

Ethical considerations on the use of AI technology in eHealth applications for neurodegenerative diseases

Maria GHEORGHE-MOISII, Cristina-Gabriela GHEORGHE, Sorin SOVIANY

National Institute for Research & Development in Informatics - ICI Bucharest, Romania

maria.moisii@ici.ro, cristina.gheorghe@ici.ro, sorin.soviany@ici.ro

Abstract: Assisted care using artificial intelligence technology is an emerging paradigm in healthcare, offering significant opportunities for improving patients' quality of life and healthcare efficiency. However, with the implementation of artificial intelligence technology in healthcare, many concerns about ethical issues regarding data usage are also developing. In this context, the article addresses the importance of ethical principles in AI-assisted care, highlighting some key aspects that need to be considered to ensure the responsible and beneficial use of this technology in healthcare. The research focuses on ethical principles regarding the implementation and development of artificial intelligence in eHealth applications, as well as the ethical implications of data use under the General Data Protection Regulation (GDPR). Use cases for applications employing users' personal data in different contexts are presented, highlighting the role of AI in eHealth, for the early detection and diagnosis of neurodegenerative conditions such as Alzheimer's and Parkinson's diseases, for personalised therapies, the continuous patient monitoring as well as for virtual healthcare specific to these diseases. A security solution based on a multimodal biometric system that can be used in eHealth applications for neurodegenerative diseases is also proposed.

Keywords: AI, ethical principles, eHealth applications, neurodegenerative diseases, security solution, GDPR.

Considerații etice privind utilizarea tehnologiei AI în aplicațiile eHealth pentru bolile neurodegenerative

Rezumat: Îngrijirea asistată utilizând tehnologia inteligenței artificiale este o paradigmă emergentă în domeniul sănătății, oferind oportunități semnificative pentru îmbunătățirea calității vieții pacienților și a eficienței asistenței medicale. Cu toate acestea, odată cu implementarea tehnologiei inteligenței artificiale în domeniul sănătății, se dezvoltă și multe preocupări cu privire la problemele etice referitor la utilizarea datelor. În acest context, articolul abordează importanța principiilor etice în îngrijirea asistată de AI, evidențiind câteva aspecte cheie care trebuie luate în considerare pentru a asigura utilizarea responsabilă și benefică a acestei tehnologii în asistența medicală. Cercetarea se concentrează asupra principiilor etice privind implementarea și dezvoltarea inteligenței artificiale în aplicațiile eHealth, precum și asupra implicațiilor etice ale utilizării datelor în conformitate cu Regulamentul General de Protecție a Datelor (GDPR). Sunt prezentate cazuri de utilizare pentru aplicațiile care folosesc datele personale ale utilizatorilor în diferite contexte, evidențiind rolul AI în eHealth, pentru detectarea și diagnosticarea precoce a afecțiunilor neurodegenerative precum bolile Alzheimer și Parkinson, pentru terapii personalizate, monitorizarea continuă a pacientului, precum și pentru asistență medicală virtuală, specifică acestor afecțiuni. De asemenea, este propusă o soluție de securitate bazată pe un sistem biometric multimodal care poate fi utilizată în aplicațiile eHealth pentru afecțiuni neurodegenerative.

Cuvinte cheie: AI, principii etice, aplicații eHealth, boli neurodegenerative, soluție de securitate, GDPR.

1. Introduction

In recent years, Artificial Intelligence (AI) technology has seen significant advances demonstrating huge potential for eHealth applications and supporting systems. eHealth systems for the care of patients with neurodegenerative diseases are a major challenge in the medical field, given the complexity of these diseases and the need for a rapid and personalized intervention to improve the chances of effective treatment.

With the accelerated progress in the field of AI ethical issues become inherent for the development and application of AI in eHealth while also requiring an approach to prevent abusive actions of human rights violations as a result of various IT operations, data transfer, protection of human dignity and privacy (Naik et al., 2022).

Ethical issues related to AI systems have an impact on all stages of the system lifecycle, from research, design and development to deployment and use, optimising the beneficial impact of AI by reducing risks and adverse outcomes.

