User-Centric Computing for Human-Computer Interaction
Prof. Samit Bhattacharya
Department of Computer Science & Engineering
Indian Institute of Technology, Guwahati

Lecture - 12
User-centric models - predictive models and taxonomy

Hello and welcome to the 12th lecture in the course User-Centric Computing for Human-Computer Interaction. As usual we will first start with a recap of what we have learned in the earlier lectures and then that will be followed by the actual content of this lecture.

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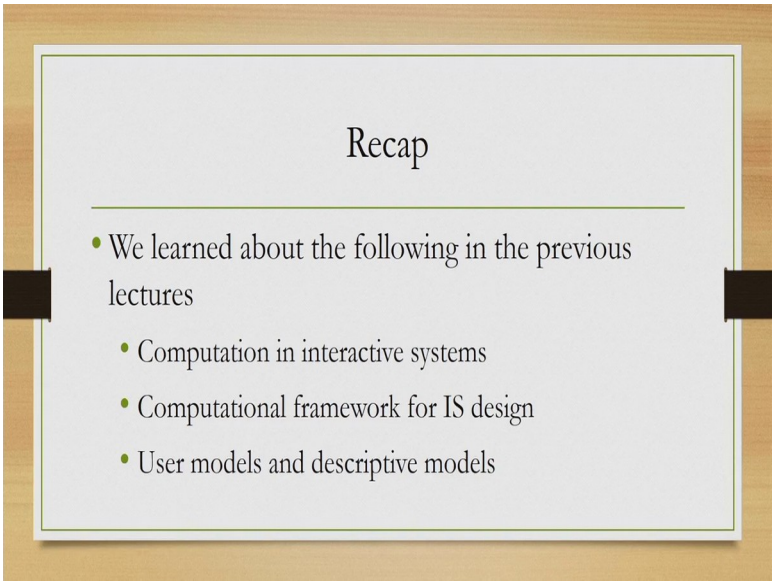

So, first of all in the previous lecture what we have learned is the idea of a framework in the context of interactive system software development process and in the framework we mentioned that the key component is the user state predictor. Now, the state predictor is based on the idea of user models and we started our discussion on the idea of user model.

We also discussed briefly the idea of descriptive models. So, if you may recollect, what we have discussed is that there are two types of models: one is descriptive, one is predictive. In descriptive models, the models essentially describe the behavior, but it has no predictive power and in the predictive model, we have mathematical equations or some computational framework to compute the state.

Now, in this lecture we will briefly introduce the idea of the predictive models. There are many such predictive models; the actual models will be discussed in subsequent lectures in details.

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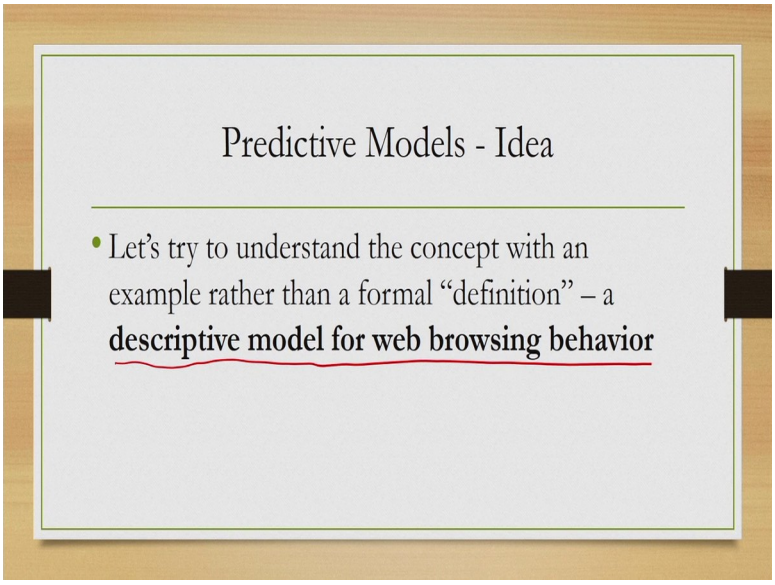

Now, before we go into the discussion of the idea of predictive model, let us try to understand what a model is and how to differentiate a descriptive model and the predictive model based on their advantages in terms of an example. The example is the descriptive model of web browsing behavior. Suppose you are asked to develop one website and you are the designer, you have to decide how to design the website, how to place the elements on the website and what should be the characteristics of those elements all these things.

Now, if you have some idea of the web browsing behavior of a user of course, your design activities will be effortless or will take at least less effort than if you start without any knowledge. Now, let us assume that we now have access to a descriptive model for web browsing behavior.

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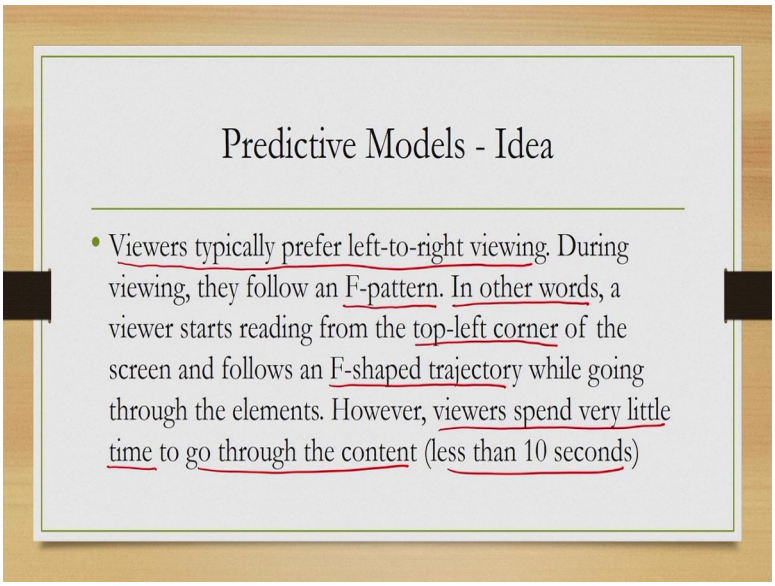

Now, what is this model? Viewers typically prefer left to right viewing that is one part of the model which tells that the viewers typically prefer left to right viewing. During viewing, they follow an F-pattern that is a pattern of viewing. So, in other words a viewer starts reading from the top left corner of the screen and follows an F-shaped trajectory while going through the elements. So, top left corner of the screen, this comes from the first statement viewers typically prefer left to right being and F-shaped trajectory comes from the second statement that they follow an F pattern.

