

Contents

Part I Introduction	1
1. Elements of Our Hybrid Existence	3
1.1 Why Study Physicality	3
1.2 Components of the Physical World	4
1.3 Kinds of Things: From Stones to Silicon	6
1.4 The Natural Order	7
1.4.1 The artificial—works of our hands	9
1.5 Coming Together	12
1.5.1 Making things usable—Human— Computer Interaction	14
1.5.2 Of designers, computer-embedded devices and physicality	16
1.6 Different Ways to Touch	22
1.7 Learning about Physicality	26
2. What's Happening Now	31
2.1 Computing in The World	31
2.1.1 Ubiquitous computing (ubicomputing)	31
2.1.2 Internet of Things	32
2.1.3 Invisible intelligence	33
2.1.4 Sensors, surveillance, and smart cities	34
2.1.5 Nanotechnology and smart dust	35
2.2 Technology at Our Fingertips	37
2.2.1 Tangible user interfaces (TUI)	37
2.2.2 Haptics and smart materials	37
2.3 Up Close and Personal	39
2.3.1 Mobile and personal devices	39
2.3.2 Wearable computing and fashion	40
2.3.3 Physiological computing	41

2.4	Blending Digital and Physical Worlds	42
2.4.1	Simulated reality	42
2.4.2	Virtual reality	43
2.4.3	Augmented reality and mixed reality	44
2.5	Robots and Automation	45
2.5.1	Human–robot interaction	45
2.5.2	Not being there—telepresence robots	46
2.5.3	Robots you live in	49
2.6	Digital Fabrication and DIY Electronics	49
2.6.1	Digitized industry	49
2.6.2	3D printing and digital fabrication	51
2.6.3	DIY electronics and hacking	51
2.6.4	Maker culture, from coding to crafting	53

Part II | Human Body and Mind 55

3.	Body	57
3.1	Body as a Physical Thing	57
3.2	Size and Speed	59
3.3	The Networked Body	61
3.4	Adapting IT to the Body	63
3.5	The Body as Interface	65
3.6	As Carrier of IT—The Regular Cyborg	68
4.	Mind	72
4.1	Mind as a Physical Thing	72
4.2	Memory and Time	74
4.3	Just Numbers	76
4.4	Multiple Intelligences	77
4.5	The Brain as Interface	83
4.6	Creativity and Physicality	85

5.	Body and Mind	89
5.1	Whole Beings	89
5.2	Sensing Ourselves	89
5.3	The Body Shapes the Mind—Posture and Emotion	92
5.4	Cybernetics of the Body	94
5.5	The Adapted Body	99
5.6	Plans and Action	103
5.7	The Embodied Mind	108
6.	Social, Organizational, and Cultural	112
6.1	Personal Contact	112
6.2	Intimacy	114
6.3	Mediation and Sharing	116
6.4	Socio-organizational Church—Turing Hypothesis	120
6.5	Culture and Community of Practice	123
6.6	Political	125

Part III | Objects and Things 129

7.	Physicality of Things	131
7.1	Physics and Naïve Physics	131
7.2	Rules of Physical Things	133
7.3	Continuity in Time and Space	135
7.4	Conservation of Number and Preservation of Form	135
7.5	Emotion and Nostalgia	137
7.6	All Our Senses	139
8.	Interacting with Physical Objects	145
8.1	Affordance Revisited—What We Can Do and What We Think We Can Do	145
8.2	Affordances of the Artificial	146
8.3	Adapted for New Actions	148

8.4	Action as Investigation	153
8.5	Letting the World Help	156
9.	Hybrid Devices	162
9.1	Abstraction—Software as if Hardware Doesn't Matter	162
9.2	The Limits of Hardware Abstraction	165
9.3	Specialization—Computer-embedded Devices	169
9.4	What Does It Do?	170
9.5	Mapping	172
9.6	Feedback	180
9.7	The Device Unplugged	185
9.7.1	Exposed state	186
9.7.2	Hidden state	188
9.7.3	Tangible transitions and tension states	194
9.7.4	Natural inverse	197
10.	Tools, Equipment, and Machines	202
10.1	Tools and the Development of Humankind	202
10.2	Affordance, Understanding, and Culture	204
10.3	Heidegger, Hammers, and Breakdown	207
10.4	From Philosophy to Design: Designing for Failure	212
10.5	Breakdown and Reflection	216
Part IV Space		223
11.	Physicality of Space	225
11.1	Void—Matrix or Myth	225
11.2	From Nothing—Points, Lines, and Circles	227
11.3	Flatness—The Shape of Space	230
11.4	Uniformity—Continuity and Fracture	233
11.5	Scale—Size Matters	236
11.6	Relativity and Locality	240

