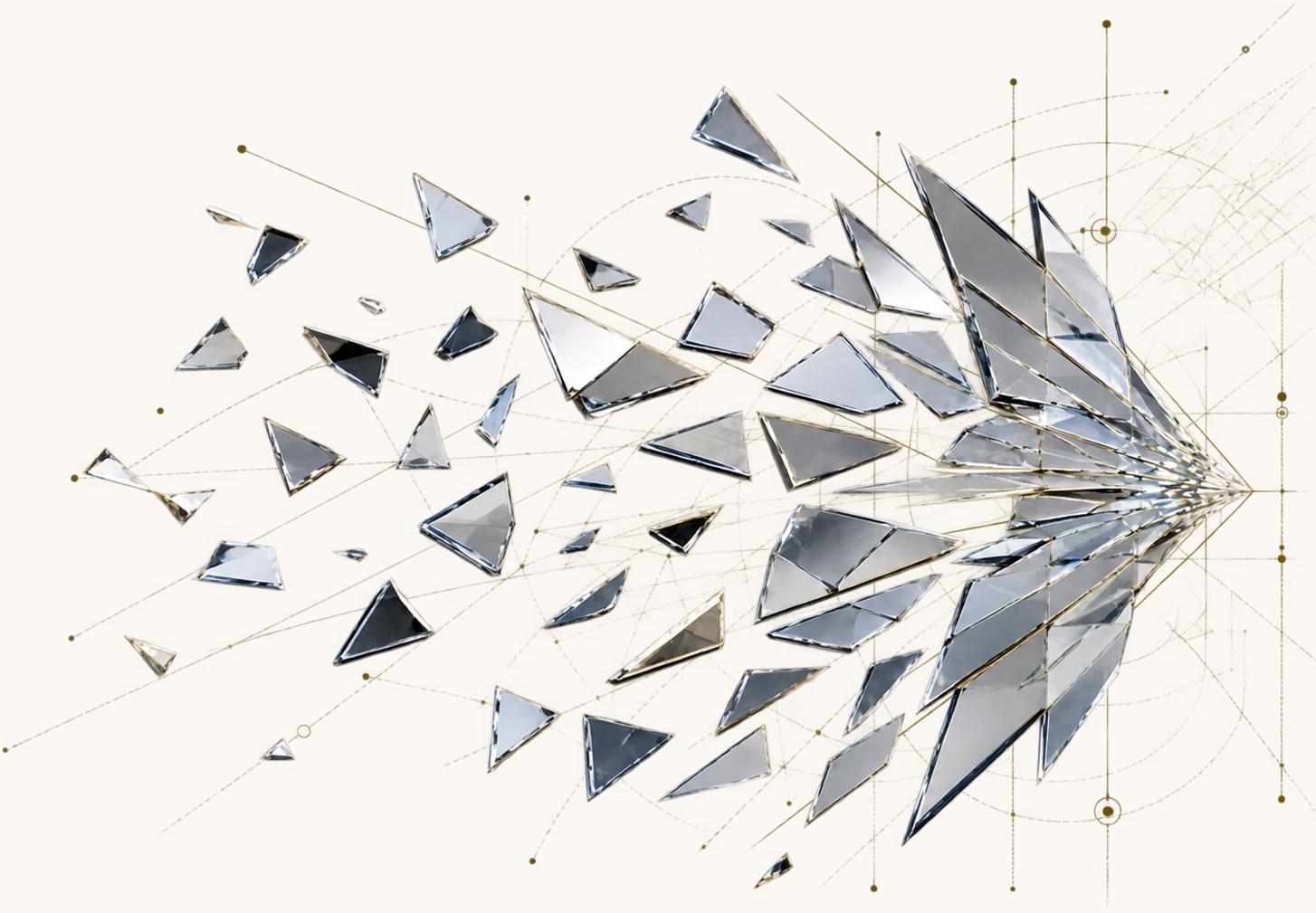


ARTIFICIAL INTELLIGENCE AND NATIONAL TECHNOLOGY REFLECTIONS





TÜRKİYE BİLİMLER AKADEMİSİ
TURKISH ACADEMY OF SCIENCES



ARTIFICIAL INTELLIGENCE AND NATIONAL TECHNOLOGY REFLECTIONS

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ABBREVIATIONS

5G	Fifth-Generation (mobile network)
6G	Sixth-Generation (mobile network)
AAAI	Association for the Advancement of Artificial Intelligence
AASSA	Association of Academies and Societies of Sciences in Asia
ACL	Association for Computational Linguistics
ACM	Association for Computing Machinery
AGI	Artificial General Intelligence
AI	Artificial Intelligence
AI2	Allen Institute for AI
AIA	Artificial Intelligence Act
AIC	Artificial Intelligence Center
AI/ML	Artificial Intelligence / Machine Learning
AIMS	Artificial Intelligence Management System
AIPA	Artificial Intelligence Policies Association
ALLEA	All European Academies
AMD	Advanced Micro Devices
ANAB	ANSI-ASQ National Accreditation Board
API	Application Programming Interface
ASELSAN	Military Electronics Industries (Askeri Elektronik Sanayi)
ASI	Artificial Super Intelligence
ATP	Academic Thesis Program
AWS	Amazon Web Services
BERT	Bidirectional Encoder Representations from Transformers
BPU	Brain Processing Unit
BS	Base Station
BTYPK	Science, Technology and Innovation Policies Board
CAGR	Compound Annual Growth Rate
CBDDO	Digital Transformation Office of the Presidency
CCO	Coverage and Capacity Optimization
CCW	Convention on Certain Conventional Weapons
CDL	Creative Destruction Lab
CE	Circular Economy
CEFR	Common European Framework of Reference for Languages
Cfpd	Critical Foreign Policy Decisions
CMU	Carnegie Mellon University
CN	Core Network
CNN	Convolutional Neural Networks
