Computer Science and Philosophy: In Search of a Nexus

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Abstract. This research aims to map and analyse the nexus between philosophy and computer science: ontological and epistemological, as well as axiological aspects. It is arguably known traditionally that philosophy is regarded as the mother of all rational sciences; However, there has been little hitherto discussion about the connections between the two. On the other side, philosophy is systematic inquiry into human mind and behaviour as well in order to give the meaning in every object of study. For computer scientists, understanding the nexus between philosophy and computer science will advance the ability to think through the consequences of novel ideas and widen the perspective. This study used preliminary bibliographic study using literature research methods, which carried out by investigating various interdisciplinary studies, especially computer science and information technology in terms of philosophy and its branches. The results reveal that there are strong connection between these two disciplines, mainly in ontological, epistemological and axiological aspects. On axiological and ethical aspect, the link is very important, and philosophy has potential role in ethical problem solving that arise from within the academic discipline of computer science.

1. Introduction

Today, philosophy and computer science and information technology are regarded as two separate or even unrelated disciplines, but the recent trend in the development of computer science and information technology increasingly requires a philosophical foundation, especially in ethical aspects and law such as piracy, sharing, hacking, data privacy, and many more. The connection between the two is not limited only in ethical and law aspect, but also in broader aspects of philosophy. This paper tries to map and analyse the nexus between philosophy and computer science. Aristotle, who is known as the father of the science of logic, from the beginning aspired to make a rule of thought that produces valid and objective conclusions, regardless of human subjectivity. This set of rules is called syllogism, a method or valid thinking algorithm, as a computer requires a certain algorithm to produce the correct calculation results. Alan Turing is considered one of the main pioneers in the history of the development of modern computer science. It is interesting how he in his paper "Computing Machinery and Intelligence", started with a question and philosophical dialectics: "I propose to consider the question," Can machines think? " This should begin with definitions of the terms "machine" and "think". Furthermore, Turing tried to maintain his belief that a machine could think and compete with humans in logical-rational searches. For the possibility of a theological objection, that something that thinks must have a soul. Likewise, he tries to answer mathematical objections, the objection argument that thinking requires awareness, etc. This philosophical-theoretical dialectic has become one of the rationale in the development of subsequent computer science and technology.

Although Alan Turing is not known as a philosopher, this shows that philosophical matters cannot be separated from the revolution and development of computer science. Boolean logic and algebra which is a very important mathematical device in computer science were pioneered and formulated by a celebrated logician, mathematician, and philosopher named George Boole. Boolean algebra cannot be
separated from the tradition of Aristotelian logic. From this, it is very clear that the development of computer science cannot be separated from the underlying philosophical thinking. Moreover, the rapid development of computer science and information technology increasingly requires philosophical views, especially those concerning the ethical and legal aspects. It is no exaggeration to have a higher education institution that offers computer science and philosophy study programs like those of Oxford University. However, investigations that map the relationship between the two disciplines of science are still lacking, therefore, this preliminary study aims to map in general but comprehensive the link between philosophy and computer science. In general, philosophy is traditionally divided into three main branches namely: metaphysics which includes ontology, epistemology, and axiology. In addition to these three branches logic is also sometimes included in a branch of philosophy, and is regarded as a primary tool for understanding philosophy as a whole. This study tries to review and map out the possibilities of the relationship between each branch of philosophy and computer science, including information technology.

This research aims to map and analyse the nexus between philosophy and computer science: ontological and epistemological, as well as axiological aspects. This study is a preliminary bibliographic study using literature research methods, which is carried out by investigating various interdisciplinary studies, especially computer science and information technology in terms of philosophy and its branches. After a review of the literature, we will map the nexus of discipline in these four aspects of philosophy, namely: ontology, epistemology, axiology and logic, and the possibility of future research development.

2. Method

This study is a preliminary bibliographic study using literature research methods, which is carried out by investigating various interdisciplinary studies, especially computer science and information technology in terms of philosophy and its branches. After a review of the literature, we will map the nexus of discipline in these four aspects of philosophy, namely: ontology, epistemology, axiology and logic, and the possibility of future research development. Teaching philosophy through technology. References collected are scientific papers in the computer science and informatics relating to key philosophical words such as axiology, epistemology, ethics, ontology, metaphysics, and philosophy itself. Also refers to the earliest works of pioneering scholars of computer science to see the background of the birth of computer science.

