List of Figures

Figure 1.1: Classification of Computational Approaches ................................................................. 3
Figure 1.2: Principal Constituents of Soft Computing Family ............................................................. 5
Figure 1.3: Search Techniques (Source: Fakhreddine & Clarence, 2004) ................................................... 9
Figure 1.4: Multiple Intelligence Model .................................................................................................. 15
Figure 1.5: Flow of Chapters of Thesis .................................................................................................. 23
Figure 2.1: Basic Evolution Cycle .......................................................................................................... 27
Figure 2.2: Life Cycle of Genetic Algorithm .......................................................................................... 30
Figure 2.3: Example of Search Space ...................................................................................................... 31
Figure 2.4(a): Parent 1 using Binary Encoding ......................................................................................... 33
Figure 2.4(b): Parent 2 using Binary Encoding ......................................................................................... 33
Figure 2.5(a): Parent 1 using Permutation Encoding ............................................................................... 33
Figure 2.5(b): Parent 2 using Permutation Encoding ............................................................................... 33
Figure 2.6(a): Chromosome “A” using Direct Value Encoding ............................................................... 34
Figure 2.6(b): Chromosome “B” using Direct Value Encoding ............................................................... 34
Figure 2.6(c): Chromosome “C” using Direct Value Encoding ............................................................... 34
Figure 2.7: Operational Structures of Tree Encoding ............................................................................. 35
Figure 2.8(a): Parent 1 before Single Point Crossover ............................................................................ 38
Figure 2.8(b): Parent 2 before Single Point Crossover ............................................................................ 38
Figure 2.8(c): Child 1 after Single Point Crossover ............................................................................... 38
Figure 2.8(d): Child 2 after Single Point Crossover ............................................................................... 38
Figure 2.9(a): Parent 1 before Double Point Crossover .......................................................................... 39
Figure 2.9(b): Parent 2 before Double Point Crossover .......................................................................... 39
Figure 2.9(c): Child 1 as a Result of Double Point Crossover ................................................................. 39
Figure 2.9(d): Child 2 as a Result of Double Point Crossover ................................................................. 39
Figure 2.10(a): Parent 1 before Multi Point Crossover ............................................................................ 39
Figure 2.10(b): Parent 2 before Multipoint Crossover ............................................................................ 39
Figure 2.10(c): Child 1 after Multi Point Crossover ............................................................................... 40
Figure 2.10(d): Child 2 after Multi Point Crossover ............................................................................... 40
Figure 2.11(a): Parent 1 before Uniform Crossover ............................................................................... 40
Figure 2.11(b): Parent 2 before Uniform Crossover ............................................................................... 40
Figure 2.11(c): Child 1 after Uniform Crossover ................................................................................... 40
Figure 2.11(d): Child 2 after Uniform Crossover ................................................................................... 40
Figure 2.12(a): Parent 1 before Partially Mapped Crossover ................................................................. 41
Figure 2.12(b): Parent 2 before Partially Mapped Crossover ................................................................. 41
Figure 2.12(c): Child 1 after Partially Mapped Crossover ..................................................................... 41
Figure 2.12(d): Child 2 after Partially Mapped Crossover ..................................................................... 41
Figure 2.13(a): Parent 1 and Parent 2 before Matrix Crossover ............................................................. 42
Figure 2.13(b): Child1 and Child 2 after Matrix Crossover ................................................................... 42
Figure 2.14(a): Parent 1 before Mutation ............................................................................................... 43
Figure 2.14(b): Child 1 after Mutation ................................................................................................. 44
Figure 2.15(a): Boolean Logic ............................................................................................................... 48
Figure 2.15(b): Fuzzy Logic .................................................................................................................. 48
Figure 2.16: Example of Membership of Crisp set and Fuzzy Set .......................................................... 50
Figure 2.17: Triangular Membership Function ....................................................................................... 52
Figure 2.18: Trapezoidal Membership Function .................................................................................... 52
Figure 2.19: Gaussian Membership Function ......................................................................................... 53
Figure 4.2: Generic Framework for Evolutionary Fuzzy System