COMPAS	Correctional Offender Management Profiling for Alternative Sanctions
COVID-19	Coronavirus Disease 2019
CPU	Central Processing Unit
CSCW	Computer Supported Cooperative Work
CSI	Channel State Information

CV	Computer Vision
CVC	Corporate Venture Capital
CVPR	Conference on Computer Vision and Pattern Recognition
DARB	Data and AI Review Board
DCAF	Geneva Centre for Security Sector Governance
DCV	Dynamic Capabilities View
DE	Differential Evolution
DIB	Defence Industrial Base
DL	Deep Learning
DoD	Department of Defense
DOI	Digital Object Identifier
DPU	Data Processing Units
DRC	Democratic Republic of Congo
DTO	Digital Transformation Office
EBA	Educational Informatics Network
ECHR	European Convention on Human Rights
EDIH	European Digital Innovation Hubs
EEG	Electroencephalography
EPRS	European Parliamentary Research Service
ERC	European Research Council
EU	European Union
FAT	Fairness, Accountability, and Transparency
FDA	Food and Drug Administration
FHEA	Fellow of the Higher Education Academy
FLI	Future of Life Institute
FPV	First-person-view
G20	Group of Twenty
GA	Genetic Algorithm
GAN	Generative Adversarial Network
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GII	Global Innovation Index
GP	Genetic Programming
GPAI	Global Partnership on Artificial Intelligence
GPS	General Problem Solver
GPT	Generative Pre-trained Transformer
GPU	Graphics Processing Unit
GRU	Gated Recurrent Unit
HAMLE	Technology-Oriented Industry Initiative
HAVELSAN	Air Electronic Industries (Hava Elektronik Sanayi)
HPC	High-Performance Computing
HRW	Human Rights Watch
HTR	Handwritten Text Recognition
IAP	InterAcademy Partnership
IBM	International Business Machines
ICAIE	International Conference on Artificial Intelligence and Education

