

## Index

- A-Design, 78, 82, 91, 139, 140, 161, 193,  
 199, 205, 212, 214, 216, 218, 224, 312,  
 443, 458–462, 464
- A-Design theory, 193
- abstraction grammar, 73, 199, 200, 202
- active element, 192, 205, 206, 208–210,  
 212, 224
- agents, 140, 193, 194, 214–218, 284, 285, 313,  
 317, 433, 436–438, 441, 458, 459, 462
- AIRCYL, 242, 432
- airplane, 80, 443, 446–448, 451
- algebra of shape, 27, 32
- ambiguity, xii, xxiii, 13, 14, 16, 18, 20, 21, 24,  
 34, 61, 62, 64, 255
- analog circuit, xxiv, 280, 391–396, 398, 401,  
 403, 404, 406, 407, 409–411, 413–415,  
 418, 419, 421–427
- analytical method, xxi, 242, 243
- arc consistency, 232
- artificial heart, 78, 79, 81, 82, 87, 88, 91
- artificial heart grammar, 81, 82, 87
- artificial intelligence (AI), i, vii, xxii–xxiv, 7,  
 19, 61, 64, 90–92, 94, 125, 188, 224–229,  
 242, 264–269, 312, 314, 315, 317–319,  
 357, 358, 360, 361, 365, 390, 406, 424,  
 428, 440, 441, 464, 465
- ASIC, 391, 424, 426
- assignment, 11, 15, 48, 49, 58, 66, 232, 252,  
 278, 313
- automotive, i, 102, 120, 122, 169, 221, 393
- backtracking, 231, 232, 236, 239, 241, 242,  
 269, 398, 401, 405, 406
- BACON, 443, 450, 455–457, 462
- basic element, 22–26, 28–35, 41, 47, 66
- behavioral equation, 217, 460
- BEP model, 261, 262
- BOGART, 246
- bond graph, 67, 91, 180–188, 190–193, 199,  
 205, 206, 208–210, 212, 224, 226, 232,  
 233, 237, 459
- bond graph chunk, 180–187, 191, 193, 233
- Boolean operation, 25, 30, 34
- CAD (*see* computer-aided design)
- CADET, 232, 244, 246, 251, 262, 266
- case-based reasoning, 243, 244, 246, 250, 256,  
 263, 266, 267
- CASECAD, 244
- catalog design, 180, 196, 197, 198, 203, 204,  
 219, 223, 224, 278
- causal explanation, 251, 256, 257
- causal processes, 257
- cellular automata, 47, 133, 163, 168, 169
- Chomsky hierarchy, 44, 46
- circuit designer's apprentice, 246
- circuit sizing, 399–401, 403, 404, 407, 410
- circuit synthesis, xxiv, 395, 401, 403, 404, 407,  
 409, 411–414, 419, 423, 424, 426
- CMOS, 391, 393, 409, 418, 424, 425
- coding, 144, 147, 148, 160, 196, 275–277, 289,  
 290, 307, 308, 338
- coffee maker, 73, 74, 76, 77, 81–84, 86–90
- coffee maker grammar, 73, 76, 81–84, 86–89
- cognition, 453, 454, 458, 464
- combinatorial optimization, xxiv, 7, 125, 284,  
 285, 318, 421
- combinatorial search, xii, 6, 8, 18
- compiler, viii, xxiv, 131, 156, 163, 197, 227,  
 423, 425, 428, 429, 431–437, 439–441
- compliant mechanisms, 105, 118, 119, 122,  
 123, 225, 356
- composition of interest, 383
- compound shapes, 34
- computational model, 92, 201, 204, 226, 318,  
 442, 443, 457, 458, 463, 465