Figure 4.1: Concepts that Describes a Framework

Figure 3.2: Approaches for Genetic Fuzzy System

Figure 3.1: General Structure of Genetic Fuzzy Rule Based System

Figure 3.0: Approaches for GA based Optimization for FLC

Figure 2.23: Sigmoid Membership Function

Figure 2.22: Bell Shaped Membership Function

Figure 2.21: Sigmoid Membership Function

Figure 2.20: Bell Shaped Membership Function

Figure 2.19: Binary Bit String after applying GA Operator on Parent 1

Figure 2.18: Binary Bit String after applying Mutation on Parent 2

Figure 2.17: Binary Bit String after applying GA Operator on Parent 1

Figure 2.16: Binary Bit String after applying Mutation on Parent 2

Figure 2.15: Binary Bit String after applying GA Operator on Parent 1

Figure 2.14: Binary Bit String after applying Mutation on Parent 2

Figure 2.13: Binary Bit String after applying GA Operator on Parent 1

Figure 2.12: Binary Bit String after applying Mutation on Parent 2

Figure 2.11: Binary Bit String after applying GA Operator on Parent 1

Figure 2.10: Binary Bit String after applying Mutation on Parent 2

Figure 2.09: Binary Bit String after applying GA Operator on Parent 1

Figure 2.08: Binary Bit String after applying Mutation on Parent 2

Figure 2.07: Binary Bit String after applying GA Operator on Parent 1

Figure 2.06: Binary Bit String after applying Mutation on Parent 2

Figure 2.05: Binary Bit String after applying GA Operator on Parent 1

Figure 2.04: Binary Bit String after applying Mutation on Parent 2

Figure 2.03: Binary Bit String after applying GA Operator on Parent 1

Figure 2.02: Binary Bit String after applying Mutation on Parent 2

Figure 2.01: Binary Bit String after applying GA Operator on Parent 1

Figure 2.00: Binary Bit String after applying Mutation on Parent 2

Figure 1.99: Binary Bit String after applying GA Operator on Parent 1

Figure 1.98: Binary Bit String after applying Mutation on Parent 2

Figure 1.97: Binary Bit String after applying GA Operator on Parent 1

Figure 1.96: Binary Bit String after applying Mutation on Parent 2

Figure 1.95: Binary Bit String after applying GA Operator on Parent 1

Figure 1.94: Binary Bit String after applying Mutation on Parent 2

Figure 1.93: Binary Bit String after applying GA Operator on Parent 1

Figure 1.92: Binary Bit String after applying Mutation on Parent 2

Figure 1.91: Binary Bit String after applying GA Operator on Parent 1

Figure 1.90: Binary Bit String after applying Mutation on Parent 2

Figure 1.89: Binary Bit String after applying GA Operator on Parent 1

Figure 1.88: Binary Bit String after applying Mutation on Parent 2

Figure 1.87: Binary Bit String after applying GA Operator on Parent 1

Figure 1.86: Binary Bit String after applying Mutation on Parent 2

Figure 1.85: Binary Bit String after applying GA Operator on Parent 1

Figure 1.84: Binary Bit String after applying Mutation on Parent 2

Figure 1.83: Binary Bit String after applying GA Operator on Parent 1

Figure 1.82: Binary Bit String after applying Mutation on Parent 2

Figure 1.81: Binary Bit String after applying GA Operator on Parent 1

Figure 1.80: Binary Bit String after applying Mutation on Parent 2

Figure 1.79: Binary Bit String after applying GA Operator on Parent 1

Figure 1.78: Binary Bit String after applying Mutation on Parent 2

Figure 1.77: Binary Bit String after applying GA Operator on Parent 1

Figure 1.76: Binary Bit String after applying Mutation on Parent 2

Figure 1.75: Binary Bit String after applying GA Operator on Parent 1

Figure 1.74: Binary Bit String after applying Mutation on Parent 2

Figure 1.73: Binary Bit String after applying GA Operator on Parent 1

Figure 1.72: Binary Bit String after applying Mutation on Parent 2

Figure 1.71: Binary Bit String after applying GA Operator on Parent 1

Figure 1.70: Binary Bit String after applying Mutation on Parent 2

Figure 1.69: Binary Bit String after applying GA Operator on Parent 1