ICCR	International Conference on Cyber Resilience
ICLR	International Conference on Learning Representations
ICML	International Conference on Machine Learning
ICTON	International Conference on Transparent Optical Networks
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IUM	International Islamic University Malaysia
IJAET	International Journal of Adult Education and Technology
ILO	International Labour Organization
IMF	International Monetary Fund
IMT	International Mobile Telecommunications
IMT-2030	International Mobile Telecommunications 2030
IoT	Internet of Things
ISBN	International Standard Book Number
ISO	International Organization for Standardization
ITS	Intelligent Tutoring Systems
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
IUI	Intelligent User Interfaces
KVKK	Personal Data Protection Law (Kişisel Verilerin Korunması Kanunu)
LAWS	Lethal Autonomous Weapons Systems
LLM	Large Language Model
LSTM	Long Short-Term Memory
LTA	Land Transport Authority
LTE	Long Term Evolution
MAC	Medium Access Control
MEB (MoNE)	Ministry of National Education
MEMS	Micro-Electro-Mechanical Systems
METU	Middle East Technical University
MIT	Massachusetts Institute of Technology
ML	Machine Learning
MMA	Matrix Multiply Accelerator
MOIT	Ministry of Industry and Technology
MOOC	Massive Open Online Course
MRI	Magnetic Resonance Imaging
MTYZGM	Directorate General for National Technology and Artificial Intelligence
MÜSİAD	Independent Industrialists' and Businessmen's Association Müstakil Sanayici ve İşadamları Derneği
NAIS	National Artificial Intelligence Strategy
NATO	North Atlantic Treaty Organization
NBER	National Bureau of Economic Research
NGO	Non-Governmental Organization
NISQ	Noisy Intermediate-Scale Quantum
NIST	National Institute of Standards and Technology
NLP	Natural Language Processing

OECD	Organisation for Economic Co-operation and Development
ORCID	Open Researcher and Contributor ID
OTS	Organization of Turkic States
PD	Presidential Decree
PDR	Preliminary Design Report
PQC	Post-Quantum Cryptography
PSO	Particle Swarm Optimization
PUE	Power Usage Effectiveness
Q&A	Question and Answer
QAOA	Quantum Approximate Optimisation Algorithm
QKD	Quantum Key Distribution
QPU	Quantum Processing Units
QSDC	Quantum Secure Direct Communication
QUBO	Quadratic Unconstrained Binary Optimisation
RAM	Readiness Assessment Methodology
RAN	Radio Access Network
R&D	Research and Development
RL	Reinforcement Learning
RMF	Risk Management Framework
RNN	Recurrent Neural Network
RPA	Robotic Process Automation
RRM	Radio Resource Management
SAIL	Stanford Artificial Intelligence Laboratory
SAYZEK	Defense Industry Artificial Intelligence Cluster
SDG	Sustainable Development Goals
SI	Swarm Intelligence
SIGAI	Special Interest Group on Artificial Intelligence
SME	Small and Medium-sized Enterprise
SRI	Stanford Research Institute
SSB	Presidency of Defense Industries (Savunma Sanayii Başkanlığı)
STB	Ministry of Industry and Technology (Sanayi ve Teknoloji Bakanlığı)
STEAM	Science, Technology, Engineering, Arts, and Mathematics
STEM	Science, Technology, Engineering, and Mathematics
SVM	Support Vector Machines
T3	Turkish Technology Team (Türkiye Teknoloji Takımı)
T3AI	T3 Foundation Artificial Intelligence (large language model)
TBV	Turkish Informatics Foundation
TEKNOFEST	Aerospace and Technology Festival (Teknoloji Festivali)
TOPS	Trillion Operations Per Second
TPU	Tensor Processing Unit
TRAI	Turkish Artificial Intelligence Initiative
TRL	Technology Readiness Level
TSA	Tabu Search Algorithm
TSMC	Taiwan Semiconductor Manufacturing Company
TUBITAK	Scientific and Technological Research Council of Türkiye
TÜBA	Turkish Academy of Sciences

UAE	United Arab Emirates
UAV	Unmanned Aerial Vehicle
UE	User Equipment
UGV	Unmanned ground vehicles
UIST	User Interface Software and Technology
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
UNESCO	United Nations Educational Scientific and Cultural Organization
US	United States
USA	United States of America
USV	Unmanned surface vehicles
VC	Venture Capital
VDK	Vergi Denetim Kurulu
WEF	World Economic Forum
WIPO	World Intellectual Property Organization
WUE	Water Usage Effectiveness
XAI	Explainable Artificial Intelligence
YÖK (CoHE)	The Council of Higher Education
YZE	Artificial Intelligence Institute
YZF	Artificial Intelligence Factory

FOREWORD

As Türkiye's national science academy, the Turkish Academy of Sciences (TÜBA) is responsible for advancing scientific knowledge, supporting excellence in science, and contributing to the development of evidence-based national science and technology policies. Since its establishment, TÜBA has sought to bolster the scientific ecosystem in our country by promoting high-quality research, supporting young scientists, encouraging interdisciplinary collaboration, and championing the dissemination of scientific thinking across society. We believe that scientific knowledge and qualified human capital are the most valuable resources for achieving sustainable development, technological independence and international competitiveness.

