Preface

The lack of feedback-invariance of mathematical formulations of nonlinear control theory has been a thorn in the side of understanding the basic structure of control systems. Moreover, it is a thorn whose presence has largely come to be accepted, and this has prohibited a complete understanding of certain fundamental structural problems for nonlinear systems. One way to understand the issue is as follows: just as an explicit parameterisation of system dynamics by state, i.e., a choice of coordinates, can impede the identification of general structure, so it is too with an explicit parameterisation of system dynamics by control. However, such explicit and fixed parameterisation by control is commonplace in control theory, leading to definitions, methodologies and results that depend in unexpected ways on control parameterisation. This unexpected dependence makes it virtually impossible to comprehensively address the fundamental structural problems in control theory, such as controllability and stabilisability.

In this monograph, we present a framework for modelling systems in geometric control theory in a manner that does not make any choice of parameterisation by control; the systems are called 'Tautological Control Systems'. For the framework to be coherent, it relies in a fundamental way on topologies for spaces of vector fields. As such, we take advantage of recent characterisations of topologies for spaces of vector fields possessing a variety of degrees of regularity: finitely differentiable; Lipschitz; smooth; real analytic. As part of the presentation, therefore, locally convex topologies for spaces of vector fields are comprehensively reviewed. It is these locally convex topologies that provide for the unified treatment of time-varying vector fields that underpin the approach.

This monograph presents simply the foundations of the approach, as well as the basic results that indicate the structural attributes of 'Tautological Control Systems'. In particular, we are able to prove the feedback-invariance of the approach. Future work will involve using this feedback-invariant approach to address the basic problems of control theory, e.g., controllability, stabilisability, and optimality.

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