Observation Theory

Script V11B – Stochastic and Deterministic Variables

Hello,

Following the introduction on the main concepts of estimation problems, we now need to take a closer look at the main ingredients of the mathematic model: the observations and the parameters.

The goal of this video is to discuss the nature of these ingredients.

We will distinguish two types of variables: deterministic ones and stochastic ones

Again, we start with our problem of measuring the width of the canal, using different techniques.

Let's start defining the mathematical model by sketching our problem on a piece of paper…

We draw a cross-section of the canal, and insert the "unknown parameter", denoted by the letter 'x'

So, we call the width of the canal 'x'.

It is unknown.

We could ask ourselves, will we ever be able to truly know the value of x?

The answer to this question is no.

We will never be able to know that value.

The only thing we can do is try to get close to the true but unknown value of x.

What we can do, is get an estimate of this unknown parameter, and hope that this estimate is close to the truth.

This parameter x is what we call a deterministic variable.

It has one value (which we don't know).

But we do know that this value is a single number.

There is only one correct answer to the question about the width of the canal.

Let's go back to the site with the students…

The measurements that the students performed are not deterministic.

Repeating the measurement several times with different instruments, perhaps even by other observers, will typically yield different values.

We call this type of variable stochastic, their value will be drawn from a certain distribution.

This will be discussed in the next videos.

An alternative name for a stochastic variable is a random variable.

Here, the word random should not be interpreted as ‘arbitrary’ (as in colloquial language), but as a variable which can have a value within a certain range.

To summarize, in an estimation problem we have unknowns, or parameters (which are deterministic) and observations , or measurements (which are stochastic).

The difference between these two will become very important in this course.

Now, there is one more thing I would like to bring to your attention.

For this we need to go back to the ‘unknowns’.

In the sketch, the width of the canal is unambiguous, we simply draw some dashed lines to indicate the width of the canal.

However, obviously a sketch is an “idealization” of reality.

In real life, this is not so easy.

For example…

In this example, the unknown width is ‘interpreted’ by a student, who holds the rope at a position which he considers to be representative.

Another person would probably make a different decision.

In this example, the effect would easily be in the order of several centimeters.

This team uses expensive and precise equipment, but they represented the unknown width of the canal by the location of two rods, which are not really at the edge.

Note that these rods are even not straight, so measuring between their tops can yield up to a decimeter of difference.

The same problem would hold for the team applying the 'boy-scout' method.

It is clear that the rod is not really at the land-water interface.

We now know that real-life measurements will differ from the idealized 'mathematical' model.

Once we have linked the mathematical model to the real-world, this difference usually cannot be noticed.

We refer to this difference as the 'idealization accuracy'

In this video, we discussed the nature of the ingredients of an estimation problem.

We distinguished parts, which are deterministic from variables, which are stochastic (or random).

We also showed how the process of linking of the mathematical model to the real world could introduce errors, labeled as idealization accuracy.

In the following, we will assume that the mathematical model is an adequate description of reality.