Today, humanity is experiencing one of the most profound technological transformations in history, driven by the rapid advancement of artificial intelligence (AI). AI is no longer confined to computer science; it is transforming virtually every scientific discipline, including medicine, engineering, the social sciences, education, economics, law and the humanities. New AI-driven methodologies are accelerating scientific discovery by providing unparalleled analytical capabilities, thereby changing the way knowledge is produced, shared, and utilized. However, these developments also raise important questions concerning ethics, governance, transparency, security and the future relationship between human and machine intelligence.

In this context, TÜBA keeps a close eye on emerging scientific and technological developments, contributing to national science policy through its thematic and specialized working groups. These groups bring together distinguished scientists and experts from various fields to evaluate technological transformations, identify strategic opportunities and challenges, and inform decision-makers and the public about emerging trends. By publishing scientific reports, holding workshops and conferences, and producing other publications, TÜBA aims to raise public awareness and provide guidance on developments that are reshaping science, technology and innovation ecosystems in Türkiye and around the world.

AI has also become a central theme in international scientific dialogue. TÜBA actively contributes to discussions and policy development within major international scientific organizations and academy networks, including the InterAcademy Partnership (IAP), All European Academies (ALLEA), the International Science Council (ISC), Science 20 (S20), the Association of Academies and Societies of Sciences in Asia (AASSA) and the World Science Forum. On these platforms, the transformative impact of AI on science, society, education, governance and economic development has become a key discussion point. We are delighted that Türkiye will host the World Science Forum in Istanbul in 2027, which will provide a valuable opportunity for the global scientific community to continue discussing the opportunities and challenges posed by AI and related technologies.

This volume brings together valuable contributions from distinguished authors across various scientific disciplines, examining AI from multiple perspectives. The book explores the scientific foundations, technological developments, societal implications, ethical dimensions, policy considerations and future prospects of AI within the broader framework of the National Technology Initiative. In this respect, the book serves as an expanded second volume of TÜBA's National Technology Initiative: Social Reflections and Türkiye's Future, published in 2022, focusing specifically on the transformative role of AI in contemporary society.

I would like to express my sincere gratitude to all the authors and contributors who shared their expertise and insights for this publication. I would also like to thank the Turkish Technology Team Foundation (T3 Foundation) and the KÜME Foundation for their valuable cooperation and contributions to this important work. Lastly, I am grateful to Mr. Selçuk Bayraktar for his invaluable support for the National Technology Initiative and for his contributions to the growth of Türkiye's science and technology ecosystem.

This book will serve as a valuable reference for researchers, students, policymakers, and anyone interested in understanding the opportunities, responsibilities, and future directions emerging in the age of artificial intelligence.

With the hope that this work will contribute to scientific advancement, technological development, and the future prosperity of our country and humanity, I present it to our readers with my deepest appreciation.

Prof. Dr. Muzaffer ŞEKER

Turkish Academy of Sciences (TÜBA), President

FOREWORD

Humanity has rebuilt its vision of civilization with every major technological leap. The transformation we face today with artificial intelligence is likewise a civilizational threshold at which humanity's relationship with knowledge, production, and truth is being reshaped. This new era is concerned not only with what we are capable of producing, but also with the kind of world we wish to build. For us, this process represents a new and strategic phase in strengthening our aspiration for full independence in every field.

The global race in artificial intelligence has evolved from a pursuit of technological superiority into a struggle over which values will shape the future of humanity. Today, we are facing not just economic competition, but also a technocapitalist attempt at global domination, in which powerful technology monopolies view war, peace and human life as mere "optimization problems". We are living in a period when ethical and moral values, priorities and conceptions of humanity are being reconsidered. In a world where AI is playing an increasingly important role in decision-making processes, issues such as justice, transparency, security and moral values have never been more important. Therefore, alongside the production of technology itself, the principles upon which technology is developed have become a strategic determinant.

