

Universidade do Minho
Escola de Engenharia

Carla Maria Leite Rebelo

Ethics in IST: challenges and directions for practice and research

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Carla Maria Leite Rebelo
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Ethics in IST: challenges and directions for practice and research

Master's Dissertation
Integrated Master's in Engineering and Management of Information Systems

Work performed under the supervision of
Professor João Eduardo Quintela Varajão

July 2023

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And finally, the quote where I found the greatest motivation: "If you only do what you can do, you'll never be more than you are now" (Carloni & Nelson, 2016).

STATEMENT OF INTEGRITY

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Ethics in IST: challenges and directions for practice and research

ABSTRACT

Ethics, as a set of moral principles that guide an individual's behavior, assisting them in doing what is right, must be present in any decision taken by technology and information systems professionals, even if it is an unconscious process intrinsic to the individual.

Given its importance, ethics in technologies and information systems has been a subject under study for several decades; however, little research has been carried out focused on the ethical challenges of emerging technologies and, in particular, how codes of ethics are concerned with answering them. In order to fill this gap, a literature review was conducted to identify the ethical challenges of emerging technologies and to understand the main topics investigated in the literature on codes of ethics. The current versions of codes of ethics were analysed, followed by a proposal for an updated Unified Structure of Codes of Ethics.

Overall, this research identified forty-five ethical challenges associated with ten emerging technologies, of which eighteen are represented in the Unified Structure, indicating that, although there is some coverage, there is still room for improvement. This thesis ends with a set of recommendations for future research, encouraging an in-depth study of ethical challenges, combined with an update of the codes of ethics to reflect the results obtained and concluding with the recommendation to study the awareness of ethical challenges by technologies and information systems' actors.

Keywords: codes of ethics; emerging technologies; ethical challenges; information and system technologies' ethics.

RESUMO

A ética, enquanto conjunto de princípios morais que guiam o comportamento de um indivíduo, auxiliando-o a fazer o que está certo, deverá estar presente em qualquer decisão tomada pelos profissionais de tecnologias e sistemas de informação, ainda que a mesma possa ser um processo inconsciente, intrínseco ao indivíduo.

Dada a sua importância, a ética em tecnologias e sistemas de informação é um tema em estudo há várias décadas; contudo, tem sido realizada pouca investigação focada nos desafios éticos das tecnologias emergentes e, em particular, no estudo da resposta que lhes é dada pelos códigos de ética. De modo a colmatar esta lacuna, foi conduzida uma revisão de literatura, de forma a identificar os desafios éticos de tecnologias emergentes e a compreender quais os principais tópicos investigados na literatura sobre códigos de ética. Foram também analisados os códigos de ética e apresentada uma Estrutura Unificada de Códigos de Ética atualizada.

Deste trabalho resultou a identificação de quarenta e cinco desafios éticos associados a dez tecnologias emergentes, dos quais dezoito se encontram representados na Estrutura Unificada, indicando que, embora haja alguma cobertura, ainda há espaço para melhoria. Esta dissertação termina com um conjunto de recomendações para pesquisa futura, incentivando um estudo mais aprofundado dos desafios éticos, aliado a uma atualização dos códigos de ética de maneira a refletir os resultados obtidos, concluindo com a recomendação para se estudar o quão consciencializados os atores do universo das tecnologias e sistemas de informação estão deste assunto.

Palavras-chave: códigos de ética; desafios éticos; ética das tecnologias e sistemas de informação; tecnologias emergentes.

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List of Abbreviations and Acronyms

IS Information System

IT Information Technology

IST Information Systems and Technologies

AI Artificial Intelligence

ICT Information and Communications Technology

1. INTRODUCTION

This chapter is divided into five sections, including a contextualization of the theme, the motivation underlying the research, the purpose of the work and its importance, a synthesis of the research methodology, as well as the document structure.

1.1 Context

Ethics refers to the moral judgments about the right and wrong made by an individual (Vadastreanu et al., 2015, p. 3), relying on their personal convictions (Laudon, 1995). As a matter of fact, "when faced with alternative courses of action or alternative goals to pursue, ethics helps us to make the correct decision" (Laudon, 1995, p. 34). As a discipline, it relates to the "study of morality and the use of such theories in judging issues of right and wrong" (Bull, 2009, p. 2) and comprehends a set of theories, including Virtue Ethics, Utilitarianism, and Deontology.

Information systems and technologies (IST) encompass the "technicality" of information technologies (IT) and the concerns of Information Systems (IS) on the social and organizational use of those technologies. Putting it simply, "IS is IT in use" (Wakunuma & Stahl, 2014, p. 384).

"Technology itself (...) is ethically neutral" (Kluge, 2020, p. 1096); it is from its use that ethical and moral concerns arise ((Ogar et al., 2018); (Kluge, 2020)). Thus, its correct and ethical use will likely result in advances fulfilling a legitimate goal, but if ethics are disregarded, due to the inherent socio-technical aspect of IST, "the interaction between technology and human actors" may end up raising ethical concerns (Wakunuma & Stahl, 2014) in need to be solved. Moreover, new developments can lead to new ethical challenges, which IST professionals must be ready to address, as they are "expected to make the "correct" choice based on professional training" (Smith, 1992, p. 6). To support the solution of ethical dilemmas, these professionals rely on codes of ethics to, through the presented principles and guidelines, understand how to best approach an ethical dilemma.

1.2 Motivation and Relevance of Research

Ethics played an essential role since the beginning, with people dedicated to sharing their philosophies on the topic, leading to the creation of disciplines and theories inside of ethics as the opinions diverged. These differences in points of view are intrinsic to human beings, making it necessary to create tools to support any IST professional whenever an ethical dilemma arises, such as the codes of ethics.

Emerging technologies are known for the advances they provide, but close attention should be paid to the ethical challenges they arise. Ethics should be seen as a process of human understanding and reasoning, not as a static condition that is achieved (Laudon, 1995). Codes of ethics must also share this principle, seeking to follow developments and keep up to date so that IST professionals can rely on them when a potentially unethical situation emerges.

However, in order to ensure codes of ethics remain useful as technologies evolve and that the technologies' use for social and organizational goals can be improved, it is essential to identify the ethical challenges of these developments and, thereupon, analyse the current codes and study the need for a revision or update of their conducts.

1.3 Purpose of the Investigation and Research Method Synthesis

This investigation aims to identify and characterize the current ethical challenges raised by emerging technologies in order to study the coverage of these challenges by the existing codes of ethics. For this, a literature review was performed, followed by a review of the Unified Structure of Codes of Ethics and Conduct proposed by Ribeiro (2020), which acted as a basis for understanding whether or not the challenges are being considered in the codes of ethics.

The result of this work seeks to answer the three following research questions:

RQ1: What are the current ethical challenges resulting from emerging technologies (IST)?

RQ2: Do codes of ethics effectively answer the current challenges observed in IST?

RQ3: What are the main themes researched in the scientific literature focused on codes of ethics?

1.4 Document Structure

This document is structured into six chapters, starting with a contextualization of the theme, the motivation underlying the research, the purpose of the work and its importance, and a synthesis of the research methodology. The second chapter presents the fundamental concepts of the theme as well as related literature. The third chapter outlines the research approach, including the research opportunity, methodology, and process. The fourth chapter presents the results obtained from the literature review and a proposal for an updated Unified Structure of Codes of Ethics. The fifth chapter is dedicated to the discussion, where the results were analysed, and avenues for development and research were proposed. Lastly, the final chapter concludes the investigation, presenting the contributions to practice and research, identifying the study's limitations, and proposing future research.

2. BACKGROUND

This chapter includes the fundamental concepts of the theme as well as the related literature.

2.1 Fundamental Concepts

2.1.1 Ethics

Ethics deals with the moral principles that guide an individual's behavior (Kluge, 2020), assisting them when a decision between right and wrong must be made. Ethics refers to the "concept of what is right and fair conduct or behavior" (Carroll (1991) as cited in Payne & Landry (2006, p. 82)) and can be seen as a "set of behavior that maintains a society" (Bryson, 2018, p. 1). Lastly, it relates to the "study of morality and the use of such theories in judging issues of right and wrong" (Bull, 2009, p. 2).

Ethical approaches can be divided into Virtue Ethics, Consequentialism (Utilitarianism), and Deontology.

Virtue Ethics goes back to Aristoteles, who advocated people should develop intrinsic characteristics in order to behave more virtuously and, with that, provide well-being to both the individual and the community (Mingers & Walsham, 2010). That said, an action is good or right if, and only if, it is overall virtuous; the "right action depends on intrinsic human values (such as benevolence, generosity, justice, honesty) which orients [one's] actions" (Ologeanu-Taddei, 2022, p. 2). It explores "the reason a decision was made or an action was taken", rather than the action itself or its consequences (Siegel & Pappas, 2021, p. 216).

Consequentialism was developed as Utilitarianism by Jeremy Bentham and John Stuart Mill (Mingers & Walsham, 2010), aiming to maximize the good, focusing on the consequences rather than the actions (Siegel & Pappas, 2021). This theory argues that utility must be maximized, meaning that "an act that produces the greatest happiness for the greatest number of people, measured in terms of 'pleasure' and 'the absence of pain', is a morally right action" (Vartiainen & Siponen, 2010, p. 34). This way, there are two aspects to consider: "that it is the consequences of an act that count; and that the act is judged in terms of the degree of goodness that results" (Mingers & Walsham, 2010, p. 835). Utilitarianism can be summarized as the answer to "What is the greatest possible Good for the greatest number?" (Thelisson, 2018, p. 387).

Deontology (from the Greek, meaning duty) was first developed by Immanuel Kant and states that "what makes a choice right is its conformity with a moral norm", emphasizing moral duties or rules (Thelisson, 2018, p. 386). Kant's theory lays in two maxims: "act only on maxims that you would want to be universal laws (the thesis of universality)", meaning an individual must act as if the rules by which s/he is governed could be applied to everyone and in any situation, "and always treat other people as an end, never only as a means (the rule of human dignity)" (Vartiainen & Siponen, 2010, p. 34). This way, it focuses on the act itself, rather than its consequences or what motivated the individual. Thus, "actions are to be seen as morally right or wrong, just or unjust, in themselves regardless of their consequences. The end never justifies the mean" (Mingers & Walsham, 2010, p. 835). Deontology implies acting based on one's moral rules, though arguing that choices can be morally prohibited even if the consequences are positive (Sljivo et al., 2017). Succinctly, "the correct decision to make does not depend on an outcome, but on a set of fundamental duties" (Davison, 2009, p. 6).

In conclusion, "a utilitarian will point out the fact that the consequences of helping someone in need will maximize well-being, a deontologist to the fact that, in doing so, the agent will be acting in accordance with a moral rule such as "Do unto others as you would be done by" and a virtue ethicist to the fact that helping the person would be charitable or benevolent" (Thelisson, 2018, p. 387).

2.1.2 Ethics in IST

IT refers to the use of computers and software to manage information, including its storage, protection, processing, transmission, and retrieval (Hamiti et al., 2013). An IST project is a temporary endeavour undertaken to create a unique product, service, or result (PMI, 2017). This kind of project can be distinguished from other IT projects for being socio-technical undertakings performed to "improve the organization and to achieve business benefits" (Varajão, 2018).

"Ethics has been described by IT ethicists as a rational system designed to determine right and wrong in specific contexts" (Payne & Landry, 2006, p. 82). From all of its disciplines, deontology, as the one focused on the exercise of a profession (Ribeiro, 2020), can be thought of as the base for creating codes of ethics.

"Ethical codes are more than a tool to support ethical behavior; they are fundamental to the definition of ethics" (Udas et al., 1996, p. 722). Codes of ethics identify a set of principles that an IST professional must follow in the exercise of their profession. Moreover, as IT systems creation involve taking into consideration ethical values from different stakeholders (Bowern et al., 2006), codes of ethics also have a role in dealing with this diversity of values, helping to uniformize behaviours inside the IST

community. These codes offer guidelines on how to react whenever an ethical dilemma arises (from "a decision or an action [that] has the potential to impair or enhance the well-being of an individual or a group of people" (Martinsons & So (2000) as cited in Davison (2009, p. 3))).

Given the need to enforce ethics in IST, from its design to its use, various disciplines were created over the years. Ashok et al. (2022) identified eight research domains: computer ethics, technoethics, information ethics, roboethics, machine ethics, computational ethics, Information and Communications Technology (ICT) ethics and AI ethics.

Computer ethics covers "the study of the ethical questions that arise as a consequence of the development and deployment of computers and computing technologies" (Rahanu et al., 2021, p. 4). It is concerned with the social impact computer technology may have, whereby formulates policies for its ethical use (Ashok et al., 2022).

