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# Artificial Intelligence in Medicine

20th International Conference  
on Artificial Intelligence in Medicine, AIME 2022  
Halifax, NS, Canada, June 14–17, 2022  
Proceedings

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ISSN 0302-9743                      ISSN 1611-3349 (electronic)  
Lecture Notes in Artificial Intelligence  
ISBN 978-3-031-09341-8              ISBN 978-3-031-09342-5 (eBook)  
<https://doi.org/10.1007/978-3-031-09342-5>

LNCS Sublibrary: SL7 – Artificial Intelligence

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# Preface

The European Society for Artificial Intelligence in Medicine (AIME) was established in 1986 following a very successful workshop held in Pavia, Italy, the year before. The principal aims of AIME are to foster fundamental and applied research in the application of artificial intelligence (AI) techniques to medical care and medical research, and to provide a forum at biennial conferences for discussing any progress made. Thus, the main activity of the society until recently has been the organization of a series of biennial conferences, held in Marseilles, France (1987), London, UK (1989), Maastricht, The Netherlands (1991), Munich, Germany (1993), Pavia, Italy (1995), Grenoble, France (1997), Aalborg, Denmark (1999), Cascais, Portugal (2001), Protaras, Cyprus (2003), Aberdeen, UK (2005), Amsterdam, The Netherlands (2007), Verona, Italy (2009), Bled, Slovenia (2011), Murcia, Spain (2013), Pavia, Italy (2015), Vienna, Austria (2017), and Poznan, Poland (2019).

AIME made a decision at its board meeting in 2019 to make the AIME conference truly international and host it in North America for the first time in 2020. However, due to the global coronavirus pandemic, the decision was made to forgo an in-person meeting for the 2020 conference (the 18th iteration), which was to be held in Minneapolis, USA, for a virtual one. The continued pandemic in 2021 forced the organizers of the 19th AIME conference, originally planned to be hosted in Porto, Portugal, to go virtual as well. Therefore, the 20th International Conference on Artificial Intelligence in Medicine (AIME 2022) represents the first in-person AIME conference to be held outside of Europe. This volume contains the proceedings of AIME 2022, hosted by Dalhousie University in Halifax, Canada, during June 14–17, 2022.

The AIME 2022 goals were to present and consolidate the international state of the art of AI in biomedical research from the perspectives of theory, methodology, systems, and applications. The conference included two invited keynotes, full, short, and demonstration papers, tutorials, a workshop, and a doctoral consortium. In the conference announcement, authors were invited to submit original contributions regarding the development of theory, methods, systems, and applications for solving problems in the biomedical field, including AI approaches in biomedical informatics, molecular medicine, and health-care organizational aspects.

Authors of papers addressing theory were requested to describe the properties of novel AI models potentially useful for solving biomedical problems. Authors of papers addressing theory and methods were asked to describe the development or the extension of AI methods, to address the assumptions and limitations of the proposed techniques, and to discuss their novelty with respect to the state of the art. Authors of papers addressing systems and applications were asked to describe the development, implementation, or evaluation of new AI-inspired tools and systems in the biomedical field. They were asked to link their work to underlying theory, and either analyze the potential benefits to solve biomedical problems or present empirical evidence of

benefits in clinical practice. All authors were asked to highlight the value their work created for the patient, provider, and institution through its clinical relevance.

AIME 2022 received 113 submissions across all types of paper categories. Submissions came from authors in 29 countries, including submissions from Europe, North and South America, Asia, Australia, and Africa. All papers were carefully peer-reviewed by experts from the Program Committee, with the support of additional reviewers, and by members of the Senior Program Committee. Each submission was reviewed in most cases by three reviewers, and all papers by at least two reviewers. The reviewers judged the overall quality of the submitted papers, together with their relevance to the AIME conference, originality, impact, technical correctness, methodology, scholarship, and quality of presentation. In addition, the reviewers provided detailed written comments on each paper and stated their confidence in the subject area. One Senior Program Committee member was assigned to each paper and they wrote a meta-review and provided a recommendation to the scientific chair.