It is precisely at this point that the vision of the National Technology Initiative of Türkiye serves as a guiding principle, shaping technology through the values of our ancient civilization. Our civilization is one of the heart. Technology in the hands of one without heart, without compassion, becomes nothing more than an instrument of destruction. This approach is based on the idea that human beings, the noblest of all creation, or Ashraf al-Makhluqat according to our beliefs, should be at the center, while also enhancing technological development and production capacity. The determination to become a rule-maker in transformative fields such as artificial intelligence is not about being a mediocre follower in a lane defined and governed by others, but about building an entirely new paradigm founded on justice and compassion. In this respect, our growing ecosystem embodies a vision of conscientious progress, shaped not only by technical competence, but also by thought, morality and responsibility.

Within this framework, it becomes even clearer that human willpower is the fundamental force that determines the direction of technology. The technology celebrated today as artificial intelligence is, essentially, nothing more than a statistical prediction algorithm unaware of its own existence. However, human beings transcend these lifeless numbers. They are not products of statistics, but of will and spirit. For artificial intelligence to serve humanity, a conscious approach to governance and a robust ethical framework are essential. All stakeholders, including technology developers, academia, the public sector, private industry and civil society, must demonstrate a strong and united commitment to a common goal.

Reflecting this civilizational perspective, this work offers a holistic view of artificial intelligence, examining it through a broad framework that encompasses global developments, Türkiye's national approach and forward-looking discussions. By addressing the opportunities and risks of artificial intelligence, this book illuminates an era in which the relationship between technology and humanity is being redefined. In this respect, the book aims to help us not only understand the present, but also contribute to constructing a future vision grounded in values.

The truth is that the key to the future does not lie in the dark lines written by others, but in our own will and in the profound secret of becoming 'one' while preserving human dignity.

I would like to thank TÜBA President Prof. Dr. Muzaffer Şeker, as well as all the authors and editors, for their contributions to the publication of this volume.

Selçuk BAYRAKTAR

Chairman of the Board of Trustees

T3 Foundation and KÜME Foundation

EDITORIAL NOTE

Every transformative era is defined by a technology that reshapes the means of production, as well as the way societies think, govern, compete and imagine their future. Today, AI is that defining technology. In just a few decades, AI has evolved from an academic research discipline into a fundamental capability that influences scientific discovery, industrial production, national security, public administration, healthcare, education, finance, communications and human interaction. Crucially, AI has also become a strategic asset that is increasingly determining the technological competitiveness and geopolitical standing of nations.

The emergence of AI signifies much more than just another phase of digital transformation. It marks the beginning of a new technological paradigm in which knowledge itself becomes the main driver of economic growth, social development and national resilience. As algorithms become capable of learning, reasoning and generating, and of supporting increasingly complex decision-making processes, countries face the dual challenge of adopting these technologies as well as developing the scientific, institutional, ethical and industrial capacities required to shape their evolution. AI is therefore both a scientific revolution and a strategic imperative.

It is in this context that the book ‘Artificial Intelligence and National Technology Reflections’ has been prepared. This volume takes a multidimensional approach to AI, examining it as a phenomenon situated at the intersection of science, engineering, public policy, economics, security, governance, education, ethics and national development. Bringing together distinguished scholars, engineers, policymakers and practitioners from a variety of disciplines, this book provides an integrated perspective, connecting the global evolution of AI with Türkiye’s national technological aspirations, and extending the discussion towards the opportunities and responsibilities that will shape the coming decades. The aim is to give readers a thorough understanding of how AI is changing the relationship between technology, society, and national capability.

The book’s intellectual architecture reflects this holistic vision. Its three main sections are successive stages of a single narrative. Together, they guide the reader from an understanding of AI’s global foundations and the development of national capabilities and institutions to an examination of future technological, ethical, and societal transformations. Progressing from ‘Global Landscape’ to ‘National Landscape’ and finally ‘Future Landscape’ is an intentional intellectual journey that demonstrates how sustainable leadership in AI requires continuous interaction between scientific knowledge, national strategy and long-term vision.