Technoethics aims to explore how technology alters the power of individuals. Information ethics studies the "relationship between the creation, organization, dissemination, and use of information, and the ethical standards and moral codes governing human conduct in society". Roboethics focus on understanding and regulating the ethical consequences of robots. Machine ethics "is concerned with how machines behave toward human users and other machines". Computational ethics brings a computational perspective to ethics theory. ICT ethics is defined as "ICT affect human attitudes, values and behavior, and set conditions for human identity, existence, and change". Finally, AI ethics concerns to "responsibility, transparency, auditability, incorruptibility, predictability and morality of machines" (Ashok et al., 2022), ensured through the development of guidelines and frameworks to guide the ethical use of AI in society (Chowdhury & Oredo, 2022). Bilal et al. (2021) stated emerging technologies and their use of artificial intelligence and internet of things applications created the need for the concept of data ethics. Thus, data ethics is defined as the study of "moral problems related to data (including generation, recording, curation, processing, dissemination, sharing and use), algorithms (including artificial intelligence, artificial agents, machine learning and robots) and corresponding practices (including responsible innovation, programming, hacking and professional codes), in order to formulate and support morally good solutions" (Floridi & Taddeo (2016) as cited in Bilal et al. (2021, p. 2)).

2.2 Related Literature

In this section, the literature related to the research questions of this dissertation is detailed.

Almost forty years ago, Mason (1986) proposed four ethical issues of the information age: privacy, accuracy, property and accessibility (PAPA). Although identified at a different time, these ethical issues remain current and are used as a basis for some works, such as by Young et al. (2020). Mason (1986, p. 5) stated privacy is threatened by the growth of information technology "with its enhanced capacity for surveillance, communication, computation, storage, and retrieval" and "the increased value of information in decision-making". In particular, with the growth of IT, this ethical issue is exacerbated when relationships between data are created, threatening the privacy of individuals who may, at one point, have shared isolated details about themselves that, when connected, would reveal more of the individual than s/he may have wanted. These data files merging and the errors they may carry lead to a concern for accuracy, the second issue identified by Mason (1986). This growth in information raises questions about intellectual property rights, as the information, which is costly to produce, is easy to reproduce and share with others, making it "hard to safeguard since, unlike tangible property, it becomes communicable and hard to keep it to one's self". Finally, this ethical issue leads to the concern of who should have access to this information. The author identifies literacy as the main avenue to information, stating that an individual must have the intellectual skills to understand the information, the necessary access to the IT which deal with information, as well as access to the information itself.

From the considered literature, only Stahl's (2011) work is concerned with ethical challenges on a general set of emerging technologies. He starts by identifying the technologies that, in the following fifteen years, would likely become socially and economically relevant, using the ETICA project's results as a starting point. According to Stahl (2011), this project indicates the need for an "early understanding of emerging ICTs and the ethical issues they can be expected to raise", as the development of new technologies can exacerbate or even lead to new ethical issues. Hereupon, the emerging technologies proposed are: affective computing, ambient intelligence, artificial intelligence, bioelectronics, cloud computing, future internet, human-machine symbiosis, neuroelectronics, quantum computing, robotics and virtual/augmented reality. Thenceforth were pointed out the ethical issues raised by each of them, resulting in a mind map, followed by a brief discussion, showing fifty-two ethical challenges, divided by emerging technology and grouped into eight categories, presented in Figure 1.

The author state that "by exploring potential ethical issues, the paper points to the importance of an early ethical assessment of these issues in order to put policies in place that will allow addressing them". His findings result in a set of recommendations for policymakers and industry, researchers, and

civil society organizations. To the first, the ones with "an important role to create the regulatory framework and the infrastructure to allow ethics to be considered in ICT", is suggested the development of a framework covering three main areas of policy activity: support of ethical impact assessment for ICTs; establishment of an ICT ethics observatory and establishment of a forum for stakeholder involvement. Regarding the recommendations for the industry, researchers, and civil society organizations, these are oriented to the incorporation of ethics into ICT research and development and the facilitation of ethical reflexivity in ICT projects and practice.

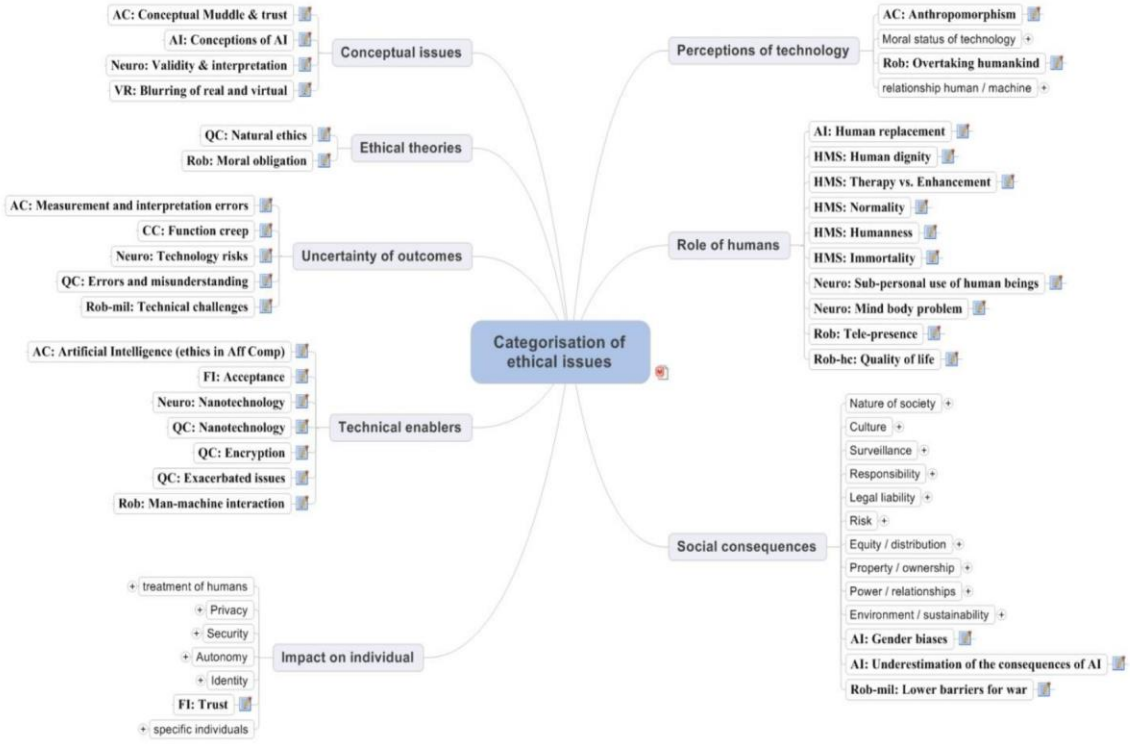


Figure 1: Categorization of ethical issues of emerging ICTs proposed by Stahl (2011)

Apart from Stahl's (2011) work, were found some articles focused on the identification of ethical issues but only on a single technology or a combination of technologies, such as Ryan's (2021) work on ethical issues in Artificial Intelligence and Big Data. No literature focused on verifying if the existing codes of ethics answer the challenges raised by emerging technologies was found.

3. RESEARCH APPROACH

This chapter describes the research opportunity, methodology, and process.

3.1 Research Opportunity

Since the beginning, deontologists turned principles and individual beliefs into universal rules everyone should follow. This generalization also affected the area of IST, with the creation of the Codes of Ethics that goes back to 1972, the year when the first version of the ACM Code of Ethics and Professional Conduct was released (Gotterbarn, 2018).

However, De George (2003) argued that ethical issues are often ignored whenever a new social innovation arises, as the focus is on its development. Moreover, the development referred to by the author was "so rapid that society as a whole has not had the time to digest its ethical implications". If a rapid pace of evolution was seen as that fast 20 years ago, nowadays, one should be prepared for the rising of new technologies every moment; hence the importance of ensuring that codes of ethics address the challenges related to new technologies.

Ethics should be seen as a process of human understanding and reasoning, not as a static condition that is achieved (Laudon, 1995). Codes of ethics must also share this principle, seeking to follow developments and keep up to date so that IST professionals can rely on them when a potentially unethical situation emerges. That said, despite the importance of ethics and the attention that has been given by professional associations, there is a lack of scientific literature focused on studying the alignment between research in IST ethics and professional concerns (Ribeiro, 2020).

Given the research gap identified, this dissertation's underlying research questions are as follows:

RQ1: What are the current ethical challenges in emerging technologies (IST)?

RQ2: Do codes of ethics effectively answer the current challenges observed in IST?

RQ3: What are the main themes researched in the scientific literature focused on codes of ethics?

3.2 Research Methodology

The research design includes a systematic literature review, following the PRISMA guidelines, which consists of "a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies included in the review" (Moher et al., 2010, p. 264). This will be conducted using the PRISMA statement, which

consists of a 27-item checklist, that includes a set of criteria divided into seven sections (title, abstract, introduction, methods, results, discussion, and funding), and a four-phase flow diagram (Moher et al., 2010).

3.3 Research Process

The literature review was carried out in three selected databases – Scopus, Web of Science and AIS eLibrary –, from September 2022 to February 2023. Three search queries were conducted in order to answer the research questions. First, to understand the concept of ethics in IST search expressions were used, which included "ethic*" (to include words such as ethic, ethics and ethical), "information systems" and "information technolog*", to narrow the results to these areas. Secondly, keeping present the research questions, two different queries were searched, one including terms such as "ethical challenges" and the other "codes of ethics", also narrowing the results to the IST area with the same previous keywords. The first query aims to answer the three research questions, the second is focused on the first question, and the third is related to the third research question. The ethical challenges query was filtered by year, with only being considered articles published between 2010 and 2022 as the challenges refer to emerging technologies. To all of the queries, except the one related to the codes of ethics, was applied a filter by area to ensure the relevance of results.

The resulting records were added to an Excel file and the duplicates were removed, to support the screening phase. Then, each article title, keywords, and abstract were analysed to match the goals of the research. The inclusion criteria were academic publications focused on the theme, in English language, addressing specific emerging technologies (in these cases published after 2010) or codes of ethics. In total, 1199 articles were excluded in this phase, either because the title or keywords did not mention any of the search terms; the abstract, although containing those terms, showed the article was not related to the research theme; they were not in English language or because the article was not accessible. During the eligibility phase, the resultant articles were analysed for either the identification or discussion of ethical challenges or the analysis of codes of ethics. Ninety-seven records were excluded, as they did not answer any of the research questions or only mentioned the ethical challenges topic without elaborating, thus not being relevant to the discussion. Finally, 48 studies were included in the final analysis, resulting from a rigorous examination. Figure 2 depicts the full process.

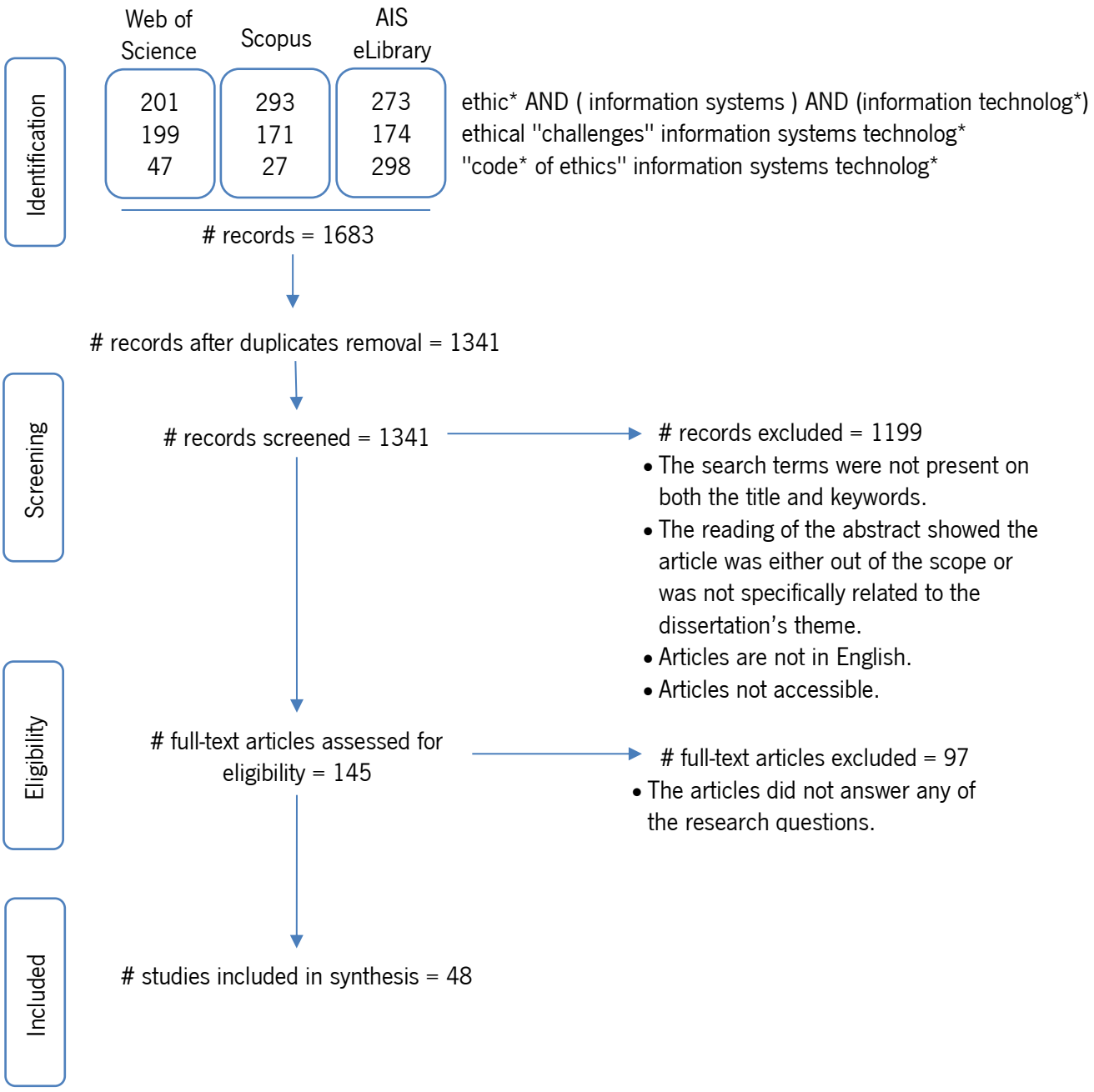


Figure 2: PRISMA flow diagram

After selecting the articles, the content was analysed. For each article, were identified the referred ethical challenges, compiling the respective descriptions, which were later on associated with certain conducts of the codes of ethics, here represented by the Unified Structure of the Codes of Ethics, so that the coverage given by the codes of ethics to the identified challenges could be understood. This structure was revised to include the updates made to the codes of ethics considered. On the other hand, in the articles referring to codes of ethics, sought to understand which areas the research was involved in, compiling this information into two different areas.

