Chapter 7

Conclusion and Future Scopes

7.1 Conclusion

In this thesis, various tuning methods of FOPID controller using meta-heuristic algorithms for different applications are studied using simulation. In this regard, the performance of the modern meta-heuristic techniques are evaluated by considering different applications such as Automatic voltage regulator system (AVR), 1st order delay system like heat flow system (HFS), Nonlinear cruise control system etc. The modern meta-heuristic algorithms such as Ant Lion Optimization (ALO), Grey Wolf Optimization (GWO), Moth Flame Optimization (MFO) and Particle Swarm Optimization (PSO) have been implemented for tuning the FOPID controller for different applications.

Ant Lion Optimization (ALO) is one of the recently proposed meta-heuristic techniques most commonly used for optimization problems. Design and performance evaluation of PID and FOPID controller for AVR system using ALO is presented in this thesis. The ALO is deployed to optimize the controller parameters by selecting different objective functions. In view of this, different objective functions such as Integral Absolute Error (IAE), Integral Square Error (ISE), Time multiply Absolute Error (ITAE), Time multiply square error (ITSE) etc are used to enhance the PID and FOPID controller. The result obtained from the simulation shows that the proposed ALO based PID controller performs better than some recently developed meta-heuristic optimization techniques such as Grey Wolf Optimization (GWO), Bacteria Foraging Optimization Algorithm (BFOA) etc. Moreover, the proposed ALO optimized FOPID outperforms all the PID based methods and some recently reported optimization methods such as PSO-FOPID and Cuckoo Search-FOPID techniques. Further, the robustness analysis is carried out which

demonstrates that the ALO based FOPID controller withstands to wide variations in the system parameters.

Design and performance evaluation of FOPID controller optimized employing Ant Lion Optimization (ALO), Grey Wolf Optimization (GWO), Moth Flame Optimization (MFO) and Particle Swarm Optimization (PSO) for heat flow system is presented in this thesis. The IAE, ISE, ITAE and ITSE objective functions are employed to evaluate the controller performance. Simulation studies are carried out to make a comparison between stated objective functions. The result shows that ALO optimized FOPID for heat flow system gives better result than other methods. In addition to transient analysis, the bode analysis and robustness analysis have been implemented to show the efficiency of the proposed controller.

Performance evaluation of PID and FOPID controller for an automobile cruise control system is proposed in this thesis. An automobile cruise control system which is a third order delay system is considered for the design and performance analysis purpose. At the outset, the superiority of FOPID controller over PID is demonstrated for the third order delay system. The Ant Lion Optimization (ALO) is deployed to optimize the PID controller parameters and PID with bode reference model. The Integral Square Error (ISE) objective function is deployed to measure the performance of the controller. The ALO optimized PID controller gives superiority value than the ALO optimized PID with bode reference model and recently reported methods such as Genetic Algorithm (GA), state space and fuzzy controller. For the design of FOPID controller, fmincon solver is used. The FOPID controller outperforms than all other methods presented for the automobile cruise control system. Moreover, the sensitivity, complementary sensitivity and disturbance rejection behavior of the proposed controller is studied and found satisfactory.

Finally, the FOPID controller design using Ant Lion Optimization (ALO) is extended for first order delay system, second order unstable system and third order system. It is observed that the ITAE objective function for considered first order system, ISE objective function for second order system and IAE for third order system gives better performance. The result obtained from the simulation demonstrates that the FOPID controller performs better than the PID controller. From the bode analysis, it has been observed that the systems gives stable gain margin and phase margin.

A maiden attempt has been made in this thesis for the optimal design of FOPID controller for different systems from first order to higher order by deploying the recently developed meta-heuristic optimization techniques. Both the transient and frequency analysis of the proposed controllers for different applications revels that the FOPID gives better stable result.

7.2 Future scopes

Research and development is a continual and a relentless process. For any research work already carried out, there is always a scope of improvement and lot many avenues open up for carrying out further research work. The results obtained from this work may encourage one to further investigates the following problems in future

- Design of FOPID controller for MIMO linear as well as delay system.
- Implementation of FOPID controller in real time configuration.
- Design of FOPID controller using multi-objective ALO.