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ORIGINAL RESEARCH ARTICLE

Artificial intelligence and decision problems: The need for an ethical context

José Luis Verdegay, M. Teresa Lamata*, David Pelta, Carlos Cruz

Department of Computer Science and Artificial Intelligence, University of Granada, Granada 18071, Spain. Email: mtl@decsai.ugr.es

ABSTRACT

Computers process information and make decisions. Until recently, the decisions they made were not complex, but due to the incessant technological advances that are taking place, systems based on artificial intelligence are achieving levels of competence in decision-making that in many contexts equal or surpass those of humans. These are autonomous decision-making systems that, although they can increase the capacity and efficiency of people in their fields of action, they could also replace them, something that is of concern to society as a whole. Avoiding dysfunctions in these systems is a priority social, scientific and technological objective, which requires theoretical models that include all the richness and variety of decision problems, that precisely define the elements that characterize them and that address the ethical principles that should guide their operation. This article describes each of these aspects in separate sections.

Keywords: artificial intelligence; autonomous decision systems; decision processes; decision problems; ethics; concurrency

1. Introduction

It seems that our daily life is controlled by artificial intelligence (AI), algorithms, and that our future will depend on them. They are present daily in the media, in our conversations or in social networks. And the truth is that news referring to them worries and frightens us to the point of provoking our distrust. We tend to talk about them and their consequences emphatically, but often with great ignorance, enabling scenarios that are unrealistic or difficult to justify scientifically[1].

An algorithm is an ordered sequence of steps, free of ambiguity, such that, when carried out faithfully, in a finite time will result in the solution of the problem posed, having thus performed the task for which it was designed. Algorithms are therefore not like recipes, which may have imprecise rules. On the contrary, they are iterative processes that generate a succession of points, according to a given set of instructions and a stopping criterion, and as such are not subject to technological constraints of any kind, i.e., they are absolutely independent of the technological equipment available to solve the problem they face[2]. It is the program in which the algorithm is written that depends on the available

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technology, i.e., an algorithm that can solve a very complicated problem is useless if it cannot be executed, if it cannot perform its calculations on an appropriate machine; which, as has been said, is the mission of the program in which the algorithm is coded and of the computer that is used.

In many cases, this has led to a significant slowdown in scientific progress in different fields of knowledge, such as heuristics, dynamic programming, weather forecasting or exploratory data analysis. We knew the algorithms that could provide answers to problems of importance to society (recognition of DNA sequences, optimal itineraries, catastrophe alarms, rules of conduct, weather forecasts, etc.), but we could not program and execute them because the available technology did not allow it, i.e., the available computers could not calculate the solutions sought in reasonable times.

However, the reduction in the price of computers, the increase in their speed and the tremendous increase in their capabilities, which has been occurring unceasingly since the end of the 20th century, has had two important consequences. The first is the fact that today there is practically no area where there is a problem that cannot be tackled with a computer. This is precisely the case of AI, which is now omnipresent in any real activity in our daily lives. The second consequence is that we are witnessing the fourth industrial revolution. Indeed, if the third revolution was characterized by the democratization of information, giving rise to the well-known information society, supported by the new information and communication technologies (ICT) and renewable energies, this fourth revolution we are experiencing is marked by emerging technological advances in a number of fields (robotics, quantum computation, biotechnology, internet of things, etc.), among which the Internet of things, etc., stands out.), among which AI, algorithms, stands out and justifies being called the digital revolution, describing a so-called 5.0 society.

AI plays a key role in this fourth industrial revolution mainly due to five characteristics, which uniquely give it a special nature: transparency, because we do not usually detect it when we interact with an AI-equipped system; its difficulty, because the essential reference for its work is no more and no less than human beings; its adaptability, because it is context-dependent and can therefore be polymorphic; its transversality, because it is context-dependent and can therefore be polymorphic; its transversality, because there is currently no field that is not affected by its applications; and, finally, its necessary and permanent renewal and improvement, as is inherent to the area of ICTs, which lead to a need for immediacy in the responses as in no other field.

Society's suspicions and precautions regarding AI-based systems are based on the fact that it has been proven that when these systems are managed with intelligent automation techniques, they can increase and, in some cases, replace, by means of completely autonomous programs, people's capacity to act and make decisions. In the following, for brevity, we will call these systems autonomous decision systems (ADSs)[1], although they are often also referred to as automated decision systems.