4. RESULTS

This chapter presents the results obtained from the literature review, identifying ethical challenges and the main themes regarding codes of ethics addressed in the literature. Moreover, an updated version of a unified structure of codes of ethics is proposed.

4.1 Current Ethical Challenges in IST

This section includes the identification and characterization of the ethical challenges raised by emerging technologies addressed in the literature.

4.1.1 Artificial Intelligence

Artificial intelligence (AI) was first defined by John McCarthy as "the science and engineering of making intelligent machines" (Tahiru, 2021, p. 1). Nowadays, AI "focuses on how computers learn from data and mimic human thought processes" (de Miguel et al., 2020, p. 1139).

Adomavicius & Yang (2022) identified ethical challenges regarding AI and its automated decision-making capabilities. These challenges include privacy issues, observed in facial recognition technologies, dignity and autonomy, that concern automated scoring algorithms and transparency, trustworthiness and accountability challenges, found in automated medical diagnostic systems. The authors also highlighted algorithm bias, supported by Slota et al. (2022), or "lack of algorithmic fairness" (Adomavicius & Yang, 2022), which consists of the production of unfair decisions for a group of people. The authors argue that technology alone, e.g., strategies relying on statistical methodologies, cannot address the bias issue; it is required "human involvement to understand the sources of the bias". Moreover, ensuring a transparent system is an increasing concern as the newest algorithms are more and more seen as a black-box.

Kordzadeh & Ghasemaghaei (2022) state that algorithmic bias is a major concern in AI applications and that it can affect fairness perception, i.e., to what extent the algorithm is perceived to be fair. These systems are likely to discriminate and foster social inequalities when the algorithms are used to automate decision-making related to people.

According to Schedl et al. (2022), Information Retrieval Recommender Systems raise ethical questions related to fairness, non-discrimination, diversity, and transparency. Bias was found in algorithms and data used to train the AI models, resulting in the production of unfair decisions for certain groups of people. Diversity is related to the fairness principle, as the systems, in their development,

should include variations of different characteristics among individuals, ensuring an equal outcome for all stakeholders. Lastly, transparency refers to the trust individuals have in the technology, whether about the capacity to explain the AI system (explainability), the follow-up of the behavior of the system in a chronological way (traceability), or the documentation of the system development process, capabilities and limitations (communication) (Mitchell et al. (2019); OECD (2022) as cited in Schedl et al. (2022)).

Zhang & Gao (2019) identify employee replacement by AI or robots as an ethical challenge since it can lead to the dismissal of part of the workforce. The authors also point out the concern that AI will be a threat to humanity or that humans will excessively depend on AI technologies. It is mentioned the "widening inequality because of the digital divide" that is promoted by the amount of big data generated by the user, which is owned by Internet companies, around which their business model is placed. Lastly, Zhang & Gao (2019, p. 214) state that "peoples' right to privacy, freedom and information is increasingly difficult to be guaranteed".

AI presents a variety of subareas and applications, one of them the distinction between human and robot activities, as observed with Google's CAPTCHA. This system aims to perform a "reverse" Turing test, i.e., testing if a website's user is actually a human using biometric data, such as the patterns of utilization of the website. As the testing process relies on risk assessment software invisible to the user, and some of the tests do not require interaction from the user, it is not clear what use is made to the data collected and stored by the CAPTCHA. This raises the issue of lack of privacy, as the personal data from the user is being collected without warning or consent, transparency, as the testing process is seen as a black-box and sometimes the user does not even know there is an AI mechanism underneath, and fairness, as the user can be incorrectly targeted as a bot, losing its access to the website (Alizadeh et al., 2022).

Semi-intelligent information filters (SIIF) are a category of affective technology, a subset of AI. These systems interpret the data recorded from the user, such as facial expression, body posture, and physiological signals, which raises ethical questions. Grond et al. (2022) conducted a study on biomusic – a SIIF-based technology – in which the participants pointed out ethical issues related to personal privacy and data security. The point of this technology is to translate "emotion-related physiological changes into auditory output"; being this case study focused on individuals with autism spectrum disorders, it is even more important to be aware of the ethical issues. Thus, personal privacy issues relate to the disrespect of an individual's boundaries about what they want or do not want to share through biomusic, exposing their private feelings in an unwanted way. Thus, given the sensitive nature of the data, data security, including its sharing and storage, raises concerns, especially if this system could be used for surveillance.

Natural language processing (NLP) is another branch of AI, used to transcript and analyse qualitative data. It shares the same concerns as AI itself, namely data bias. Kreutzer et al. (2020) noted that if the training data reflects bias or is not representative, it will amplify social inequities. This way, if a system whose main focus is to analyse the data it collected was trained on biased data, situations like "voice recognition was found to be less accurate for women and speakers of minority dialects" (Tatman (2017) as cited in Kreutzer et al. (2020, p. 9)) or "commercially available face recognition software performed very poorly for dark-skinned women while excelling with pictures of white men" (Buolamwini & Gebru (2018) as cited in Kreutzer et al. (2020, p. 9)) will occur and reduce the accuracy of the results. Kreutzer et al. (2020) case study was on using NLP as a resource to facilitate humanitarian assistance, helping with the collection and analysis of surveys. So, if the system was biased, that would mean that, for example, women and minorities would be misrepresented in the research. Also, the lack of transparency on the sharing of algorithms or the training data used makes it hard to detect bias until the technology is fully deployed.

Valentine et al. (2022) highlight explainability, privacy, and control of user history issues related to recommender systems in mental health apps. These systems aim to predict content relevant to the individual through filtering algorithms, which operate on the user's personal information and previous usage data. Explainability suggests that "the reasoning behind an AI or algorithmic process should be explained to a user alongside the output". This way, it is important, especially in sensitive areas like mental health, to know the reason why the algorithm makes certain decisions. To obtain better recommendations, the user will have to engage in a "privacy-personalisation trade-off": the greater the knowledge a system has about an individual, the better the recommendations. On the other hand, this level of personalization requires more personal information, jeopardizing users' privacy. It is also typical for this sort of application to sell users' data to third parties. Moreover, users must have the right to control their history, either by accessing, editing, or deleting it from the system, even with the knowledge that these alterations might influence future recommendations. Accordingly, the author suggests detaching their history from the system, i.e., removing the information from the recommender system without deleting medical information.

According to Carman & Rosman (2021), the implementation of AI-based decision-making systems should be fair and aligned with human values. The authors raise the ethical challenge of ensuring this alignment with societies' values in which the system will be implemented and not only considering assumptions of universal norms which may not apply to every culture. Based on the principle of explicability, which aims to solve the accountability issue in the development of AI applications, the

authors highlight the role that developers and designers have on the moral implications of the use, misuse, and abuse of the system, especially when observed the inequality of power between the ones developing the solution (usually big corporations) and the ones affected by them (society as a whole).

Newell & Marabelli (2015) focused their analysis on the ethical issues raised by algorithmic decision-making. Besides privacy issues, the process behind this technology is unknown, and the decision-makers often ignore the reasons behind the suggestions and choices reflected in the system's output, as the predictions come from a "black-box". The authors also refer to the improper use of the data collected for different purposes other than the originally defined, which can also result in the monitorization of the individual's behavior. Lastly, these decisions can create unfair discrimination.

Aysolmaz et al. (2020) point out privacy, anonymity, and misuse of data and model as ethical concerns on algorithmic decision-making systems, as well as bias, this one for being an "obstacle in front of the "principle of justice" as part of the ethical concerns, which articulates that decisions made by algorithmic systems shall be fair and equal for all human beings". According to the authors, bias can be found in any step of the development, either by the "poorly selected and unrepresentative datasets, pre-existing bias inherent in algorithmic decision-making system coders, or technical limitations in the design", introduced by the responsible individuals.

King's (2020) work focuses on the ethics of artificial cognition, i.e. "the ethical dimensions of attribution of mental states to humans by artificial systems", and identifies presumptuous aim attributions as a moral concern. According to the author, the generalization observed in automated recommendation systems challenges the individuality of a person, as the predictions are usually made following the logic that if a group of people with the same characteristics as the individual has made this decision, then the individual itself would do the same (or as exemplified by the author: "Consider an aim attribution: Subject S aims at A. This attribution is presumptuous if and only if the primary evidence for the attribution consists of these two pieces of information: (1) S has characteristic C. (2) Most people with C aim at A."). This way, "systems that operate presumptuously fail to treat persons as individuals".

Learning analytics is usually defined as "the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (West et al., 2020, p. 60). West et al. (2020) point to privacy as a main ethical concern, followed by the inappropriate use of data, either for "selling, social sorting or reinforcing disadvantage". The personalization underlying this technology, although its advantage of a better learning journey, can bring ethical issues related to anonymization. When biometric and location data are combined, it increasingly removes the ability to anonymise data. Moreover, there are issues related to

informed consent, as there is a chance the students may not be aware of the extent of the use of their data. West et al. (2020) also raise concerns regarding data treatment, especially data cleaning processes "which are often not transparent, can perpetuate current bias and prejudice, and privilege particular student groups". Jones et al. (2021) reinforce the privacy issues and add concerns related to algorithm bias and fairness regarding the distribution of resources focused only on students the system predicts that will succeed and even the attention of the faculty, possibly neglecting the other students. Moreover, not all the assessments by the professors can be incorporated into such systems, as "not all forms of learning can be quantified and analyzed" (Williamson et al., 2020).

According to Giermindl et al. (2022, p. 417) view on people analytics, i.e., the use of analytics and algorithms in human resources functions, "treating employees as quantifiable data objects, rather than as cultural, sentient social human beings is ethically questionable", as the information is being used to manage humans and their behavior in an organization. On the other hand, human-related factors are hard to measure because "human behavior is much more complex and much less predictable than that of machinery or other tangible assets, [so] reducing complex human characteristics and behavior for representation by data points and numbers is problematic".

Tahiru (2021) argues that the implementation of AI in education will result in the dismissal of teachers and that the important role of data in AI applications raises trust and privacy issues. The author refers to accountability as another ethical challenge: who will be held accountable if there is a leak of the data or if there is a bias in the system's assessment?

In their work, Al Shazly et al. (2020, p. 41) identify three ethical concerns in the development of AI systems: "Is the training data representative of the intended stakeholders of the system? Is the decision-making process fair, and unbiased? Are the actions of the system explainable, repeatable?"

Mogaji et al. (2021) work on the implications of AI on the digital marketing of financial services to vulnerable customers highlights the importance of an ethical collection of data, especially considering that financially vulnerable individuals tend to look for sources of financial services used to acquire their information, sharing it with companies that may target them with advertisements. This way, the authors advocate for consent on the collection of the user's information and its anonymization, assuring that personal details are removed. At last, they state this collected data should not be sold to a third party.

Maedche et al. (2019) state that AI-based digital assistants may endanger human autonomy as this pervasive technology can both increase it, "by supporting deliberate and intentional actions", and interfere with human agency, reducing one's control. Even though the support given by such systems is

positive, their constant use can lead to addiction and incapability to perform certain tasks, now attributed to the assistant. The author also identifies biased training data as an ethical issue.

Paul et al. (2022) refer to robots as an application of AI technology that raises ethical challenges related to employee replacement and eventual job losses, as well as the dehumanization of society. The substitution of relationships before characterized by human-to-human interactions by human-to-robot interactions may be morally debatable, as the cost of this decision is yet to be known, and it is not clear whether it is "ethical to encourage humans to build relationships with technology in the way they have become accustomed to building relationships with humans". Additionally, as these systems are meant to support decision-making or even deciding on an individual's behalf, embedding ethics within technology can be a critical challenge, either for not being consensual "whose ethics are to be embedded into such a system" or for the technical difficulty in doing so.

Bilal et al. (2021) identify "privacy, trust, surveillance, and data quality" as ethical challenges raised by AI. Ryan et al. (2021) identify ethical issues related to both AI and Big Data and categorize them into short-term, medium-term, and long-term by the time required to address them. In the short-term, the authors point out privacy and control of data, as well as the lack of transparency of processes dealing with data. The lack of accuracy of the results produced by AI can be an issue deriving from the lack of reliability of the technology and may result from bias and discrimination on the algorithms. The medium-term issues may result from the integration of AI techniques into larger socio-technical systems and comprise the risk of individuals being put under surveillance, jeopardizing their privacy, freedom, autonomy, and self-determination. It may even raise issues related to justice, power imbalances, and discrimination, this one related to the categorization of an individual not only based on their online behavior but also on their gender or belonging to specific groups, which may contribute to inequality. In the long term, issues were identified concerning the possibility of AI developing capabilities that may surpass human intelligence and have dystopian consequences.

