



# Ethical issues deriving from the delayed adoption of artificial intelligence in medical imaging

Giuseppe Placidi<sup>1</sup>

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## Abstract

Medical imaging (MI) has assumed a central role in medicine. Artificial intelligence (AI) has revolutionized computer vision and it is also approaching to impact deeply MI. Fundamental ethical matters have raised and teams of experts around the world are involved in defining ethical borders for AI in MI. However, reading the extremely detailed proposals, it is clear that the treated ethical arguments have been completely redefined and specifically structured for AI in MI. Instead, many of them should be inherited from other technologies already in use in MI. The complete re-definition of ethical principles could produce contradictions and delays for AI adoption in MI, thus arising important ethical concerns. In this paper, potential ethical issues related to AI delay are presented: the objective is to contribute to reuse some concepts from other technologies to streamline the arguments and avoid these concerns.

**Keywords** Artificial intelligence · Medical imaging · Ethical issues · Ethical concerns

## 1 Introduction

Medical imaging (MI) is an explosive field as the technologies for visualizing the internal structure of the body exploit several interactions between biological tissues and waves in the electromagnetic spectrum, at different frequencies. Nowadays, imaging is at the core of medical practice both for diagnostic and clinical purposes. The enormous amount of data, also collected per single examination (an MRI examination often consists of hundreds of images collected with different sequences [1]), makes the job of radiologists very hard. Indeed, radiologists are required to become experts in even richer imaging strategies, and have to produce diagnoses faster and faster, also using augmented reality obtained by the fusion of several imaging modalities. Radiology has assumed a fundamental role in personalized medicine and in the treatment of chronic diseases.

In this scenario, artificial intelligence (AI), due to high versatility and increased performance, could take up a fundamental role in MI, being applicable to all aspects of the

imaging pipeline (acquisition, reconstruction, processing, fusion, interpretation and quantification) [2–4]. In fact, AI has the potential to: lower costs and time for acquisition; reduce artifacts and noise; improve image reconstruction; facilitate data analysis and interpretation; allow early detection of lesions and objectively quantify their extension. All of this allows new systematic and reproducible evaluation of disease progression and drug modulation.

One of the most important advantages of AI in MI is its capability to autonomously solve problems, these last ones mostly consisting in finding patterns from images, learning by data. The learning process can be either supervised, by annotated data, or unsupervised, by not annotated data. In the supervised case, the most frequent in MI, some data sets are first annotated independently by several radiologists. The resulting annotations concur to obtain a synthesis: the more likely annotation, also called “ground truth”, used to train and validate the AI systems. The ground truth is a necessary statistical mediation, being the imaging interpretation an uncertain process that does not allow to take the true annotation [5].

The use of AI in MI creates important ethical concerns regarding data (ownership and privacy, biases, data annotation and ground-truth generation), algorithms, trained models and medical practice, which are extensively treated and discussed in [6–9]. In what follows, we retrace the same

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✉ Giuseppe Placidi  
giuseppe.placidi@univaq.it

<sup>1</sup> A2VI-Lab, c/o Department of Life, Health and Environmental Sciences, University of L'Aquila, Via vetoio, Coppito 2, 67100 L'Aquila, Italy

aspects, in the same order, but from a different perspective. The objective is to contribute to the reuse of some concepts from other technologies to streamline the arguments and avoid contradictions which would delay the adoption of AI in MI and, as a consequence, be source of ethical concerns.

## 2 Ethical issues of AI in MI

Artificial intelligence combines hardware and software to solve automatic reasoning problems, relying on learning by example strategies where data are strategic. They are statistical solvers which: calculate predetermined features, or tables of weights for a huge set of parameters (the construction of relationships between data) during a training phase; refine the parameters in a validation phase; apply the refined parameters to solve problems in a final operating phase. Roughly speaking, AI systems use some data to learn reasoning procedures and then apply them on new data to perform autonomous reasoning. The use of AI, particularly in MI, rises important ethical aspects ranging from the use of data, of trained models, up to medical practice, as reported in Fig. 1.