Figure 1.68: Binary Bit String after applying Mutation on Parent 2

Figure 1.67: Binary Bit String after applying GA Operator on Parent 1

Figure 1.66: Binary Bit String after applying Mutation on Parent 2

Figure 1.65: Binary Bit String after applying GA Operator on Parent 1

Figure 1.64: Binary Bit String after applying Mutation on Parent 2

Figure 1.63: Binary Bit String after applying GA Operator on Parent 1

Figure 1.62: Binary Bit String after applying Mutation on Parent 2

Figure 1.61: Binary Bit String after applying GA Operator on Parent 1

Figure 1.60: Binary Bit String after applying Mutation on Parent 2

Figure 1.59: Binary Bit String after applying GA Operator on Parent 1

Figure 1.58: Binary Bit String after applying Mutation on Parent 2

Figure 1.57: Binary Bit String after applying GA Operator on Parent 1

Figure 1.56: Binary Bit String after applying Mutation on Parent 2

Figure 1.55: Binary Bit String after applying GA Operator on Parent 1

Figure 1.54: Binary Bit String after applying Mutation on Parent 2

Figure 1.53: Binary Bit String after applying GA Operator on Parent 1

Figure 1.52: Binary Bit String after applying Mutation on Parent 2

Figure 1.51: Binary Bit String after applying GA Operator on Parent 1

Figure 1.50: Binary Bit String after applying Mutation on Parent 2

Figure 1.49: Binary Bit String after applying GA Operator on Parent 1

Figure 1.48: Binary Bit String after applying Mutation on Parent 2

Figure 1.47: Binary Bit String after applying GA Operator on Parent 1

Figure 1.46: Binary Bit String after applying Mutation on Parent 2

Figure 1.45: Binary Bit String after applying GA Operator on Parent 1

Figure 1.44: Binary Bit String after applying Mutation on Parent 2

Figure 1.43: Binary Bit String after applying GA Operator on Parent 1

Figure 1.42: Binary Bit String after applying Mutation on Parent 2

Figure 1.41: Binary Bit String after applying GA Operator on Parent 1

Figure 1.40: Binary Bit String after applying Mutation on Parent 2

Figure 1.39: Binary Bit String after applying GA Operator on Parent 1

Figure 1.38: Binary Bit String after applying Mutation on Parent 2

Figure 1.37: Binary Bit String after applying GA Operator on Parent 1

Figure 1.36: Binary Bit String after applying Mutation on Parent 2

Figure 1.35: Binary Bit String after applying GA Operator on Parent 1

Figure 1.34: Binary Bit String after applying Mutation on Parent 2

Figure 1.33: Binary Bit String after applying GA Operator on Parent 1

Figure 1.32: Binary Bit String after applying Mutation on Parent 2

Figure 1.31: Binary Bit String after applying GA Operator on Parent 1

Figure 1.30: Binary Bit String after applying Mutation on Parent 2

Figure 1.29: Binary Bit String after applying GA Operator on Parent 1

Figure 1.28: Binary Bit String after applying Mutation on Parent 2

Figure 1.27: Binary Bit String after applying GA Operator on Parent 1

Figure 1.26: Binary Bit String after applying Mutation on Parent 2

Figure 1.25: Binary Bit String after applying GA Operator on Parent 1

Figure 1.24: Binary Bit String after applying Mutation on Parent 2

Figure 1.23: Binary Bit String after applying GA Operator on Parent 1

Figure 1.22: Binary Bit String after applying Mutation on Parent 2

Figure 1.21: Binary Bit String after applying GA Operator on Parent 1

Figure 1.20: Binary Bit String after applying Mutation on Parent 2

Figure 1.19: Binary Bit String after applying GA Operator on Parent 1

Figure 1.18: Binary Bit String after applying Mutation on Parent 2

Figure 1.17: Binary Bit String after applying GA Operator on Parent 1

Figure 1.16: Binary Bit String after applying Mutation on Parent 2

Figure 1.15: Binary Bit String after applying GA Operator on Parent 1

Figure 1.14: Binary Bit String after applying Mutation on Parent 2

Figure 1.13: Binary Bit String after applying GA Operator on Parent 1

Figure 1.12: Binary Bit String after applying Mutation on Parent 2