A small committee consisting of the AIME 2022 scientific chair, Dr. Wojtek Michalowski (University of Ottawa), and ourselves as conference co-chairs, Dr. Martin Michalowski (University of Minnesota) and Dr. Syed Sibte Raza Abidi (Dalhousie University), made the final decisions regarding the AIME 2022 scientific program, with input from the application demonstration chair Dr. William Van Woensel (Dalhousie University) for the demonstration papers. This process began with virtual meetings starting in March 2022. As a result, 16 long papers (an acceptance rate of 15%), 11 short papers, 12 posters, and 7 demonstration papers were accepted. Each long paper was presented in a 20-minute oral presentation during the conference. Each short paper was presented in an 8-minute presentation, and the posters and demonstration papers were presented during dedicated sessions on the main conference days. The papers were organized according to their topics in the following main themes: (1) Knowledge-based Systems; (2) Machine Learning; (3) Medical Image Processing; (4) Predictive Modeling; and (5) Natural Language Processing. The 2021 Rising Star Award winner (Dr. Arianna Dagliati) gave an invited talk describing her research in temporal data mining. Prizes were awarded for best student paper, best bioinformatics paper, and a new John Fox memorial award for the best paper in the fields of Computer Interpretable Guidelines, Soundness and Safety in Critical Systems, or Explainability.

AIME 2022 had the privilege of hosting two invited keynote speakers: Dr. David L. Buckeridge, Professor in the School of Population and Global Health at McGill University, giving the keynote entitled “Translating AI into Practice in Healthcare – Opportunities, Challenges, and Possible Solutions,” and Dr. Bo Wang, Assistant Professor in the Department of Laboratory Medicine and Pathobiology and Department of Computer Science at the University of Toronto and CIFAR AI Chair at the Vector Institute, describing “Opportunities and challenges of artificial intelligence for organ transplantation.”

The doctoral consortium received nine PhD proposals that were peer reviewed. AIME 2022 provided an opportunity for six of these PhD students to present their research goals, proposed methods, and preliminary results. A scientific panel consisting of experienced researchers in the field provided constructive feedback to the students in an informal atmosphere. The doctoral consortium was chaired by Arianna Dagliati (University of Pavia).

Two workshops were initially accepted for AIME 2022, with acceptance decisions made by the conference co-chairs and the workshop chair Dr. Jose M. Juarez (University of Murcia). However, due to unforeseen circumstances only one workshop took place during AIME 2022. This workshop focused on the challenges and problems of applying AI in nursing and provided a platform for discussions about the recent advances, cutting edge AI methods, and charting a path forward for nursing AI. The workshop was chaired by nursing faculty from universities in Canada, USA, and Europe, with submissions presented by experts in AI and nursing from around the globe. The work from this workshop will be extended and presented in a special journal issue devoted to the topic.

In addition to the workshop, four interactive half-day tutorials were presented prior to the AIME 2022 main conference. The accepted tutorials were selected by the tutorial chair Dr. Enea Parimbelli (University of Pavia) along with the conference co-chairs, and they included (1) Using Machine Learning on mHealth-based Data Sources, (2) End-user Development of Mobile AI-based Clinical Apps using Punya, (3) Machine learning for complex medical temporal sequences, and (4) Data Science for Starters: How to Train and be Trained.

We would like to thank everyone who contributed to AIME 2022. First of all, we would like to thank the authors of the papers submitted and the members of the Program Committee together with the additional reviewers. Thank you to the Senior Program Committee for writing meta-reviews and to members of the Senior Advisory Committee for providing guidance during conference organization. Thanks are also due to the invited speakers, as well as to the organizers of the tutorials, the workshop, and the doctoral consortium panel. Many thanks go to the local Organizing Committee who helped plan this conference and all of the events surrounding it. The free EasyChair conference system (<http://www.easychair.org/>) was an important tool supporting us in the management of submissions, reviews, selection of accepted papers, and preparation of the overall material for the final proceedings. We would like to thank Springer and the Artificial Intelligence Journal (AIJ) for sponsoring the conference. Finally, we thank the Springer team for helping us in the final preparation of this LNAI book.