- computational synthesis, 214, 225, 358  
 computer-aided design (CAD), 3–8, 10, 11,  
 14–18, 80, 90, 91, 125, 130, 156–158,  
 160–169, 243, 244, 248, 312, 313, 357,  
 359, 360, 394, 396, 398, 399, 423–427  
 configuration space, 234, 254, 255, 269, 321,  
 324, 326, 328, 343–361  
 constraint satisfaction, 231, 232, 252  
 contact constraints, 345–347, 349–351  
 continuity, 4, 63, 168, 228  
 continuous structure, 99  
 counting, 19, 24, 28, 35, 44, 46, 58, 62–64, 407  
 critical feature, 381–384, 386  
 crossover, 144–147, 191, 272, 273, 275–277,  
 284, 286, 290, 294, 297–300, 302,  
 307–310, 313, 316, 319  
 customer needs, 170, 173–175, 183, 189, 195,  
 200, 203, 206, 218, 219, 221, 225
- decomposition, xii, 11, 28, 29, 33–36, 40, 44,  
 47, 49, 50, 52–57, 61, 62, 64, 73, 76, 81,  
 82, 86, 87, 185, 186, 208, 215, 254, 313,  
 396, 399, 432, 446  
 DENDRAL, 239, 266  
 design by example, 258, 259, 265  
 design generalization, 251, 258, 263  
 design methodology, xviii, 162, 184, 224, 225,  
 394, 396, 398, 401, 423, 425  
 design process model, 172, 175  
 determinate rule, 32, 41, 42, 48  
 discovery, viii, xix, xxii, xxiv, 63, 147,  
 442–447, 449–459, 461–465  
 discrete structures, xxiii, 19, 70, 92, 102, 105,  
 106, 125  
 distillation region, 381, 383, 386, 387  
 DURAND, xi, xiii, xviii, 1–5, 7, 14, 17, 18  
 dynamic system, 180, 181, 184–188, 190–193,  
 204, 205, 209, 212, 218, 219, 223, 225, 226
- education, i, 83, 89, 124, 454, 455, 463  
 effort flow analysis, 220, 221  
 electric generator, 442, 443, 445  
 embedding relation, 22, 24, 29, 33  
 emergence, xxi, 14, 16, 17, 66, 81, 83, 89,  
 147, 168  
 emergent, xxii, 10, 14, 15, 17, 58, 81, 83,  
 147, 163  
 EMYCIN, 239, 269  
 encoding, 5, 7, 274, 275, 288, 299, 307,  
 308, 311  
 endoskeletal structures, 93  
 engineering design synthesis, i, iv, xv–xviii,  
 xxi, xxii, 170, 220, 285, 298, 299  
 ENVISION, 251, 252, 254
- ergonomics, 219  
 etching, 129, 133, 140, 144, 148, 149, 153, 155,  
 157, 159–164, 167–169  
 Euclidean transformations, 25, 30, 34, 36  
 evaluation, 69–71, 76, 79, 83–87, 90, 118, 122,  
 140, 148, 149, 153, 158, 162, 166, 174,  
 193, 195, 205, 217, 225, 273, 274, 299,  
 300, 339, 366, 368, 406, 407, 409, 411,  
 420, 426, 448, 449, 451, 460  
 evolution strategies, 272, 273, 277, 288, 316  
 evolutionary computation, 271, 272, 277,  
 279, 281, 283–285, 298, 311–320  
 evolutionary programming, 272, 273, 277,  
 278, 312, 317, 319  
 exoskeletal structure, 93, 120  
 ExplainIT, 257, 258  
 exploration, 140, 142–144, 153, 156, 201, 236,  
 268, 270, 273, 276, 283, 297–299, 309,  
 395, 404, 407, 424, 427, 446, 449, 465
- fabrication, xxiv, 11, 13, 15, 16, 126, 127,  
 129–134, 140, 141, 143, 144, 148,  
 153–165, 168, 169, 393, 398, 399  
 Faraday, 442–446, 449, 455, 458, 462, 464  
 feasible space, 85, 403, 454  
 frame-based system, 238  
 FROB, 254  
 functional parameter, 193, 195, 214, 459  
 fuzzy system, 272, 279, 287–291, 294, 297, 298
- generalized disjunctive programming, 364  
 generative rule, 6  
 genetic algorithm, xxiii, 110, 118, 122–124,  
 144, 148, 152, 154, 160, 162, 163, 165,  
 169, 190, 191, 231, 270, 272–278, 280,  
 284, 285, 286, 299, 302, 306, 311–320,  
 357, 403, 408, 411, 425, 459  
 genotype, 144, 146, 275, 299, 300  
 geometric constraints, 191, 222, 333, 345,  
 355, 356, 431
- grammar  
 abstraction, 73, 199, 200, 202  
 artificial heart, 81, 82, 87  
 coffee maker, 73, 76, 81–84, 86–89  
 graph, 47, 67, 73, 91, 92, 202–204, 224, 226  
 lathe, 68, 72, 82–84  
 robot arm, 72, 73, 82, 83  
 set, 14, 47, 68  
 shape, i, vii, xxii, xxiii, xxv, 5–7, 14, 19,  
 65–73, 76–86, 88–92, 114, 168, 218, 236,  
 440, 460  
 truss, 70, 80, 81, 86  
 graph grammar, 47, 67, 73, 91, 92, 202–204,  
 224, 226