4.1.2 Machine Learning

Machine Learning is an emerging AI branch able to convert big data into algorithms (de Miguel et al., 2020), which in turn gives out predictions. In specific, predictive analytics uses sets of data to predict from data correlations (Mühlhoff, 2021). Given its use in support of life-changing decisions, it raises ethical questions such as unfair bias and discrimination. Mühlhoff (2021) states that what the author calls "predictive privacy" is being threatened by predictive analytics, i.e., this technology, with its predictions based on statistic correlations, fails to protect individuals against "unfair treatment and

infringements on their autonomy, dignity, and well-being resulting from the use of information" generated. This way, and keeping in mind that the results can be used in important decisions concerning an individual's life, information about them can be predicted by these systems without their knowledge and using data related to many other individuals. Moreover, the author raises privacy concerns related to these predictions, as the model can use less sensitive information about the individual and anonymous data left by other users as input from which a set of sensitive information about an individual can be predicted, such as health or socioeconomic information (take the prediction of diseases such as depression based on an individual's post on Facebook as an example (Merchant et al. (2019) as cited in Mühlhoff (2021)). Hence, "privacy is compromised not by the information disclosed by the subject, but by the information revealed by many others (i.e., by the users of networked services as involuntary donors of training data)".

In the processing of the data, developers must be careful with biases in the data, making sure they are addressed. These biases, particularly the ones related to socioeconomic status, have the power to influence the model, which in turn influences the user, leading them to make decisions (and some to their detriment, e.g., financially vulnerable users encouraged to borrow money at higher rates) without realizing (Mühlhoff, 2021). Yapo & Weiss (2018) reflect on the consequences brought by machine learning bias, from results only containing white males when images of CEOs were searched on Google, to racist algorithms which tagged black people as "animals" or "apes" in Flickr.

De Miguel et al. (2020) point out the lack of transparency related to the algorithms used in machine learning, an ethical challenge inherited from AI, as it is unfeasible to a developer, as it is to the final user, to understand how a certain technique produces a certain inference. Nevertheless, companies may be unwilling to share the code behind the algorithm for security reasons, as it could be used by malicious agents. The author also states that the distrust in the algorithms is strengthened by bias affecting both algorithms and training data, hence influencing interpretation and decision.

4.1.3 Conversational Agents

Conversational agents (CA) are AI applications created to improve human-computer interaction (HCI) (Wambsganss et al., 2021). Wambsganss et al. (2021) state that CA can reinforce stereotypes due to design bias: the agents usually have feminine characteristics which "are supposed to improve the attitude towards the agents, but also solidify specific gender roles". The models are prone to bias, which can result in errors that lead to unfair outcomes, and generally opaque, raising issues of accountability and transparency. Additionally, CAs may be used to collect sensitive data, jeopardizing user's privacy.

Lee et al. (2022) refer to this form of HCI as conversational user interfaces, identifying ethical challenges related to trust and gender bias.

4.1.4 Blockchain

Blockchain is a type of decentralized database structure composed of transactions and blocks (records) (Radzi et al., 2023), widely known for being the technology behind bitcoin and other cryptocurrencies (Nakamoto, 2008). According to Calvaresi et al. (2019), blockchain can raise issues related to General Data Protection Regulation applications and environmental sustainability. Tang et al. (2019) propose a framework that presents blockchain's ethical impacts. Blockchain presents privacy issues, as it is not entirely anonymous: if an "e-wallet provider or an exchange service provider are attacked, the identity of participants would be revealed and in danger". The historical data is also stored on the blockchain, jeopardizing the right to be forgotten. Blockchain can guarantee that the data, once in the system, cannot be modified or abused, but cannot assure the original accuracy of the data. This technology presents equality challenges in its development, since, even being an open-source software, only a few developers contribute to the core platform, raising concerns about the diversity of the developer community.

4.1.5 Self-driving Cars

Smart vehicles make intelligent decisions through the gathering and analysis of large amounts of data (Birek et al., 2018). Birek et al. (2018) identify ethical issues related to the accountability of the decisions made by the system, the application of advanced AI, and the manipulation of sensitive personal data. These vehicles are responsible for making complex decisions "to promote the driver's safety and satisfaction by relying on various factors". But it is important to define who will be held accountable when a decision made by a product of technology harms people, like a change performed on the engine's configuration, which results in an accident. The algorithms behind the system must be "resilient against ill-intended and malicious manipulations", which brings the importance of the transparency of the algorithms. Lastly, the data must be handled with care, as it might include information such as "location history, social media interactions or physiological signal information relevant to the driver's health and affective state". Its main goal is to be used by the car to predict the driver's intentions, but it could also be shared or used by other organizations connected to the vehicle, in some cases, without the proper user consent.

Sljivo et al.'s (2017) work focuses on ensuring ethics in Dependable Technological Service Systems, i.e. systems dependent on service providers to assist with the flow of information between interconnected devices, in which smart cars are included. The author identifies "the trolley problem" as a safety-related ethical challenge, which consists of the scenario where "a conductor of a trolley has the choice of staying on the planned track and running over five people, or turn the trolley onto a track where it would only kill one person, assuming there is no traffic on it" (Hussain & Zeadally, 2019). According to Sljivo et al.'s (2017), this challenge refers to the ethical dilemmas that smart vehicles can face, for which they must have been programmed to decide. Notwithstanding, there is no consensus on the morality of the final decision, for it depends on the ethical theory in which the individual believes (Sljivo et al., 2017).

4.1.6 Industry 4.0

Industry 4.0 is a subset of the fourth industrial revolution, and it is composed of cyber-physical systems, such as robots, the Internet of Things, the cloud, and cognitive computing. Rahanu et al. (2021) identified a set of ethical challenges, such as privacy, risk of surveillance, distrust, data security, unemployment of the workforce due to the technology implementation, lack of regulation, standards, and forms of certification, and the challenge to protect intellectual property.

4.1.7 Internet of Things

The Internet of Things (IoT) is "the process of information generation, use, and its afferent and efferent flow in various smart devices, applications, and services" (Chaudhuri, 2017, p. 7). Chaudhuri (2017) refers the importance of algorithmic accountability as a way to "prevent biased decision making and erroneous output", since IoT systems and the resulting interconnection of subsystems, in which data transactions are made, can be opaque to the users. The author points security and privacy of data as ethical concerns raised by the users of these systems.

4.1.8 Smart Homes

Smart homes refer to a set of technologies set up on a house that will learn from the interaction with the house's inhabitants and can be "defined by the physical building, the technologies that connect and monitor the activities both in and beyond the building, and the residents whom it can engage both directly and indirectly with" (Ehrenberg & Keinonen, 2021, p. 3). Ehrenberg & Keinonen (2021) point out privacy and data security as the main ethical challenges in smart homes. The authors argue that

persuasive technologies "raises ethical questions on whether it is acceptable to influence behavior in specific directions deliberately or if it can cause 'moral laziness' by delegating ethical decisions to machines", as the primary focus of these technologies, usually based on AI, comprehends different ways of influencing one's behaviour. This way, smart homes' technologies seem to reinforce existing power structures, some of them related to gender roles, presenting ethical issues related to control (when one of the elements of the household has more knowledge, thereby control, over the technology).

Ambient assisted living is an area part of intelligent environments focused "on the domains of health and social care in the home environment" (Jones et al., 2015, p. 1). Jones et al. (2015) identify six ethical challenges related to this field: privacy, data protection, security, transparency, autonomy, equality, and dignity. Privacy concerns can relate to potential breaches of privacy when the devices share more information than the user allows. The "ubiquity, connectedness, invisibility, increased capacity for memory, sensing ability and potential for profiling" of these smart devices increases the privacy concerns, as well as the sensitive nature, "high quality and large quantity" of the data collected. This way, these systems raise concerns about their monitoring and surveillance capabilities. Data protection issues can arise from "storage, retention and disclosure of personal data, the access to, and secondary uses of, such data by key stakeholders and third parties, and the risks of accidental or intentional leaking of sensitive data", and are associated with lack of confidentiality, trust and informed consent. As it happens in AI systems, intelligent environments lack transparency, as they are constituted by technologies that are hard to understand, including the reasoning behind the decision-making processes.

4.1.9 Wearable Devices

According to Anaya et al. (2018), wearable devices, which comprise wearable technology (such as smartwatches), smart textiles, and medical care devices, have privacy, security and informed consent ethical issues associated. The authors focus their study on medical care devices and highlight the improper access third parties have to the personal and sensitive information stored in these devices. One of the conclusions of this study is that even if the user does not associate privacy issues with informed consent, they recognize the need for shorter and more understandable privacy policies to inform the legal actions in case of misuse of information.

4.1.10 Augmented Reality

Augmented reality (AR) is a technology that "enables humans to view and interact with digitally augmented visual content that is realistically overlayed on and interacts with the physical world", going from superimposed text information to interactive 3D objects (Mahr et al., 2023, p. 1).

Regenbrecht et al. (2022) anticipate ethical challenges regarding pervasive AR, in a phase where there are not yet any applications developed for this technology, which refers to "the continuous and ubiquitous experience of computer-mediated reality". This way, foreseeing the ethical issues of pervasive AR, based on the challenges already observed in augmented reality technologies, would allow the consideration of these challenges in design and implementation decisions. Traditional AR implemented in mobile phones for games and marketing purposes raises concerns about privacy associated with unwanted exposure, biased perception of reality, and contextualized marketing. Pervasive AR shares the same privacy concern, now regarding the long-term capture of information about the user and their environment. Consequently, it can be identified consent challenges, as it would be near impossible to gather consent from all the people involved. The author raises issues about ownership related to the overlap of the physical and virtual worlds. AR already raised this issue, for example, associated with Pokémon Go and the physical locations where virtual activities took place. In pervasive AR, property ownership is not clear either. In fact, "places and spaces currently defined by, e.g., streets, buildings, people, and their appearance will suddenly also be affected by the presence and appearance of their virtual counterparts". So, even if the owners possess the physical property, it may not mean they own the virtual place, not having rights when it comes to virtual vandalism. The data obtained from pervasive AR, such as facial expressions or locations, have the potential to be exploited and manipulated, even being used to create unauthorized digital user twins. The pervasiveness of this technology can lead to health issues associated with the long-term effects of AR exposure. Moreover, users can experience changes in their beliefs engendered by the illusions associated with AR. But contrary to traditional AR, this pervasive technology may make it difficult to distinguish illusions from the real world, as the physical interface (the head-worn device) would disappear. As this may be relevant for areas such as therapy or education, it also opens space to manipulate the user. Finally, this emerging technology can exacerbate inequalities.

4.1.11 Big Data

Big data is commonly characterized by the five Vs: volume, velocity, variety, veracity, and variability, to which was recently added visualization (Young et al., 2020).

Chang & Lin (2018) identified ethical issues regarding big data in credit reporting. According to the authors, the quality of the data, especially the presence of errors, will influence the output and have a major impact on people's lives, as it means they may no longer be eligible for credits. Also, due to the lack of transparency of the algorithms responsible for these decisions, the data process cannot be accessed, and the individual does not have ground to question the decisions made. This lack of transparency also affects the data collection, which means the individual cannot question the data accuracy either. The output of the system can be used to target vulnerable individuals as well. Finally, the generalization produced by the algorithms will lead to judgments made about an individual based on group information and inferences, leading to discrimination. In this case, it can even aggravate the wealth gap, as the system can assume an individual cannot pay a credit, not based on their income but on their group's data.

Young et al. (2020) apply to big data the framework proposed by Mason (1986), suggesting the addition of behavioural surveillance, interpretation, and governance to the already identified privacy, accuracy, property, and accessibility ethical issues. Behavioural surveillance derives from the privacy issue and refers to the possibility of surveillance based on the great amount of data collected, which reveals individual activity, such as location. It discusses "behavior that is observed by virtue of active choices made by a user", through a cost-benefit trade-off, "as well as behavior data acquired through passive means of observation and collection". Interpretation originates from the accuracy issue, relating to the bad quality of the data used to train models, resulting in biased on incorrect conclusions: the "garbage in, garbage out" principle. Furthermore, "if algorithms are implemented before independent and comprehensive testing can be conducted, the impact of big data is more likely to result in harmful outcomes, even if the original motivations are well intended". On the other hand, consumers and producers must be aware of the risks of statistical analysis, and make decisions considering other factors, assuring "statistics cannot be any smarter than the people who use them". Finally, governance is influenced by all PAPA's issues and involves "ensuring that necessary controls are in place to handle future ethical challenges". The authors consider self-regulation, carried out by the industry and the companies themselves, and regulation, the responsibility of the governments. Both entities "should play a role in mitigating unethical and illegal behavior".

4.1.12 Ethical Challenges Summary

To sum up, the analysis of all the emerging technologies (IST) resulted in the forty-five ethical challenges identified in Table 1.