3. Results and Discussion

Ontology, as generally understood, is defined as the theory of 'being', the study of what is considered 'there', while epistemology is a branch of philosophy which investigates the origin, structure, methods and validity of knowledge; where axiology is the study on values, ethics and aesthetics.

The study of the relationship of ontology with computer science has begun for example starting in the field of Artificial Intelligent and then developing now in semantic web or web 3.0. Anthropology defines as: "The term (ontology, -from author) is borrowed from philosophy, where Ontology is a systematic account of Existence. For AI systems, what "exists" is that which can be represented ... Thus, in the context of AI, we can describe the ontology of a program by defining a set of representational terms. In such an ontology, definitions associate the names of entities in the universe of discourse (e.g. classes, relations, functions, or other objects) ... "[7,8]. In the semantic web, computers are expected to understand human language and thoughts and understand communication between computers. Therefore the computer must understand the meaning of the word (semantic) and the sentence structure (syntax) of human language when it identifies a collection of words. Computers must understand the subject, predicate, and object of a sentence. Therefore, ontology in the semantic web is a set of definitions that connect terms used as subjects and objects with their predicates of vocabulary. But the study of the connection of ontology with computer science lies deeper, namely the answer to "what is called information" ontologically? Where is the information in the dual mind "mind and body" in the discourse of Western philosophy? A study of this has been done for example by Boersema. According to
Boersema, information is not included in the mental-physical ontological division known in Western philosophy, but it is a third type of ontology that is between the two. The study of epistemological relations with computer science can be viewed from two sides: Firstly, how computer science influences philosophy. Secondly, how philosophy is used in the study of computer science. The former, for example, was carried out by Bynum and Moore. They studied how computer technology had influenced philosophy and philosophers in modern times. This influence is first, on the way they communicate and work in everyday life, in writing their works and discussing remotely with their colleagues on philosophical topics, on the way they seek scientific references, the way they look social, political and cultural symptoms not only through books or directly but also digitally through social media. Second, the influence of computers on their thinking. How computers have helped them think and analyze. Third, is the aspect of ethics, namely how they are faced with the challenge of validity and the truth of the information they receive due to a flood of information digitally. Studies of computer use in science have also been studied, for example by Segura. According to him, the use of computers has epistemological influences in science. Terms that have been used for a long time such as 'model', 'uncertainty', 'logic', 'learning' or 'proof' have experienced a shift in meaning with the existence of computer technology. At present, it is not only humans who produce science but humans + machines are producers of science, so a new epistemology is needed called "computational epistemology", which is defined as: "the computational processes implied or required to achieve human knowledge.". Segura proposed a scientific method improvement in scientific activities which he called Integrative Approach to Computation (IAC). McCarthy has studied philosophical relationships with AI, he saw that both had similarities and also problems. How can the facts obtained in the real world be represented in the memory of a computer, and what rules are needed to guarantee the validity of the results obtained from these facts? In addition, the issue of simulating using computers is also an epistemological study, for example a study conducted by Greca et al. McCarthy concludes that: "Philosophy has more direct relation to artificial intelligence than it has to other sciences.". In his paper Greca et al. tried to review how the issues that emerged from the philosophy of science on the use of computers as a simulation in science. As for the later, namely from the epistemology side as a tool for computer science or the study of philosophical influences in the study of computer science, for example on fundamental epistemological questions such as "what is the meaning of knowing computer science?". Does it need a single answer or is it based on a variety of backgrounds? Like gender, profession, age, etc. These include questions about what the true meaning of computer science itself is. The next question arises. This is because computer science is a relatively new discipline, namely where is the position of computer science? Is he a branch of mathematics, natural sciences, or technique? Studies like this have been carried out by Eden. The epistemological study of computer science is also widespread in pedagogical areas, because if you take John Dewey's view that teaching and learning are "the spectator view of knowledge," the success of information transmission becomes very valuable. Then what is the position of the internet as a carrier of information in this pedagogical process? Brey considers that computers are ontological and epistemic devices at the same time because they function as cognitive devices that expand and assist human cognitive functions. In science, the use of computer aids distinguishes two types of epistemological science, namely computer-assisted science and computer-assisted science. Primiero terms the assisted science as a Software-intensive science (SIS). This epistemic difference raises several philosophical issues from the design of algorithms and mining data that are used against computer error calculation results and trust in results obtained from calculations using computers, and the relationship between scientific statements and codes used in computational models.