The ethical use of data in applications is a critical issue as AI relies on data for decision making. How this data is stored, processed, transmitted and interpreted has a significant impact on individuals, organisations and therefore society.

The article of Naik et al. (2022) highlights the ethical considerations that arise in relation to the use of AI-based care. These depend, among other things, on the particular technology, its role and the patient-specific data associated with the use of AI-assisted care in the context of using applications for neurodegenerative diseases.

Ethical issues for AI with application in the field of healthcare are complex and relate to different aspects of protecting human rights and ensuring individual welfare. A human-centred view of AI for health means that the human user should have full control over health care systems and medical decisions (European Commission, 2018). Furthermore, the use of health data for learning phases in the operation of AI systems must consider privacy protection and confidentiality of patient data based on their informed consent (WHO, 2021).

Biometric authentication is part of a process of validating a user in order to securely access a particular application or system. Biometric technologies are based on the ways in which individuals are uniquely identified based on one or more biological characteristics, for example: facial recognition, fingerprint, hand geometry, retinal or iris scanning, digital signature and voice analysis (Cohal & Rotună, 2017).

To improve the biometric authentication process and avoid the falsification of biometric data, a unique identification model based on a multi-layer mechanism is proposed for the reliable identification of devices and their users in mobile networks and smartphone sensor data. To achieve data confidentiality, a cryptographic scheme based on the public key exchange mechanism is included (Apostol et al., 2023).

The article is further structured as follows. Section 2 presents the role of AI technology in assisted care, and Section 3 addresses the importance of ethical issues in AI-assisted care. Ethical principles are highlighted in Section 4, and ethical implications in the use of patient data under GDPR are included in Section 5. Section 6 covers use cases for AI technology in neurodegenerative conditions. Perspectives on ethics as well as data security in the context of AI-based medical applications are outlined in section 7. Finally, Section 8 outlines the conclusions of this paper.

2. The role of AI technology in assisted care

The role of AI in assisted care has become increasingly evident, offering valuable opportunities for improving early diagnosis, developing personalised therapies, continuous patient monitoring and providing virtual healthcare as follows:

- *Early diagnosis:* AI systems can analyse large amounts of patient medical and imaging data, detecting less obvious patterns associated with neurodegenerative diseases at an early stage. This early diagnostic capability is essential in slowing down the rapid progression of these diseases and allows medical intervention at an early stage, when treatments can be more effective. By applying machine learning algorithms and advanced data analysis technologies, AI can help identify early signs of neurodegenerative diseases such as Parkinson's before symptoms become visible to patients or doctors (Ehrenberg et al., 2020; Ramirez et al., 2020). This allows patients to benefit from more personalised treatments and care better adapted to their specific needs.
- *Personalised therapy:* AI systems can analyse individual patient data, including medical history, genetic profile and reactions to previous treatments, to suggest personalised treatment options. By understanding the specifics of each patient, AI technology can enable the selection of the most suitable therapeutic schemes to support treatment efficacy and minimise the risks associated with generic treatments. In addition, through AI the patient's progress can be continuously monitored and, moreover, therapies can be adapted according to the stage of the condition, ensuring a more dynamic and personalised approach to medical care.
- *Continuous monitoring:* AI has made it possible to continuously monitor patients with neurodegenerative conditions. Smart devices and sensors can record relevant data on motor

activity, cognitive functions and other medical parameters, providing essential information for doctors on disease progression and response to treatment schemes. This non-invasive, real-time monitoring allows healthcare professionals to detect minor but potentially predictable changes in patient health and intervene promptly, reducing the risk of complications and improving patients' quality of life.

- *Virtual healthcare:* AI-based chatbots provide virtual healthcare and quick answers to patients' or their families' questions. With the help of artificial intelligence, these chatbots are able to provide accurate and up-to-date information about neurodegenerative conditions, treatments, side effects of medication and other health-related issues. These virtual resources are available 24/7, allowing patients to get immediate assistance and support regardless of the time or their location. In addition, the use of virtual healthcare can relieve pressure on medical staff, allowing them to focus more on complex cases and direct patient care.

