Contents

Introduction 1

1 Beginnings of Communication Technology in the 20th Century 7
1.1 Communication Network 9
1.2 Network Analyses 20
1.3 Ernst A. Guillemin, Lotfi A. Zadeh, Dr. Jekyll and Mr. Hyde . 32
1.4 Ideal and Optimum Filters 39
1.5 Generalizations 45
1.6 Let's go digital! 48
1.6.1 A View from 1950 into the Future of 1965 55
1.6.2 System Theory 57
1.6.3 From System Theory to the Theory of Fuzzy Systems . . 63

2 Logical Tolerance, *Ensembles Flous* and *Probabilistic Metrics* 65
2.1 The Vienna Circle 65
2.2 Karl Menger: "From the Criterion of Meaning to the Principle of Tolerance" 77
2.2.1 Menger's Conventionalism 85
2.2.2 Alfred Tarski's Support 89
2.2.3 The Principle of Logical Tolerance 93
2.3 Probabilistic or Statistical Metrics and *Ensembles Flous* 98

3 General Systems Theory and Cybernetics 111
3.1 General Systems Theory 113
3.2 Cybernetics 120
3.3 Communication Theory 129
3.4 "The Cybernetics Group" 137
3.5 Von Neumann, the Computer and the Brain 148
3.6 Pattern Recognition with the Perceptron 153
3.7 Automata 158

4 From Circuit Theory to System Theory . . . 165
4.1 Dynamic Programming . . . 167
4.2 Identification Problems and a "Time Out" in Princeton . . . 170
4.3 "Optimal Fetishism", Expanded Linearity Concepts and Adaptive Systems . . . 176
4.3.1 Optimality . . . 177
4.3.2 Linearity . . . 179
4.3.3 "Non-Inferiority" . . . 180
4.3.4 Adaptivity . . . 183
4.4 Zadeh's System Theory . . . 186
4.4.1 The State Space Approach . . . 188
4.4.2 A Renaissance of General Systems Theory? . . . 192
4.4.3 System States as Input-Output State Relation Pairs . . . 195
4.5 Zadeh's Decision . . . 197

5 Fuzzy Sets and Fuzzy Systems . . . 201
5.1 The Genesis of Fuzzy Set Theory . . . 203
5.2 Fuzzy Sets and Fuzzy Systems . . . 212
5.2.1 Fuzzy Sets . . . 213
5.2.2 Fuzzy Systems . . . 215
5.2.3 Fuzzy Classes of Systems . . . 216
5.2.4 Optimization under Fuzzy Conditions . . . 217
5.2.5 First Papers on Fuzzy Sets . . . 218
5.3 The Article *Fuzzy Sets* . . . 219
5.4 An Interpretation for Unions and Intersections . . . 224
5.5 System Theory and Fuzzy Systems . . . 228

6 Fuzzifications . . . 235
6.1 Reactions . . . 235
6.2 Fuzzy Automata . . . 241
6.3 Fuzzy Algorithms . . . 245
6.4 Fuzzy Turing Machines . . . 254
6.5 Fuzzifications of Elements of Mathematical Theory . . . 254
6.6 Other Fuzzifications . . . 259
6.7 Fuzzy Control . . . 266
6.8 The First "Fuzzy Logic Controller" for Controlling a Steam Engine . . . 270

7 The Fuzzification of Medical Diagnostics . . . 283
7.1 Mechanization in Medical Diagnostics . . . 286
7.2 Biomedicine and Digital Computers . . . 288
7.3 Computer Systems in Medicine . . . 303
7.4 Computer-Assisted Diagnosis at Vienna General Hospital . . . 307
7.4.1 CADIAG . . . 309
7.4.2 CADIAG-I . . . 314
7.4.3 From CADIAG-I to CADIAG-II . . . 317

7.5 Fuzziness in Medicine . . . 320
7.5.1 "Medical Knowledge" . . . 325
7.5.2 CADIAG-II . . . 331

8 Conclusion . . . 337

Afterword by Lotfi A. Zadeh . . . 351

References . . . 353

List of Figures . . . 391

Index of Names . . . 399

Index of Subjects . . . 405