Table 1: Ethical challenges of emerging technologies

Accessibility	Discrimination	Lack of informed consent
Accountability	Diversity	Lack of regulation, standards, and forms of certification
Accuracy	Employee replacement	Manipulation
Alignment of AI with human values (and the culture in which it will be implemented)	Environmental sustainability	Ownership
Anonymity	Equality	Power imbalances
Anonymization of data	Ethical collection of the data	Presumptuous aim attributions
Autonomy	Excessive dependence on AI	Privacy
Bias	Explainability	Protect intellectual property
Control	Fairness	Right to information
Data manipulation	Freedom	GDPR
Data protection	Generalization	Security
Data quality	Governance	Self-determination
Data treatment	Inappropriate use of data	Surveillance
Dehumanization of society	Individuality	Transparency
Dignity	Interpretation	Trustworthiness

4.2 Codes of Ethics

This section starts by updating a previous work focused on identifying codes of ethics. This information will be an input to the revision of a Unified Structure of Codes of Ethics.

4.2.1 Identification of Codes

Ribeiro (2020) identified 44 organizations with codes, divided into codes of ethics, professional conduct, and practice. Codes of ethics express the principles that define the moral essence of an organization, while codes of conduct expand the moral principles addressed in a code of ethics. The codes of professional practice are used as a guide to individual decision-making (Ribeiro, 2020). Table 2 presents an updated version of Ribeiro (2020)'s work.

Table 2: Identification of Codes of Ethics, adapted and updated from Ribeiro (2020)

	Organizations/ societies/ associations	Year of the latest version	Type of Code	Was it updated?	Reference
Members of the National Society IFIP	Association for Computing Machinery (ACM)	2018	Code of Ethics and Conduct	No	(Gotterbarn et al., 2018)
	Australian Computer Society (ACS)	2023	Code of professional ethics	Yes	(ACS, 2023)
		2014	Code of professional conduct	No	(ACS, 2014)
	Associazione Italiana per l'Informatica e il Calcolo Automatico (AICA)	2015	Code of ethics	No	(AICA, 2015)
		2015	Code of conduct	No	(AICA, 2015)
	British Computer Society (BCS)	2022	Code of conduct	Yes	(BCS, 2022)
	Canadian Information Processing Society (CIPS)	2022	Code of ethics and professional conduct	Yes	(CIPS, 2022)
		2018	Code of ethics and standards of conduct	No	(CIPS, 2018)
	Computer Society of India (CSI)	ND	Code of ethics	No	(CSI, N.D.)
	Institute of Information Technology Professionals South Africa (IITPSA)	2021	Code of ethics	Yes	(IITPSA, 2022)
		ND	Code of good practice	No	(IITPSA, 2022)
	The Computer Society of Zimbabwe (CSZ)	ND	Code of ethics	No	(CSZ, N.D.)
	Gesellschaft fiir Informatik (GI)	2018	Ethical Guidelines	Yes	(GI, 2018)
	Irish Computer Society (ICS)	ND	Code of Professional Conduct	No	(ICS, N.D.)
	Institute of Electrical and Electronics Professionals (IEEE)	2020	Code of ethics	Yes	(IEEE, 2020)
		2014	Codes of conduct	No	(IEEE, 2014)

	Organizations/ societies/ associations	Year of the latest version	Type of Code	Was it updated?	Reference
	IT Professionals New Zealand (ITPNZ)	2017	Code of ethics	No	(ITP, 2017)
	Singapore Computer Society (SCS)	ND	Code of conduct	No	(SCS, N.D.)
	Sociedade Brasileira de Computação (SBC)	2013	Code of ethics	No	(SBC, 2013)
	Finnish Information Processing Association (TIVIA)	2014	Code of ethics	No	(TIVIA, 2014)
	Information Processing Society of Japan (IPSJ)	2022	Code of ethics	Yes	(IPSJ, 2022)
	Ordem dos Engenheiros (OE)	2016	Code of ethics and deontology	Yes	(OE, 2016)
	Computer Society of Sri Lanka (CSSL)	ND	Code of conduct	No	(CSSL, N.D.)
		ND	Code of ethics	No	(CSSL, N.D.)
	Schweizer Informatik Gesellschaft SI (SIGSI)	2019	Code of ethics	No	(SIGSI, 2019)
Other Societies at the Continental level	Council of European Professional Informatics Societies (CEPIS)	-	-	-	-
	South East Asia Regional Computer Confederation (SEARCC)	1993	Code of ethics	No	(SEARCC, 1993)
Other Societies	Slovensko društvo Informatika (SDI)	-	-	-	-
	American Society for Information Science (ASIS)	ND	Code of ethics	No	(ASIS, N.D.)
	Association of Independent Information Professionals (AIIP)	2002	Code of ethics	No	(AIIP, 2002)
	Association of Software Professionals (ASP)	-	-	-	-

Organizations/ societies/ associations	Year of the latest version	Type of Code	Was it updated?	Reference
Building Industry Consulting Service International (BICSI)	ND	Code of Ethics and Professional Obligations	No	(BICSI, N.D.)
Geospatial Information & Technology Association (GITA)	2009	Code of ethics	No	(GITA, 2009)
Information Systems Security Association (ISSA)	2007	Code of ethics	No	(ISSA, 2007)
International Web Association (IWA)	ND	Code of ethics	No	(IWA, N.D.)
Network Professional Association (NPA)	2007	Code of ethics	No	(NPA, 2007)
Colegio de Profesionales en Informática y Computacion (CPIC)	2013	Code of ethics	No	(CPIC, 2013)
Hong Kong Computer Society (HKCS)	-	-	-	-
Institute for Certification of Computing (ICCP)	ND	Code of ethics and conduct	No	(ICCP, N.D.)
	ND	Code of ethics	No	(ICCP, N.D.)
Institute for the Management of Information Systems (IMIS)	ND	Fundamental principles	No	(IMIS, N.D.)
Software Engineering Ethics and Professional Practices (SEEPP)	1999	Code of ethics and professional practice	No	(SEEPP, 1999)
Association Of Information Technology Professionals (AITP)[1]	ND	Code of ethics	Yes	(AITP, N.D.-a)
	ND	Standard of conduct	Yes	(AITP, N.D.-b)

[1] In 1997, its designation evolved from Data Processing Management Association (DPMA) to Association of Information Technology Professionals (AITP).

	Organizations/ societies/ associations	Year of the latest version	Type of Code	Was it updated?	Reference
	Information Technology Association of America (ITAA)	2014	Code of ethical conduct and ethics procedures manual	Yes	(ITAA, 2014)
	Colegio de Ingenieros del Perú (CIP)	2018	Code of ethics	Yes	(CIP, 2018)
	Association Information Systems (AIS)	2019	Code of ethics and professional conduct	Yes	(AIS, 2019)
	Computer Professionals for Social Responsibility (CPSR)	-	-	-	-
	Information Processing Professionals Association of Korea (IPAK)	-	-	-	-
	Japan Information Service Industry Association (JISA)	-	-	-	-
	Vereniging van Registerinformatici (VRI)	-	-	-	-
	Centro de la Informatica, Telematica y Medios Afines (CITEMA)	-	-	-	-

For some organizations, like Information Processing Professionals Association of Korea, Hong Kong Computer Society, Council of European Professional Informatics Societies, Association of Software Professionals, Computer Professionals for Social Responsibility, and Centro de la Informatica, Telematica y Medios Afines, no code was found. For others, such as Japan Information Service Industry Association, Vereniging van Registerinformatici, and Slovensko društvo Informatika, it was not possible to accurately verify the year of publication of the code because of the language in which the codes were written.

Therefore, it was not possible to analyse its contents in detail to look for contributions to the reviewed Unified Structure of Codes of Ethics and Conduct.

4.2.2 Revision of the Unified Structure of Codes of Ethics and Conduct

Ribeiro (2020) proposed a Unified Structure of Codes of Ethics and Conduct resulting from an analysis of a compilation of codes from 44 organizations and their conducts. Since then, thirteen codes have been updated, making it necessary to revise this structure in order to contemplate the new norms.

Hence, based on the updated codes identified in Table 2, additions are suggested to the Unified Structure (Ribeiro, 2020), maintaining the same organization into six sections: Preamble, Definitions, General Principles, Professional Responsibilities, Professional Leadership Principles, and Code Compliance.

Figures 3, 4 and 5 present this new structure, emphasizing the newly added conducts, presented with a thicker edge.

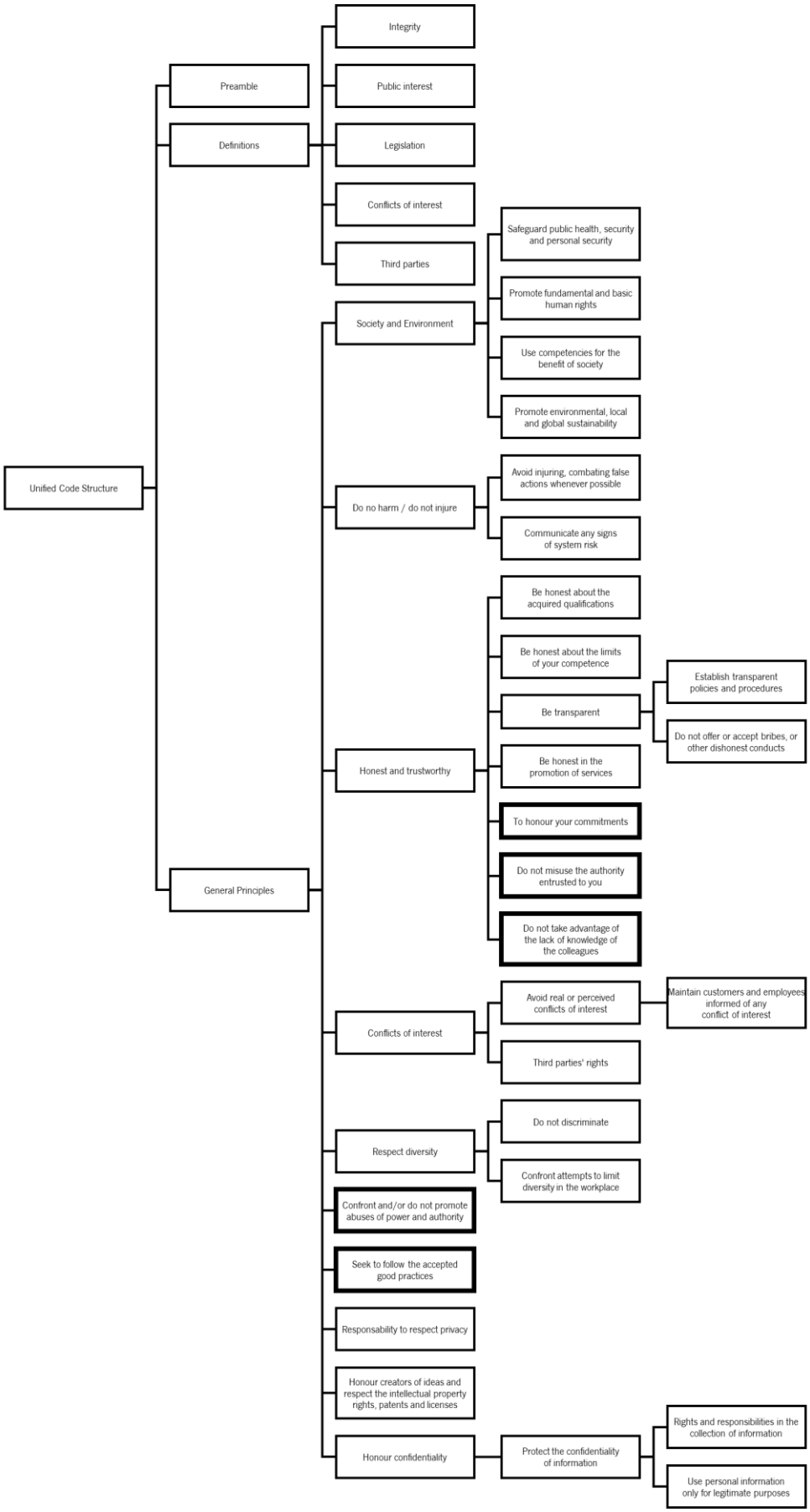


Figure 3: Reviewed Unified Structure of Codes of Ethics and Conduct (part 1)



Figure 4: Reviewed Unified Structure of Codes of Ethics and Conduct (part 2)



Figure 5: Reviewed Unified Structure of Codes of Ethics and Conduct (part 3)

4.2.3 Unified Structure of Codes of Ethics and Conduct and the ethical challenges representation

In this section, the Unified Structure was analysed to understand how codes of ethics answer the ethical challenges discussed in the literature. In section 4.1 were identified forty-five ethical challenges raised by emerging technologies. From these, eighteen were mentioned in the conducts of the Unified Structure. Table 3 presents the coverage of ethical challenges by the unified structure.

