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# METHODS AND TOOLS FOR DEVELOPMENT A HYBRID AND INFORMATION CONTROL SYSTEMS OF TECHNOLOGICAL COMPLEX

**Abstract.** The relevance of the development of software complexes for the control of technological complex is determined by such trends as the emergence of innovative technologies for the development of computer programs.

The power management control system development and vehicle test results for a medium-duty hybrid electric truck are reported in this paper. The design procedure adopted is a model-based approach, and it was based on the dynamic programming technique. A vehicle model is first developed, the optimal control action that maximizes fuel economy, then it is solved by the dynamic programming method. A near-optimal control strategy is subsequently extracted and implemented in the MATLAB XPC-Target rapid-prototyping system, which provides a convenient environment to adjust the control algorithms and accommodate various I/O configurations. Dyno-testing results confirm that the proposed algorithm helps the prototype truck to achieve an impressive 45% fuel economy improvement over the benchmark vehicle

This article discusses the possibilities of creating a hybrid system for the possibility of optimal control over the process of burning fuel in a vehicle using intelligent technologies.

**Keywords:** hybrid control system, information system, mathematical model, technological complex, synthesis, supervisory powertrain controller.

**Introduction.** Nowadays, most systems can be modelled by the mathematical and analytical methods developed over the last two decades. Therefore, control engineers can have good understanding of any systems and the desired behaviour can be achieved [1]. Also during the last two decades, the exponential drop in price of computing power made computers widely available. Computers are used in most control systems today.

A computer which acts as a logic decision unit processes input provides output in digital form, ie 0 and 1. It is also known as a discrete-time system. It is easy to see that a system which processes only continuous-time data is called a continuous-time system, that is, it can be represented by mathematical functions [2].

Moreover, it is common to have a mixture of both logic and continuous systems. While all the generators produce continuous-time data, the computer receives those data and processes them in discrete form. This kind of systems is known as ***hybrid control system*** [3].

A typical hybrid system is arranged in two (or more) layers. Different levels of abstractions of the plant model are used at each layer of the hierarchy. In the bottom layer, the plant model is usually described by means of differential and/or difference equations. This layer contains the actual plant and any conventional controllers working at the same level of abstraction. In the top layer, the plant description is more abstract. Typical choices of description language at this level are finite state machines, fuzzy logic, Petri nets, etc. Typically, the controllers designed at this level are discrete event supervisory controllers. The two levels communicate by means of an interface that plays the role of a translator between signals and symbols [4].

The control architecture described above appears in a wide variety of applications and forms the heart of most hybrid system formalisms. This results from the requirement that control systems are expected to be autonomous (e.g., in case of highway automation, the vehicles are supposed to be driven automatically without human intervention), requiring the controller not only to calculate feedback control laws for specific tasks, but also to plan the sequence of actions in order to achieve the specified goal [5]. Planning is inherently a discrete process, which is represented by the higher layers of the hierarchy whereas the continuous time control laws that execute each action constitute the lower layers. Switching controllers, Intelligent Control, Expert Control, and Motion Control, among others [6].

In general, a hybrid system denotes a system composed of two unlike components. A hybrid control system is a control system with both analog and digital parts. Such a system generates a mixture of continuous and discrete signals, which take values in a continuum (such as the real numbers R) and a finite set (such as{a,b,c}), respectively.

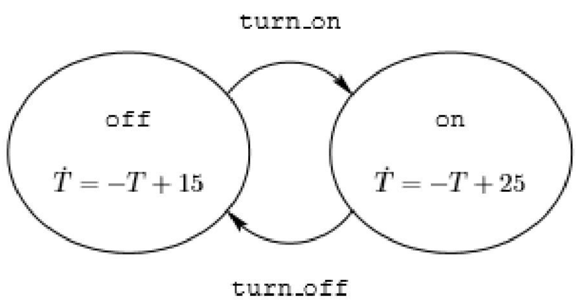
A continuous-valued signal typically takes values in the set of real numbers (e.g., a temperature T taking values in the interval [−20,100] degrees Celsius), while a discrete-valued signal takes value in a discrete (often finite) set (e.g., a thermostat valve V taking the values{on,off}). The signals can either depend on time or be event-driven. A continuous-time signal is updated continuously through a differential equation (e.g., $T(t) = -T(t) + 1$) while a discrete-time signal is updated through a difference equation (e.g., $T(t + 1) = T(t) + 1$). An event-driven signal, on the other hand, is updated when an internal or external event happens (e.g., the switching on of the thermostat, V + := on, could be driven by the event that the temperature goes below 15 degrees, $T < 15$). Note that a discrete-time signal can be interpreted as an event-driven signal being updated when the event "sampling" takes place [7].

Let us develop a simple hybrid control system, which illustrates how continuous and discrete signals may interact. The example describes the problem of maintaining the temperature T of a room at some desired level (about 19 degrees Celsius, say). If the radiator is off, the temperature dynamics is given by

$$T = -T + 15$$

and if it is on the temperature, dynamics is given by

$$T = -T + 25.$$




Hybrid control system modeling the heating of a room

When the thermostat turns on the radiator, the hybrid system jumps from the off to the on state through the discrete transition turn on. It jumps back again when the thermostat turns off the radiator. The temperature T, which is a continuous-time variable, is governed by one of the two differential equations depending on the current discrete state.

It is convenient to represent a hybrid system by a graph. The hybrid system describing the heating of the room can be modeled as the graph shown in figure. The two vertices of the graph represent the two discrete modes of the system: the radiator is either off or on. As long as the radiator is off, the temperature T will follow the dynamics specified in the left mode, i.e., T will tend to 15. When the event marked turn_on is triggered, the discrete state of the system jumps from the off to the on mode. The transition is