The crucial fact, as we have said, is that this substitution of functions could produce, sooner rather than later, structural changes in society as a whole; massive job losses and therefore the undervaluation and disqualification of the people who performed them; unknown effects on the systems they can manage or undesirable situations of ungovernability. It is therefore clear that:

(a) ethical issues relating to the behavior of SuDS should be included in their technological design, so that they can be understood as promoters of innovation rather than threats, and

b) in the event of this substitution of functions, that it does not produce dysfunctions, i.e., that the corresponding system acts exactly like the human supervisor on duty, reproducing and improving its behavior and trying to avoid the unavoidable and im-foreseeable failures that people may have when making decisions, especially when these have to be made in unfamiliar environments[3].

Aware of these two demands on the ethical nature and proper functioning of SAuDs, multiple organizations around the world[4,5] among which there is no shortage of Spanish ones[6–8] have begun to discuss the conditions under which such systems should perform, as well as the premises that should guide their design, construction and material location, to which should be added the most important of all: that these systems be built and designed on solid theoretical bases that minimize the errors that a bad design could produce, since dysfunctions in their activity can have extraordinarily important consequences[9].

The objective of this article is to review some of the theoretical aspects that are indispensable for the construction and design of UDS, as well as to comment on some of the conditions that multiple organizations have proposed for the performance of such systems. To this end, the article is structured as follows. The second section describes what a decision process is, and the third defines the essential elements of a general decision problem (and tacitly its counterpart, the optimization problem), highlighting the role played by two fundamental elements: the type of information available and the context in which the UDS will perform. The fourth section is devoted to the different types of information that can be considered and to describe several possible contexts, many of them proposed in an original way. Finally, we show some lines of action concerning the inclusion of ethical or legal responsibility aspects in the design of the SuDS.

2. Decision processes

Decision theory has traditionally been associated with the fields of economics, statistics and operations research. In any of them, the main problem that has been addressed, rather than how to decide, has been how to make the best decision, so that, implicitly, the main problem underlying a decision problem is that of optimization, i.e., selecting the best alternative in a given situation.

Decision-making is consubstantial with humans, that is, with people. All day long we do nothing but make decisions, trying to make the best possible ones, in any field of human activity. There is no professional field that escapes the necessary and continuous decision making. Whether at work, in the family, in business, etc., we must make decisions. And we also have to make the best decisions, so we have to consider a double aspect: the normative and the descriptive, or, in other words, we have to consider how to decide, which is the normative aspect of the decision process, and what is the decision to be made, which is known as the descriptive version of the process.

For a long time, progress in decision theory has followed parallel paths, depending on whether the study was carried out from the normative or descriptive point of view, so that it seemed that decision theorists worked with their backs to the decision-makers in the real world and, as if they were different worlds, both outside the realm of what was happening in the world of economics. In fact, the basic models being identical, and therefore the results, what was translated in each case as a solution to the problem could have different versions, and therefore appear to be different solutions.

The successive social transformations of recent years have brought computers, robots, cell phones and, in short, all kinds of intelligent devices into our daily lives. With this, the need has arisen to teach these devices, these SAuDs, to be able to decide, and to do so in an optimal way. Therefore, knowing as specifically and in detail all the elements that are part of a decision process is as important as having the guarantee that the result of the actions of a SuDS will be as correct as the model itself allows.

In this context, decision theory emerges as an essential element that plays a very important role in this digital society in which we live and in which AI-based systems, and particularly SuDS, will modify our living habits, cause structural changes in society as a whole, undesirable effects on the systems they can manage, undesirable situations of ungovernability or massive job losses, with the consequent risk of the discussion of the people who used to perform them. For this reason, for SuDS to operate correctly, i.e., to make the right decisions, requires as much knowledge as possible of how to develop a decision-making process, something that Herbert Simon[10] identified in three stages: determining the options available for making a decision; determining the courses of action, the solution methodologies available to us; and finally deciding. In a little more detail, these three stages are called and described as follows:

Intelligence stage, in which we try to determine how we can decide, i.e., to specify as much as possible what data are available, the type of information we will have to handle or the logical reasoning mechanisms that the decision-makers will be able to use.