The first part, 'Global Landscape of Artificial Intelligence Technology', establishes the scientific and technological foundations upon which the rest of the book is based. Understanding AI requires an appreciation of its historical evolution, the scientific principles that underpin it and the global dynamics that continue to influence its development. The chapters begin with TÜBA's contribution, which examines the transformation of science in the age of artificial intelligence and shows how AI is reshaping research methodologies and the production, dissemination, and governance of knowledge. They then trace the evolution of AI from symbolic systems to machine learning, deep learning, generative AI, and explainable AI, as well as exploring the emerging discussions surrounding artificial general intelligence.

This section highlights the technological evolution that has made modern AI possible as well as the enabling infrastructures that have contributed to this development. These include large-scale data ecosystems, advanced processors, high-performance computing and large language models. It also considers AI as a tool for geopolitical competition, showing how nations are competing through economic power, computational capacity, talent, research ecosystems, semiconductor technologies and innovation networks. The discussion then moves on to cover international collaboration, sustainability, labour markets, intelligent communication systems and education. It emphasises that AI is a phenomenon that is scientific, economic, social and geopolitical all at once. Together, these chapters provide readers with a comprehensive understanding of the global AI ecosystem and the forces currently redefining international technological leadership.

While the first part establishes the global context, the second part, 'National Landscape of AI (Türkiye Perspective)', demonstrates how these worldwide developments translate into national capability. This transition is one of the book's defining characteristics. While other books treat global developments as external trends, this one explores how countries can transform scientific advances into strategic national assets through coherent public policy, institutional coordination, human capital development, industrial innovation and long-term investment.

Within this framework, the National Technology Initiative emerges as the central organising principle that connects technology with national development. The chapters analyse the National AI Strategy in Türkiye, the contributions of the Turkish Technology Team (T3) Foundation, TEKNOFEST, and the T3AI initiatives. They also examine regulatory developments and the growing integration of AI in defence industries, public administration, education, entrepreneurship and research ecosystems. Together, these contributions demonstrate that a successful AI transformation requires institutions that can support sustainable scientific production, entrepreneurial dynamism, interdisciplinary collaboration and public trust.

Importantly, this book's national perspective does not advocate technological isolation. Instead, it argues that meaningful participation in the global AI ecosystem requires robust domestic capabilities. Nations that develop qualified human resources, advanced research infrastructures, reliable governance mechanisms, competitive innovation ecosystems and value-based technological policies can become active contributors to technological change. The second part illustrates how national technology policies can promote scientific independence, economic competitiveness and strategic resilience in an increasingly interconnected world.

The third part, 'Future Landscape of Artificial Intelligence', starts with KÜME Foundations' chapter, and broadens the discussion to encompass the long-term implications of AI for humanity, beyond present capabilities. Having set out the global scientific foundations and the national strategic perspective, the volume moves on to consider the future of technology itself. The final section acknowledges that AI is still in its infancy and that its most profound consequences are yet to be realised.

The chapters investigate the evolving relationship between AI and various fields, including culture, governance, ethics, quantum technologies, artificial general intelligence, human-AI collaboration, environmental sustainability, AI safety, trust, accreditation, optimisation techniques and future risks. Rather than making speculative predictions, the chapters examine the institutional, philosophical and technological choices that will influence the development of AI in the coming decades.

This section's emphasis on the inseparability of future technological progress and ethical responsibility is a particularly valuable contribution. As AI systems become more autonomous and are integrated into critical infrastructures, societies must strengthen governance, transparency, accountability, explainability and human oversight mechanisms simultaneously. Rather than presenting issues such as deepfakes, autonomous weapons, misinformation, environmental impacts, algorithmic fairness, and trustworthy AI as peripheral concerns, the book highlights them as central components of responsible technological development. By doing so, the book reinforces the idea that sustainable innovation requires technological excellence and institutional maturity.

Taken together, these three sections reveal the central philosophy that underpins the entire book. AI cannot be understood through a single disciplinary lens. Its development depends on scientific research, engineering innovation, industrial capacity, educational transformation, legal frameworks, ethical reflection, international cooperation and strategic public policy all working together simultaneously. While each chapter offers a unique perspective, collectively they demonstrate that AI is best understood as an ecosystem whose success hinges on the interaction of numerous interconnected components.