- graphic element, 3  
 Guadet, xviii, 1, 2, 18
- hardware description language (HDL),  
 393–395, 396, 426
- homogenization, 98–100, 102, 104, 121,  
 123–125, 138, 160, 225, 312
- IBIS, 233, 251, 262
- IC (*see also* integrated circuit), 168, 391, 393,  
 394, 396, 398, 399, 423, 425–427
- IDAC, 404–405, 413
- IDeAL, 62, 84, 85, 88, 206, 247, 298, 368, 439
- impedance synthesis, 187, 205
- industrial mass production, 3
- inheritance, 144, 273
- integrated circuit (IC), ix, xxiv, 166, 167, 279,  
 391, 398, 423–428
- intelligent structure, 121
- invention, xx, xxii, xxiv, 13, 14, 21, 22, 38,  
 61, 63, 161, 269, 312, 316, 322, 363,  
 389, 442–446, 449, 451–455, 458,  
 462–464
- KEKADA, 443, 450, 457, 458, 461, 462
- kinematic synthesis, vii, xxiii, 269, 321,  
 322, 326, 328, 335, 340, 354–356,  
 360, 361
- kinematics, xiii, 61, 63, 64, 86, 196, 219, 266,  
 267, 321–324, 326–328, 330, 333–336,  
 354, 356–361
- kinetics, 322
- knowledge representation, 224, 228, 237,  
 239, 265, 266, 378, 389
- knowledge-based system, xxiii, 228, 237,  
 239–242, 249, 250, 264, 266
- Krebs, 443, 445, 446, 449, 455, 457, 458, 461,  
 462, 464
- Kritik2, 244, 247, 262
- labeled shape, 33, 66, 68
- labels, 32–34, 47, 66–68, 74, 77, 78, 81, 87
- Lagrange's theorem, 43
- language, xx, xxi, 5, 6, 7, 16, 18, 19, 44, 47,  
 66–70, 82, 84, 85, 89–92, 112, 113, 125,  
 130, 158–160, 166, 167, 172–174, 180,  
 186, 193, 196, 197, 212, 218, 219, 228,  
 239, 244, 258, 264, 265, 393, 395, 396,  
 422, 425, 426, 428, 429, 432–435, 438
- lathe grammar, 68, 72, 82–84
- layer, 3, 15, 33, 54, 115, 121, 127–129, 134,  
 148, 149, 247, 248, 279, 280, 386,  
 387, 430
- layout assembly, 414, 419
- layout synthesis, 136, 154, 163–165, 169, 281,  
 396, 401, 414, 415, 420, 426
- LEAP, 179, 246, 247
- LearnIT, 232, 247–249, 268
- level-sets, 134
- library, iv, xii, 135, 182, 183, 185, 196, 199,  
 201–204, 230, 233, 242, 261, 318, 394,  
 401, 403–405, 407, 416, 422
- linkages, 256, 267, 268, 277, 280, 322,  
 335, 337, 339, 342, 354, 355, 357, 359, 360
- logic, xxii, xxiv, 16, 29, 61, 63, 65, 89, 130,  
 158, 228, 268, 288, 316–318, 391, 393,  
 394, 422, 430, 431, 436, 465
- machine learning, xxiii, 162, 228, 229, 242,  
 243, 250, 263–265, 267, 268, 299, 314,  
 428, 465
- macrocell-style layout, 415
- magnetic induction of electricity, 443
- material design, 104
- material distribution, 98, 99, 102, 104, 105,  
 109, 122
- means-ends analysis, 365–367, 371, 372, 374,  
 375, 389
- mechanical advantage, 321, 322, 325–328,  
 332, 334, 354–356
- mechanism design, xxiii, 342, 351, 353, 357,  
 358, 360, 361
- MEMS (*see* microelectromechanical  
 systems)
- method development, 116, 178, 179, 186
- microelectromechanical systems (MEMS), i,  
 xxiii, 50, 77, 81, 82, 84, 86, 87, 90, 119,  
 126, 130–132, 135, 157–169, 194, 196,  
 218, 271, 317, 355, 361, 460
- micromachining, 128, 129, 134, 167
- microsystem, vii, xxiii, 126, 127, 129–132,  
 134, 135, 138, 140, 143, 148, 156–158,  
 164, 165, 167–169
- modularity, 147, 148, 176, 276, 277, 285
- modules, 176, 181, 218, 226, 246, 256, 277,  
 429, 434–438
- motion synthesis, 351, 354, 359, 360
- multi-agent system, 271, 314, 441
- mutation, 120, 145, 146, 191, 272, 273, 276,  
 286, 290, 300, 302, 306, 310, 311
- MYCIN, 239, 265, 268, 269
- natural selection, 144, 273
- Newton, 191, 254, 258, 322, 450
- NEWTON, 253, 254
- OASYS, 403, 405