Design stage, which deals with everything related to the modeling of the problem in order to clearly define the options, their consequences or the comparison mechanisms to be used. This is a highly theoretical stage in which knowledge of other similar situations is essential in order to distinguish similarities and differences.

The choice stage, which includes the application of the necessary methods to optimize our decision, but considering possible revisions of our choice in view of what the model proposes as the first option. The choice, although guided by an optimization process, before its final adoption may be subject to negotiations and modifications, suggested or imposed by external conditioning factors.

As shown in **Figure 1**, the overcoming of these three stages implies their sequential and circular realization since, at the end of the third stage, the reconsideration again from the first stage of the model that we have to solve is obligatory.

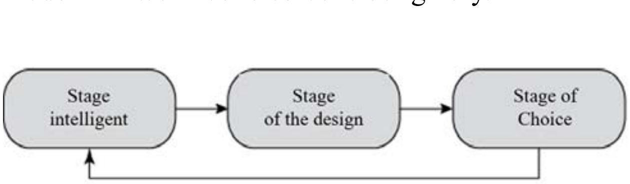

Figure 1. Development of a decision process
Source: own elaboration.

In other words, as a whole, different tasks have to be tackled during these three stages: identifying the problem, obtaining the information necessary for its formulation, determining possible solutions, evaluating these solutions and selecting an execution strategy, i.e., the implementation strategy from which the final solution could eventually be reconsidered.

All this involves the handling of concepts such as decision maker, consequences, order, context of the choice, among others, which, although known, in today's world may adopt new versions, which could entail decision mechanisms that deserve to be analyzed in the light of this new situation, in order to be able to export to the SAuD with the greatest fidelity the mechanisms that we people use for decision making, thus ensuring their safety, effectiveness and efficiency.

In what follows, therefore, we will try to formalize a framework that will serve to identify the elements necessary to be able to approach a decision problem with the consequent optimization of the decision-maker's interests. To this end, the components that describe a Decision Problem are presented below, and some new concepts are introduced.

3. Elements of a general decision problem

Classically, the establishment of a decision problem requires knowledge of the following essential elements[11]:

A decision-maker, which can be a single person, whether natural or legal, or a group of decision-makers.

A set of actions on which the decision-maker can choose. Obviously, for there to be a problem, there must be at least two elements.

A set, called ante, consisting of the situations (usually called states of nature) that the decision-maker may encounter when making a choice, and which he cannot control.

A set of consequences associated with each action and state.

A criterion that orders the consequences. This criterion need not be unique in the case of more than one decision-maker.

The type of information available, which need not necessarily be probabilistic in nature.

The duration of the process, which could be uni-stage or multi-stage, regardless of the number of stages, such as those described in **Figure 1**, that are carried out to solve the problem.

The non-random context in which the chosen action will finally be determined, which can influence the choice of methodology.

Thus, if we assume in all that follows: an individual decision-maker, i.e. we do not consider models involving multiple decision-makers, which give rise to group decision making problems (GDM), a single ordering criterion, thus avoiding multi-criteria decision making problems (MCDM), and that the duration of the process is limited to one stage, so as not to enter into problems more typical of control theory, without prejudice to the fact that this stage is carried out in several phases, as described in **Figure 1**, it will result that a decision problem is described by a sextet (X, I, E, C, ≤, K) that includes the set X of possible actions for the decision maker, the available information I, the environment E, the set C of the consequences of the actions, the criterion that orders the consequences, and the context K in which the decision maker decides.

On these two elements, available information and context, so far not included in the standard definition of general decision problems, we must specify certain aspects that will help us to better model the problem to be solved in each case.

In real-world problems, in the problems that people pose and solve every day and, therefore, in the problems that we want to model for implementation in the SuDS of our interest, it is practically impossible to have all the necessary information. Therefore, for the remainder of this article we will assume that we have incomplete information for the resolution of the problem in question. Although this incompleteness is traditionally assumed to be probabilistic, what this uncertainty about the information really refers to is that we do not know exactly what will happen when we choose a particular course of action, i.e., what the concrete consequence of our decision will be if some initial data is not accurate[15]. As is evident, such incompleteness may have characteristics other than probabilistic ones. In this sense, Smithson's[12] taxonomy of ignorance, illustrated in **Figure 2**, can be particularly useful and revealing.