So, the idea of F shaped trajectory is that when we look at the objects we follow a trajectory that looks like an F or the F letter in the English alphabet. It is also mentioned in the descriptive model that viewers spent very little time to go through the content so, less than 10 seconds. So, in other words, we have a descriptive model which talks about a particular behavior observed in the viewers of web pages. So, the behavior states that that typically access the web elements in a left to right manner and follow the F shaped trajectory in addition it is known that users typically spend very less time, very little time to access the elements to look at the elements.

Now, of course, although we are saying that this is descriptive model, this is not our original model the statements that are part of this model have come from various sources including the work by Nielsen which found that the F pattern trajectories followed in on screen reading behavior.

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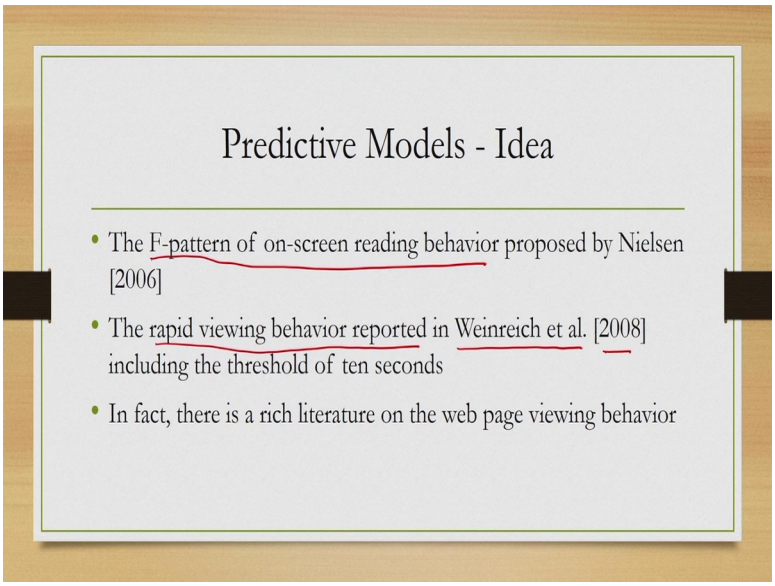

The rapid viewing behavior that is the behavior which states that the users spend very less time while viewing an on screen document. It was reported by Weinrcich et al. in 2008. So, all the things that we mentioned in the descriptive model and many other things, all these are taken from literature. There is a very rich literature on how users view website. But that is not our main concern, our main concern is the model and what it tells us, it tells us specific things about the way user behaves.

Now, from that specific way from the knowledge of those specific ways, a designer can get some information on how to organize the elements on the screen.

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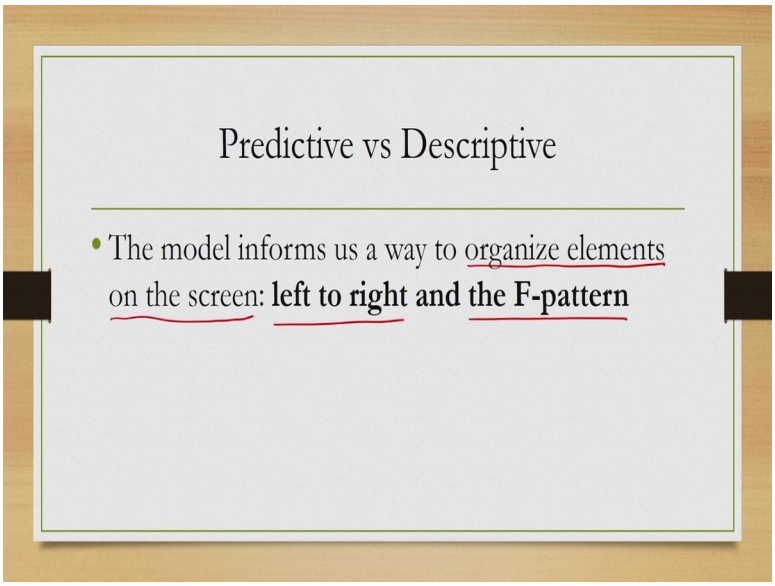

So, typically in the left to right and following the F trajectory; so, when we want our users to view the elements, the way we organize them should follow these guidelines that they should be placed in a left to right manner and the viewing pattern should match the F pattern which is already known.

