Mathematical Methods and Techniques in Signal Processing - I
Prof. Shayan Srinivasa Garani
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture – 05
Introduction to state space representation

So, let us look into a general generalized linear discrete time model. Often we will find these models very useful in practice.

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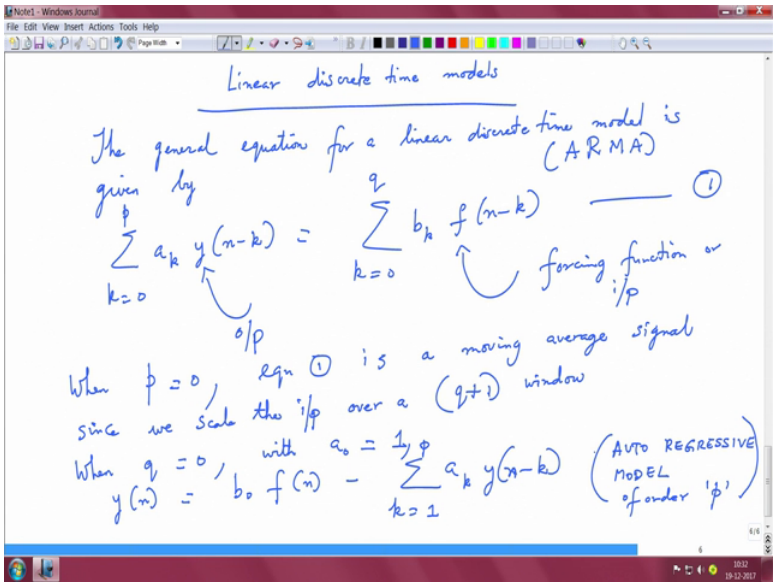

So, the general equation for a linear discrete time model is given by summation a k y of n minus k, k going from 0 to p equals summation b k f of n minus k, k equals 0 to q. So, this f is basically the input or the forcing function, and this is the output, y is the output which self expresses itself with various delays, it self expresses itself with various delays.

Now, when p equals 0, equation 1 is a moving average. So, then p equals 0 basically you just are looking at one term right and the scalar a naught can be pulled outside so you just have y n and this is basically the average of the forcing function. And the average it is, itself it is there is some weight to this average we are these b ks. So, when p equals 0 equation 1 is a moving average signal since we scale the input over a q plus 1 window, q plus 1 because from k equals 0 to q you have q plus 1 points. So, therefore, over a k q plus 1 window you are going to average the signal.

Now, when q equals 0 with a naught equal to 1 this is interesting because we have y of n equals b naught f of n minus summation a k y of n minus k, k going from 1 to p. Now, just rewriting this equation again, right. So, this is the forcing part and the output at time n depends upon the previous outputs at various time delays at n minus 1, n minus 2, n minus 3 so on. So, this is essentially an auto regressive model. So, this general equation is basically the autoregressive moving average model and it is also called ARMA model, autoregressive moving average. So, when p equals 0 it becomes moving average, when q equals 0 it becomes auto regressive right, it is auto regressive model of order p. Why it is called auto regressive? Because this signal y of n self expresses itself, itself expresses itself and therefore, it is called an auto regressive model and these models can be expressed in the form of signal flow graph that all of us are familiar from undergraduate signals and systems.

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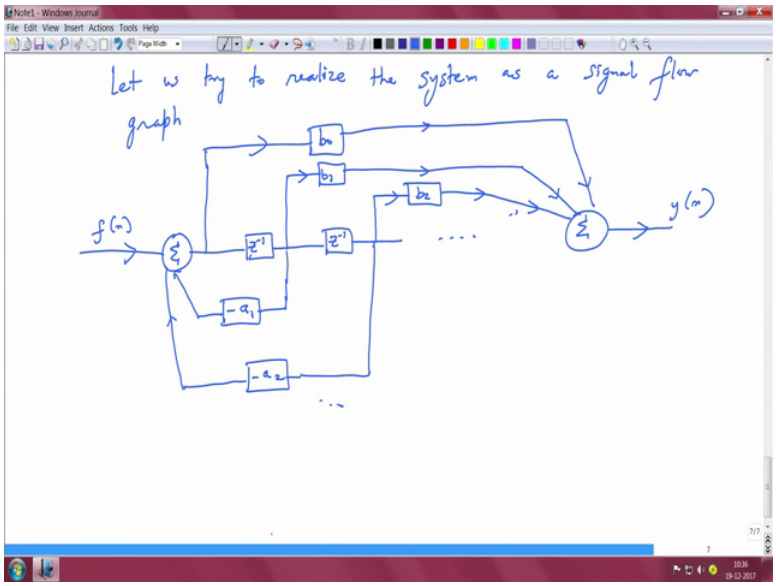

So, let us try to realize the system as a signal flow graph now how do we get this graph. Now, we have various tab delays, now we have a forcing function f of n. At this point it is scaled by b 0 and gets to the output, then f of n going through this delays f of n minus 1, f of n minus 1 is scaled by b 1 and then gets to the output so on and so forth.

You can think of having all these gains b naught, b 1, b 2 so on taken off at various tab delays they get some. So, that is one component for y of n. But also y of n can be expressed as a regression from the outputs at various other delays right. So, therefore,

now from this delay you can have a feed, this is a feed forward path and giving you the arrows in the forward direction that is fights a feed forward path plus we also have a feedback path right, from this delay there is a feedback path. We have a minus a 1 as again it just goes back into the feedback path and then at this point we have minus a two as a gain and that gets to the feedback path and so on and so forth. Basically at various tab delays you should have a feed forward path and you have to have a feedback path and that is a general form of a signal flow graph for realizing this ARMA model right, autoregressive moving average model.

And this is very useful because in the later part we will build the state space representation for this generalized discrete time model and we will analyze this more carefully to subsequent lectures.

So, we will stop here.