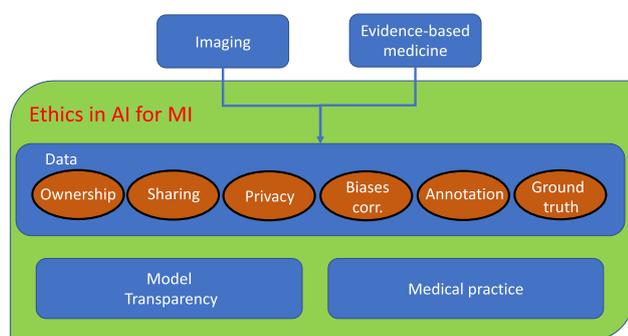
Regarding ethics in the use of data (middle-left part of Fig. 1), that is ownership, sharing (including consent to share) of anonymized personal data and privacy, they can be treated as in the case of any imaging modality, such as CT or MRI, where data are massively produced and their management is regulated by legal and ethical codes [10]. Hence, these ethical aspects could be directly inherited by those of other digital systems.

Regarding biases, data annotation and ground-truth generation (middle-right part of Fig. 1), AI can be treated as a statistical study (evidence-based medicine) where a representative data set, in a given scenario, has to be collected, purged of outliers, used to model specific behaviors and/

or to derive protocols. In these cases, the responsibility of composing the representative sample to derive robust and correct models is not of the inferential procedures but it is of the human operators, who already have a professional Code of Ethics. The same principle applies to AI where biases, for example due to age, gender or ethnicity, can be greatly reduced by adopting multi-center strategies in which the sharing of data, experiences, opinions and annotations are fundamental to construct models resembling reality at best. To ensure data validation and robustness, a suggestion is that the ownership, the maintenance and the responsibility for accessing and using data sets for training, validation and test of AI systems are demanded to internationally recognized agencies, monitored and driven by scientific societies and technical working groups.

Regarding ethics of algorithms and trained models (bottom-left part of Fig. 1), reference is made to “transparency”, that is to the complete disclosure and access for the analysts to each internal element of AI systems [6]. This is correct for procedural software, which, however, has shown scarce validity in the uncertain MI problems. Instead, deep learning models have often millions of parameters with reasoning strategies which cannot be explained in details, but just motivated in their general principles. For them, usual transparency is impossible [11, 12] but an effective paradigm exists: move from transparency of the procedures to transparency of the outputs which can be ascertained statistically, not for a single instance, through a systematic approach, similarly to what occurs in evidence-based medicine. The evaluation is statistical, performed on representative data sets. For AI, the representative data sets should be furnished by the above international agencies to which also statistical validation and model certification should be demanded. When an AI producer wants to certificate a model for MI, it has to submit it to these independent agencies that would carry on some tests on new, “blind” and proprietary data sets. At the end of the process, a score will ascertain the passing of the test to which the certification of the model will follow. This aspect is fundamental to avoid deadlocks: pretending to interpret AI like a procedural software is equivalent to reduce AI to a procedural software that, performing very poorly in MI, would be kept away from MI. This aspect, deeply stressed in [6], is delaying the adoption of AI in MI without a justified reason.

Regarding medical practice (bottom-right part of Fig. 1), it is usually remarked the fact that a technical innovation often crosses the line of ethics and this may harm patients, individuals and society [13]. For this reason, ethical values are proposed to stem indiscriminate applications of AI, define metrics for evaluating the respect of ethical guidelines, recognize and alert the community when unethical behaviors are discovered. This is another controversial aspect: if the radiologist constantly supervises the job of an



**Fig. 1** Ethical issues for AI in MI regarding data, model transparency and medical practice. Ethics regarding data can be fully inherited both from medical imaging and from evidence-based medical procedures. Model transparency and medical practice deserve specific definitions

