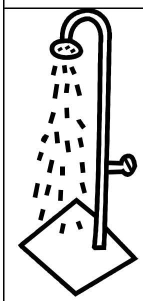
Modelling and control summaries

by Anthony Rossiter

Intro. to feedback 1 – human feedback

OPEN LOOP CONTROL FAILS due to lack of measurement and therefore an inability to plan appropriate updates to the system input.

HUMAN PROCEDURES FOR ENSURING THE CORRECT STEADY-STATE OUTPUT



How do you control the temperature in a shower?

1. Estimate the required cold/hot balance and run for 10s.
2. Monitor and increase cold/hot if required.
3. Monitor for 10s and adjust again if required.
4. Keep iterating until happy.
5. In general the adjustments get smaller each time as we get closer to the required temperature – that is the **adjustments are in proportion to the temperature error**.

Getting speed of a car correct.

1. Depress accelerator expected distance required.
2. Wait 5 seconds and then monitor speed – is this OK?
3. If too slow, depress more , else if too fast lift off accelerator slightly.
4. Wait 5 seconds and monitor speed.
5. If too slow, depress more , else if too fast lift off accelerator slightly.
6. Wait 5 seconds and monitor speed.
7. Continue to iterate until happy!

Tuning a guitar – again it will be obvious that there is a fundamental procedure involving: monitor, adjust, monitor, adjust, etc.

SUMMARY OBSERVATIONS: **Effective control relies on the monitor-adjust procedure. However,**

WHAT ADJUSTMENT EXACTLY DO WE MAKE?

1. Do we turn the taps 10^{o} or 90^{0} or 360^{o}?
2. Do we depress the accelerator 1mm, 1cm or 10cm?
3. Do we tighten the guitar string a whole turn, half a turn, a quarter of a turn?

HUMAN WEAKNESSES

Maintain the car speed for 48hr (with no break). Maintain the temperature in a reactor tank at 400^{o} for 6 months. Simultaneously adjust 20 different inputs to keep an output in specification (try play station) for 2 weeks.

Humans get bored easily, make mistakes if asked to do repetitive tasks for long periods, are not good in hostile environments, cannot deal with many simultaneous tasks, are expensive, cannot do fast timescales, etc.

Humans must be replaced by an automated control procedure!

WHAT CAN GO WRONG?	
Fukishima nuclear reactor (inability to deliver desired input). Tacoma Narrows Bridge Collapse. Uncontrolled exothermic reactions (e.g. oil and petrol combustion). Inverted pendulum (rockets and segways). Positive feedback through a microphone and amplifier (poor use of measurement). F22 crash landing due to sensor failure (measurement information erroneous).	It is not enough to introduce a monitor and adjust procedure. The adjustment is based on some rule – if the rule is poorly chosen, then the output behaviour can be very poor, or even divergent. The literature is full of examples of disasters causing by a failure of the chosen law.

OBSERVATIONS AND CHALLENGES

1. It is clear that feedback is often essential to ensure good behaviour of many processes and thus we get the products we need: quality paint or detergent, correctly graded fuel, DVD players that work, car engines that are reliable and efficient, etc.
2. Feedback is the process of monitoring an output followed by appropriate change to the input. It is called feedback because we **feedback the output to effect the input**. If the input was not affected this would not be feedback as the measurement has had no impact on behaviour.

HOWEVER

1. Feedback changes the behaviour, this can be for both better or worse.
2. There is a need for a systematic design to the adjustment process (denoted control law) to ensure the resulting behaviour is better.
3. Including feedback implies increased cost in modelling, design, components and power as well as vulnerability to instability.

STUDENTS HAVE TO UNDERSTAND HOW TO DESIGN AN ADJUSTMENT PROCESS THAT IS SAFE AND EFFECTIVE – THIS IS THE STUDY OF FEEDBACK CONTROL SYSTEMS AND WITHOUT IT MUCH OF MODERN TECHNOLOGY WOULD FAIL TO WORK.