

# Contents

|                                                   |                                                  |           |
|---------------------------------------------------|--------------------------------------------------|-----------|
| <b>1</b>                                          | <b>Introduction</b>                              | <b>1</b>  |
| 1.1                                               | Weird Mods of Excitable Automata                 | 3         |
| 1.2                                               | Excitation on Proximity Graphs                   | 6         |
| 1.3                                               | Automated Search for Localisations               | 8         |
| 1.4                                               | Reaction-Diffusion, Automata and Populations     | 8         |
| 1.5                                               | Minimal Models of Population Dynamics            | 9         |
| 1.6                                               | Towards Computing in Reaction-Diffusion Automata | 11        |
| 1.7                                               | Collision-Based Computing in Excitable Automata  | 13        |
| 1.8                                               | Spiral Rule Automata                             | 14        |
| 1.9                                               | Memristors in Cellular Automata                  | 16        |
| 1.10                                              | On Colors                                        | 18        |
| <br><b>Part I Phenomenology and Localisations</b> |                                                  |           |
| <b>2</b>                                          | <b>Reaction-Diffusion Binary-State Automata</b>  | <b>21</b> |
| 2.1                                               | Precipitating Automata                           | 22        |
| 2.2                                               | Diffusion-Association Automaton                  | 25        |
| 2.3                                               | Functional Classification                        | 29        |
| 2.4                                               | Excitable Automata without Refractory State      | 29        |
| 2.5                                               | Summary                                          | 34        |
| <b>3</b>                                          | <b>Retained Excitation</b>                       | <b>37</b> |
| 3.1                                               | Rectangularly Growing Domains                    | 38        |
| 3.2                                               | Diamond-Shaped Growing Domains                   | 42        |
| 3.3                                               | Octagonally Growing Domains                      | 48        |
| 3.4                                               | Almost Disc-Shaped Growing Domains               | 52        |
| 3.5                                               | Amoeboid Growth of Mixed-State Patterns          | 53        |
| 3.6                                               | Not Growing Domains of Excitation                | 56        |
| 3.7                                               | Domains with Small Number of Still Localizations | 61        |
| 3.8                                               | Mobile Localizations                             | 65        |
| 3.9                                               | Summary                                          | 65        |

|          |                                                                    |     |
|----------|--------------------------------------------------------------------|-----|
| <b>4</b> | <b>Mutualistic Excitation</b>                                      | 67  |
| 4.1      | Phenomenology of Mutualistic Excitation                            | 68  |
| 4.2      | Mobile Localisations                                               | 70  |
| 4.3      | Stationary Localisations                                           | 80  |
| 4.4      | Huge Localisations                                                 | 88  |
| 4.5      | Characterising Localisations                                       | 92  |
| 4.6      | Excitation Rules Rich with Localisations                           | 93  |
| 4.7      | Summary                                                            | 94  |
| <b>5</b> | <b>Dynamical Excitation Intervals: Diversity and Localisations</b> | 97  |
| 5.1      | Morphological Diversity                                            | 99  |
| 5.2      | Generative Diversity and Localisations                             | 107 |
| 5.3      | Summary                                                            | 113 |
| <b>6</b> | <b>Excitable Delaunay Triangulations</b>                           | 115 |
| 6.1      | Structural Properties of Delaunay Automata                         | 117 |
| 6.2      | Absolute Excitability                                              | 121 |
| 6.3      | Relative Excitation                                                | 123 |
| 6.4      | Summary                                                            | 133 |
| <b>7</b> | <b>Excitable <math>\beta</math>-Skeletons</b>                      | 135 |
| 7.1      | Absolutely Excitable Skeletons                                     | 137 |
| 7.2      | Relatively Excitable Skeletons                                     | 141 |
| 7.3      | Stability of Localised Oscillators                                 | 151 |
| 7.4      | Summary                                                            | 151 |
| <b>8</b> | <b>Evolving Localizations in Reaction-Diffusion Automata</b>       | 155 |
| 8.1      | Breeding Glider-Supporting Rules                                   | 156 |
| 8.2      | Likelihood of Gliders                                              | 156 |
| 8.3      | Quasi-chemical Reaction                                            | 158 |
| 8.4      | Reductions of Transitions Functions                                | 161 |
| 8.5      | Summary                                                            | 162 |

## Part II Population Dynamics

|           |                                         |     |
|-----------|-----------------------------------------|-----|
| <b>9</b>  | <b>Population Dynamics in Automata</b>  | 165 |
| 9.1       | Mutualism                               | 166 |
| 9.2       | Commensalism and Amensalism             | 168 |
| 9.3       | Parasitism                              | 169 |
| 9.4       | Competition                             | 177 |
| 9.5       | Summary                                 | 180 |
| <b>10</b> | <b>Automaton Mechanics of Mutualism</b> | 183 |
| 10.1      | Phenomenology                           | 184 |
| 10.2      | Localisations in Mutualistic Systems    | 185 |
| 10.3      | Summary                                 | 193 |

**Part III Computation with Excitation**

|           |                                                                  |     |
|-----------|------------------------------------------------------------------|-----|
| <b>11</b> | <b>Voronoi Automata</b> .....                                    | 199 |
| 11.1      | Voronoi Automata .....                                           | 199 |
| 11.2      | Constructing Voronoi Diagram on Voronoi Automata .....           | 202 |
| 11.3      | Arbitrary-Shaped Planar Objects and Contours .....               | 202 |
| 11.4      | Summary .....                                                    | 207 |
| <b>12</b> | <b>Adders and Multipliers in Sub-excitable Automata</b> .....    | 209 |
| 12.1      | Adders .....                                                     | 210 |
| 12.2      | Multipliers .....                                                | 216 |
| 12.3      | Summary .....                                                    | 228 |
| <b>13</b> | <b>Computing in Hexagonal Reaction-Diffusion Automaton</b> ..... | 229 |
| 13.1      | Input Interface .....                                            | 233 |
| 13.2      | Memory Device .....                                              | 235 |
| 13.3      | Routing and Tuning Signals .....                                 | 237 |
| 13.4      | Binary Operations .....                                          | 240 |
| 13.5      | Implementation of the Finite State Machine .....                 | 242 |
| 13.6      | Transformation of Two- and Four-Bit Strings .....                | 244 |
| 13.7      | Six Bit Coding .....                                             | 250 |
| 13.8      | Scylla and Charybdis: Outcomes of Passing between Two Eaters ... | 252 |
| 13.9      | Summary .....                                                    | 255 |
| <b>14</b> | <b>Semi-memristive Automata: Retained Refractoriness</b> .....   | 263 |
| 14.1      | Methods: Experiments and Classification .....                    | 264 |
| 14.2      | Classes .....                                                    | 264 |
| 14.3      | Hierarchies .....                                                | 270 |
| 14.4      | Travelling Localisations .....                                   | 277 |
| 14.5      | Summary .....                                                    | 283 |
| <b>15</b> | <b>Structural Dynamics: Memristive Excitable Automata</b> .....  | 287 |
| 15.1      | Phenomenology .....                                              | 289 |
| 15.2      | Oscillating Localisations .....                                  | 296 |
| 15.3      | Dynamics of Excitation on Interfaces .....                       | 300 |
| 15.4      | Building Conductive Pathways .....                               | 302 |
| 15.5      | Summary .....                                                    | 308 |
| 15.6      | Appendix .....                                                   | 309 |
|           | <b>Epilogue</b> .....                                            | 311 |
|           | <b>References</b> .....                                          | 313 |
|           | <b>Index</b> .....                                               | 327 |