The study of Saheb et al. (2021) emphasizes the role of adopting a code of ethics and regulations for the use of AI in eHealth with the aim of significantly reducing misuse and the likelihood of adverse effects.

3. The importance of ethical issues in AI-assisted care

A human-centred view of AI in eHealth means that people should have full control over health care systems and medical decisions. Furthermore, the use of health data for learning processes of AI systems must maintain the protection of privacy and confidentiality of patient data by ensuring their informed consent.

With the integration of AI into healthcare processes, significant ethical challenges arise that need to be addressed responsibly and carefully. Among the most acute ethical issues in AI-assisted care there are (Siau & Wang, 2020):

- *Privacy and data security:* In AI-assisted care, the technology involves processing and handling highly sensitive patient health information. Ensuring confidentiality and data security is a key ethical imperative. It is the responsibility of institutions and developers to implement appropriate security measures to protect patient data from unauthorized access and use for malicious purposes. Patient health data is considered sensitive personal data, and failure to respect confidentiality can lead to violations of patients' fundamental rights and loss of trust in the technologies concerned.
- *Transparency and explainability:* In the medical context, trust in AI-based systems is essential for their acceptability and adoption in practice by doctors and patients. AI systems should be transparent in the way they make decisions, so that users understand the reasoning and rationale behind their recommendations. The transparency and explainability of AI systems allows doctors to better assess and understand the outcomes generated by the technology, which increases confidence in the accuracy of suggested diagnoses and treatments. In addition, explainability is also essential from the perspective of patients, who have the right to understand the decision-making process that affects their health and lives.
- *Avoiding discrimination:* Another crucial ethical issue in AI-assisted care is ensuring that the technology does not perpetuate or amplify discrimination. The data used to train algorithms must be unbiased and avoid bias based on demographic characteristics or other irrelevant variables. Otherwise, there is a risk that the AI-based system will provide unfair and discriminatory recommendations, which could have adverse consequences for certain patient groups. Avoiding discrimination and ensuring the neutrality of AI is essential to ensure equal access and appropriate care for all patients.
- *Accountability and transparency in development:* In developing AI for assisted care, researchers and developers must demonstrate accountability and ethical integrity. The development process should be transparent and involve collaboration with medical specialists, patients and ethicists. This can ensure that AI technology is useful, safe and respects the fundamental ethical values of healthcare. Adopting a rigorous ethical framework in the development of AI helps prevent potential abuses and errors that could seriously harm the health and well-being of patients.

4. Ethical principles for the development and implementation of AI technology

Ethical principles play a vital role in ensuring that the development and application of these systems are consistent with human values and fundamental rights. Ethical principles emphasizing the importance of confidentiality, transparency and accountability in the use of AI (UNESCO, 2021) are key principles that must be followed to promote an ethical and healthy environment for AI development and implementation (Figure 1).



Figure 1. Ethical principles for the development and implementation of AI technology

- *Proportionality and the requirement not to cause harm to end-users and beneficiaries*
The use of AI must be proportionate and consistent with the legitimate objectives of its application. It is essential that AI systems are designed and implemented in a way that does not infringe upon the fundamental rights and freedoms of individuals. The principle of proportionality emphasises the importance of balancing the benefits of the technology against the potential risks and negative impacts on society and the individual.
- *Safety and security*
A fundamental principle in AI ethics is ensuring that technology does not cause human or material harm. AI systems must be designed and implemented to be resilient to cyber-attacks and prevent situations where they can cause significant harm or risk to users and society as a whole.
- *Fairness and non-discrimination*
The principle of fairness and non-discrimination emphasises the need for the benefits of AI technology to be accessible to all, regardless of the demographic or social characteristics of users. AI applications should avoid discrimination and bias, ensuring that all individuals benefit equally and fairly from technology.
- *Sustainability*
The principle of sustainability emphasises the need for continuous assessment of the human, social, cultural, economic and environmental impacts of AI technologies. Developers and users of AI should ensure that the technology is consistent with the principles of sustainable development and promotes the long-term well-being of society.
- *Right to privacy and data protection*
Privacy and protection of personal data are key principles in AI ethics, especially in the medical field. Developing appropriate methodologies for the protection of personal data and ensuring the security of sensitive medical information is imperative to maintain trust in AI.
- *Human oversight and determination*
The principle of human oversight and determination emphasises that an AI system can never replace ultimate human responsibility and judgement. Despite technological progress, critical decisions must still be made by humans, ensuring a more humane and responsible approach to the use of AI technology.

