# Speed control of peristaltic pump

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The thesis entitled "Speed control of peristaltic pump" concludes Gabriel Ingesson and Helena Sandberg MSc degrees from Lund's Technical University and Technical University of Denmark. This popular science article intends to describe the project they worked on during the autumn of 2012.

## Hemodialysis

The human body is incredibly sensitive to changes in the external and internal environment. For example, a small change in body temperature has a large effect on our general wellbeing. It is therefore important that the body maintains in a relatively constant internal environment, a condition known as homeostasis [?]. As a rule of thumb to achieve homeostasis is that the amount of food and fluid should be the same as what we excrete. The body secretes most of the excess fluid and toxic byproducts through the lungs and the kidneys where the kidneys are responsible for the largest quantity.

The kidneys have a variety of vital functions such as regulating blood pressure, filter out toxic byproducts and regulate ion and pH level in the blood. It is a very efficient organ where approximately 1200 ml of blood passes through the kidneys every minute. Since we cannot live without our kidneys it is very important that we have a good substitute for those cases when the kidneys fail to function.

Dialysis treatments are extremely important for people suffering from renal impairment. The dialysis machine performs the processes that the kidneys would normally have done. There are different types of dialysis treatments, but in this project the filtration of the blood occurs in an external machine. This type of treatment takes about 4 hours and is carried out approximately 3-5 times a week. The blood is transported from the patient to the dialysis machine through a set of plastic tube and blood flow through the machine is driven by a peristaltic pump. See Figure 1 for an overview of the different steps in the dialysis treatment and the basic constitution of the peristaltic pump.

The peristaltic pump consists of a rotor and two pressing rollers. The tubing is retained in a semi-circular chamber around the pump. When the

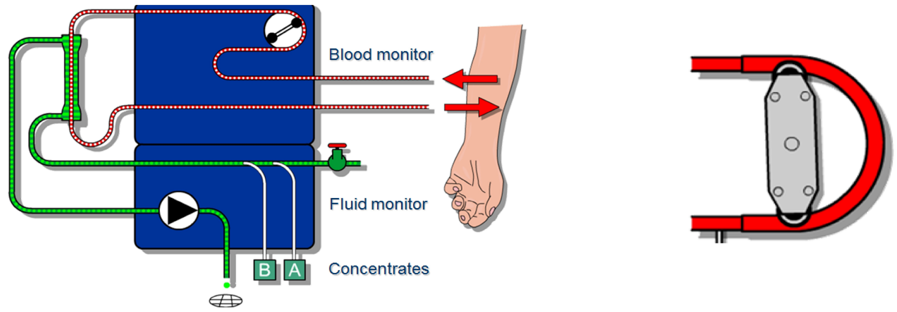


Figure 1: Left: illustrative figure of the dialysis treatment procedure. Right: simple drawing of the peristaltic pump.

pump starts rotating, the pressure rollers will compress the blood-filled tube and force the blood forward. The pump is driven by a DC-motor.

During treatment the patient has got two needles in one arm. One is known as the arterial needle, where the blood flow is directed towards the dialysis machine. The second is called the venous needle and here the cleansed blood is returned to the body. Common blood flows during treatment is about 200 - 400 ml / min. The blood pressures can be measured before and after the dialysis machines using pressure sensors.

A serious complication that can occur during the treatment is when the venous needle, for some reason, dislodges from the patient's arm. This is a critical condition since the patient will lose a large amount of blood in a short time. About 200 patients die every year due to this complication called venous needle dislodgement (VND). In order to avoid VND it is important to have a safety monitoring system that quickly detects if the venous needle is dislodged and stop the treatment.

Such a safety monitoring system is currently being developed at Gambro in Lund. The idea behind the system lies in the fact that when the venous needle comes off, it will no longer be possible to determine the patient's heart pulses and would therefore indicate for VND.

## Problem formulation

In order to implement a venous needle safety monitoring system it was necessary for the pump to have an as constant period time as possible. The excisting system that controlled the pump speed was not sufficiently good, since the period time variation was large. The object of the project was analyze the excisting control system and come up with an improved control method which could maintain a more constant period time.

## Project results

It was found that the variation in period time using the existing control system was caused by a combination of high frequency disturbances and unsufficient resolution in the control signal that drove the motor.

Results showed that using a simple PI controller with a filter that removed high-frequent signals the period time standard deviations could be more than halved. A PI controller uses a feedback signal in order to calculate the difference between wanted motor speed and actual motor speed, i.e. the motor speed error. The PI controller uses the error to compute a motor drive signal that acts to remove the motor speed error. As can be seen in the Figure 2 the actual motor speed $y$ is sent back to the controller as well as the wanted motor speed $y_r$.

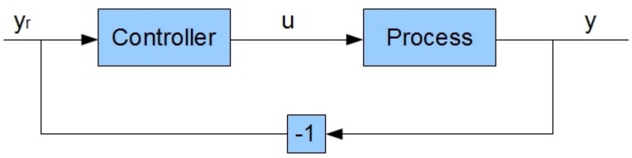


Figure 2: Block diagram showing the basic controller-process structure. $y_r$ is the wanted motor speed, $y$ is the actual motor speed and $u$ is the motor drive signal. The controller is a PI controller and the process consists of a motor and the peristaltic pump.