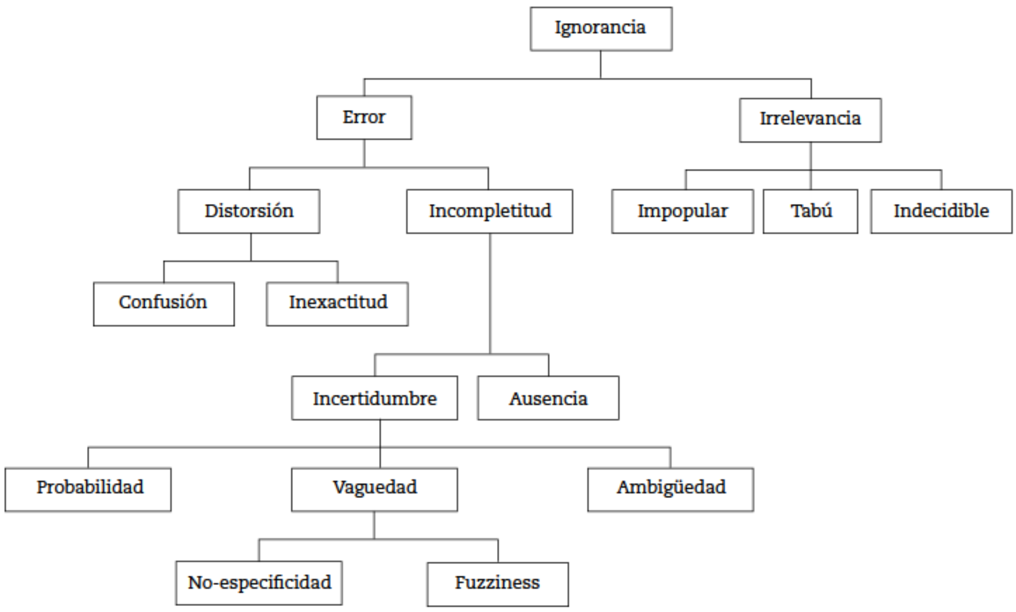

Figure 2. Smithson's Taxonomy of Ignorance.

Source: own elaboration.

A complete and detailed description of this taxonomy is beyond the scope of this paper, but note that, according to it, having incomplete information about the elements involved in our problem may be due to one of the following two reasons:

That there is some uncertainty, i.e., lack of certainty about the true values of the data and parameters involved in the model.

There is a real absence of information (a case that will not be considered here), i.e. there are values of the model under consideration that are completely unknown.

In fact, the existence of the variables that would give these values would be unknown.

In turn, we can consider three different types of uncertainty, depending on whether its origin is ambiguous, vague or probabilistic, i.e., according to whether:

There is a finite number of options for each value (ambiguity): the hotels are in the metropolitan area, or the data are given by ranges of values (vague): we will travel during the day, i.e., between 7 a.m. and 5 p.m., or that, chance (probabilistic): the duration of the trip depends on the means of transport that we will use.

In the particular case, less treated from the point of view of the development of a SAuD that we are considering here, if the information we have is of a vague or ambiguous nature, which on the other hand is the most common in real practical applications, this information can be managed with methodologies and techniques from the field of fuzzy sets and systems[13,14] and thus, in parallel to when the information is random in nature, we can identify three environments:

Certainty environment: it is characterized because the state of nature that will occur is concede, but that state is defined by means of a fuzzy set or a linguistic variable. For example, the states of nature for the weather on a certain day may be: cool, pleasant or hot. In certainty environment we can know that tomorrow it will be hot, but that does not mean that we know exactly (with certainty, as it would be in the random case) what the temperature will be.

Environment of possibility: this occurs when there is a distribution of possibility over the states of nature. This situation is like that in the risk environment when the information is probabilistic, but now more associated with the concept of factuality than with that of randomness and, therefore, without having to verify such axiomatic information.

Indeterminacy environment: arises when any information about which of the states of nature is present is completely ignored, i.e., we know that there is a possibility distribution over the states of nature, but we do not know the rest of the information that would serve to realize that possibility.