- *Transparency and explainability*

The principle of transparency and explainability refers to the ability of an AI system to explain the decision-making process. This is an essential requirement for ensuring understanding and confidence in the outcomes provided by the technology for both healthcare professionals and patients.

- *Accountability*

The principle of accountability emphasises the importance of respecting human rights and fundamental freedoms and ensuring environmental protection. AI developers and users have an ethical responsibility to ensure that technology is used in an ethical and responsible manner.

- *Awareness and education*

The principle of awareness and education refers to the need to increase public awareness and understanding levels of AI technologies. An open data approach and AI education accessible to all can help promote the responsible and informed use of AI technology.

- *Adaptive governance and collaboration*

A fundamental principle in AI ethics is adaptive governance as well as collaboration. This involves open participation and cooperation between different stakeholders in the development and regulation of AI technology, both at governmental and international levels. In this way, the ethical and responsible development and use of AI technology can be ensured.

5. Ethical implications of using patient data under GDPR

AI can link different types of information which can have major consequences. According to the General Data Protection Regulation – GDPR, "personal data" means any representation of information that allows the identity of a person to whom the information applies to be reasonably inferred, either by direct or indirect means (European Parliament, 2016).

A key feature in handling such information is protecting the identity of the individuals to whom the data applies. Any representation of information that could reasonably allow the identity of an individual to be inferred, either by direct or indirect means, is subject to strict data protection and privacy regulations.

The concept of "personal data" covers any information that relates to an identified or identifiable person, including data that can be combined or linked to infer a person's identity. Such data may include obvious information such as name, address or telephone number, but also more subtle data such as preferences, behaviour or demographic characteristics, which in combination can lead to the identification of a person.

It is essential that developers and users of AI-based applications be aware of the risks associated with linking and analysing personal data and take appropriate measures to protect the privacy and confidentiality of individuals. Data protection regulations and standards, such as the GDPR in the European Union, have been introduced to ensure that the processing of personal data is carried out in accordance with ethical principles and to give individuals adequate control over their personal information.

The European Union's General Data Protection Regulation (European Commission, 2018) has introduced strict rules for the protection of personal data and imposed a number of ethical implications on the use of individuals' data in multiple contexts. Created to protect the rights of individuals with regard to the processing of personal data, it imposes a set of principles that must be respected by anyone processing such data, including in the context of the use of AI in eHealth applications targeting neurodegenerative conditions.

In the context of these developments, more attention should be paid to the ethical and legal implications of the use of personal data, especially in eHealth applications and systems. The GDPR was introduced to protect the rights and privacy of individuals by imposing a set of strict principles and regulations on the collection, storage and processing of personal data.

Data processing in eHealth applications must comply with the principles of lawfulness, fairness and transparency, limited purpose, minimization, accuracy, limited storage, and data integrity and

confidentiality (European Parliament, 2016). These ethical principles ensure that patient data is used in a responsible way, protecting their privacy and fundamental rights as follows in Figure 2.



Figure 2. GDPR - Data Protection Principles

- *Lawfulness, fairness and transparency in data processing*

In the context of apps, personal data must be processed in a lawful, fair and transparent way with regard to the user. Users must be clearly informed about the collection and processing of their data and have access to information on how this data will be used by a certain app.

- *Limited purpose of data processing*

Personal data should only be collected and processed for the specific, explicit and legitimate purpose for which it was provided by the user. Any further use of such data must be consistent with the original stated purpose and have an adequate legal basis.

