# NDP BASED CONTROL OF ANKLE PROSTHESIS

**Sesh Commuri**
*Associate Professor, School of Electrical and Computer Engineering*
*Stephenson Research and Technology Center*
*University of Oklahoma, Norman.*
*(405) 325-4302; (405) 325-3442 (fax); scommuri@ou.edu*

## ABSTRACT

This research investigates the development of a computer controlled foot/ankle prosthesis that can better mimic biomechanical function and natural human locomotion (NHL) in order to achieve a level of restoration that allows amputees to approach natural function. Control of such an ankle joint is a difficult task complicated by the lack of adequate dynamic models of the system, and the presence of measurement and approximation errors. The presence of human-in-the-loop further complicates the design of the real-time control system. Current state of the art in prosthetic design for transtibial (below the knee) amputees is based to a large extent on the biomechanics of linear walking on level surfaces. Such foot/ankle prosthesis cannot accommodate for changing gait function or changes in the environmental parameters. The research team addresses the development of high performance foot/ankle prosthesis through the design of an innovative "variable resistance" hydraulic damper that can be used for the ankle joint of the prosthetic foot in conjunction with a linear actuator. The research team proposes to develop a Neural Network based Approximate Dynamic Programming (NDP) control mechanism that can be applied for the control of the ankle wherein the temporal as well as distance information and the gait kinetics will be used to train the controller. Theoretical results in the design and stability analysis of NDP controllers will be developed to guarantee the performance of the computer controlled ankle. *Mechanical properties testing* of prosthetic ankle-foot systems will be studied and benchmark tests to enable the comparison of various ankle prosthetics will also be developed.

The project team comprising of researchers from academia, medical research, and industry will team with a leading prosthetic manufacturer to test and validate the technology.

<u>Intellectual Merits:</u>
The proposed design will result in a prosthetic ankle whose flexion and stiffness can be controlled in real time. This is a revolutionary design and no such prosthesis is currently available in the market. The stability analysis of the NDP algorithms will further the theoretical knowledge in this area, making it possible to design sub-optimal controllers for a large class of nonlinear systems. Such theoretical results do not exist in the literature today. The tests for the mechanical properties developed in this project will enable the scientific performance based comparison of prosthetic ankles and will serve as a benchmark for comparing the performance of controllers based on Approximate Dynamic Programming.

<u>Broader Impacts</u>:
The prosthetic ankle developed in this research in conjunction with the NDP control strategy will minimize gait asymmetry in the affected individual and thereby minimize long term pathological conditions. Improvement in the performance of the ankle under all functional gait conditions will substantially improve the quality of life and lower the costs of long term care. The project will also advance the educational and research goals by furthering the robotics and biomedical engineering curriculum at the University of Oklahoma. Industrial training and internships will help train the next generation of students to become better engineers. The funding will also help retain crucial intellectual resources in Oklahoma, an EPSCoR state.

Key Words: Prosthetic Feet; Nonlinear Adaptive Control; Adaptive Critic Systems; Gait Analysis.