Second, with respect to context, as we mentioned above in defining the choice stage described by Simon, the action that the decision-maker finally chooses as optimal may be conditioned by the context, K, in which the problem takes place.

A context, regardless of the nature of the information available, is defined as a set of rules, often established in the form of logical predicates, which establish the qualitative characteristics that the decisions we choose to solve our problem must have.

The best-known contexts are the classical ethical and concurrency contexts[11]:

Ethical context, which may appear in decision-making processes that take place in very specific and professional fields, such as the legal, military, medical or, in general, any other where the final decision is subject to compliance with a certain "code". In this context, it is not only a matter of making decisions in accordance with certain moral behaviors, but rather of decisions being based on interests that conform to ethical codes. This is typically the case when a law firm decides that a certain course of action is the optimal one, but then must abandon it for reasons of professional ethics.

The ethical context is usually defined by a set of "best practices" to which decision-makers must conform.

Concurrence or competitive context, suitable for decision processes in which several decision-makers compete to achieve an outcome that is the best possible for each at the expense of the harm that their decision may cause to the others. It occurs in situations mainly associated with games in which what one player wins is what his opponent loses. It is important to note that the fact that there is more than one decision-maker does not imply that it is a GDM problem, since the aim is not to reach a decision for the group, but rather that each player acts on his or her own.

With these contexts we can also consider as classic, due to their initial recognition in the field of economics, although later in all areas, these others:

Induced context, directly inspired by the nudge theory of Nobel Richard Thaler and Sunstein[15], which recommends using positive reinforcement and indirect suggestions to get decision-makers, people in general, to do certain things. This approach, and therefore this context, is based on the belief that these types of reinforcements and suggestions are more effective than precise instructions, strict legislation or authoritarian controls.

Dissuasive context, contrary to the previous one, is considered when the problem statement is free of peculiarities that may influence the decisions to be taken, being exclusively interested in finding the best solution with respect to the predefined comparison criterion. In general, this context, in which the decision-maker chooses his courses of action with rational criteria, without external influences and for variables that take positive real values, will be the one we will assume here for the purposes of the theoretical study of solutions to the problem.

But, in addition to these classical contexts, there are others that have recently emerged that deserve to be mentioned. Specifically, the following are new contexts that may condition our decisions:

Context of the presence of unseen adversaries (ADM), which occurs when the decisions we make are known to our adversaries. Decision-making in the presence of adversaries poses difficulties inherent to a situation that sometimes requires resorting to suboptimal decisions just to confuse adversaries. Such situations clearly arise in the military domain, but also in areas such as perimeter surveillance, computer game development, design of intelligent systems for personnel training, cybercrime, etc. An adversary is an entity whose benefits (in some sense) are inversely proportional to ours. This adversary can alter our benefits by taking certain actions and, in addition, it can observe our actions/decisions having the opportunity to learn our behavior pattern. This learning will lead him to be more effective in his attempt to maximize his benefits and minimize ours. This context is different from the competition context, since in the former we do not know whether or not there is an adversary and, if there is, we know nothing about him, while in the latter we know that there is an opponent competing against us to diminish our profits.

Crisis context, which occurs when there are exceptional circumstances (e.g., catastrophes, accidents, etc.) and in which the best possible decision must be taken from among those available, which are not usually all the possible ones. Sometimes this best available decision may coincide with the optimal solution to the problem. However, in most cases this will not be the case, due to various factors such as the lack of resources to explore the entire space of alternatives, the possible disappearance of alternatives, the sudden infeasibility of some others, etc. In these cases, a good solution strategy, inspired by the design of preconditioning algorithms, can be the protocolization of the problem, so that when the emergency arises, an action protocol can be consulted that minimizes the risks of a bad action as much as possible, thus increasing the possibility that the solution to the problem in emergency cases and the optimal solution to the problem without emergencies coincide.

