Recursion and Control:Verifying Properties of Adaptive Systems

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Control feedback structures execute computations on reals. They are the foundation for adaptive behavior in modern electrical and electronic systems. A linear feedback system consists of a control loop, including sensors, control algorithms and actuators, is arranged in such a fashion as to try to regulate a variable at a setpoint or reference value. The system modifies a control parameter which directly affects that output based on the relationship between the currently measured value of the regulated variable and the setpoint. We use such systems daily and their applications abound in aerospace, automotive and more broadly in electrical engineering. Electronic Control Units or ECUs are designed to control mechanical systems (actuators, etc.) through calculations carried out by control algorithms in the ECU's embedded software on inputs provided by sensors and by other ECUs over a Controller Area Network (CAN) using the CAN Protocol. This is a packet based network much like the current Internet Protocol with attendant notions of latency and packet broadcast frequency.

An important requirement for designing the software for ECUs and control feedback structures in general is the need to verify key properties of its system behavior, already during the design phase. This requires that we formalize its control algorithms and that we provide tools for reasoning about their execution and computations.