1 Overview

- How do you treat a system?
- Example: A muscle stretch reflex
- Open and closed loops
- Distributed and lumped parameter models

2 Essay

What's the most efficient way to tell someone else how a system works?

Right, you visualize it.

First you have to think about, what belongs to the system you want to model and what doesn't or is neglectable.

For example, let's assume we want to make a model of how muscle and brain interact.

So, it's clear, that the brain and muscle belong to our system. We could consider modeling all neurons, but we only want to have a raw model, so we neglect them.

Thus we can draw a picture like Fig. 1

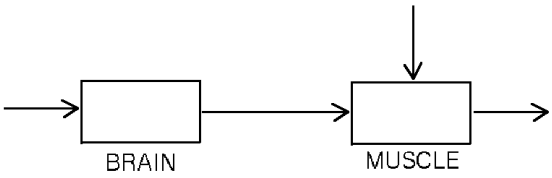

Figure 1: A raw muscle model

This is called a block diagram. The blocks represent the interacting parts and the arrows the direction of interaction.

On the left you have some input, for instance our consciousness which makes the brain act on the muscle. But the muscle can also be stretched by an external force, so there is an additional error, which represents a "disturbance", meaning an unknown change of the state of the system.

Such a system is called an **open loop** system.

A generalized open loop system looks like Fig. 2

When we want to model the muscle more accurately, we notice that there is some feedback mechanism (as in almost all physiological systems).

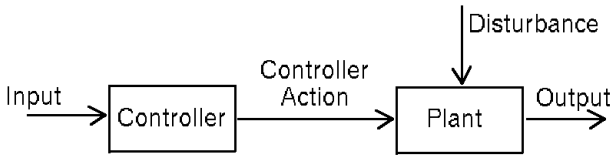

Figure 2: An open loop system

Let's look, for instance, at the muscle stretch reflex, which is most clearly illustrated as the knee jerk.

When you stretch the muscle (for our system this is a disturbance from equilibrium), there is a signal sent to the reflex center in the spinal cord, which reacts by making the muscle shorten.

The block diagram then looks like Fig. 3

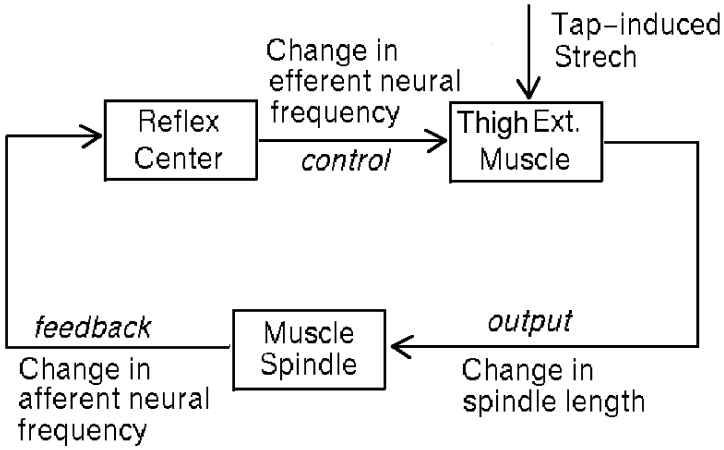

Figure 3: Model for muscle stretch reflex

This is called a **closed loop** system.

Again, a more generalized graph in Fig. 4

But is this model really correct?

There is not one homogeneous muscle, there are many small fibers, which are connected in parallel and serial.

In our model we lumped all these fibers together and have only one set of characteristic parameters, such as length and force. Thus this model is called a **lumped parameter** model.

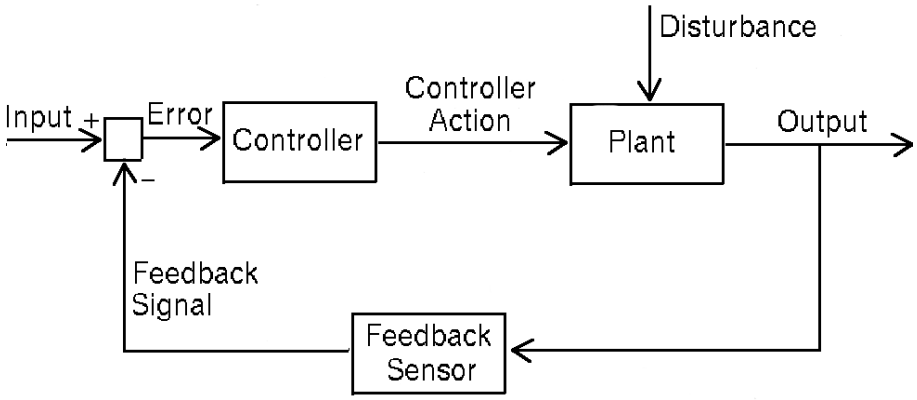

Figure 4: A closed loop system

If we would consider the details of the muscle and different parameters for different fibers (they must be different, because when there are less fibers in parallel, then they have to sustain a larger force), we would have a much more complicate, but more accurate model, which is then called **distributed parameter** model.

Because of this distribution in space, our system output not only depends on time, but on space, too, i.e. we can't use ODE (ordinary differential equations) any more. We have to apply PDE (partial differential equations). A distributed parameter model can be viewed as a network of many infinitesimally small lumped parameter submodels.