VI. CONCLUSION AND FUTURE WORKS

The inexpensive and reliable fuzzy modeling & control has turned out to be a useful complement to traditional modeling & control when both the complexity and uncertainty about the system increases. This thesis has focused on stability analysis methods, approximation methods and methods for the design of fuzzy controllers for a class of nonlinear systems. In the first two chapters fuzzy models that can effectively be used for modeling of complex systems with good approximation capabilities and those that can be used to control systems guaranteeing stability with high performance are reviewed.

The main contributions in this thesis are presented in Chapter III, IV & V.

1) The results of Chapter III are summarized below:
   a) Modified stability conditions for Takagi-Sugeno fuzzy controllers are presented.
   b) It is proved that the existence of a common positive definite matrix for Reduced Stability Condition for Takagi-Sugeno Fuzzy Controller (RSCTSFC, Theorem 20) with \( r(r+1)/2 \) inequalities does not ensure the existence of a common definite matrix ensuring Stability for Takagi-Sugeno Fuzzy Controller (SCTSFC, Theorem 19) with \( r^2 \) inequalities, whereas a common positive definite matrix for SCTSFC always implies the existence of common positive definite matrix for RSCTSFC.
   c) Better bounds of the stability conditions of Takagi-Sugeno fuzzy controllers are derived.
   d) A simple stability condition is suggested that finds a common positive definite matrix easily.

2) The results of Chapter IV are summarized below:
   a) Takagi-Sugeno fuzzy model with variable coefficient is presented and
proved that it can approximate any nonlinear function to any degree of accuracy.

b) Variable gain Takagi-Sugeno fuzzy controller (VGTSCF) is presented.

3) Chapter V presents methodologies developed for the optimal design of a fuzzy logic controller, that achieves parameter optimization and rule-base optimization of the system. The methods blends the GA and rule-base of fuzzy logic controller in a natural way. The methods are summarized below:

a) Design of Mamdani type fuzzy controllers using GA with rule selection scheme.

b) Design of Mamdani type fuzzy controllers using GA with variable length chromosome.

c) Design of consequent parts with guaranteed stability for Takagi-Sugeno fuzzy controllers using genetic algorithm.

d) System identification with simultaneous design of antecedent and consequent parts that ensures stability using genetic algorithm.

e) Design of Takagi-Sugeno fuzzy controllers having stability properties using varying length chromosome.

Benchmark control problems are simulated in all the cases and the results are promising. The genetic algorithmic methods for designing fuzzy logic controllers developed can easily be modified and tailored so that they are applicable to various other problems including classification, clustering, system identification, image processing, speech synthesis/ recognition etc.

**Future Works:**

Further research will be concentrated on developing an intelligent control systems using genetic algorithm, neural network and fuzzy rule-based systems

1) which automatically optimizes the number of variables in the antecedent
parts (i.e., allowing variable (different) number of inputs in the antecedent part).

2) which simultaneously considers AND and OR combinations in the antecedent part.

3) for generating fuzzy control rules for chaotic systems having extremely large search space.

4) which works on parallel computers.

5) for online identification of fuzzy rules.