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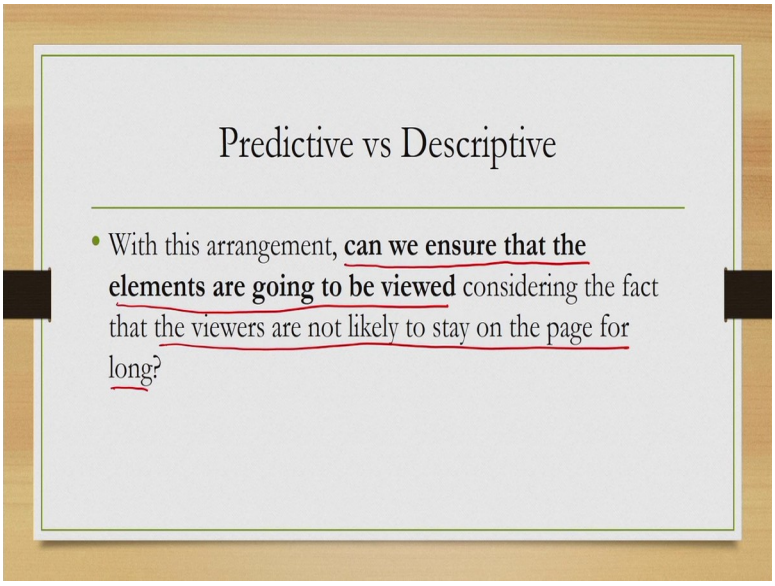

The question is with this arrangement, can we ensure that the elements are going to be viewed? Why we are concerned about this question? Because, there is also the fact that, the viewers are not likely to stay on the page for a long time. So, when we ensure that the

elements are arranged you know a such that this left to right viewing behavior and the F trajectories of behavior are supported, can we ensure just with this arrangement that all the elements that are there on the page will be viewed by the end users since viewers are not likely to stay for long? That is not possible.

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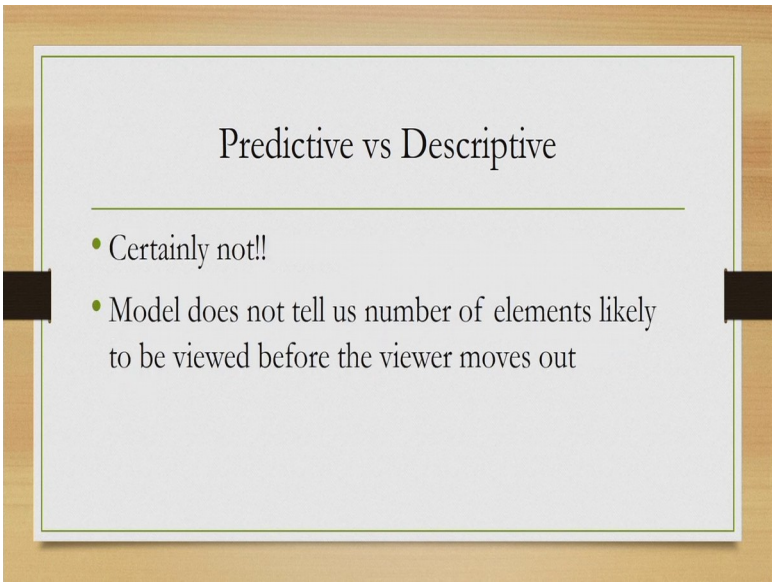

This model this descriptive model does not tell us for how long user is going to view an element unless we have that information or some indication of that. It is not possible for us to tell whether all the elements that are there in an web page will be seen by the viewer.

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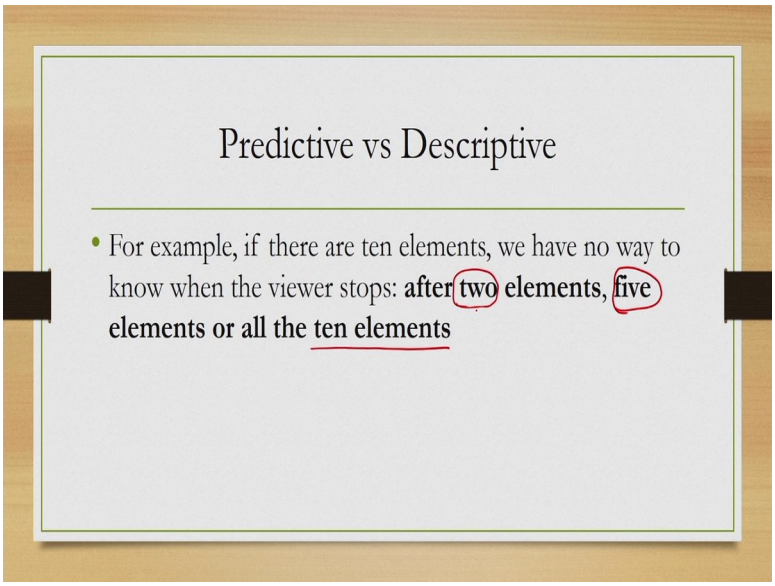

In order to understand that question further, suppose in the web page that you design. There are 10 elements, now we ensure that they are placed in a left to right manner and you expect the users to follow the F pattern by the way you arrange the elements.

All these are fine, but how can you say that all the ten elements will be viewed? How can you say that the user will not move out of the web page after viewing say 2 elements or say 5 elements or whether they are going to view all the 10 elements? So, at what point the user moves? Whether at the end of the ten elements or after leaving lesser than the ten elements such as two elements or five elements. So, what do we need in order to answer this question?

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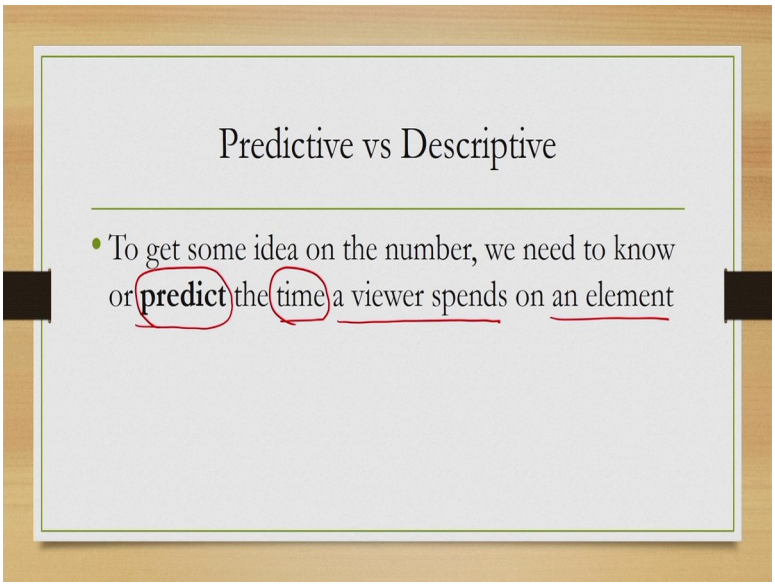

We need something to predict the time a viewer spends on an element. So, essentially that is our requirement in order to answer the question how much time a user spent on each element and we need to predict that time.