- Palladio, 5, 65  
 parallel computation, 53  
 part relation, 25–27, 29, 36, 45, 49, 58  
 passive element, 188, 192, 205, 210  
 path-finding, 229, 231  
 phenotype, 144, 275, 299, 300  
 photolithography, 128, 159, 165, 167  
 ports, 181, 182, 184, 214, 215, 236, 264, 429, 438, 459  
 predicate calculus, 429, 433, 438, 439  
 price, 36, 114, 393, 429, 438  
 PRIDE, 240–242, 267, 432  
 PRINCE, 80, 258–260  
 problem space, 229, 446, 450–454, 458, 459, 461, 463, 465  
 problem-solving, 7, 228, 231, 232, 240, 243, 249, 365, 389, 447, 451–453, 455, 464  
 production rule, 47, 237, 239, 240, 242, 266, 429, 436  
 production system, xxii, xxiv, 6, 66, 84, 92, 199  
  
 qc-space, 255, 260, 261  
 QSIM, 252  
 QUAL, 251, 256  
 qualitative physical reasoning, 228, 229, 250, 262–264  
  
 R1, 237–240, 242, 265, 267, 269  
 redesign, 115, 206, 221, 225, 265, 395, 398–401, 412, 420, 426, 447  
 remove and simulate, 257  
 research model, 172, 176–178, 180, 183, 186, 190, 191, 193, 196–199, 201, 204, 218, 220  
 residue curve map, 379, 382, 385  
 RF circuit, 391  
 robot, 72, 73, 82, 83, 279, 280, 317, 320, 321, 323–325, 328–335, 337–340, 342, 344, 349, 354–361  
 robot arm grammar, 72, 73, 82, 83  
 robust design, 152, 153, 161, 162, 166, 242, 313, 319  
 Roriczer, 8, 10–12, 14, 15, 19  
 rule-based system, 66, 229, 237–239, 242, 279, 406  
  
 SACON, 239, 265  
 schema, 22, 48–50, 58, 61, 64, 66, 300–302  
 scientific process, xx  
 seeing, 11, 23, 24, 28, 29, 35, 46, 55, 58, 62–64, 432, 443  
 SEGS, 133, 148, 164  
  