May 2022

Martin Michalowski  
Syed Sibte Raza Abidi

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# Translating AI into Practice in Healthcare – Opportunities, Challenges, and Solutions (Invited Talk)

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**Abstract.** The potential for Artificial Intelligence (AI) in healthcare has been evident for decades and the opportunity has grown with increasing volumes of data and advances in machine learning. Despite this potential, the translation of AI-based innovations into healthcare practice has been limited by challenges along the development and implementation pipeline. For example, barriers to data access, technology debt in clinical practice, and limited AI expertise in healthcare systems pose challenges to translation. Potential solutions exist for many challenges and health systems should align solutions to create environments that support the translation of effective AI-based innovations to healthcare settings.

**Keywords:** Artificial intelligence · Healthcare · Implementation

## 1 Opportunities

Researchers and clinicians have long recognized the potential for artificial intelligence (AI) to support decision-making in healthcare [1]. Decades of research have advanced our understanding of the ability of AI to support decisions by clinicians (e.g., diagnosis, therapy), healthcare administrators (e.g., scheduling, resource demand prediction), and patients (e.g., chronic disease management). Given the increasing volumes of data and advances in machine learning, technology leaders have argued that AI will transform the practice of medicine [2].

## 2 Challenges

Despite the potential, empirical assessments have found little evidence of AI-enabled applications impacting healthcare [3]. This gap, between the potential of AI and the reality in clinical care, is the result of challenges that innovators face in developing, evaluating, and deploying AI-based healthcare products and services. At the development stage, assembling and coordinating the necessary clinical and AI expertise can be challenging. Another challenge at this stage is access to data from multiple settings

sufficient for developing robust models capable of generating unbiased output from real data. In terms of evaluation, quantifying the effectiveness and cost-effectiveness of AI has proved to be challenging, with generally few, poor-quality evaluations available [4]. Finally, deployment and scaling of AI is often challenged by the technology debt in clinical practice settings and the limited expertise and resources available for managing and maintaining AI within healthcare systems.

### 3 Solutions

Fortunately, there is considerable activity to overcome the challenges encountered in translating AI into clinical practice. Many academic health centers, often with private-sector partners, have established centers for clinical innovation. These centers bring together expertise in healthcare, AI, and management with the goal of designing high-impact products and services that have the potential to scale. Solutions to data access are also being developed, including data governance frameworks that span clinical practice and research, federated approaches to model building, and advances in synthetic data generation. Evaluation remains challenging, but adoption of guidelines for evaluation studies [5] and networks for pragmatic trials and real-world evidence offer promise. Deployment and scaling of AI will be supported by broader digital transformation to modernize healthcare settings with a focus on interoperability [6]. Finally, training and establishment of data science units within healthcare systems [7], ideally jointly across operations and research can also support deployment and management of AI in healthcare.

### References

1. Musen, M.A., Middleton, B., Greenes, R.A.: Biomedical informatics. *Comput. Appl. Heal. Care Biomed.* 795–840 (2021)
2. Bajwa, J., Munir, U., Nori, A., Williams, B.: Artificial intelligence in healthcare: transforming the practice of medicine. *Futur. Heal. J.* **8**, e188–e194 (2021)
3. Yin, J., Ngiam, K.Y., Teo, H.H.: Role of artificial intelligence applications in real-life clinical practice. *Syst. Rev. J. Med. Int. Res.* **23**, e25759 (2021)
4. Voets, M.M., Veltman, J., Slump, C.H., Siesling, S., Koffijberg, H.: Systematic review of health economic evaluations focused on artificial intelligence in healthcare: the tortoise and the cheetah. *Value Health* **25**, 340–349 (2022)
5. Luo, W., et al.: Guidelines for developing and reporting machine learning predictive models in biomedical research: a multidisciplinary view. *J. Med. Int. Res.* **18**, e323 (2016)
6. Ricciardi, W., et al.: How to govern the digital transformation of health services. *Eur. J. Public Heal.* **29**, 7–12 (2019)
7. Desai, M., et al.: Establishing a data science unit in an academic medical center: an illustrative model. *Acad. Med.* **97**, 69–75 (2022)

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