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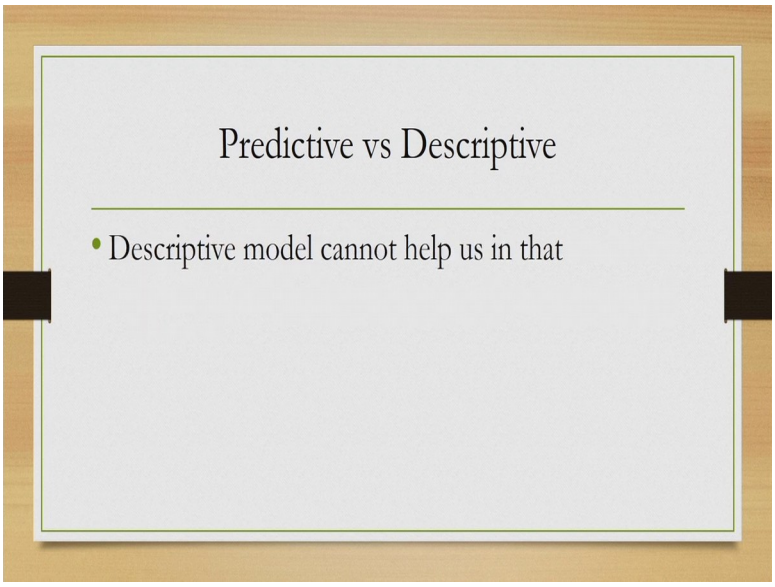

And we cannot do that with the help of a descriptive model as we have just seen because the model just describes how a user behaves it does not tell us anything about how to predict that time.

So, there a predictive model can be useful. Now what is that model? Let us again consider the same example.

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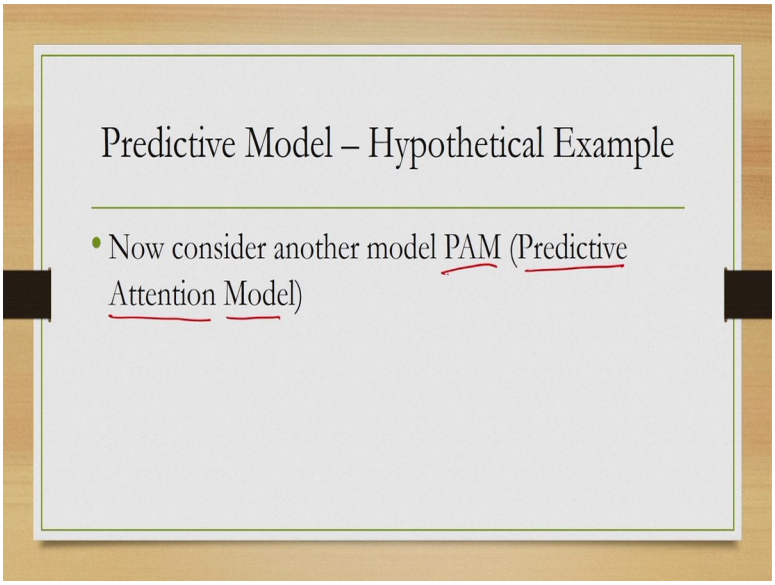

Now, let us assume that we have a hypothetical model called PAM or Predictive Attention Model. So, this is at for the time being let us assume that this is a hypothetical model and we are using it to explain the idea of a predictive model.

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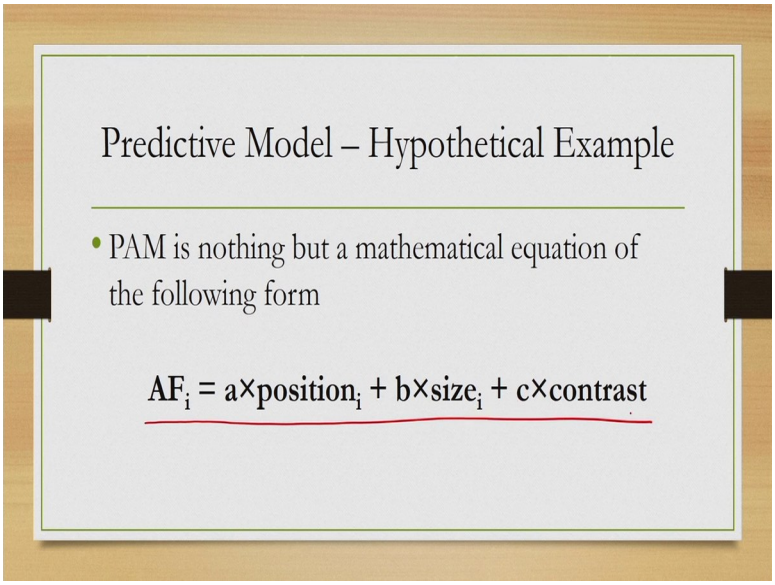

So, what is this model? It is nothing, but a mathematical equation of the following form.

$$AF_i = a \times position_i + b \times size_i + c \times contrast$$

So, the model is unlike in the previous case where we have a one paragraph of description of the model, here when we talk of this predictive attention model or PAM; it is just this equation.