Context of sustainability, associated with what is understood by sustainable decisions in a specific ecosystem. Parallel to the definition of "sustainable development"[16], for a decision to be sustainable it must satisfy the expectations of the moment in which it is taken, i.e., be optimal in some sense established by the decision-maker, and at the same time not compromise the choices that may be made in the future regarding the problem in question. Therefore, it makes perfect sense to consider the contexts for making decisions that, adjusting to the needs of the problem in question, allow us to be able to solve the same problem again when it arises, without being conditioned by previous decisions. This context, although generally associated with environmental issues, is not limited to that environment. The "occasional" purchase of equipment without a minimum analysis of its sustainability, even if it is the result of a perfectly developed decision-making process, more often than desired produces undesired results that, in the end, demonstrate that the decision-making process was poorly carried out. On the other hand, although sustainable behavior is always ethically plausible, this context is not like the previous ethical context, since the latter is more oriented to issues of conflicts of interest and moral character.

Dynamic context, in which now when the best possible decision is made, the conditions that led to that decision change and may cause that first optimal decision to no longer be optimal. A simple example explains these situations where the best solution may change as the decision-making process unfolds. We want to buy a certain accessory over the Internet. We find a model that satisfies us and is our best option (it may be a temporary offer). We carry out all the formalities requested and pay the amount. However, more often than might be expected, we are soon informed by the e-supplier that the requested add-on cannot be sent to us because the inventory is "sold out" (the result of a massive avalanche of buyers who independently, but simultaneously, opted for the add-on in question). This context is typical of transportation, management or investment problems[17], and increasingly occurs in social networks.

Context of corporate social responsibility (CSR), understood as a way of running companies, based on the management of the impacts that their activity generates on their customers, employees, shareholders, local communities, environment and on society in general[18]. In short, CSR is a concept whereby the company voluntarily integrates the social and environmental dimensions into its business operations and its relations with stakeholders, which is highly topical and can and should modify the courses of action of decision-making processes. The context that defines CSR is not the same as that of ethics, although they may have some similarities, since the latter focuses more on the moral consequences of decisions. Decision-making in a CSR context, especially in the case of public corporations, is conditioned by what is called "accountability" which, in all cases, can change the choice of the best action that would be taken if this CSR context were not contemplated.

A context of stress, which arises because finding a balance between work and family that reconciles both worlds is becoming increasingly difficult. Finding "down time" in which we can relax is difficult and the demands at work are overwhelming. Thus, life is becoming more stressful and stress has consequently become one of the factors that decision-makers must consider in most critical situations. In business, stress can be detrimental to the success of managers in making key decisions. Making strategic decisions is the most critical component of an executive's job, and although executive decisions generally have very important consequences, executives must make high-impact decisions regardless of the situations and conditions they assume, knowing that executives who make decisions under stress in limited time and resources or uncertainty may be forced to reduce their alternatives[19]. Decision making under stress can have disastrous consequences.

As is obvious, each of these contexts will depend on each specific situation, so it is not easy to go much deeper into each of them. But in all cases, and regardless of whether we have complete information or not, these contexts are defined by rules, i.e. by logical predicates, which describe each situation analyzed and allow their modeling with relative ease. Therefore, the relevance they can have in the design, construction and development of SuDS is more than evident and, due to the undesired consequences of making a decision in an inappropriate context, especially when we are working in an ethical context, their analysis and modeling have become a priority line of research in AI to which much effort and attention is being devoted worldwide. The following section is devoted to describing how the implementation of ethical behavior in SAuD is being addressed at the European level.

4. Ethics and SuDS

As already noted, the practical performance of SuDS, i.e., their operability in the different environments of the real working world, must be very careful because when these systems are managed with intelligent automation techniques, they can replace people's ability to act and make decisions, which is not exactly easy to assume depending on the fields of application in which it occurs, especially if it is done on a massive or purely commercial basis. The subject is important and attracts a great deal of attention worldwide, both from an academic point of view[20–23] and from a practical point of view, which is what we will focus on in what follows.

Informatics Europe is a private organization that represents to the European Union the European informatics research and academic community. This institution, together with the ACM Europe Council, which aims to increase the level and visibility of the activities of the Association for Computing Machinery (ACM) in Europe, and the ACM Europe Policy Committee (EUACM), published a report in 2018 that sets out the measures to be taken into account to achieve a balanced and effective development of SAuDs in society[24], the main lines of which are given below.