Another defining strength of this volume is its interdisciplinary nature. The contributors represent a wide range of fields, including computer science, engineering, law, economics, education, international relations, public administration, communication, defence studies, sustainability and philosophy. This diversity enables the book to transcend conventional disciplinary boundaries, reflecting the inherently multidisciplinary nature of AI itself. Readers are therefore invited to understand the broader transformations that accompany them across scientific, institutional, economic and societal domains.

The book also reflects a significant shift in the way contemporary AI scholarship is conceptualised. Much of today's literature either focuses on highly specialised technical developments or on isolated ethical and policy debates. In contrast, 'AI and National Technology Reflections' seeks to integrate these dimensions into a coherent analytical framework. It examines scientific progress alongside governance, technological capability alongside national strategy, innovation alongside responsibility, and global developments alongside local implementation. This integrated approach provides a more comprehensive understanding of AI as a technological revolution and a societal transformation.

The book's contribution to ongoing discussions surrounding the National Technology Initiative is equally significant. AI is becoming one of the main drivers of scientific competitiveness, industrial productivity, national security and digital sovereignty. By linking AI research to broader issues of national technological development, the book shows how scientific excellence can promote sustainable economic growth, institutional resilience and international competitiveness, all the while remaining firmly rooted in ethical principles and human-centred values.

For researchers, this book is an extensive, multidisciplinary reference work that covers the scientific foundations, strategic dimensions and future trajectories of artificial intelligence. For policymakers, it offers an integrated perspective on governance, regulation, education, innovation policy and institutional capacity building. Students and educators will find it to be a comprehensive introduction to one of the defining technological transformations of our time. For industry leaders and entrepreneurs, it highlights the opportunities and challenges of building competitive AI ecosystems. For all readers interested in the future of technology, it offers a balanced exploration of the opportunities and responsibilities involved.

This book is not intended to provide definitive answers to all the questions raised by artificial intelligence. Instead, its purpose is to encourage informed discussion, critical thinking, interdisciplinary collaboration and responsible innovation. The rapid evolution of AI means new scientific discoveries, technological breakthroughs and policy challenges will continue to emerge. Nevertheless, the principles explored

throughout these chapters, scientific rigour, technological excellence, ethical responsibility, institutional resilience and long-term strategic vision, will remain essential foundations for navigating this transformation.

As AI continues to reshape the future of science, economies, governments and societies, there is an increasingly urgent need for comprehensive, interdisciplinary and internationally informed scholarship. We hope that ‘Artificial Intelligence and National Technology Reflections’ will serve as both a valuable academic reference and an enduring contribution to the broader global conversation on artificial intelligence. Bringing together scientific insight, national experience and forward-looking reflection, this volume aims to promote the development of AI that advances knowledge, strengthens institutions and serves humanity, thereby contributing to a more innovative, responsible and sustainable technological future.

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KÜME Foundation

PART I



GLOBAL LANDSCAPE OF ARTIFICIAL INTELLIGENCE TECHNOLOGY



PART II



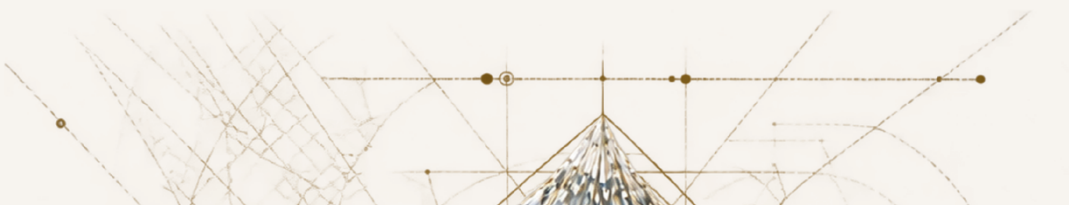
NATIONAL LANDSCAPE OF ARTIFICIAL INTELLIGENCE (TÜRKİYE PERSPECTIVE)



PART III



FUTURE LANDSCAPE OF ARTIFICIAL INTELLIGENCE



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