Contents

LIST OF ABBREVIATIONS....4
NOMENCLATURE....5
LIST OF FIGURES....6
LIST OF TABLES....10
ABSTRACT....13
CHAPTER 1 INTRODUCTION....15
1. 1 CONTROL SYSTEM....15
1. 2 INTELLIGENT CONTROL SYSTEM....17
1. 3 UNCERTAINTY AND FUZZY LOGIC....21
1. 4 FUZZY LOGIC BASED CONTROL SYSTEM....23
1. 4. 1 STRUCTURE OF A FUZZY CONTROLLER....24
1. 5 ENTROPY FUNCTION AND OPTIMIZATION....26
1. 6 CONTRIBUTION OF THIS RESEARCH....27
1. 7 ORGANIZATION OF THESIS....28
CHAPTER 2 LITERATURE REVIEW....29
2. 1 FUZZY LOGIC BASED CONTROL SYSTEMS....29
2. 2 MEMBERSHIP FUNCTION....32
2. 2. 1 TYPES OF MEMBERSHIP FUNCTION....34
2. 2. 2 MEMBERSHIP FUNCTION DEVELOPMENT....36
2. 3 Entropy function and its significance....51
2. 3. 1 Optimization of MF using Fuzzy Entropy....51
2. 3. 2 Research gap....54
2. 4 Objective function for optimization....55
2. 5 Aim and scope of work....61
2. 5. 1 Inverted pendulum system....61
2. 5. 2 Twin rotor MIMO system....62

2. 5. 3 Magnetic levitation system 62

2. 5. 4 Controller performance and evaluation parameters 62

CHAPTER 3 FUZZY LOGIC CONTROL FOR INVERTED PENDULUM SYSTEM 64

3. 1 Problem formulation 64

3. 2 Mathematical modeling 66

3. 3 Fuzzy logic control 67

3. 3. 1 Optimized fuzzy logic control 69

3. 4 Simulation model and real-time experiment results 70

3. 4. 1 Real-time PID control 71

3. 4. 2 Real-time fuzzy logic control 74

3. 4. 3 Real-time optimized fuzzy logic control 77

3. 5 Comparative analysis 79

3. 5. 1 Comparison of proposed controller with referenced work 82

3. 6 Conclusion 85

CHAPTER 4 FUZZY LOGIC CONTROL APPLICATION FOR TWIN ROTOR MIMO SYSTEM 87

4. 1 Problem formulation 87

4. 2 Mathematical modeling 88

4. 3 Fuzzy logic control 91

4. 4 Optimized fuzzy logic control 93

4. 5 Simulation model and real-time experiment results 94

4. 5. 1 Real-time PID control 96

4. 6 Real-time fuzzy logic control 99

4. 7 Real-time optimized fuzzy logic control 102

4. 8 Comparative analysis 105

4. 8. 1 Comparison of proposed controller with referenced work 108

4. 9 Conclusion....114

CHAPTER 5 FUZZY LOGIC CONTROL APPLICATION FOR MAGNETIC LEVITATION SYSTEM....118

5. 1 Problem formulation....118

5. 2 Mathematical modeling....120

5. 3 Fuzzy logic control....121

5. 3. 1 Optimized fuzzy logic control....122

5. 4 Simulation model and real-time experiment results....123

5. 4. 1 Real-time PID control....124

5. 4. 2 Real-time fuzzy logic control....126

5. 4. 3 Real-time optimized fuzzy logic control....127

5. 5 Comparative analysis....129

5. 5. 1 Comparison of proposed controller with referenced work....131

5. 6 Conclusion....134

CHAPTER 6 CONCLUSIONS AND FUTURE SCOPE....136

6. 1 Research objectives....136

6. 2 Experimental setups for result verification....137

6. 3 Performance evaluation....137

6. 3. 1 Inverted Pendulum System....137

6. 3. 2 TRMS....138

6. 3. 3 Maglev system....138

6. 4 Scope for further research....139

REFERENCES....140

A.1 PUBLICATIONS RELATED TO PhD WORK....146

A.2 RESUME....147