Table 3: Representation of the identified ethical challenges on the Unified Structure of Codes of Ethics

Challenge	Is it covered by the Unified Structure?	Section of Unified Structure
Accessibility	No	-
Accountability	Yes	Professional responsibilities \ Responsibility \ Accept professional responsibility for their work; Professional Leadership Principles \ To be accountable for the work of the ones under supervision
Accuracy	Yes	General Principles \ Honour confidentiality \ Protect the confidentiality of information \ Rights and responsibilities in the collection of information
Alignment of AI with human values (and the culture in which it will be implemented)	No	-
Anonymity	No	-
Anonymization of data	No	-
Autonomy	No	-
Bias	Yes	General Principles \ Respect diversity \ Do not discriminate
Control	No	-
Data manipulation	No	-
Data protection	No	-
Data quality	Yes	General Principles \ Honour confidentiality \ Protect the confidentiality of information \ Rights and responsibilities in the collection of information
Data treatment	No	-
Dehumanization of society	Yes	Professional Leadership Principles \ Responsibilities with the systems \ Control the level of integration of systems into society's infrastructure
Dignity	Yes	General Principles \ Society and environment \ Promote fundamental and basic human rights

Challenge	Is it covered by the Unified Structure?	Section of Unified Structure
Discrimination	Yes	General Principles \ Respect diversity \ Do not discriminate
Diversity	Yes	General Principles \ Respect diversity
Employee replacement	No	-
Environmental sustainability	Yes	General Principles \ Society and environment \ Promote environmental, local and global sustainability
Equality	Yes	General Principles \ Respect diversity
Ethical collection of the data	Yes	General Principles \ Honour confidentiality \ Protect the confidentiality of information \ Rights and responsibilities in the collection of information
Excessive dependence on AI	No	-
Explainability	No	-
Fairness	No	-
Freedom	No	-
Generalization	No	-
Governance	No	-
Inappropriate use of data	Yes	Professional Responsibilities \ Robust security \ Restrain system and data access \ Do not access the system or someone else's data
Individuality	No	-
Interpretation	No	-
Lack of informed consent	No	-
Lack of regulation, standards and forms of certification	No	-
Manipulation	No	-
Ownership	No	-
Power imbalances	No	-
Presumptuous aim attributions	No	-
Privacy	Yes	General Principles \ Responsibility to respect privacy; General Principles \ Honour confidentiality \ Protect the confidentiality of information

Challenge	Is it covered by the Unified Structure?	Section of Unified Structure
Protect intellectual property	Yes	General Principles \ Honour creators of ideas and respect intellectual property rights, patents and licenses
Right to information	No	-
GDPR	Yes	Professional Responsibilities \ Respect the laws and regulations of the organization
Security	Yes	Professional Responsibilities \ Robust security \ Restrain system and data access \ Do not access the system or someone else's data
Self-determination	No	-
Surveillance	No	-
Transparency	Yes	General Principles \ Honest and trustworthy \ Be transparent \ Establish transparent policies and procedures
Trustworthiness	Yes	General Principles \ Honest and trustworthy

4.3 Scientific Literature Focused on Codes of Ethics

In this section, the literature focused on codes of ethics is presented, divided into the main themes identified: Codes of Ethics Comparison and Influence of Codes of Ethics on IST Professionals.

4.3.1 Codes of Ethics Comparison

Ribeiro & Varajão (2022), following the same methodology adopted by Oz (1992), analysed and compared the latest versions of ACM, CIPS and BCS' codes of ethics, aiming to identify changes made to these codes since Oz's (1992) work publication and reflect if the author's recommendations "are reflected in the current versions of the codes". This way, the characteristics of the mentioned professional ethical codes were grouped by obligation (to society, employer, clients, colleagues, organization and profession) and followed by the actual comparison between the principles of each code. Juxtaposing the results obtained 30 years ago and the more recent ones exposed in Ribeiro & Varajão (2022) work, it is possible to conclude that changes in the structure and content of the codes were made and overall, "the

current codes are more detailed and include a higher number of conducts, which is reflected in the length of the documents", indicating the "growing concern and awareness regarding IS professionals' expected behavior". Nevertheless, the authors argue there is still room for improvement, and there is still a need for a "shared and coherent" code of ethics (i.e., the codes from now on being based on a common set of standards of ethical conduct, but not implying that a "single and universal" code has to be created), which can be followed by all IS professionals.

Payne & Landry's (2006) work focuses on suggesting a unified code of ethics that suits both business and IT. According to the authors, "technology infusion into business" and "business and IT ethics are similar enough to be used to develop a uniform code of ethics for both business and IT professionals", so the suggestion of a unified code of ethics would ensure their approaches to a problem were similar. The authors base this premise on two frameworks of business ethics: the Kantian analysis and the one formulated by Raiborn & Payne (1990). These works resulted in principles of consistency, respect for individuals, autonomy, integrity, justice, utility, and competence. These were grouped and matched with the comparison between IT professional's codes of ethics (namely codes proposed by ICCP, ACM and AITP) made by Oz (1993). This way, a unified code was proposed, composed of three principles: "Treat constituents fairly with uniformity in consistent situations, regarding safety, knowledge and good faith. Assure freedom of choice by providing information that is accurate, relevant and complete to all appropriate stakeholders"; "Use good faith in decision making and assessment activities" and "Assess utility and competence of project and self in light of the social and individual needs and abilities of stakeholders and society".

Oz (1992), as cited in Phukan (1995), stated that the five codes of ethics analysed lacked guidelines for prioritizing ethical conflicts, concluding that a "unified code would better serve IS professionals and would enhance public perception of the profession".

Pye & Warren (2006)'s study aims to compare the key principles of the 2003 version of Australian Computer Society (ACS) Code of Ethics and the Australian Standard for ICT Governance, through the analysis of both documents. The conclusion is that they differ on purpose, tone and approach to ethical issues, being the Standard for ICT Governance more prone to raise ethical dilemmas, as it is ethically vague. The ACS Code of Ethics is composed of 10 principles that should be followed by all of the ACS members. The authors state that the code "delivers ethical suggestions that are directly focused on empowering the individual with ethical advice to enable an IT professional to decide upon the appropriate professional behavior in the particular ethical situation". This way, the code offers guidance on how to approach ethical dilemmas, but it is not a step-by-step methodology on what to do. It "promotes a bottom-

up style of management that encourages the IT professional to drive ethical behavior for themselves, their colleagues and perhaps ultimately the ethical behavior of the business organization".

Bowern et al. (2006) discuss the need for a new version of the 2005 one of the ACS Code of Ethics to follow the evolution of ICT profession. The authors identify two types of codes: codes of conduct ("'how the person to whom it applies conducts him [sic] or herself in an ethical manner") and codes of practice ("how the person to whom it applies carries out his or her work technically"). They take the lessons learned from the evolution of ACM/ IEEE's code SECEPP (Software Engineering Code of Ethics and Professional Practice) as a starting point. The creation of this code was motivated by the need to document the professional responsibilities of software engineers. It faced two problems in achieving the goal of using the code to "educate practitioners and the public; and to facilitate ethical decision making in accordance with these responsibilities", as it is important to develop codes that are not so specific, with a definition of all of the ethical behaviour of a professional, they will be obsolete by the time they are approved, or so general they lack guidance for being too abstract.

The ACS Code of Ethics is divided into two sections: the first includes a policy statement and a declaration of six values and ideals; the second section explores these values through a detailed set of 37 statements (the standards of conduct). Complementary to the code of ethics there is the Code of Professional Conduct and Professional Practice, created to "provide more practical guidance in the day-to-day activities of ICT professionals". An ACS report identified a set of changes suggested to their code of ethics: "The meaning and use of the Code needs to be clarified, to explain exactly what role the Code does, and should play, as a way to provide guidance and education; The role and activities of the Disciplinary Committee in the ACS should be reviewed and amended, if required; Consideration is required as to whether the Code should take into account the fact that ACS members come from different cultural backgrounds, and that they may interpret some of the clauses in different ways; The code should be consistent with international standards since, although the software is developed or designed in Australia, it has international consequences; An editing process to resolve these existing issues should be established, ensuring that the Code is maintained to reflect the changing nature of the ICT industry''. ACS' Committee on Computer Ethics identified some other issues on the present code, such as "Unlike some other codes around the world, the ACS code has no system of prioritisation, for the inevitable situations of conflict between clauses in the code" and "The power of sanction (disciplinary committee) relationship to the code is poorly defined."

Wheeler (2003) compared the ACM, ACS, and British Computer Society (BCS) codes of ethics. The author highlights that the codes do not offer guidelines on the acknowledgment of the existence of

unforeseen ethical dilemmas, instead acting as assistance when a dilemma is identified by a professional. The ACM code of ethics suggests "questions related to ethical conflicts can best be answered by thoughtful consideration of fundamental principles, rather than reliance on detailed regulations", while ACS, on their Standard of Conduct, indicates that "on these occasions, the member must weigh up the relevant factors and choose to act in the manner which is most consistent with the Code of Ethics, given the circumstances". BCS code of conduct proposes that each member decide based on their personal judgment while considering the code requirements. It is concluded that a section on whistleblowing is only presented in the ACM code and that none of the three address the potential issue of an international conflict of interest.

4.3.2 Influence of Codes of Ethics on IST Professionals

Harrington (1996) looked for an understanding of the influence of codes of ethics on computer abuse intention. The author divided her research into generic company codes and IS-specific codes of ethics. The latter "provides guidelines for judgments about appropriate behavior in technology use", which are not clear on the generic company codes, resulting in difficulties for the IS professional to relate to generic guidelines and to apply them to specific situations such as computer abuse. The study concluded that IS-specific codes of ethics directly affect the judgment and intention of performing computer abuse activities.

Pierce & Henry (1996) state that ethical decisions are influenced by "the individual's own personal code, any informal code of ethical behavior that exists in the workplace, and exposure to formal codes of ethics" and aim to understand the importance of these codes on organizational contexts. The results indicate that a formal company code of computer ethics impacts decision-making. The authors defend that "formal codes should be developed by practicing professionals [and] then submitted to legal counsel rather than the reverse", to ensure that the content of the code suits the IS profession and is easily understood. In particular, "computer ethics codes should contain a discernible philosophic direction, be substantial enough in detail to be used as a framework to guide ethical conduct, and contain specific topics of concern". The informal code must be communicated to all employees and should be constantly evaluated to ensure it remains up to date. The individual's personal code is not easily affected by the business setting but rather influenced by "ethics study, professional codes, and law". This way, companies can positively influence personal codes of ethics through "company-sponsored professional memberships and training on new computer law provisions which impact the jobs of employees".

5. DISCUSSION

This chapter analyses the results and suggests avenues for development and research.

5.1 Identified Challenges

The systematic literature review identified a set of forty-five ethical challenges related to eleven emerging technologies. The codes of ethics, based on the updated version of the Unified Structure of Codes of Ethics proposed by Ribeiro (2020), were analysed to understand the coverage of these challenges. Table 4 depicts the relationships between these topics.

Table 4: Relationship between emerging technologies, ethical challenges, and codes of ethics coverage

	Artificial Intelligence	Machine Learning	Conversational Agents	Blockchain	Self-driving Cars	Industry 4.0	Internet of Things	Smart Homes	Wearable Devices	Augmented Reality	Big Data	Unified Structure of Codes of Ethics and Conduct Section
Accessibility											x	-
Accountability	x		x		x		x					Professional responsibilities \ Responsibility \ Accept professional responsibility for their work; Professional Leadership Principles \ To be accountable for the work of the ones under supervision
Accuracy	x			x							x	General Principles \ Honour confidentiality \ Protect the confidentiality of information \ Rights and responsibilities in the collection of information
Alignment of AI with human values (and the culture in which it will be implemented)	x											-
Anonymity	x											-
Anonymization of data	x											-
Autonomy	x							x				-
Bias	x	x	x									General Principles \ Respect diversity \ Do not discriminate
Control								x				-

	Artificial Intelligence	Machine Learning	Conversational Agents	Blockchain	Self-driving Cars	Industry 4.0	Internet of Things	Smart Homes	Wearable Devices	Augmented Reality	Big Data	Unified Structure of Codes of Ethics and Conduct Section
Data manipulation					x							-
Data protection								x				-
Data quality	x			x							x	General Principles \ Honour confidentiality \ Protect the confidentiality of information \ Rights and responsibilities in the collection of information
Data treatment	x											-
Dehumanization of society	x											Professional Leadership Principles \ Responsibilities with the systems \ Control the level of integration of systems into society's infrastructure
Dignity	x	x						x				General Principles \ Society and environment \ Promote fundamental and basic human rights
Discrimination	x	x									x	General Principles \ Respect diversity \ Do not discriminate
Diversity	x											General Principles \ Respect diversity
Employee layoff/ replacement	x					x						-
Environmental sustainability				x								General Principles \ Society and environment \ Promote environmental, local and global sustainability
Equality	x			x				x		x		General Principles \ Respect diversity
Ethical collection of the data	x											General Principles \ Honour confidentiality \ Protect the confidentiality of information \ Rights and responsibilities in the collection of information
Excessive dependence on AI	x							x				-
Explainability	x											-
Fairness	x	x	x									-
Freedom	x											-
Generalization	x	x										-
Governance											x	-

	Artificial Intelligence	Machine Learning	Conversational Agents	Blockchain	Self-driving Cars	Industry 4.0	Internet of Things	Smart Homes	Wearable Devices	Augmented Reality	Big Data	Unified Structure of Codes of Ethics and Conduct Section
Inappropriate use of data	x				x				x	x		Professional Responsibilities \ Robust security \ Restrain system and data access \ Do not access the system or someone else's data
Individuality	x											-
Interpretation											x	-
Lack of informed consent	x				x			x	x	x		-
Lack of regulation, standards and forms of certification						x						-
Manipulation										x		-
Ownership										x		-
Power imbalances	x		x					x			x	-
Presumptuous aim attributions	x											-
Privacy	x	x	x	x		x	x	x	x	x	x	General Principles \ Responsibility to respect privacy; General Principles \ Honour confidentiality \ Protect the confidentiality of information
Protect intellectual property						x					x	General Principles \ Honour creators of ideas and respect intellectual property rights, patents and licenses
Right to information	x											-
Gdpr				x								Professional Responsibilities \ Respect the laws and regulations of the organization
Security	x				x	x	x	x	x			Professional Responsibilities \ Robust security \ Restrain system and data access \ Do not access the system or someone else's data
Self-determination	x	x						x				-
Surveillance	x					x		x			x	-

	Artificial Intelligence	Machine Learning	Conversational Agents	Blockchain	Self-driving Cars	Industry 4.0	Internet of Things	Smart Homes	Wearable Devices	Augmented Reality	Big Data	Unified Structure of Codes of Ethics and Conduct Section
Transparency	x	x	x		x		x	x			x	General Principles \ Honest and trustworthy \ Be transparent \ Establish transparent policies and procedures
Trustworthiness	x	x	x			x		x				General Principles \ Honest and trustworthy

As depicted in Figure 6, privacy is the ethical issue more often related to emerging technologies, being stated on ten of those, followed by transparency (seven times) and the lack of informed consent, security, and accountability (five times each).