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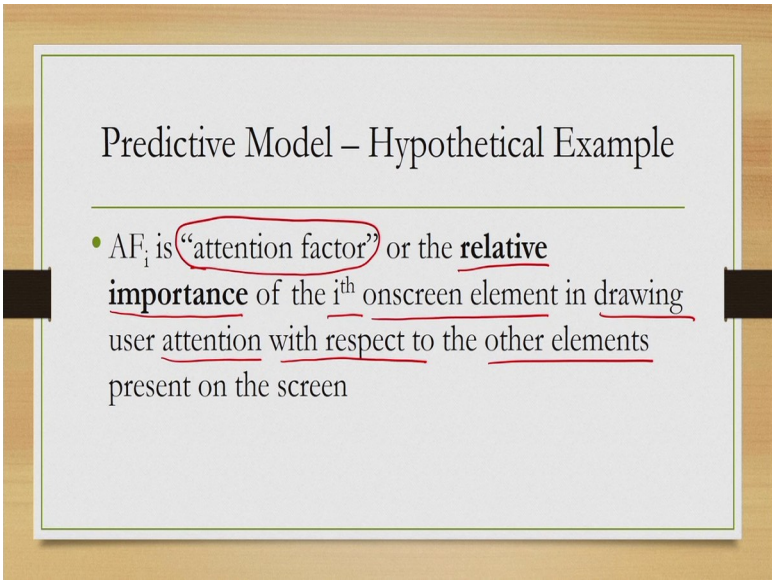

What these terms means? We can think of AF i as a factor, let us call it attention factor. So, when we get a value of this factor using the equation, it essentially tells us the relative importance of the i'th on screen element in drawing the attention of the user with respect to other elements present on the screen. So, we compute AF i and it gives me some idea of the relative importance of the corresponding element in drawing attention of the users with respect to the other elements present on the screen.

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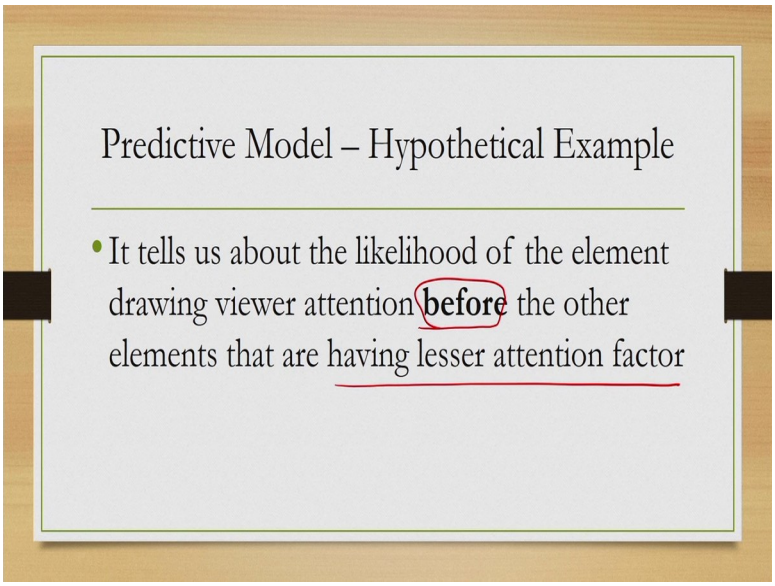

In other words, it tells us about the likelihood of the element drawing viewer attention before the other elements that are having lesser attention factor. So, we consider this attention factor computation as a way to tell us which element is likely to draw attention before the other elements.

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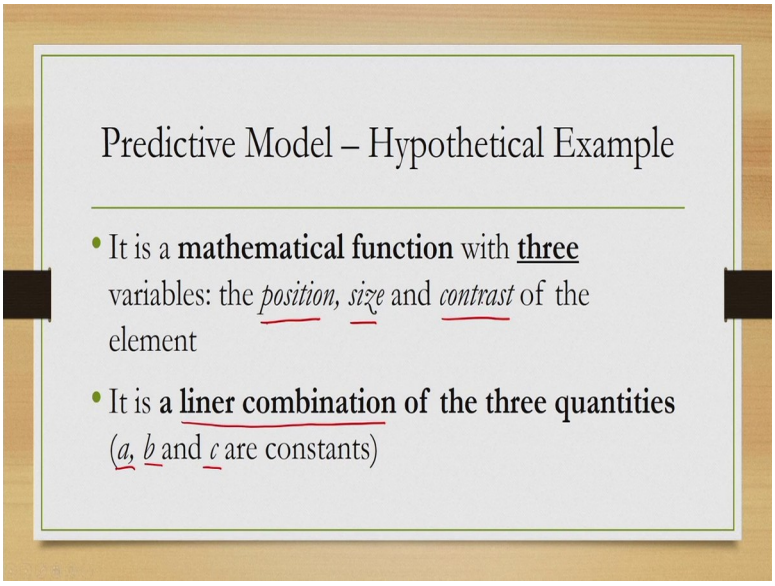

So, it is a mathematical function having three variables; the position, the size and the contrast. Now, I hope these terms are self explanatory position and size is of course, self explanatory where the object is positioned on with respect to the screen reference frame

and what is the size of the object and contrast is essentially the color contrast. And the mathematical function is nothing, but a linear combination of the three quantities where there are three constants a, b and c. We have a mathematical equation which is a linear combination of three quantities position, size and contrast and there are three constants a, b and c.