AI system, there is no reason to construct superstructures which, inexorably, will slow down the adoption of AI in MI. It is sufficient to adopt the system and continuously check its behavior to improve it when necessary. Ultimately, this too is a well-known practice in evidence-based medicine. The construction of a preventive barrier is difficult, delaying and useless since the probability that an AI could harm the patient is scarce considered the central role of the radiologists. An opponent to this reasoning is the fact that radiologists could be tempted to favor machine-generated decisions. This is not a good argumentation for two reasons: (1) a bad human practice cannot be imputed to technology (it would be the same as to affirm: “as far as some MRI examinations could contain artifacts and/or be wrongly interpreted, we discard MRI”); (2) the machine-generated decision could be a valid support for radiologists to reinforce their opinion or to stimulate a deep meditation when differences and disagreements occur. This last point is important: in radiology, “double reading” has proven to increase the quality of diagnosis but it is normally recommended just for selected, high-risk examinations since, for an extensive usage, it would require too many human resources [14]. Therefore, at the moment, we are tolerating the fact that in radiology potential human errors occur due to single reading oversights, despite having AI systems ready for supervised double reading. In this sense, AI in MI does not significantly alter how ethical issues are dealt with.

When discussing of ethics of AI in MI, important considerations are referred to social and economic changes, many of which would be extremely unfavorable for the most vulnerable communities around the world [6]. This aspect is also referred to the fact that these communities would have poorer data sets to validly train AI systems and, for this reason, would be left behind. A deep discussion is presented in [6] regarding how to ensure that AI is beneficial overall and that the distribution of benefits among the possible stakeholders is just and equitable. This is in principle true, but not in the facts: AI has to be trained with very huge and complete data sets on very high performing, GPU-based, parallel computers but, after training, it can run on normal personal computers without the assistance of other data sets. For this reason, it could be especially suited for remote and vulnerable countries where the availability of experienced radiologists is rare, more than having imaging systems (it is frequent the presence of high-tech imaging equipment unused for lack of qualified personnel). In those cases, AI could be very useful both for supporting inexperienced personnel and for contributing to train them. Besides that, the adoption of AI could lower the costs of diagnosis that should also imply a huge benefit for patients of vulnerable communities. However, aside from the previous advantages, this could raise also ethical concerns regarding, for example,

the increase of diagnoses to which affordable treatments could not follow, or leading to overdiagnosis with potential consequences of iatrogenic harms.

### 3 Conclusion

The discussion regarding ethical implications of using AI in MI is right and dutiful and, what is more, the enormous work carried on by technical agencies and scientific societies is commendable. However, AI has been charged of too many ethical issues pertaining to people more than to technology. In fact, most of these ethical duties can be inherited from those of digital radiological systems and of evidence-based medical procedures. Other ethical norms have to be expressively coined for AI, but the responsibility of their compliance is always human. Until AI is trained with sufficiently large and varied data sets to constitute a sufficiently large body of knowledge, it will continue to make coarse mistakes. But, even when a “perfect digital radiologist” would be ready, it will continue to make mistakes as an expert radiologist,... at best [13]. The key issue to consider is that AI has to be put beside radiologists, not in place of radiologists, for the same reason why radiology aspires to “double reading”. By offering double reading to radiologists, AI could be also accepted with its biases and imperfections anyway helpful to find better solutions [15]. Radiologists have the ultimate decision, as there are numbers of factors that AI, in its reasoning, cannot consider and also a lot of situations in which AI can be fooled [16]. Indeed, as a supporting tool, AI is like a sort of new imaging modality whose results have to be rightly interpreted, contextualized, confirmed, corrected or rejected. In this way, potential risks due to overdiagnosis could be greatly mitigated. AI systems offer physicians the opportunity to make what they do in a new way, to boost productivity and accuracy. AI can take over time-consuming routine tasks, freeing up time and resources to focus radiologists’ attention on individual patients, and thereby moving from volume-based toward value-based radiology. It is time to consider the inclusion of AI-specific Ethic norms inside the medical “Code of Ethics” to remind radiologists who use AI that their profession is central and that the last word is to them. In this way, AI is put in the position not to harm the patient and to be quickly adopted in the MI, even if not yet in its final and robust form, thus avoiding ethical concerns due to a delay.

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## Declarations

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