- *Data minimisation*

Within applications, personal data must be limited to what is strictly necessary to achieve the stated purpose. This avoids excessive collection of information and ensures that only relevant data is processed.

- *Accuracy of data*

Personal data processed in applications must be accurate and, where necessary, kept up to date. Ensuring the accuracy of data is essential for making the correct decisions and in the best interest of the user.

- *Limited data storage*

Personal data should only be kept for as long as necessary for the purpose for which it was collected and processed. Once it is no longer necessary to keep such data, it should be deleted or anonymised to protect the privacy of users.

- *Data integrity and confidentiality*

Personal data processed in applications must be protected against unauthorised or unlawful processing. Appropriate security measures must be implemented to prevent accidental data loss, destruction or damage.

The GDPR therefore protects personal data regardless of the technology used to process the data - it is "technology neutral" and applies to both automatic and manual processing, provided the data is organised according to predefined criteria. It also does not matter how the data is stored - in an ICT system, by video surveillance or on paper; in all these cases, personal data is subject to the protection requirements formulated in the GDPR.

6. Use cases for AI technology in neurodegenerative diseases

The study of El-Sappagh et al. (2023) highlights current achievements in the use of AI systems in the early diagnosis and assessment of the progression of Alzheimer's disease. It also

provides main guidelines for improving AI systems while respecting basic ethical principles. The characteristics of reliable applications of AI in the medical field are indicated.

The article of Ford et al. (2023) provides recommendations for the ethical implementation of AI technology used in the early detection of dementia. The presented digital tools (digital biomarkers, mobile devices, wearable and mobile sensors, etc.) for the early detection of dementia were evaluated considering the ethical principles of screening programs for potential patients.

Early detection or diagnosis at the incipient stages of Parkinson's disease (PD), referred to as stages 1 and 2, is one of the key concerns in order to apply the therapeutic regimen and significantly delay the long-term progression of the disease. The paper of Shcherbak et al. (2023) presents an approach based on wearable sensors (accelerometer, gyroscope and magnetometer) and machine learning methods, such as feature extraction, dimensionality reduction and classification. Eleven common exercises were considered and health data was collected from 113 individuals. Data analysis, performed using the mentioned machine learning methods, reached a significant improvement in the accuracy of diagnosing PD at early stages, with f1-micro scores of 0.78 and 0.88 for stages 1 and 2 of this condition.

Wearable sensors can be used for early diagnosis at home and for continuous and long-term monitoring of PD, as they can detect various features from tremor and body movements to motor on-off phases (Rovini et al., 2017). Moreover, for the diagnosis of conditions such as Alzheimer's Disease, PD and mild cognitive impairments, handwriting analysis can be used by modelling and analysing features that are extracted from wearable devices and from among which the most relevant ones are then selected to be applied in the traditional learning model. Feature selection allows one to increase the performance of this learning model but also to eliminate irrelevant, noisy and redundant features (De Stefano et al., 2019; Zhao et al., 2023).

The role of AI in the process of integrating and analysing large volumes of patient health data, through which personalized treatment can be prescribed, especially for neurological conditions, is highlighted in (Gupta & Kumar, 2023). These large volumes of data are retrieved from various digital sources, such as electronic health records, databases, media, etc. and then integrated and analysed, and machine learning and deep learning algorithms are used to determine risk factors, to detect diseases and propose specific and personalised therapies.

Alowais et al. (2023) presented an updated overview of the role of AI in healthcare, with possible applications in diagnosis of conditions, personalized treatment recommendations, and patient engagement. AI tools can use high-volume datasets and identify condition-specific features, thus going beyond the performance of specialists in various aspects of healthcare. In addition, AI tools provide an increased accuracy, along with low costs, saving time and minimised human errors. AI can contribute to improved health management of individuals, development of personalised therapies, optimisation of drug dosing, provision of virtual healthcare, support of mental health, enhancement of patient education and, last but not least, an increased trust in the relationship between patients and doctors. The associated challenges of data privacy, ethical and legal considerations, and the need for human expertise were highlighted.