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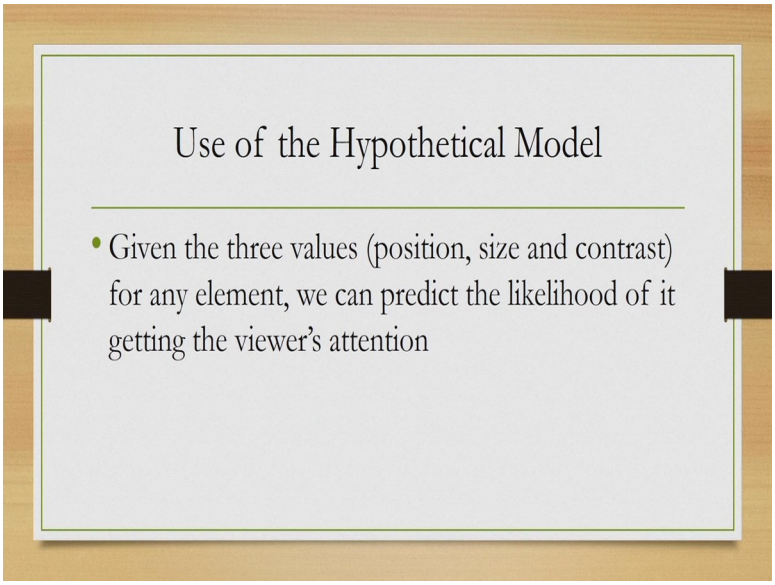

Now, if for my design, I can obtain the values of the three variables position, size and contrast and I know the constant values a, b and c then, I can compute this attention factor for the particular element and I can do that for all the elements present on the interface or the webpage.

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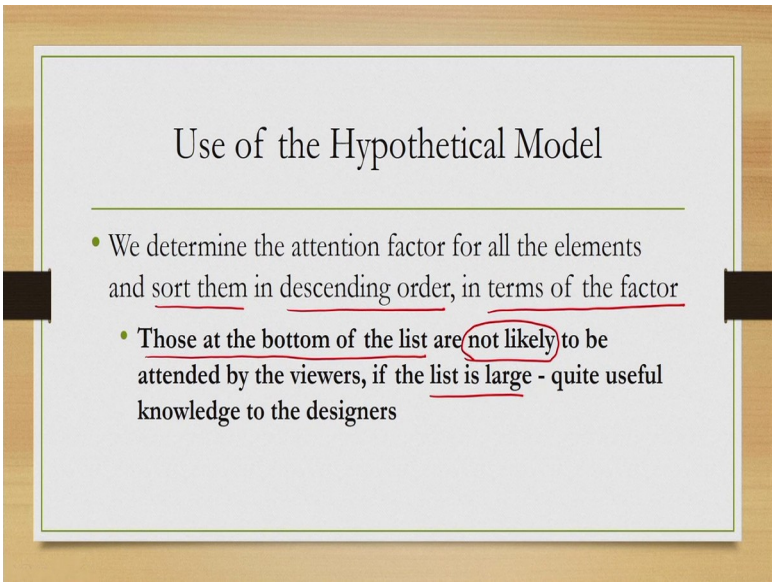

So, with this knowledge of the attention factors of individual elements present on it web page, what we can do? We can sort those elements according to their attention factor. So, we can sort them in descending order or ascending order whatever you wish in terms of the factor and those at the bottom of the list assuming a sorting done in descending order. So, those at the bottom of the list are not likely to be attended by the viewers if the list is large.

Of course, here also we are unable to answer our question directly whether all the elements will be viewed, but we can make some prediction that if I have say a set of 20 elements, it is less likely that the bottom placed 5 elements in terms of their attention factor are going to be viewed within the 10 second time period which is likely to be the attention span of the user for the website. However, if we have only 5 elements, then it is likely that all the elements will be viewed irrespective of the difference in attention factor.

So, if the list is large, then we can assume that bottom placed elements may not get the attention of the users.

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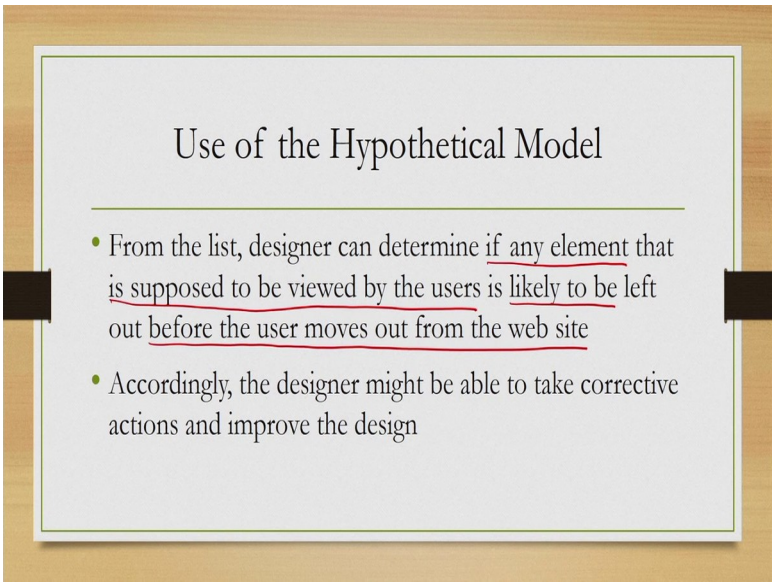

Now, with this knowledge what we can do or what a designer can do? From the list, a designer can determine if any element that is supposed to be viewed by the users is likely to be left out before the user moves out from the website. So, as I said suppose there are 20 elements in the list out of which the bottom 5 are likely to be left out.

Now, in those bottom 5 whether there is some element that actually the designer wanted the user to see, but because of the design of the element it came in the bottom of the list instead of remaining on the top. So, then the designer can actually choose to modify the design. So, that its attention factor improves and it comes in say the top five elements as for the list.

