

Moral design and green technology

Moral design and green technology

Edited by

Bart Wernaart
Gerard Schouten



BRILL | WAGENINGEN ACADEMIC



This is an open access title distributed under the terms of the [CC BY-NC-ND 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/) license, which permits any non-commercial use, distribution, and reproduction in any medium, provided no alterations are made and the original author(s) and source are credited. Further information and the complete license text can be found at <https://creativecommons.org/licenses/by-nc-nd/4.0/>

The terms of the CC license apply only to the original material. The use of material from other sources (indicated by a reference) such as diagrams, illustrations, photos and text samples may require further permission from the respective copyright holder.

Cover illustration: Exploring city nature. The cover (as well as the book's illustrations) was created by Berry Sanders with the assistance of the generative AI tool Midjourney.

The Library of Congress Cataloging-in-Publication Data is available online at <https://catalog.loc.gov>
LC record available at <https://lccn.loc.gov/2025010888>

Typeface for the Latin, Greek, and Cyrillic scripts: "Brill". See and download: brill.com/brill-typeface.

ISBN 978-90-04-71167-9 (hardback)

ISBN 978-90-04-73077-9 (e-book)

DOI 10.3920/9789004730779

Copyright 2025 by Bart Wernaart and Gerard Schouten. Published by Koninklijke Brill BV, Plantijnstraat 2, 2321 JC Leiden, The Netherlands.

Koninklijke Brill BV incorporates the imprints Brill, Brill Nijhoff, Brill Schöningh, Brill Fink, Brill mentis, Brill Wageningen Academic, Vandenhoeck & Ruprecht, Böhlau and V&R unipress.

Koninklijke Brill BV reserves the right to protect this publication against unauthorized use.

For more information: info@brill.com.

This book is printed on acid-free paper and produced in a sustainable manner.

Contents

- List of figures and tables VII
Contributors XI
- 1 Moral design and green technology 1
Bart Wernaart and Gerard Schouten
 - 2 Sustainability struggle: economics, business, and technology
A brief history and future challenges 5
Bart Wernaart
 - 3 Democratizing green technology with the public stack 27
Max Kortlander, Anne-Marie Sweep and Imme Ruarus
 - 4 Behavioural insights for moral design and green technology 48
Jeske Nederstigt
 - 5 The moral programming of XR, and what we can learn from the
AI experience 68
Leon Kester, Bart Wernaart and Nadisha Marie Aliman
 - 6 Citizen science for nature 82
Simona Orzan and Gerard Schouten
 - 7 The role of technology in human–nature connectedness
Case studies on citizen participation 97
Derk Jan Stobbelaar and Jetske G. de Boer
 - 8 Food ethics and technology
Towards food innovation with crowdsourced ethics 120
*Bart Wernaart, Sonja Floto-Stammen, Marieke van Vliet, Anika Kok and
Natalia Naranjo Guevara*
 - 9 How natural is our food?
How relevant is that word for the design of future food? 136
Niels Louwaars
 - 10 How to apply green AI in practice?
Moving from FLOPs to CO₂ footprint 153
Qin Zhao and Gerard Schouten

- 11 Lessons learned from developing green software 168
Luís Cruz and Petra Heck
- 12 A daily data workout!
Being in correspondence for a green data revolution 186
Danielle Arets and Jessie Harms
- 13 Added value of AI for studying urban plants 196
Barbara Gravendeel and Yannick Woudstra
- 14 Adding contextual information to object detection models: a wildflower
monitoring case 208
Georgiana Manolache and Gerard Schouten
- 15 ARISE: a Dutch dataspace connecting nature and people 233
*Elaine van Ommen Kloeke, W. Daniel Kissling, Julian Evans,
Chantal Huijbers, Jacob Kamminga and Gerard Schouten*
- Index 253

Figures and tables

Figures

- 3.1 Private stack, state stack, and public stack illustrations 29
- 3.2 Public, private, and state stack continuum 29
- 4.1 Two systems in the brain that control behaviour (Kahneman, 2011) 54
- 4.2 Original Technology Acceptance Model (Davis, 1986) 57
- 4.3 The diffusion process (Rogers, 1995) 58
- 4.4 The Strategies and Motives for Resistance to Persuasion (SMRP) Framework (Fransen *et al.*, 2015) 59
- 4.5 Self-Determination Theory (Ryan and Deci, 2000) 62
- 5.1 Illustration of the Socio-Technological Feedback Loop from a human-machine interaction perspective (Aliman and Kester 2022a) 75
- 5.2 Illustration of the Socio-Technological Feedback Loop from a system life-cycle perspective 76
- 6.1 Equipped with a torch and landing net, a group of nature enthusiasts visit pools in and around the city of Eindhoven 83
- 6.2 The number of active environmental citizen science projects through the years, according to the inventory maintained by the European Commission (JRC, 2018) 85
- 6.3 Impact of all citizen science projects on SDGs 88
- 7.1 Technology tends to reduce our connection with nature 99
- 7.2 Theoretical model of the mutual influence between system level and daily life level 100
- 7.3 Case study 1, walking apps may be designed to stimulate people to connect more strongly to nature, e.g. by providing information and stories 108
- 7.4 Case study 2, citizen science organized by the Dutch Butterfly Conservation foundation. Buckets with LED-light are used by citizen scientists to record moths in the Netherlands, while butterflies may be recorded along transects 111
- 7.5 Case study 3, IJsselstein is a municipality in the Netherlands with a large collection of fruit trees in the public green space. Technology, including a website and GIS application, provides insight into the uniqueness of this collection and helps to coordinate activities associated with it 113
- 8.1 The value profiles of two people that participated in the moral food lab. Note that the size of the words is in no way correlated with the number of times the words were mentioned 129
- 8.2 The average percentage of values people spoke in, grouped by how they responded to question B 130
- 10.1 Typical AI lifecycle model 155