The starting point of that report is that since in practice it would be dangerous to hold expert committees or the industry involved in each use case responsible for ethical issues related to SAuDs, since primarily what is required is a deep understanding and incorporation of ethics throughout the design of the technology, social and moral values should not be seen as mere "risk factors" or constraints, but as the main drivers and shapers of innovation and, therefore, must be incorporated into SAuDs from the very first moment of their conception. To this end, a series of technical, ethical, legal, social, economic and educational recommendations are made, which are summarized below.

a) Technical recommendations

Establish means, measures and standards to ensure that SAuDs are objective. All key actors (government institutions, academia, industry, international institutions, NGOs and citizens) should be involved in the formulation of norms and practices that ensure the public good as the first criterion that should drive the design and construction of SuDS. These standards should be formulated in a flexible manner so that they will endure in the face of rapidly evolving technology and industrial applications of WWFs. To facilitate this goal, it is necessary to encourage AI research to develop a solid theoretical basis for automated decision making.

b) Ethical recommendations

Ensure that ethics is kept at the forefront of SAuD development and implementation and is an integral part of it. As with health and biology, member countries and the European Union should develop ethics committees to advise social, political, academic and legal organizations on the positive and negative consequences of SuDS initiatives, tools and systems. Also, as a guarantor of the public interest, a new (European) agency should be created to oversee the development and deployment of SuDS across Europe.

Promote the design of value-sensitive SuDS. Special programs on value-sensitive techniques should be designed in higher education, emphasizing that the social values and ethical priorities of users must be considered in all aspects and elements associated with a SuDS.

c) Legal recommendations

Clearly define legal responsibility for the use and impact of SuDS. The basic principles that currently govern the development of SuDS from an informatics-professional point of view should be the basis for a broad debate among legal and technical experts, the media and society in search of new legal norms to govern the widespread implementation of SuDS. In particular, the general disclaimer on almost all current software needs to be reconsidered and revised or rejected if, as it seems, it is not applicable to many current or future uses of SuDS. The (European) agency proposed in the second recommendation should encourage and facilitate this discussion and propose appropriate legislation.

d) Economic recommendations

Ensure that the economic consequences of the adoption of SuDS are always fully considered. Among its first official initiatives, in order to issue appropriate guidelines and regulations, the proposed new agency should begin by issuing reports on several specific economic and socio-economic problems to which the development and accelerated implementation of SuDS is likely to give rise.

It should be explicitly recognized that the agency's mission will always be oriented toward two inherently interrelated objectives: to promote the evolution and responsible use of SuDS and to minimize their potential personal, social and economic disruptions to individuals and nations. In this regard, a fundamental aspect to be considered is that of the sustainability of SuDS.

As is well known, the AI industry is often compared to the oil industry, since once data is extracted and refined, as with oil, it can be a highly lucrative commodity. Thus, as with fossil fuels, the process of training the algorithms that underlie SAuD has a huge environmental impact.

Indeed, Strubell, Ganesh and McCallum[25] show an assessment of the energy consumption required to train several common high-dimensional models in AI finding that the process can pollute the equivalent of more than five times the CO2 emitted by a mid-range car over its entire lifetime (including the manufacturing itself), not to mention the emissions from a passenger's round-trip air travel between two U.S. airports (NYC and SFO), which undoubtedly demonstrates a very substantial environmental impact (**Figure 3**):

To this figure should also be added the damage caused by the waste we generate, the so-called digital waste, i.e. e-mails, CDs, videos, audios, etc., which we abandon in any form every day and which require ever larger servers for storage, with the consequent energy consumption. According to Schwartz, Dodge, Smith and Etzioni[26] and reports conducted by Greenpeace, available on their website, the electricity consumed globally for the storage of this type of digital material is steadily increasing, going from 632 trillion kilowatts in 2,007 to 1,963 trillion expected by 2020, which, equivalent to the CO_2 emitted, amounts to 1,034 megatons (1,034 million tons).

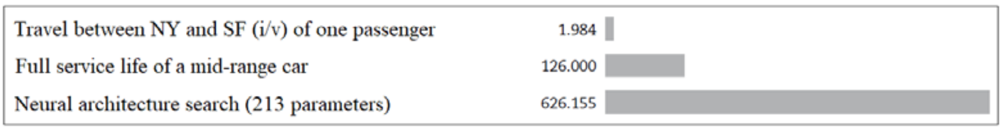

Figure 3. Equivalent to consumption in pounds of CO_2.

