Chapter 7

Conclusions and future scope

7.1 Conclusions

The primary objective of this thesis work was the development of dexterous, low-cost, externally-powered transradial prosthesis, for which the following tasks have been executed.

- A low-cost, wearable sEMG sensor was designed for the reliable detection of muscle contraction from the remaining upper-limb of amputees. The designed sensor was validated in terms of various parameters and successfully applied for controlling hand prosthesis using a proportional control scheme.
- To overcome the limitations of wet electrodes in the designed EMG sensor, dry electrodes made of the silver palette were introduced in the upgraded sensor. The dry electrode based sEMG sensor showed better performance than the commercial sensor (based on wet electrodes) and was positively realized for hand prosthesis control.
- A multifunctional prosthetic hand was developed to perform six different grip activities deploying only a single-channel EMG signal from the subjects. The classification based control scheme employed in the developed hand makes it effortless, low-cost, and effective compared to the current prosthetic hands (using pattern recognition based control).
- In order to overcome the shortcomings associated with EMG systems, a novel force myography sensor was designed for the reliable detection of muscular contractions from the residual upper-limb of amputees. This sensor provides an alternative solution to the EMG sensor without electrical interference and any need for electrodes. The sensor was further tested on amputees to control a prosthetic hand.
- An affordable force myography controlled 3D printed transradial prosthesis was designed, having dedicated socket assembly for amputees. The hand implements

proportional based position control, which utilizes FMG signals from the compact sensor. A successful trial of the hand prototype was made on five different below-elbow amputees. Subjects wearing the hand prosthesis were able to execute delicate tasks of daily living such as picking objects, drinking water, opening bottles, driving a bicycle, etc.

7.2 Future scope

- The developed multi-functional hand prosthesis provides up to six grasping patterns utilizing input from a single-channel EMG sensor. The number of gripping activities of the hand can be increased further by increasing the number of sensor channels and upgrading the control system. Such an arrangement can be achieved by using multi-channel EMG sensors, FMG sensor array, or together using both these sensors for detecting muscular contraction information from multiple locations. Implementing a multi-channel sensor approach may increase the prosthetic hand's functionality and increase the system complexity.
- A more accurate and delicate grasping of the prosthetic hand can be attained by introducing a closed-loop control system, receiving feedback from tactile sensors.
- Besides electromyography and force myography, there is one more technique called optomyography, which can detect muscular contractions without making any contact with the skin. However, this approach requires a complex signal conditioning unit and several calibrations. This technique can become a thrust area of research for the hand prosthesis application.