11.7	Time Too	244
11.8	Terra Firma	247
11.9	Patterns in the Landscape	249
12.	Comprehension of Space	252
12.1	Early Understanding of Space	253
12.2	Childhood and Larger Spaces	253
12.3	Feeling and Acting in Space	255
12.4	Seeing Space—3D Vision	257
12.5	Mental Space	259
12.6	Maps, Sketches, and Cartography	261
12.7	Paths and Narrative	264
12.8	The Language of Space	267
12.9	Culture and Time/Space	268
12.10	Virtual Space	270
12.11	Place and Non-place	272
12.12	Journey or Destination	274
13.	The Built Environment	279
13.1	Introduction	279
13.2	Physical–Digital Layers	279
13.3	Temporal Layering	285
13.4	Digital–Physical Playgrounds	288
13.5	The Conquest of Space	288
13.6	Computer Mediation	290
13.7	Digital Culture	290
13.8	The Internet of Things	295
13.9	Human Technology	300
14.	Digital Augmentation of Space	301
14.1	Control over Space	301
14.2	Mobile Phones and Mobile Applications	303
14.3	Pervasive and Public Displays	306
14.4	Interacting with Public Displays	308

14.5	Public Roles, Privacy, and Intrusion	311
14.6	Space as Interface	314
14.7	Mixed Reality—Real Space Meets Virtual	317
14.8	Computational Space	320
14.9	Designing Intelligent Spaces	322
14.10	Fruits of Success	325
14.11	Hyperlocal	326
Part V Computation and Information		329
15.	Representation and Language	331
15.1	Fire	331
15.2	Representation	333
15.3	Ideas	335
15.4	Externalization	337
15.5	From Knowing to Knowing about Knowing	342
15.6	Language and Learning	344
15.7	The Origins of Language	346
15.8	Interpretation	349
15.9	Internalization	352
15.10	The Development of Self	353
16.	Reproducibility	356
16.1	Moulds, Plans, and Mass Production	359
16.2	Singularity and Scarcity	363
16.3	The Irreproducible and Impermanent	366
16.4	Recording	369
16.5	Decontextualization	373
17.	Embodied Computation	378
17.1	The Physics of Information	378
17.2	Turing Machine or Touring Machine?	383
17.3	Physical Locality of Computation	384
17.4	Time and Distance	385

17.5	Finitude and Moore's Law	388
17.6	Smaller and Smaller, More and More	390
17.7	Stand Up and Walk—Robots Come of Age	394
	17.7.1 Environment	396
	17.7.2 Embodied communication	396
17.8	Money	398
	17.8.1 Money as value	398
	17.8.2 Money as information	400
18.	Connecting Physical and Digital Worlds	406
18.1	Visual Identifiers	406
18.2	Electronic Tagging	409
18.3	Intrinsic Properties	411
18.4	Marking the Environment and Media	412
18.5	Digital Identifiers of Physical Things	414
18.6	Bringing Them Together	417
18.7	Doing Things	420
18.8	Ways of Knowing	422
Part VI The Theory and Practice of Physicality		427
19.	Design Lessons and Advice	429
19.1	Introduction	429
19.2	Lesson 1: Prototype a Lot	429
19.3	Lesson 2: Context Offers Complications and Solutions	437
19.4	Lesson 3: Be Human-centric	444
19.5	Lesson 4: Highly Abstracted and Selective Physicality Can Be Powerful	446
19.6	Lesson 5: Sometimes Using Physicality Just Makes More Sense	448

20. Prototyping and Tool Support	454
20.1 Introduction	454
20.2 The Problem with Digitality	454
20.3 Interaction Design Tools	459
20.4 State Transition Diagrams	462
20.5 Storyboarding	464
20.6 Paper Prototyping	465
20.7 Video	469
20.8 Software/Hardware Hybrid Approaches	469
20.9 Serious Toys	470
20.10 Bespoke Kits	471
20.11 Office Software	472
20.12 The Power of the Keyboard	472
20.13 Programmable Boards	473
20.14 Internet of Things	474
20.15 Automated PCB Design Tools	476
21. Computational Modelling and Implementation	480
21.1 Modelling	480
21.1.1 Continuity	481
21.1.2 Intention	482
21.2 Software — Engineering, Architecture, and Security	484
21.2.1 Where do you do computation?	484
21.2.2 Where am I?	486
21.2.3 Networks	488
21.3 Working with Electronics	489
21.4 Time and Delays	491
21.4.1 Delay-sensitive interaction	492
21.4.2 Physical actions take time	494
21.4.3 Coding it	498
21.5 Pragmatics	500
21.5.1 Resilience	500
21.5.2 Cost and size	501

22. Theory and Philosophy of Physicality	503
22.1 Gathering Threads	503
22.2 What It Means to Be Physical	503
22.3 Ghosts of Physicality	505
22.3.1 Money	506
22.3.2 Space	507
22.4 Embodied Cyborgs	508
22.5 The Limits of Embodiment	511
22.6 The Extended Genome	512
22.7 Hybrid Ecologies	515
22.8 From Object to Agent	520
22.9 Deep Digitality	523
22.10 Final Call	526
<i>Bibliography</i>	527
<i>Image Credits</i>	562
<i>Index</i>	564