 selection, 10, 70, 79, 97, 144–146, 160, 165, 191, 199, 205, 224, 232, 236, 267, 268, 271–273, 275–277, 281, 286, 290, 299, 300, 302, 303–307, 310, 311, 314, 317, 366, 396, 398–401, 403, 405, 407, 422, 425, 427, 432, 441, 451  
 separation scheme synthesis, 383  
 set grammar, 14, 47, 68  
 set-based, 180, 197, 198, 435, 441  
 shape annealing, 19, 68–73, 78, 82, 83, 85–88, 90–92, 112, 114, 115, 123–125, 318, 319, 460, 465  
 shape grammar, i, vii, xxii, xxiii, xxv, 5–7, 14, 19, 65–73, 76–86, 88–92, 114, 168, 218, 236, 440, 460  
 shape rule, 36–38, 42, 44–51, 53, 57, 61–64, 66, 74, 79, 168  
 shape rule application, 38  
 shape substitution, 5  
 shape synthesis, xxii, 315, 353  
 simulated annealing, 7, 69, 71, 73, 90–92, 114, 125, 198, 201–204, 231, 236, 270–272, 278–284, 298, 312–320, 406, 410, 416, 420, 424, 452, 460, 461, 464  
 SoC, 391, 423  
 spatial relation, 40, 41, 48, 62, 92  
 species allocation, 375, 384  
 specification translation, 399–401, 403–405  
 state-space, 7, 365  
 stochastic, xxii, xxiii, 69, 73, 92, 107, 110, 114, 140, 142–144, 229, 231, 236, 237, 270, 271, 273, 282, 286, 302, 303, 314, 318, 410, 426  
 stochastic optimization, xxii, 69, 114, 237, 273  
 strategic process synthesis, 381  
 structural configuration, vii, 93, 94, 97, 98, 102, 105–107, 114, 120, 121, 123, 124, 279  
 structural optimization, 121, 123–125, 259, 389  
 structure behavior function (SBF), 244, 245, 247  
 subshape, 3, 6, 8, 11, 14–16  
 subsystem, xii, 2, 14, 73, 74, 78, 79, 83, 86, 87, 193, 210, 218, 288, 393, 430, 437  
 superstructure optimization, 364, 366, 390  
 surface modeling, 16, 17  
 symbolic equation, 407  
 syntax, 1, 5, 70  
 synthesis  
 circuit, xxiv, 395, 401, 403, 404, 407  
 computational, 214, 225, 358  
 engineering design, i, iv, xv–xviii

- impedance, 187, 205
- kinematic, vii, xxiii, 269, 321, 322
- layout, 136, 154, 163–165, 169, 281
- motion, 351, 354, 359, 360
- separation scheme, 383
- shape, xxii, 315, 353
- strategic process, 381
  
- TABOO learning, 142
- TABOO search, 271, 272, 283, 284, 298, 311–314, 317–319
- technology retargeting, 395
- tolerance, 35, 321, 325, 352, 353, 356, 360, 395, 398, 399, 413
- tool development, 178, 179, 186, 196
- top-down substitution, 1
- topology construction, 110–112, 114, 115
- topology reduction, 108, 115
- transformation operator, 365, 366
- truss, 14, 50, 67, 70, 80, 81, 83, 86, 91, 92, 96, 102, 106, 107, 111, 112, 114, 115, 118, 122–125, 236, 279, 285, 297, 315, 318, 319
- truss configuration, 86
- truss design, 92, 112, 125, 285, 297, 319
- truss grammar, 70, 80, 81, 86
- tube routing, 80, 282
- Turing machine, 40, 47
  
- unit operation, 362–365, 367, 372, 374, 383, 384, 388
- urea, 443, 445, 446, 457, 458, 46
- user interface, 16, 196, 219
- utility, 113, 161, 276, 297, 312, 428, 429, 438
  
- virtual work, 321, 322, 325–327, 332, 334, 354, 355
- visor, 221
- VLSI, xii, xiii, xxi, xxiii, 129–131, 156–159, 165, 220, 226, 227, 239, 246, 269, 270, 278, 279, 281, 284, 285, 311, 313, 316, 317, 319, 424, 425, 429–432, 434, 435, 441
- vocabulary element, 17
  
- weight, 33, 34, 54, 63, 66, 70, 77, 80, 81, 83, 92, 95, 96, 99, 102, 108, 109, 113, 115, 123, 194, 205, 215, 217, 236, 252, 259, 260, 286, 430, 436, 448, 451, 456, 460, 463
- workspace, 321, 322, 324, 328–330, 332–342, 354–356, 358, 359
- Wright Brothers, 443, 446–449, 451, 459, 462, 464, 465
  
- XCON, 239, 265