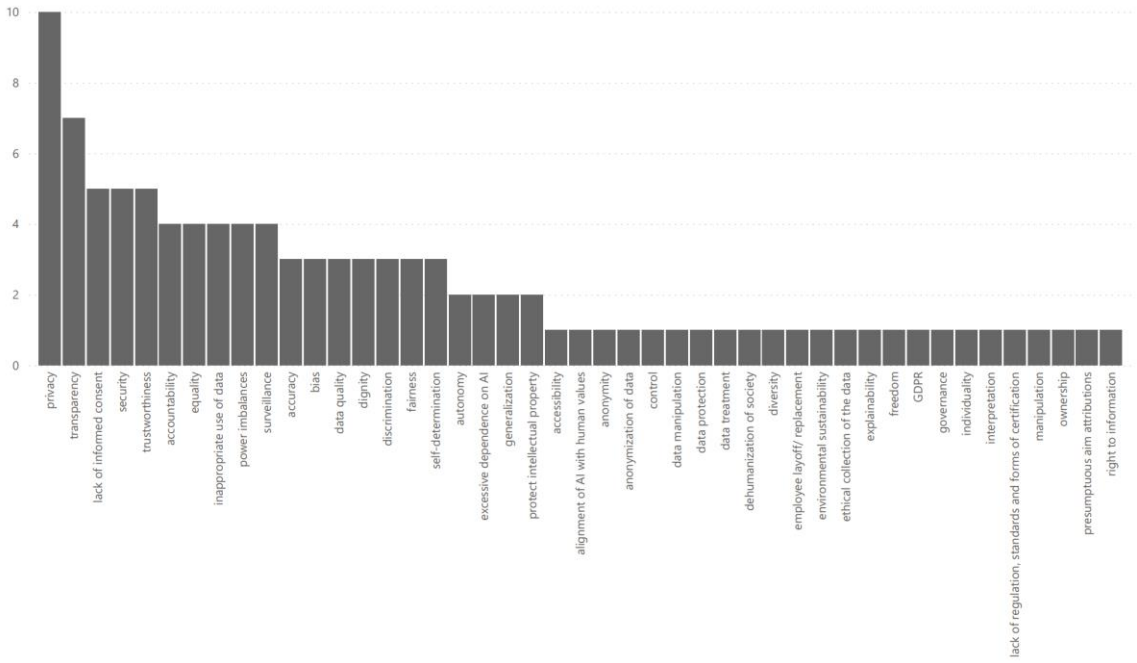


Figure 6: Frequency of ethical issues by the considered emerging technologies

Figure 7 shows that artificial intelligence is the technology with the highest number of ethical issues, thirty-three, possibly justified by the attention drawn to it in the literature due to its pervasiveness. It is followed by smart homes (fourteen) and big data (eleven).

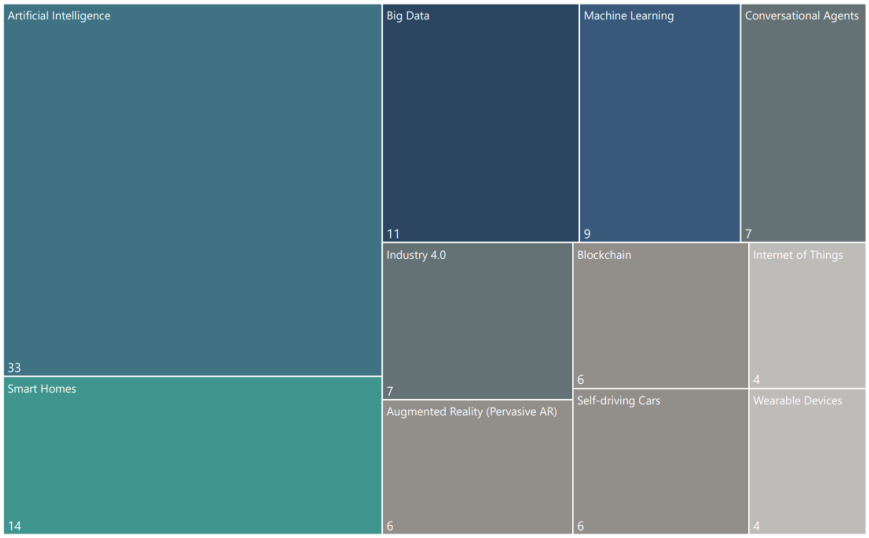


Figure 7: Number of ethical challenges per technology

From the articles included in the literature review, privacy remains the most quoted ethical challenge being mentioned in twenty-two articles as Figure 8 shows, followed by bias (fifteen times) and transparency (twelve times).

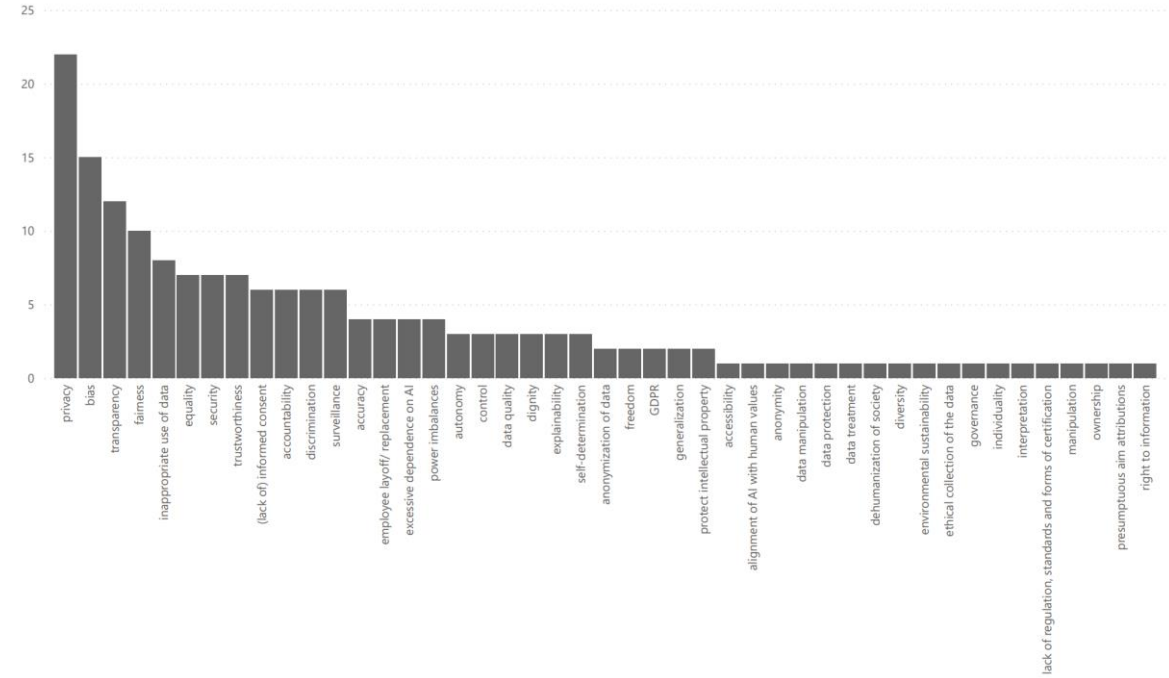


Figure 8: Frequency of ethical issues as reported in the reviewed literature

The presented results are meant to fill the gap in the knowledge regarding the identification of ethical issues in emerging technologies since little literature on this topic was found.

In the literature, Stahl (2011) categorized the ethical issues of eleven emerging ICTs – affective computing, ambient intelligence, artificial intelligence, bioelectronics, cloud computing, future internet, human-machine symbiosis, neuroelectronics, quantum computing, robotics and virtual/augmented

reality – resulting in fifty-two ethical issues. Both works have similar ethical issues identified from the two emerging technologies in common. In the case of AI, the author identified four ethical issues: conceptions of AI, underestimation of the consequences of AI, human replacement and gender biases. The last two were also identified in the literature review, even if here bias was broadly used to include data, algorithmic and gender bias. Regarding VR/AR, the author identified the blurring of the real and virtual as an ethical issue. This is related to the manipulation concern identified previously, as the manipulation can only occur when the individual is not able to distinguish what is real from what is not. There are other common ethical issues in this author's work, such as surveillance, privacy, security, autonomy and environment/sustainability, but it lacks the reference to which technology these challenges are related or if those are common to all the emerging ICTs covered by the article.

Mason's (1986) identification of the four ethical challenges of the information age remains current, as they were associated with the emerging technologies studied. Privacy is a transversal ethical challenge to most emerging technologies, being the most quoted issue in the literature. In AI, blockchain and big data, accuracy was stated as a concern. Property, here encapsulated in the protect intellectual property issue, was identified in industry 4.0 and big data, while accuracy was only discussed in big data.

To "spice up" the study, ChatGPT was used to compare the literature review results with an AI tool results. ChatGPT is an AI-powered tool that allows anyone to interact with the system through a conversation. According to this research, two of the challenges related to AI are employee replacement (Paul et al. (2022) and Zhang & Gao (2019)) and excessive dependence on AI (Zhang & Gao (2019), Maedche et al. (2019) and Ryan et al. (2021)). With these concerns in mind, the first research question, "What are the current ethical challenges in emerging technologies (IST)?" was asked to this platform, requesting a detailed answer. The results can be found in Appendix I. These included ethical challenges for ten technologies: biotechnology and genetic engineering, internet of things, virtual reality and augmented reality, self-driving cars, blockchain and cryptocurrencies, quantum computing, brain-computer interfaces, synthetic biology, big data analytics, big data analytics and social media and algorithmic content curation. From this list, five technologies are common to this research (with the difference that chatGPT presented results to big data analytics, a sub-area of big data).

Comparing the results obtained from chatGPT and the systematic literature review (SLR) in Table 5, chatGPT brought some new challenges to three of these technologies but did not refer most of the challenges identified. Nevertheless, in virtual/augmented reality chatGPT mentioned data privacy, specifying the privacy concern identified in the literature; it also identified challenges of the impact this technology has in user perception, which is an issue from which the manipulation concern derives since

an individual is more easily manipulated when lacks the capability to distinguish between the real and virtual. Regarding self-driving cars, chatGPT referred to the liability it has in accidents, which is related to the accountability challenge identified.

That being said, even though chatGPT is a valuable instrument for other purposes, an AI tool could not have replaced the work accomplished in this specific case. However, its ease of use, and readiness for results could provoke a level of dependency on the tool, apart from the fact there is no assurance the results are accurate (in fact, one of the most recent versions was found to create fake references (Hillier, 2023)) or reliable, among the other ethical issues inherited from AI.