- 10.2 The computational effort of AI models increases according to Moore's Law of the AI era 157
- 10.3 Carbon intensity for an assortment of locations 159
- 10.4 Benchmark of CNN models for image classification 160
- 10.5 Clean data improves prediction accuracy 161
- 10.6 Clustering the E-waste dataset into device groups 164
- 10.7 Training process of a neural network 166
- 11.1 The five dimensions of sustainable software engineering 171
- 11.2 ISO 25000 quality model 173
- 11.3 Energy monitoring setup for mobile app development 175
- 11.4 Development process for AI-enabled systems, including a data and model (ML) loop 182
- 11.5 Green AI at the root of Trustworthy AI 182
- 12.1 Leaflet Media Gym, Studio Cream on Chrome 187
- 12.2 Screenshot of taste workshop by E-missions 191
- 13.1 Examples of plants in an urban environment. a) Bird's-foot Trefoil (*Lotus corniculatus*), b) Ivy-leaved Toadflax (*Cymbalaria muralis*), c) Kidney Vetch (*Anthyllis vulneraria*), d) White Clover (*Trifolium repens*), e) Dandelion (*Taraxacum officinale*), f) Yarrow (*Achillea millefolium*), g) Common Poppy (*Papaver rhoeas*), h) Ground Elder (*Aegopodium podagraria*), i) Wallflower (*Erysimum cheiri*) 198
- 13.2 Impact of green design of private urban gardens on quality of living environment. Left: tiled backyard with overheated owner with irritated respiratory tract due to allergenic pollen released by ornamental olive shrubs. Right: backyard filled with non-allergenic trees, shrubs and herbs, providing shade, water retention, food to wild animals and a general feeling of well-being to owners 201
- 13.3 Example of urban trees encouraging bird safaris. Migrating Bohemian Waxwings (*Bombycilla garrulus*) foraging for berries in a tree planted along the canal of a typical Dutch historical urban center with bird watchers enjoying the scene, while keeping a respectful distance 202
- 14.1 Challenges of flower identification 'in the wild': 1) viewpoint variations (*Papaver rhoeas*); 2) occlusion (*Ranunculus repens*); 3) clutter (*Achillea millefolium*); 4) light variation (*Leucanthemum vulgare*); 5) deformations (*Bellis perennis*); 6) intra-class variation (*Ficaria verna*); 7) inter-class similarity (*Bellis perennis*, *Leucanthemum vulgare*, *Matricaria chamomilla*) 209
- 14.2 Image recognition and object detection comparison. Image recognition (first and third) labels the entire image, while object detection (second and forth) localizes objects in an image by drawing bounding boxes around them and then labels them accordingly. Photos are crops from EWD images (Schouten *et al.*, 2024) 212
- 14.3 Diagram of the Faster R-CNN architecture 213
- 14.4 Data fusion techniques: (left) early fusion, and (right) late fusion 215
- 14.5 An overview of our multimodal object detection solution 216

- 14.6 An example of an EWD image sliced into tiles, taken from Schouten *et al.* (2024). The dashed lines show equally sized tiles. Note the difference in the number of cut wildflowers (*Calyta palustris* in this case) between the two tiling schemes 218
- 14.7 Selected flower species grouped by visual similarity. Group 1: Buttercup (aggregate), *Caltha palustris*, *Ficaria verna*; Group 2: *Bellis perennis*, Chamomile (aggregate), *Leucanthemum vulgare*. Photos are crops randomly sampled from EWD 219
- 14.8 Data alignment overview for both groups: (top) flowering phenology estimates from NDFF for the selected species and (bottom) histogram of objects counts from EWD for the selected species. The horizontal axis is the day of year ranging from 1 to 365, while the vertical axis is (top) the phenological index, normalized from 0 to 1, and (bottom) an object count 220
- 14.9 Confusion matrix with confidence threshold over 0.75 and IoU threshold over 0.50 for image-only and learned feature-level fusion elementwise addition models 227
- 15.1 Overview of the end-to-end architecture in ARISE 235
- 15.2 Manual data collection and identification (top) versus a fully automatic AI-powered solution for monitoring biodiversity (bottom) 237
- 15.3 Diversity of digital biodiversity sensors tested in ARISE. (a) Location of the three ARISE monitoring demonstration sites in the Netherlands and the deployed sensors to monitor biodiversity non-invasively and remotely. (b) Different sensors and their data volumes 239
- 15.4 Overview of the Biocloud architecture with the different layers of processing the original data sources from raw to enriched and curated data for future use and access 243
- 15.5 The active learning cycle of advanced species identification in ARISE 247