To successfully approach Huntington's disease screening and diagnosis using AI technology, Ganesh et al. (2023) highlights the need for interpretability of the extensive dataset as well as ethical concerns related to privacy and data security.

7. Perspectives on the ethics and security of using AI based on a security solution provided by a multimodal biometric system

Ethical and security perspectives regarding the use of AI in eHealth applications must be addressed at the technological level to achieve an appropriate trade-off between security and privacy (with respect to GDPR requirements for patient data management). This is a very sensitive issue for patients with neurodegenerative diseases (such as Parkinson's, Alzheimer's, multiple sclerosis) given their impact on their lives. The technological perspective can be presented with the following example, a use case for an authorized user identity security solution for eHealth applications.

Considering an application scenario in which doctors and personal assistants are authenticated to gain secure access to a database containing specific information about patients with Parkinson's disease, the addressed security model can be integrated into a platform with predictive capabilities with regard to the long-term evolution of this neurodegenerative disease.

The design of this security solution is based on a multimodal biometric system with the functional architecture illustrated in Figure 3. This architecture (Soviany et al., 2023) is associated with the general information flow for user authentication. The authentication process is based on the users' biometric data, the aim being to ensure a reliable control of their access to the medical database.

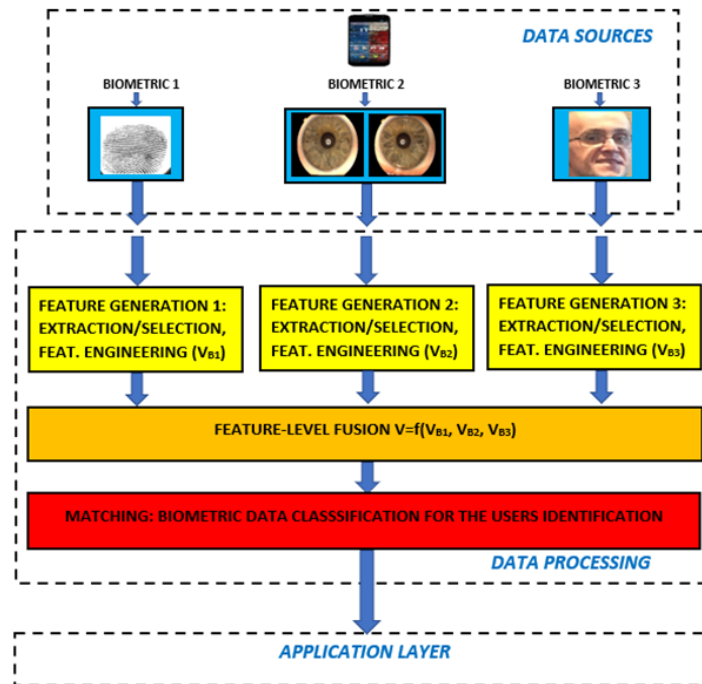


Figure 3. The multimodal biometric system architecture (Soviany et al., 2023)

The biometric data to be processed consists in personal data belonging to authorized persons (doctors, nursing staff, etc.). The security solution designed in accordance with the specific national regulations on the protection of personal data (GDPR), must be developed in such a way as to ensure the degree of security necessary to prevent and minimize privacy risks, which can be generated by any unauthorized access attempt.

The security solution is designed for users who have the ability to use their biometric data generating trusted templates for enrollment and testing respectively, and therefore only for doctors and authorized personnel. If the goals of the AI-based eHealth application for neurodegenerative conditions include remote patient access to their medical records, additional problems would arise with regard to their ability to provide high-quality biometric samples without any support from caregivers. All of these issues relate to data ethics (the use of biometrics in this case) in terms of privacy concerns. Other ethical issues can be generated by the processing chain (algorithms, models, data aggregation). For example, the feature generation process may have some impact on data privacy as it may provide additional features to the biometric patterns of individuals. How these features are used may be subject to ethical issues regarding their privacy. The low accuracy of the involved recognition algorithm could be another cause of ethical and privacy issues, as a wrong decision can have both direct and indirect consequences regarding patient data.

