A Blood Pressure Feedback Control System

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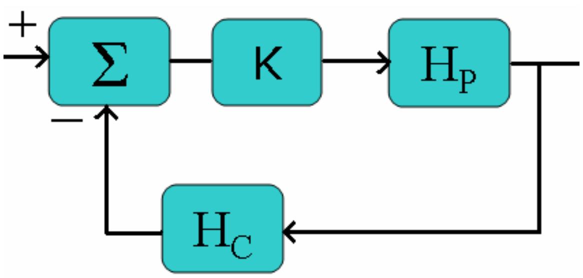
James Brien

Feedback control systems, often regarded primarily as an electronic invention, are found everywhere in nature. This is especially true in the human body, where feedback systems govern many important physiological systems. The quest to maintain homeostasis is one of the primary reasons for the hundreds of feedback loops that our bodies employ.

Feedback loops can be either positive or negative, that is, they can either control a response, diminishing it to a certain steady state value, or continually increase the response. Often, negative feedback loops are employed in order to keep conditions from exceeding some pre-determined limit.



In this case, the blood-pressure regulation system of a mammal was considered. In general, blood pressure is considered the amount of outward force exerted on the arterial walls. This is determined by cardiac output, which is the heart rate multiplied by the stroke volume of the heart. Blood pressure is thus inversely proportional to the radius of the arteries, which is controlled by the sympathetic nervous system.

In this study, rats were anaesthetized, and through a laparotomy, a branch of the left renal sympathetic nerve was connected to a computer to control stimulation. Arterial pressure was then measured with a pressure transducer.

The result of the experiment was a transfer function that is a fairly accurate representation of the baroreflex feedback control of arterial pressure in rats. The baroreceptors measure the stretch of the arterial walls, allowing the baroreflex to control the radius of the arteries.

For simplicity, a simpler version of the overall transfer function is considered. The system uses a proportional gain controller, which allows a scale factor to change the behavior of the system. The step response gives engineers an idea of how the system responds to different inputs.

In a physiologically-applied system, as in most systems, certain design constraints must be observed. In this case, overshoot, rise time, and settling time were all critical factors. The proportionality constant, K, allows us to modify these parameters to get a more desirable system. There is generally a trade-off between overshoot and rise or settling times.

The reason for design constraints vary. In pharmaceutical applications for instance, high overshoot could destabilize a patient's vitals, and perhaps even result in death. Similarly, a drug with too long a rise or settling time may not be marketable.
The design of feedback control systems, like many other aspects of engineering, depends on compromise between several variables.

Sources:

- Frequency response of renal sympathetic nervous activity to aortic depressor nerve stimulation in the anaesthetized rat.
  Emmanuelle Petiot, Christian Barrès, Bruno Chapuis and Claude Julien
  Journal of Physiology (2001), 537.3, *pp.* 949-959
- Linear modelling analysis of baroreflex control of arterial pressure variability in rats
  Bruno Chapuis, Emmanuelle Vidal-Petiot, Valerie Orea, Christian Barres, and Claude Julien
  Journal of Physiology (2004), 559.2, *pp.* 639-649