between science and philosophy have shown how science cannot progress without some philosophical context. It is interesting to note how the fundamental theories of physics have only influenced the post-mechanistic worldview to a small degree. This may be explained by a lack of understanding of fundamentality in physics itself (e.g. Lamża, 2011, p. 71nn). The mechanistic worldview was gradually and almost imperceptibly replaced by the informationistic alternative[9]. This process has been observed for some time and reported on, such as in Poland by S. Krajewski in his research on modern Neo-Pythagoreanism (Krajewski, 2007).

It is noteworthy that the informationistic worldview, in comparison to the mechanistic one, offers an important philosophical advantage. While the latter describes quite well the bottom-up causation, emphasizing the importance of general laws in the creation of nature, the former also explains the top-down causation. This is the result of the doubly causal nature of information systems: the bottom-up (i.e., physical phenomena realizing computing processes in computer systems) and the top-down (i.e., the role of a computer program in shaping computational processes). Informatics evidently shows how this double causality is not just possible but also common, and models for such causation can be formulated analogously to information processes. This change in perspective can play a significant role in

[9] The term "informationistic", while not defined in the OED, is found in literature on the subject. It has been coined in a manner similar to the term 'mechanistic' (e.g. Mul, 1999).

elucidating important philosophical problems, such as the nature of emergence, the acts of God in the world, and so on.

The acceptance of an informationistic worldview has been a gradual and evolutionary one, but it has not happened unchallenged. The transition from the 20th to the 21st centuries has seen the development of "new mechanics". This supposed return of the mechanistic perspective is predominantly observed in biological sciences[10]. Its first explicit formulation was found in a monograph published in 1993 and written by Bechtel and Richardson (1993). It is problematic how much of the "new mechanical philosophy" is actually just a revival of the historical one. It is worth noting, for example, one definition for a mechanism that features in this new philosophy of science:

"A mechanism is a structure performing a function in virtue of its component parts, component operations, and their organization. The orchestrated functioning of the mechanism is responsible for one or more phenomena" (Bechtel and Abrahamsen, 2005, p. 423).

An interesting research question is whether this new mechanistic view can be reduced to informatics. It seems informatics provides a large conceptual framework capable of encompassing the concept of mechanical explanations. A clue can be seen in how these "mechanical" explanations are combined in practice with computerized methods. Hooker suggests that the link

[10] One can find explicit statements such as "a new framework for thinking about the philosophy of science" (Craver and Tabery, 2017).

is realized through research into complex systems, which uses information frameworks but employs the redefined mechanical terminology of a "new mechanical philosophy" (Hooker, 2011a). Its "linkage" requires a detailed analysis and thorough justification, pointing in the same time towards interesting area for research.

4. An update to mathematical structuralism – a concept of the computing Universe

Regardless of the role of informatics in the "new mechanics," one should also reflect on another important element in the modern scientific picture of the world, namely the association with the astonishing efficiency of mathematical-empirical methods in the study of reality (Wigner, 1960).

Mathematical structuralism as the ontological concept of nature, as suggested by Heller (2006) and others, leads in a relatively direct manner to a recognition of the fundamental role of information[11]. In this view, "information" and "structure" are closely linked concepts that are, in principle, two different rep-

[11] Krzysztof Turek (Turek, 1978, 1981; see also Krzanowski, 2016) was the precursor of such an understanding of the subject in the Cracow environment. Today, these studies continue, as evidenced in a recent issue of *Semina Scientarum* 13 (2017). Structural representations of information are also discussed in, for example, the work of Schroeder (2015, p. 27nn) and Krzanowski (2017).

resentations of the same fundamental aspect of reality. However, the exact relation between structure and information is not obvious and would require further research. It is interesting how, almost naturally, a possible path for the unification of these representations of nature may be found in the current category theory, which is a subject of further investigation.