The described solution also requires compliance with data security and privacy regulatory guidelines to ensure patient safety and trust in AI-based eHealth applications for neurodegenerative conditions. Ensuring the informed consent of involved users and respecting patient autonomy become important issues, and patients must have the right to withdraw their consent at any time without facing negative consequences.

8. Conclusions

AI technology has already proven to be a powerful and promising tool for many applications in medicine and healthcare, greatly facilitating the work of healthcare providers and improving the patients' quality of life. AI is playing an increasingly important role in assisted care, providing innovative and personalized solutions for patients with neurodegenerative conditions. From early diagnosis to personalized therapies and continuous monitoring to virtual healthcare, AI brings multiple benefits to both patients and healthcare professionals.

Due to the processing of significant amounts of sensitive data, in AI-based eHealth applications for neurodegenerative conditions, ethical considerations must be respected from the beginning in the design and development process, for example in interdisciplinary teams, and should be a priority in the implementation and the application of AI in healthcare, with ethics playing a vital role in the development of applications and exploitation of AI in this field.

A particular problem in the use of artificial intelligence in eHealth applications is the design of a security solution in accordance with specific regulations on the protection of personal data. Data confidentiality and security, transparency and explainability, non-discrimination and accountability are fundamental issues that must be addressed to ensure an ethical, effective and equitable healthcare.

The security solution proposed in this study can be used in AI-based eHealth applications for neurodegenerative conditions while respecting security and privacy norms. By combining AI technology with appropriate ethical standards, AI-assisted care brings significant benefits to patients with neurodegenerative conditions, improving their quality of life and providing more effective solutions for addressing complex neurodegenerative diseases.

Further research and development of AI technologies should be a priority for the general community, especially for the medical community, in order to increase the quality of healthcare and improve the lives of patients with neurodegenerative conditions. A transparent and responsible use of AI in the field of eHealth would contribute greatly to the provision of healthcare in conditions of security and respect for human rights, as well as to the development of an overall ethical framework for an ever-evolving AI-based society.

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Maria GHEORGHE-MOISII is a Scientific Researcher at the Department – Communication, Applications and Digital Systems within the National Institute for Research and Development in Informatics - ICI Bucharest. She obtained the Master's degree in Organizational Management and Human Resources at Spiru Haret University of Bucharest in 2009. The main areas of interest for the research activity include: e-Government, eHealth, Internet of Things (IoT), SmartCity, SmartEnergy, the evaluation of web usability and accessibility, software testing and evaluation, business models, she is also the author and co-author of various articles published in specialised nationally and internationally recognised journals and conference proceedings.

Maria GHEORGHE-MOISII este Cercetător Științific la Departamentul Comunicații, Aplicații și Sisteme Digitale din cadrul Institutului Național de Cercetare-Dezvoltare în Informatică - ICI București. A obținut diploma de Master în Management Organizațional și Resurse Umane în cadrul Universității Spiru Haret din București, în anul 2009. Principalele sale domenii de interes pentru activitatea de cercetare includ: e-Guvernare, eHealth, Internet of Things (IoT), SmartCity, SmartEnergy, evaluarea utilizabilității și accesibilității web, testare și evaluare software, modele de business, fiind autor și coautor al unor articole publicate în reviste de specialitate și volume de conferință recunoscute la nivel național și internațional.



Cristina-Gabriela GHEORGHE graduated from The Faculty of Electronics and Telecommunications of National University of Science and Technology Politehnica Bucharest (1992). She worked in period September 1992 – April 2021 at National Communications Research Institute (INSCC) of Bucharest, in the Radiocommunications Laboratory as a manager of the projects in the framework of INSCC's Research and Development Program and as a manager of the MCSI projects she is currently working at ICI Bucharest at the Communication, Digital Applications and Systems Department as a Scientific Researcher III: participation in the elaboration of research works in the field of communication, the elaboration of speciality articles (over 30 articles), and cooperation in the elaboration of specialty books (11 books). Areas of expertise: digital video broadcasting systems (DVB-T2, DVB-H, DVB-C2, DVB-S2, DVB-RCS2), digital audio broadcasting, mobile communication systems (4G, 5G), Internet of Things (IoT), SmartCity, SmartHome, eHealth, the efficient use of energy in Next Generation Networks (NGN).