So, that is of course, a very useful knowledge for the designer to decide on modifying the design. Modifying the design in a way such that the design objectives are fulfilled so, that is the basic idea. Descriptive models are good to give us some idea of the behavior, but it is not good to help us in taking finer design decisions. Predictive models are useful in quote unquote computing behavior which helps in taking more refined decisions at many stages of the design.

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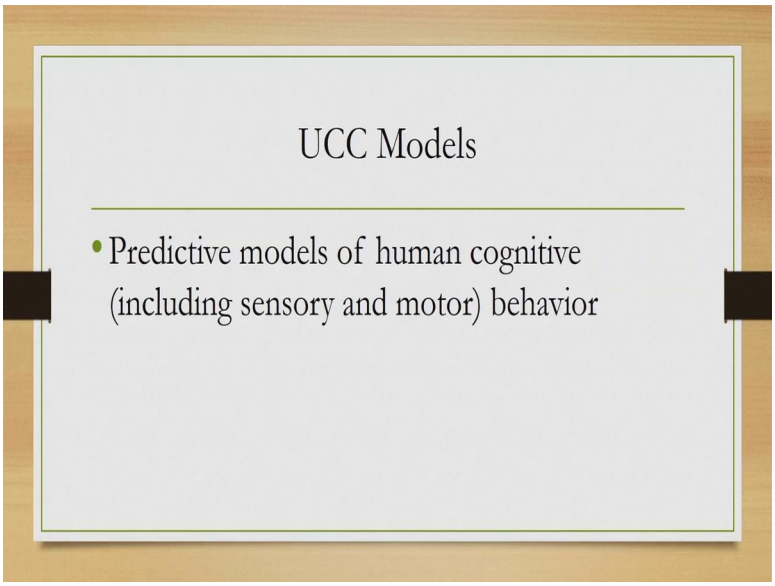

Now, let us try to have some formal idea of what is the user centric computing models which are the predictive models of human behavior. Now when we are talking of the term predictive model, we are including both sensory as well as cognitive behaviors along with that motor behaviors are also included.

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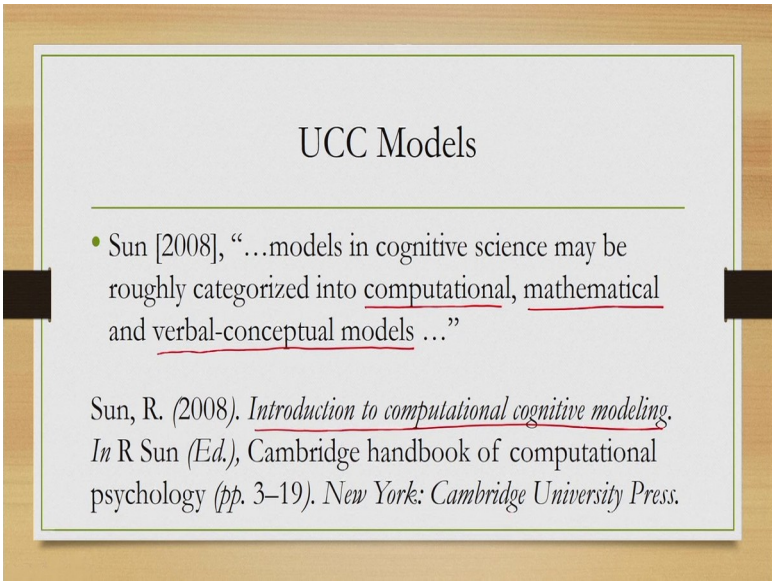

Now according to Sun, models in cognitive science maybe roughly categorized into computational, mathematical and verbal conceptual models. Now there are three types of models which are proposed computational, mathematical and verbal conceptual. Some

more idea on these models can be found in this article which was published by Cambridge handbook of computational psychology, Cambridge University Press in 2008.

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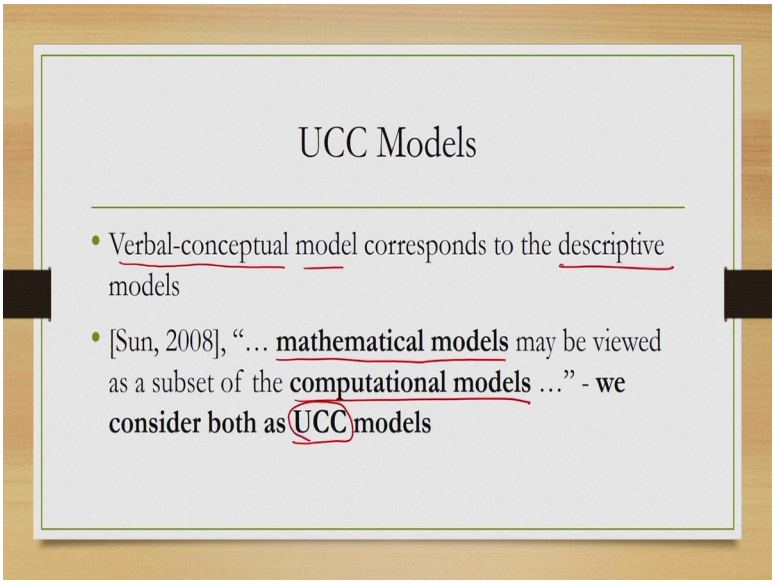

However for our understanding, we can say that verbal conceptual models are nothing, but the descriptive models and we will club together these other two categories mathematical models and the computational models as their user centric computing models which are both predictive in nature. So, then if we want to have a user centric computing model, let us try to understand what is there in the model. Let us try to understand the anatomy of a UCC model.