Ethical issues in the development of computer science and information technology or information and computer ethics (ICE) have actually been included in various educational curricula since around 1970, but it is increasingly prevalent lately. This is because the rapid development of information technology and computers has an ethical impact on humanity which is not followed by a review of the philosophy of information technology and the computers that accompany it. Luciano Floridi is among several researchers who are active in conducting research, lectures, seminars, and publications that are much related to these issues. In 2010, Floridi and several authors published The Cambridge Handbook of Information and Computer Ethics published by Cambridge University Press. This booklet contains
various results of studies of researchers on ethical issues that develop along with the development of computer science and information technology, including discussions about values in computer technology, information ethics, ethical issues in the information society, copyright, information security, ethical issues in Artificial Intelligence, Metaethics, etc. Aspects relating to ethical issues include: privacy and anonymity, accuracy, intellectual property and access which are abbreviated as PAPA; Also issues of availability, accessibility and accuracy of information are referred to as 'the triple A'; Also other issues concerning copyright, the flood of information called infoglut, issues of plagiarism, security, truth and validity of information, digital vandalism, propaganda, the spread of hoaxes, and others.

In the field of logic, the connection between philosophy and computer science has indeed happened since the very beginning. Boolean logic and algebra are the most important cornerstones of computer science currently included in Discrete Mathematics. Even logic is called "the calculus of computer science". It can be said that the birth of computer science is due to the question of whether the problem of predictive logic can be solved by a device mechanically called later as a Turing machine. The influence of logic in computer science has been investigated by Joseph Y. Halpern et. al., who examined how logic can be very effective in playing a role in computer science. The study of the Gray-Code calculation logic or also called reflected-binary-code which is very important in sensor readings has also been done for example by Ulrich Berger et al. Research logic in computer science includes fields of databases; hardware; algorithm correctness and optimization; topics in Artificial Intelligence such as modeling and verification of digital systems, knowledge representation, etc. Also studies of the "conceptual logic" of information as the logic of design are distinguished from "informal logic" and "philosophical logic" as other branches of philosophy. Conceptual logic is the logic in designing a system consisting of parts that have specific tasks: how the mechanism, its arrangement, and the relationship of one part to another.

The extensive relationship between computer science and almost all parts of philosophy shows the importance of mapping the area of research on philosophy and computer science and information technology. Philosophy of Artificial Intelligence (AI); Philosophy of Computation and Information, in the field of epistemology, for example Epistemology of Computation, Philosophy of Mind, e.g. virtual reality, computational models of reasoning, neural representation; in the field of axiology which includes Ethics and Aesthetics for example: privacy, intellectual property, ethical constraints on human-machine interaction and robotics systems etc.; in the Logic field for example: automated reasoning systems and logics, logic programming and representation; In aspects of ontology and metaphysics such as: digital or information ontology. This relationship can also include Philosophy of Language such as natural language processing (NLP), and others. The breadth of the research area shows the urgency of the offering a study programme on philosophy, computer science and information technology in higher education, especially in the case of higher education in Indonesia. For example, there are 55 computer science study programme offered by various universities in Indonesia, 60 in informatics engineering, informatics management and its varieties, however none of which are offering philosophy and computer science-informatics interdisciplinary study or research programme.

4. Conclusion
The nexus between philosophy and computer science is obvious and broad in almost every major part of philosophy; namely ontology, epistemology and axiology, as well as in logic. In fact it can be said that philosophy is a discipline that has a direct connection with computer science. Philosophical studies of computer science and information technology are therefore very important, besides in the ontological and epithemological aspects, also especially in axiological aspects such as ethics and aesthetics that are very necessary today. Furthermore, more educational institutions are needed to offer philosophical, computer science and information technology study programs in the near future.
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