Cristina-Gabriela GHEORGHE este absolventă a Facultății de Electronică și Telecomunicații din cadrul Universității Naționale de Știință și Tehnologie Politehnica București (1992). A lucrat în perioada septembrie 1992 – aprilie 2021 la INSCC București, în Laboratorul de Radiocomunicații ca manager de proiecte din cadrul Programului de Cercetare – Dezvoltare al I.N.S.C.C. și manager de proiecte MCSI și în prezent lucrează în ICI București, la Departamentul Comunicații, Aplicații și Sisteme Digitale, ca cercetător științific gradul III: participare la elaborarea lucrărilor de cercetare în domeniul comunicațiilor, elaborarea de articole de specialitate (peste 30 de articole), cooperare la elaborarea de cărți de specialitate (11 cărți). Domenii de expertiză: sisteme de difuzare video digitală (DVB-T2, DVB-H, DVB-C2, DVB-S2, DVB-RCS2), transmisie audio digitală, sisteme de comunicații mobile (4G, 5G), Internetul lucrurilor (IoT), SmartCity, SmartHome, eHealth, utilizarea eficientă a energiei în rețelele de generație următoare (NGN).



Sorin SOVIANY graduated from the Faculty of Automatic Control and Computer Science (the Computer Science Department) of National University of Science and Technology Politehnica Bucharest (2000). Currently he is a Scientific Researcher III at the Communication, Digital Applications and Systems Department within the National Institute for Research and Development in Informatics - ICI Bucharest. Previously he worked as Research Assistant at Eindhoven University of Technology, the Netherlands, between 2001 and 2003 (topics regarding Embedded Systems Design, and Iterative compilation for multimedia applications). In the period from 2003 to 2021 he worked within the Communications Terminals and Telematics Laboratory of the National Communications Research Institute (INSCC) of Bucharest, tackling research topics on data and network security and reliability, with a focus on biometric systems and Quantum Key Distribution. In 2013 he obtained his Ph. D in Electronic Engineering and Telecommunications with the thesis “Decision Optimization for Biometric Identification Systems”. He has been involved in the implementation of several telemedicine projects for Romania (TELMES, TELEASIS). Areas of expertise: biometrics, design of security systems for intrusion detection. He published over 60 papers in journals and in the context of presentations at international conferences with topics related to applied biometry for telemedicine systems` security.

Sorin SOVIANY este absolvent al Facultății de Automatică și Calculatoare din cadrul Universității Naționale de Știință și Tehnologie Politehnica București (2000). În prezent este cercetător științific gradul III în Departamentul Comunicații, Aplicații și Sisteme Digitale din cadrul Institutului Național de Cercetare-Dezvoltare în Informatică – ICI București. Între 2001 și 2003 a lucrat ca asistent de cercetare la Universitatea Tehnică Eindhoven, Olanda (teme privind proiectarea sistemelor încorporate și compilare iterativă pentru aplicații multimedia). În perioada 2003-2021 a lucrat în Laboratorul Terminale de Comunicații și Telematică la I.N.S.C.C., cu tematici în domeniul securității și fiabilității rețelelor, cu orientări spre biometrie și distribuția cheilor cuantice. În 2013 a obținut titlul de doctor în Inginerie electronică și telecomunicații cu teza de doctorat Optimizarea deciziei în sistemele de identificare biometrică. A fost implicat în realizarea unor proiecte de telemedicină în România (TELMES, TELEASIS). Domenii/teme de expertiză: biometrie, proiectare de sisteme de securitate pentru detecția intruziunilor. A publicat peste 60 de articole (în publicații științifice și cu prezentări la conferințe internaționale), cu teme de biometrie aplicată în securizarea sistemelor de telemedicină.



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