

# LINEAR VERSUS NONLINEAR HUMAN OPERATOR MODELING

*Tijana T. Ivancevic*,\* *Bojan N. Jovanovic*, *Sasha A. Jovanovic*,  
Leon Lukman, Alexandar Lukman, and Milka Djukic<sup>†</sup>  
Society for Nonlinear Dynamics in Human Factors, Adelaide, Australia  
and CITECH Research IP Pty Ltd, Adelaide, Australia

## Abstract

The motivation behind mathematically modeling the *human operator* is to help explain the response characteristics of the complex dynamical system including the human manual controller. In this paper, we present two approaches to human operator modeling: classical linear control approach and modern nonlinear control approach. The latter one is formalized using both fixed and adaptive Lie-Derivative based controllers.

**Keywords:** Human operator, linear control, nonlinear control, Lie derivative operator

## 1. Introduction

Despite the increasing trend toward automation, robotics and artificial intelligence (AI) in many environments, the *human operator* will probably continue for some time to be integrally involved in the control and regulation of various machines (e.g., missile-launchers, ground vehicles, watercrafts, submarines, spacecrafts, helicopters, jet fighters, etc.). A typical manual control task is the task in which control of these machines is accomplished by *manipulation of the hands or fingers* [1]. As human-computer interfaces evolve, interaction techniques increasingly involve a much more continuous form of interaction with the user, over both human-to-computer (input) and computer-to-human (output) channels. Such interaction could involve gestures, speech and animation in addition to more ‘conventional’ interaction via mouse, joystick and keyboard. This poses a problem for the design of interactive systems as it becomes increasingly necessary to consider interactions occurring over an interval, in continuous time.

The so-called *manual control theory* developed out of the efforts of feedback control engineers during and after the World War II, who required models of human performance for continuous military tasks, such as tracking with anti-aircraft guns [2]. This seems to be an area worth exploring, firstly since it is generally concerned with systems which are controlled in continuous time by the user, although discrete time analogues of the various

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\*e-mail: [tijana.ivancevic@alumni.adelaide.edu.au](mailto:tijana.ivancevic@alumni.adelaide.edu.au)

<sup>†</sup>Corresponding author: Dr. Tijana Ivancevic