Figure 1.11: Binary Bit String after applying GA Operator on Parent 1

Figure 1.10: Binary Bit String after applying Mutation on Parent 2

Figure 1.9: Binary Bit String after applying GA Operator on Parent 1

Figure 1.8: Binary Bit String after applying Mutation on Parent 2

Figure 1.7: Binary Bit String after applying GA Operator on Parent 1

Figure 1.6: Binary Bit String after applying Mutation on Parent 2

Figure 1.5: Binary Bit String after applying GA Operator on Parent 1

Figure 1.4: Binary Bit String after applying Mutation on Parent 2

Figure 1.3: Binary Bit String after applying GA Operator on Parent 1

Figure 1.2: Binary Bit String after applying Mutation on Parent 2

Figure 1.1: Binary Bit String after applying GA Operator on Parent 1

Figure 1.0: Binary Bit String after applying Mutation on Parent 2

Figure 0.9: Binary Bit String after applying GA Operator on Parent 1

Figure 0.8: Binary Bit String after applying Mutation on Parent 2

Figure 0.7: Binary Bit String after applying GA Operator on Parent 1

Figure 0.6: Binary Bit String after applying Mutation on Parent 2

Figure 0.5: Binary Bit String after applying GA Operator on Parent 1

Figure 0.4: Binary Bit String after applying Mutation on Parent 2

Figure 0.3: Binary Bit String after applying GA Operator on Parent 1

Figure 0.2: Binary Bit String after applying Mutation on Parent 2

Figure 0.1: Binary Bit String after applying GA Operator on Parent 1

Figure 0.0: Binary Bit String after applying Mutation on Parent 2
Figure 5.13(d): Result of 2 Bit Crossover on Parent 2
Figure 5.14(a): 2 Bit Crossover Operator on next 2 bits of Parent 1
Figure 5.14(b): 2 Bit Crossover Operator on 3 & 4 of Parent 2
Figure 5.14(c): Result of 2 Bit Crossover Operator on 3 & 4 bits of Parent 1
Figure 5.14(d): Result of 2 Bit Crossover Operator on 3 & 4 bits of Parent 2
Figure 5.15(a): 2 Bit Crossover Operator on 5 & 6 bits of Parent 1
Figure 5.15(b): 2 Bit Crossover Operator on 5 & 6 bits of Parent 1
Figure 5.15(c): Result of 2 Bit Crossover Operator on 5 & 6 bits of Parent 1
Figure 5.15(d): Result of 2 Bit Crossover Operator on 5 & 6 bits of Parent 2
Figure 5.16(a): First Parent String before Mutation Operation
Figure 5.16(b): Second Parent String before Mutation Operation
Figure 5.16(c): 2 Bits Mutation Operation on Parent 1
Figure 5.16(d): 2 Bits Mutation Operation on Parent 2
Figure 5.17(a): Next Generation Parent 1 after ascending Penalty
Figure 5.17(b): Next Generation Parent 2 after ascending Penalty
Figure 5.17(c): Result of 2 bits mutation on Parent 1 of Next Generation
Figure 5.17(d): Result of 2 bits mutation on Parent 2 of Next Generation
Figure 5.18(a): Next Generation Parent 1 after ascending Penalty
Figure 5.18(b): Next Generation Parent 2 after ascending Penalty
Figure 5.18(c): Result of 2 bits Mutation on Parent 1 of Next Generation
Figure 5.18(d): Result of 2 bits Mutation on Parent 2 of Next Generation
Figure 5.19(a): Parent 1 before applying Arithmetic Crossover Operator
Figure 5.19(b): Parent 2 before applying Arithmetic Crossover Operator
Figure 5.19(c): Child1 after applying Arithmetic Crossover
Figure 5.19(d): Child 2 after applying Arithmetic Crossover
Figure 5.19(e): Parent 1 of Next Generation by ascending Penalty
Figure 5.19(f): Parent 2 of Next Generation after ascending Penalty
Figure 5.19(g): Child 1 of Next Generation after ascending Penalty
Figure 5.19(h): Child 2 of Next Generation after ascending Penalty
Figure 5.20: Sequence of Application of Operators over Each Generation
Figure 6.1: User Interface for Decision of Appropriate Career Field
Figure 6.2: Final Penalty at the Time of Convergence
Figure 6.3: Distribution of Final Penalty
Figure 6.4: Initial Penalty after 1st Generation of GA
Figure 6.5: Distribution of Initial Penalty
Figure 6.6: Number of Generations to achieve Convergence
Figure 6.7: Comparison of Average Penalty for Each Individual Operator
Figure 7.1: Example of Application Areas Suitable for Designed Framework