Table 5: Comparison between results obtained from chatGPT and our Systematic Literature Review (SLR)

Challenge \ Technology	IoT	VR/AR	Self-driving Cars	Blockchain	Big Data Analytics
Accessibility					SLR
Accountability	SLR		chatGPT SLR		
Accuracy				SLR	SLR
Addiction		chatGPT			
Bias					chatGPT
Data governance	chatGPT				
Data manipulation			SLR		
Data quality				SLR	SLR
Discrimination					chatGPT SLR
Environmental sustainability				SLR	
Equality		SLR			
Ethical collection of the data				SLR	
GDPR				SLR	
Governance					SLR
Inappropriate use of data		SLR	SLR		
Informed consent		chatGPT SLR	SLR		chatGPT
Interpretation					SLR

Challenge \ Technology	IoT	VR/AR	Self-driving Cars	Blockchain	Big Data Analytics
Job displacement			chatGPT		
Manipulation		SLR			
Ownership		SLR			
Power imbalances					SLR
Privacy	chatGPT SLR	chatGPT SLR		SLR	chatGPT SLR
Protect intellectual property					SLR
Security	chatGPT SLR		SLR	chatGPT	
Surveillance					SLR
Transparency	SLR		SLR	chatGPT	SLR
User perception		chatGPT			

Overall, the results showed AI as the technology with the most ethical challenges, which aligns with the increasing concern with this technology, reflected in the creation of guidelines and laws to regulate these systems. The European Commission developed the Ethics Guidelines for Trustworthy AI (EC, 2019), which aims to provide guidance through a set of ethical principles that state AI systems must be developed, deployed, and used "in a way that adheres to the ethical principles of: respect for human autonomy, prevention of harm, fairness and explicability" while meeting the requirements for trustworthy AI of "(1) human agency and oversight, (2) technical robustness and safety, (3) privacy and data governance, (4) transparency, (5) diversity, non-discrimination and fairness, (6) environmental and societal well-being and (7) accountability". Though this document offers guidelines on developing, deploying and using AI, these do not constitute European legislation. For that was created The European Union AI Act (EU, 2021), a regulatory framework that aims to ensure the compatibility of AI systems with fundamental rights. It classifies AI systems into four categories: minimal or no risk, AI with specific transparency obligations, high risk and unacceptable risk. Minimal or no-risk applications do not have mandatory obligations, though the European Commission suggests developing and voluntarily following "codes of conduct for AI with specific transparency requirements". AI with specific transparency obligations must notify the user that a technology is being used, for example, that they are interacting with an AI system or that emotional or biometric categorizations are being used. High-risk systems, such as the ones used in the recruitment and selection of employees, are only permitted if they comply with

the AI requirements, while unacceptable risk systems, such as social scoring, e.g., identification of at-risk children based on irrelevant parental misbehaviour, such as missing a doctor's appointment, are prohibited.

Awareness of such challenges in technologies used in most daily activities is crucial to developing new strategies to deal with those concerns and bringing awareness to society.

5.2 Codes of Ethics Coverage

The results showed that the literature on codes of ethics is only concerned with comparing codes and exploring their influence on IST professionals' behaviour, with no work found regarding ethical challenges coverage on codes of ethics.

An attempt to fill this gap in the knowledge was made by looking for the representation of the identified challenges in the Unified Structure of Codes of Ethics. The codes covered eighteen of these challenges, although some of them, such as bias, data quality, and transparency, are not as explicit as they should be.

That being said, IST professionals must be accountable for their work, as well as for the systems' outputs, and they shall ensure data quality and accuracy. The bias challenge can be considered as part of the do not discriminate conduct, although it should be specified in the codes of ethics. It should be clear the decisions made by the systems must not be based on bias and partiality, under the risk of discriminating against individuals by their gender, ethnicity or socioeconomic status, being the IST professional responsible for assuring that the data, models and individuals involved in the process are aware of their own bias in order to develop systems which do not reflect their personal beliefs. The inappropriate use of data challenge is implied in the Professional Responsibilities section on the "do not access the system or someone else's data" conduct. Still, this challenge also refers to the improper use of data without explicit user consent, as it happens with the selling of data to third parties. Furthermore, the IST professional and the artifacts they create must be transparent. This way, they must be aware of the challenges imposed by black-box systems and technologies where they cannot explain the reasoning behind a decision.

From the discussed results, one can conclude there is a need for reflection on measures to deal with the ethical challenges. The awareness of these challenges must start with the professional codes of ethics since these are meant to guide the ethical behaviour of IST professionals (Udas et al., 1996). Thus, the identified concerns should be reflected in their guidelines, as well as considered the possibility of

regulating the IST-related professions, as it happens to law or medicine with their own general code, since that is the current reality. Both professions follow their exercise by an accepted general code, and all of the professionals belong to the same professional organization, which does not happen in the IST community, allowing "a large proportion of IT users to never be exposed to any code of conduct" (Phukan, 1995). Even though this would be an ideal situation, a more accessible approach would be to include a reference to these challenges in the existing codes.

5.3 Avenues for Development and Research

The discussion of results opens space for reflection on what should be further investigated regarding IST ethics. This section will detail some orientations for future research and development.

First of all, it is suggested an in-depth study of the ethical challenges raised by each new emerging technology not addressed in this study. From the identified ethical challenges, it is clear that some of them could, and possibly should, be associated with other technologies. For example, some ethical challenges pointed out by chatGPT as raised by a certain technology, such as job displacement in self-driving cars, were not found in the literature. Besides, research focused on specific technologies should be conducted to improve the understanding of the challenges raised. In this case, it is crucial to choose the emerging technologies wisely, based on either other research works or, for example, the Hype Cycle for Emerging Technologies proposed by Gartner, which indicates the technologies "expected to greatly impact business and society over the next two to 10 years" (Gartner, 2022).

Based on the findings of this research, the codes of ethics should be revised and updated to include these new ethical challenges, specifying them in new conducts. These should remain general enough to be applied to any situation but sufficiently specific to not cause doubts or raise ambiguity when an individual needs to follow them.

Finally, it is recommended to study the understanding of ethical issues by the different actors in IST area, from students and professors, to professionals and organizations, not only to understand the awareness that professionals, students, teachers and even organizations have on this matter but also to have information to raise awareness on ethical challenges. Various authors in the literature have studied the possibility of including ethics in software engineering programs or the creation of complementary ethics courses, but no research was done on the inclusion of ethical challenges awareness in particular. Focusing on organizations, it would be interesting to investigate whether or not ethics are taken seriously on the project lifecycle: if it is part of the project during all its process or if it is only brought up as a

reactionary measure once it is completed. Part of this discussion can lead to the suggestion of the creation of conducts on the codes of ethics oriented to enterprises, so that the codes can be disseminated to their employees, since what happens now is that only organizations like ACM share their codes with their affiliates.

Table 6 presents a set of suggested research questions divided into three areas.

Table 6: Avenues and questions for future research

Area	Possible topic	Possible research questions
Ethical challenges	In-depth study of the ethical challenges raised by each emerging technology	What are the ethical challenges of new emerging technologies?
		Which emerging technologies raise ethical privacy questions?
		Which emerging technologies raise transparency ethical questions?
		Which emerging technologies raise bias ethical questions?
		Which emerging technologies raise consent ethical questions?
		Are there common ethical challenges to all emerging technologies?
Ethical challenges awareness	Understanding of the ethical challenges by the individuals (IST teachers, students and professionals)	Are the professors and students of IST aware of the ethical challenges raised by emerging technologies?
		Are the professors and students of IST aware of the support codes of ethics can provide in situations where ethical challenges occur?
		Are IST professionals aware of the ethical challenges raised by emerging technologies?
		Are the IST professionals aware of what support codes of ethics can provide when ethical challenges occur?
	Understanding of the ethical challenges by the organizations	Are the organization's stakeholders aware of the ethical challenges raised by the emerging technologies used in the enterprise?
		Are the organization's stakeholders aware of the ethical challenges raised by the emerging technologies developed in the enterprise?
		Are there ethical guidelines embedded into the design and development of the systems?
	Raising awareness of ethical challenges	What are the most efficient ways to raise awareness on an academic level?
		What are the most efficient ways to raise awareness on an organizational level?
Codes of ethics revision	Revision of the codes of ethics to include new ethical challenges	Are the codes of ethics capable of answering the ethical challenges of emerging technologies?
		Is there an alignment between the IST professionals' ethical concerns (which are reflected in the codes of ethics) and the research carried out in IST ethics?

6. CONCLUSION

This chapter summarizes the findings of the research presenting the contributions to practice and research, the study's limitations and proposals for future work.

6.1 Contribution to Practice and Research

Although society has contact with technology on a daily basis, there is a lack of research on the ethical challenges related to emerging technologies. This investigation aims to fill a gap in the knowledge by presenting a set of forty-five ethical challenges associated with eleven emerging technologies, through a systematic literature review. Artificial intelligence is the technology with more ethical challenges identified. From those, privacy is the most referred concern in the literature, followed by bias and transparency. Furthermore, in this dissertation, an effort to update a prior unified structure of codes of ethics was made. Thirteen codes were updated, and twenty conducts were added to the structure proposed by Ribeiro (2020).

Based on these findings, a set of research questions were proposed to motivate investigation in IST ethics and, in particular, in the study of ethical challenges raised by specific emerging technologies, on the creation of awareness among individuals connected to IST and organizations to these concerns and to the revision of codes of ethics conducted by the entities which created them, to ensure that the professionals' concern related to ethical challenges are addressed in the codes meant to guide the exercise of their profession.

The resulting knowledge is useful to organizations that aim to take ethics more seriously, either by considering ethical approaches before, during, and after the development of projects or by disseminating codes of ethics among its employees; to entities wishing to update or develop comprehensive codes of ethics and codes of conduct which must include guidelines on how to address ethical challenges, raising awareness on this matter; to all individuals on the IST area, to have the knowledge to critically judge the technologies they are using, from the ones developing it to the academics and students studying it, so that every important actor is able to recognize the importance and implications of ethics.

6.2 Limitations and Future Work

Despite the insights gained from the research, it does have its limitations. In the research process, a choice was made to search for what the literature considered as emerging technologies, only

considering results after 2010 to ensure they remain relevant. In future works, a reference, such as Gartner's Hype Cycle for Emerging Technologies, can be used. Then, the research queries must include the specific name of the technology and not only the general term of emerging technologies, which opens space to the author's interpretation of whether a specific technology should or should not be considered emerging.

Furthermore, future work must assume a more foresight approach to what ethical challenges of emerging technologies could be, similar to the work developed by Regenbrecht et al. (2022) in pervasive augmented reality, a technology that is not currently being considered but which eventually will be, and will likely inherit ethical challenges from the technology it derives from. Such an approach has limitations itself, as it imposes a challenge of exacerbating "the so-called Collingridge dilemma, which states that it is difficult to predict the social consequences of an emerging technology at an early stage of its development when it might be easy to change the trajectory of technology development" (Wakunuma & Stahl, 2014, p. 384). Nevertheless, such risk may be beneficial, as these predictions may assist in the comprehension and creation of guidelines and regulations for the technology at an earlier stage since "by the time the social consequences become clearer, the technology may be well established and difficult to change" (Wakunuma & Stahl, 2014, p. 384). Hereupon, subsequent research should have a more proactive take on assuring ethics have a greater place in the systems development and, consequently, in people's lives.

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APPENDIX I

User

What are the current ethical challenges in emerging IST? Present a detailed answer.

ChatGPT

Emerging Information Science and Technology (IST) fields bring forth unique ethical challenges due to their novel and evolving nature. Here are some detailed explanations of the current ethical challenges in emerging IST:

1. Biotechnology and genetic engineering: The rapid advancements in biotechnology, including genetic engineering and gene editing, raise ethical concerns regarding the manipulation of life forms, potential misuse, and unintended consequences. Questions arise around issues such as genetic privacy, equitable access to genetic therapies, and the ethical boundaries of altering the human genome.

2. Internet of Things (IoT): The proliferation of interconnected devices in the IoT raises ethical challenges related to privacy, security, and data governance. Ensuring the protection of personal data, addressing surveillance risks, and preventing unauthorized access to IoT devices are critical considerations.

3. Virtual Reality (VR) and Augmented Reality (AR): VR and AR technologies present ethical challenges regarding their impact on user perception, psychological well-being, and potential addiction. Ensuring responsible and ethical content creation, addressing issues of consent and data privacy, and minimizing negative psychological effects are important considerations.

4. Autonomous vehicles: The development of autonomous vehicles poses ethical dilemmas, including questions about liability in accidents, decision-making in life-threatening situations, and the overall impact on transportation systems and job displacement. Balancing safety, ethical decision-making algorithms, and societal acceptance is crucial.

5. Blockchain and cryptocurrencies: The decentralized nature of blockchain technology raises ethical challenges related to the security, transparency, and legality of cryptocurrency transactions. Addressing issues of money laundering, fraud, and ensuring fair distribution of wealth are important ethical considerations in this emerging field.

6. Quantum computing: The advent of quantum computing brings forth ethical challenges concerning encryption and data security. The potential for breaking current cryptographic systems raises concerns about privacy, confidentiality, and the integrity of sensitive information.

7. Brain-computer interfaces (BCIs): BCIs enable direct communication between the brain and computer systems, raising ethical concerns related to privacy, consent, and potential invasions of cognitive autonomy. Safeguarding brain data, ensuring informed consent, and preventing unauthorized access to neural information are important ethical considerations.

8. Synthetic biology: The field of synthetic biology involves the design and construction of new biological systems, raising ethical questions about the creation of artificial life, potential ecological impacts, and biosecurity risks. Ensuring responsible research practices, risk assessments, and the ethical implications of manipulating living organisms are important considerations.

9. Big data analytics: The ethical challenges surrounding big data analytics include issues of privacy, consent, and potential discrimination. Ensuring transparency in data collection, minimizing biases, and protecting individuals' rights while utilizing large-scale datasets are important ethical considerations.

10. Social media and algorithmic content curation: Ethical challenges arise in social media platforms regarding algorithmic content curation, personalized recommendations, and the spread of misinformation. Ensuring fairness, transparency, and user autonomy while mitigating the negative impacts of algorithmic amplification pose ongoing ethical dilemmas.

Addressing these ethical challenges in emerging IST fields requires proactive engagement from interdisciplinary stakeholders, including scientists, engineers, policymakers, ethicists, and the public. Collaboration is needed to develop ethical frameworks, guidelines, and regulations to ensure the responsible development and deployment of these emerging technologies while considering their potential impact on individuals, society, and the environment.