Tables

- 7.1 Examples of changes through technology in various aspects of daily life 103
- 7.2 Types of Human Nature Connectedness (after Ives *et al.*, 2018) and examples of the role of technology 103
- 7.3 Ways in which the different types of HNC may be influenced in the three case studies 112
- 7.4 Future areas of life enhancing HNC 116
- 7.5 The potential role of technology in the symbiocene 116
- 10.1 Metrics of green AI 156
- 14.1 Selected flower species dataset description. Subspecies visually indistinguishable in the field are merged in the EWD dataset: *Ranunculus acris* and *Ranunculus repens* are labelled as Buttercup (aggregate), while *Matricaria chamomilla* and *Matricaria maritima* are labelled as Chamomile (aggregate) 219

- 14.2 Test results on Group 1 and Group 2 for all models averaged over five seeds. Best results are shown in bold 224
- 14.3 Test results per species class for the image-only baseline and the best performing feature fusion models averaged over five seeds 225
- 14.4 Test results on Group 1 and Group 2 for all classification models averaged over five seeds, hence average precision (AP) 226
- 15.1 Mapping of processes and scenarios to ARISE components 247

Contributors

Nadisha-Marie Aliman

Postdoctoral visiting scholar at Utrecht University

Danielle Arets

Professor Journalism and Innovation at Fontys University of Applied Sciences

Jetske de Boer

Professor Biodiversity and Nature-inclusive Society at Aeres University of Applied Sciences, and honorary fellow at NIOO-KNAW

Luís Cruz

Assistant professor Green AI and Sustainable Software Engineering at Delft University of Technology

Julian Evans

Researcher at Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam

Sonja Floto-Stammen

Senior researcher and lecturer in the field of business innovation, food marketing and consumer science at Fontys University of Applied Sciences

Barbara Gravendeel

Special professor in Plant Evolution at Radboud University and team lead of Evolutionary Ecology at Naturalis Biodiversity Center

Jessie Harms

Researcher, project manager at the Dutch National Climate Platform

Petra Heck

Lecturer, researcher and coordinator at Fontys University of Applied Sciences

Chantal Huijbers

Senior project manager at Naturalis Biodiversity Center

Jacob Kamminga

Assistant professor at the University of Twente

Leon Kester

Senior research scientist Responsible AI at TNO

W. Daniel Kissling

Associate professor of Quantitative Biodiversity, Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam

Max Kortlander

Writer and researcher at Waag Futurelab

Niels Louwaars

Law group at Wageningen University, and CEO at Plantum

Georgiana Manolache

Lecturer and researcher Data Science and AI at Fontys University of Applied Sciences and PhD candidate at Eindhoven University of Technology

Jeske Nederstigt

Consumer psychologist and a senior researcher Sustainable Behavioral Change at Fontys University of Applied Science

Natalia Naranjo Guevara

Researcher edible insects and senior project manager at New Generation Nutrition (NGN) [with specialisms in entomology, agribusiness, insect biology and behaviour]

Elaine van Ommen Kloeke

Program manager ARISE at Naturalis Biodiversity Center

Simona Orzan

Teacher and researcher at Fontys University of Applied Science

Imme Ruarus

Lab lead Smart Citizens Lab at Waag Futurelab

Derk-Jan Stobbelaar

Teacher and researcher at Van Hall Larenstein University of Applied Sciences

Gerard Schouten

Professor AI and Data and chair Centre of Expertise AI for Society at Fontys University of Applied Sciences

Anne-Marie Sweep

Researcher Collective Creativity and Innovation at Fontys University of Applied Sciences

Marieke van Vliet – van der Graaff

Senior researcher Moral Design Strategy at Fontys University of Applied Sciences, owner of Breinpaleis

Bart Wernaart

Professor Moral Design Strategy and chair Centre of Expertise Sustainable and Circular Transitions at Fontys University of Applied Sciences. Head of Research Fontys Business and Communication.

Yannick Woudstra

Postdoctoral researcher at Netherlands Institute of Ecology (NIOO-KNAW) and evolutionary botanist at Stockholm University

Qin Zhao

Teacher and researcher Green AI and Sustainable ICT at Fontys University of Applied Sciences