Source: own elaboration based on Strubell, Ganesh and McCallum[25].

e) Social recommendations

Legally enforce that users of SAuDs be clearly informed of all data privacies and data acquisition practices of their implementers. Machine learning works from data and therefore when and where information is collected, what is collected and the uses to which it will be put, must be described by the data provider in a concise and clear manner.

This is a fundamental aspect since, in an era of massive and widespread data capture, the right to the protection of personal information and the right to respect for privacy are a crucial challenge. Both

SuDS and web-based AI programs must comply with data protection laws and not collect, disseminate or run on data sets for whose use and dissemination consent has not been given. AI systems should not interfere with the right to privacy, which includes the right to be free from technologies that interfere with personal development and opinions, the right to establish and develop relationships with other human beings, and the right to be free from surveillance. In this regard, it may be appropriate to consider new rights, such as the right to meaningful human contact and to be free from personal profiling, measurement, analysis, training or persuasion.

Significantly increase public funding for non-commercial research related to SAuD. There is a need to incentive research aimed at better understanding machine learning and its use in systems that can influence human behavior. Many fundamental questions remain to be investigated, but public and rigorous knowledge of the results achieved by these techniques, not exclusively dependent on industry, must be a prerequisite for further debate on their acceptability and effective adoption by European companies.

f) Educational recommendations

Encourage AI-related technical university training. All university students should be trained in the practical aspects and potential of AI. Students from all disciplines should be aware of the impact this technology will have on their field and future work.

Complement technical training with socio-humanistic training at the same level. Due to the increasing impact that technology will have on society, technical curricula should also train students to face complex scenarios by complementing technical skills with the development of critical thinking, digital literacy and ethical judgment. Higher education curricula should encourage interdisciplinary studies, based on European cultural heritage, in both scientific disciplines and the liberal arts. An introduction to AI and the issues they raise should also be included in secondary school curricula.

Raise public awareness and understanding of SuDS and their impacts. There is a clear need to educate society about this technology, as it is rapidly being introduced and will affect virtually all of us in our professional and private lives. Since most people do not take additional courses after completing their training, the public media represent the defector most appropriate means to educate the general population. Accordingly, IT professionals and technology policy makers should coordinate with the press to convey the information referred to in the recommendations contained herein. Due attention should be paid to the worrying use of AI techniques to influence public opinion.

These recommendations collected in Informatics Europe[24] are not the only ones in this regard; those published in European Group on Ethics in Science and New Technologies are also distracted: Statement on AI[4] and in future of life[5], whose description and detail we do not go into because we would exceed the reasonable limits of a contribution such as this. In any case, a very complete overview of how this topic is being worked on around the world can be found in Dutton[27].

5. Conclusions

This paper was mainly devoted to delve into some important aspects related to AI-based systems, which we have referred to by autonomous decision systems (ADSs). Among them, the following stand out:

The need to incorporate to the elements defining a decision problem, and more generally to a decision process, the nature of the available information, which does not necessarily have to be of a probabilistic type, and the context in which the considered decision process must be developed. In fact, new contexts have been introduced, not previously considered, which should be considered in order to choose the best course of action in any decision process.

Based on this new concept of the decision process, countless possibilities open for approaching the performance of the SAuD with security for individuals and confidence and rigor in the results. For example, one of the areas in which SuDS are called to play a leading role is in the optimization of resources associated with new transportation models, the sustainability of different and varied ecosystems, environmental care, etc., since they have more and more parameters and are increasingly used in the decision making process, The importance of considering an ethical framework for the use of the data and the use of the data in the analysis of the data, and the need for an ethical framework for the use of the data in the analysis of the data, is of paramount importance in the analysis of the data.

The importance of contemplating a common, and therefore internationally recognized, ethical and legal framework for the design, production, use and governance of SuDS that guarantees the right to the protection of personal information and the right to respect for privacy, as well as specifying where the legal responsibility for the use and impact of SuDS lies, through new legal norms governing the massive implementation of these systems and their application. Special attention will have to be paid to systems designed to self-improve or self-replicate recursively, which can lead to a rapid increase in quality or quantity, since they will inevitably have to be subject to strict security and control measures.

Conflict of interest

The authors declare no conflict of interest.

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