In this context, one could reinterpret Heller's claims about the mathematical Universe. It seems that Michał Heller is close to the theory (although it is difficult to find unequivocal confirmation in his work) that the mathematical world is realized through computational processes. This is how the frequently quoted saying of Leibniz's "*Dum Deus calculat, mundus fit*" could be understood[12]. This view of nature as a computational process is not new because it is one of the version of pancomputationalism (see e.g. Piccinini, 2017). Thesis of computing Universe would mean that reality embodies a specific kind of computations. These "natural computations" are the reason for the emergence of cognitive structures, as well as guarantors for

[12] Of course, Leibniz's original statement was somewhat more elaborate: "*Dum Deus calculat et cogitationem exercet, fit mundus.*" Leibniz's puzzling separation of divine action from computing and cognition in the act of creation leads to numerous speculations. Let us note how the version proposed by Heller can be defended as adequate under the assumption of pancomputationalism (i.e., that all processes in nature are in essence computational). Thus, what is specific to the act of creation are in fact two sides of the same "divine calculations." It is easy to see how such an interpretation seems natural under the assumption that the mathematical nature of the world can be understood as computational.

the stability of their existence (and also the existence of any other structures). Computing universe understood this way can be naturally linked to the Augustinian concept of *creatio continua*, explaining the relationship of the Creator to creation. Interpreting this old Augustinian statement in the context of informatics could fill a gap in the previous reflections of Heller, who accepted both the mathematical nature of the world and the concept of creation. It may be that the link between these philosophical claims has in some degree been implicated by Heller.

The vision of computing Universe offers a philosophical perspective that can be seen as an explanation for the well-known concept of structuralism. It also presents new questions about the nature of the ontology of the world and provides an important companion to contemporary reflection on the concept of creation, which is a key to philosophy practiced in the context of faith. In addition, in the context of the informationistic worldview, the concept of natural computations can be understood as an expression of the computing Universe (see Polak, 2017).

5. Instead of conclusions – philosophical ideas of former Cracow Circle for modern philosophy of informatics

Concluding this review of the challenges facing the philosophy of informatics, it is worth addressing the history of philosophy and the philosophical roots of the presented concepts. When observing the current debates surrounding the impact of informatics on philosophy, one can identify significant similarities with a dispute that took place some 70 years ago about the role of the new formal logic (then called logistics) in philosophy, especially with the so-called Christian philosophies. In this context, an interesting response was supplied in Poland by Fr. Jan Salamucha, a prominent member of the Cracow Circle (see Wolak, 2005; Murawski, 2015)[13], during a discussion that took place in 1936 at the Third Polish Philosophy Congress in Cracow. Salamucha's response was later mentioned in two works: *About the mechanization of thinking* (Salamucha, 1937a) and *About the possibilities of precise formalization of analogous concepts* (Salamucha, 1937b).

Seventy years ago, Salamucha noted (about the then-new formal logic) that "existing new thinking tools cannot be eradicated" (Salamucha, 1937b). He also argued that philosophy must be precise, and therefore it must be logically "mechanizable". The main theme of Salamucha's work *About the mechanization of thinking* in the context of informatics can perhaps be better phrased as follows: "A philosophical thesis could be expressed by computing artefacts, and this would facilitate better control without removing the space for individual creativity."

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[13] We should add that the second conference in the "Philosophy in Computer Science" series took place in Cracow in 2016, and the proceedings took place in the former seminary building of the Diocese of Częstochowa at Bernardyńska St. 3, where in the 1930s, Fr. Jan Salamucha lived and worked.

In translating the meta-philosophical statements of Salamucha into modern times, one could say that informatics provides new tools for philosophical thinking. It plays a significant role in clarifying philosophical problems, and thus it cannot be dismissed. The spirit of Salamucha's philosophy is alive today in Cracow's Philosophy of Science community (at the Copernicus Center for Interdisciplinary Studies). In this context it is worth to note Robert Janusz's research on the application of computing methods to the solution of classical philosophical problems (Janusz, 2002, 2006, 2007). Let us consider one more passage from Salamucha, which is as relevant to philosophy now as it was years ago:

"It is particularly important in philosophy, where it is more difficult than in other sciences to separate mature and well-developed ideas, which with unyielding effort penetrates into the secrets of reality from the half-baked and pseudo-scientific concepts" (Salamucha, 1937a).

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