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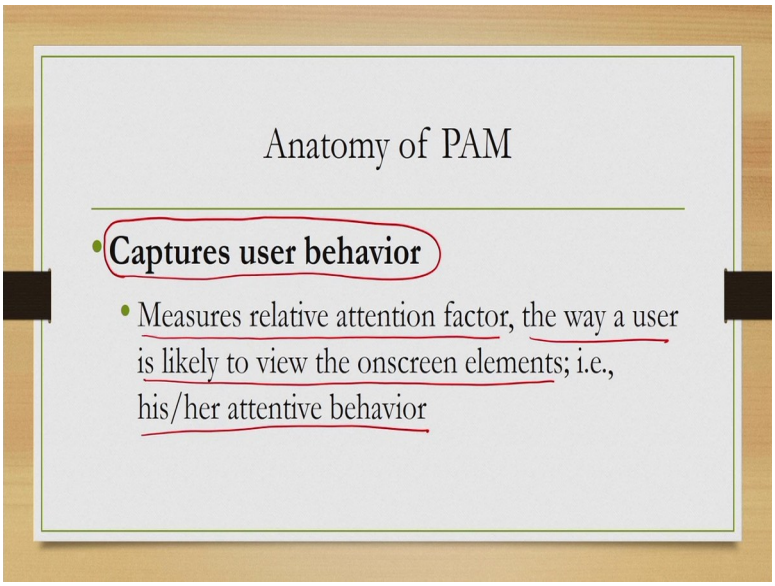

So, what it does? It captures user behavior. So, any model that is supposed to be user centric must capture user behavior. For example, the PAM or predictive attention model measures the relative attention factor which is the way a user is likely to view the on screen elements or in other words his or her attentive behavior. So, if we are calling a model user centric, then it must capture user behavior and when we are calling a model user centric computing model, then it must capture the behavior in a way such that it can be computed.

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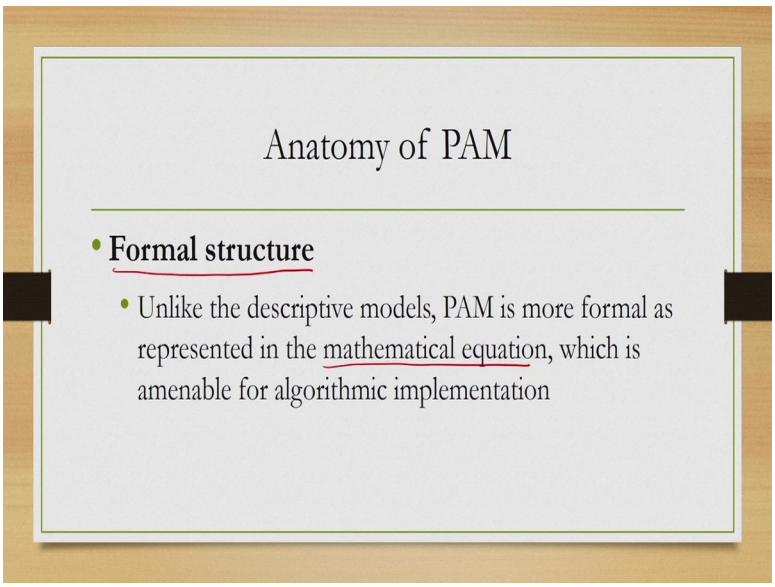

Then the model should have a formal structure unlike the descriptive model. So, earlier when we are describing the model of web page giving behavior, we simply described it in terms of natural language in a paragraph. However, when we are we were talking of PAM or the predictive attention model we used a mathematical equation. So, that is kind of a formal structure.

So, any UCC model or user centric computing model must follow a formal structure which can be a mathematical equation or it can be other formal representations and why we need this formal structure so, that we can actually implement this model as an algorithm or as a program in the computer.

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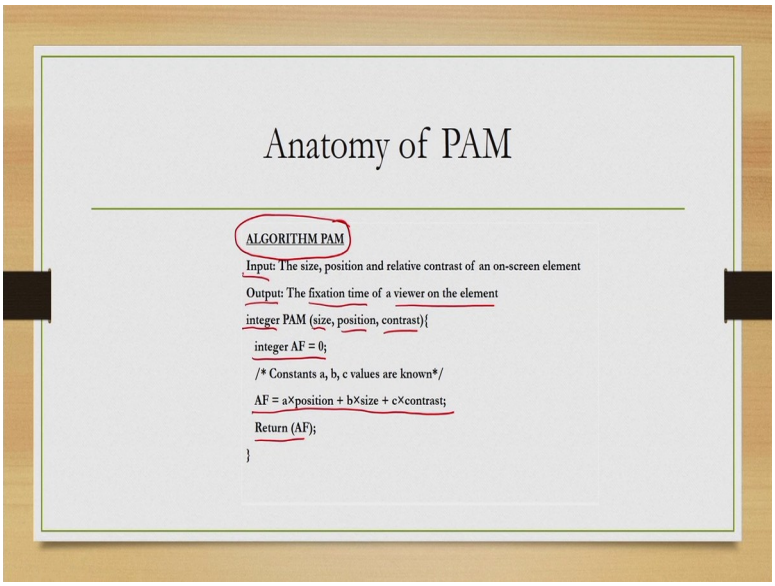

For example, this is a simple pseudo code for implementing the PAM model or we can call it the algorithm for implementation of PAM where we have input which is the size position and relative contrast of an on screen element and the output is the fixation time of a viewer on the element.

Although we are using the term fixation time, this is actually not the exact time being calculated instead an indirect indication of the fixation time in terms of the attention factor. And then in the actual function, it returns an integer or you may define it to return a real number and the text as input side position and contrast. These are variable declarations and this is the code for computing the attention factor, this ends the algorithm. So, this is a very simple implementation of the PAM.

So, if we have a formal structure, then it makes it easy for coming up which such algorithmic implementation of the model.

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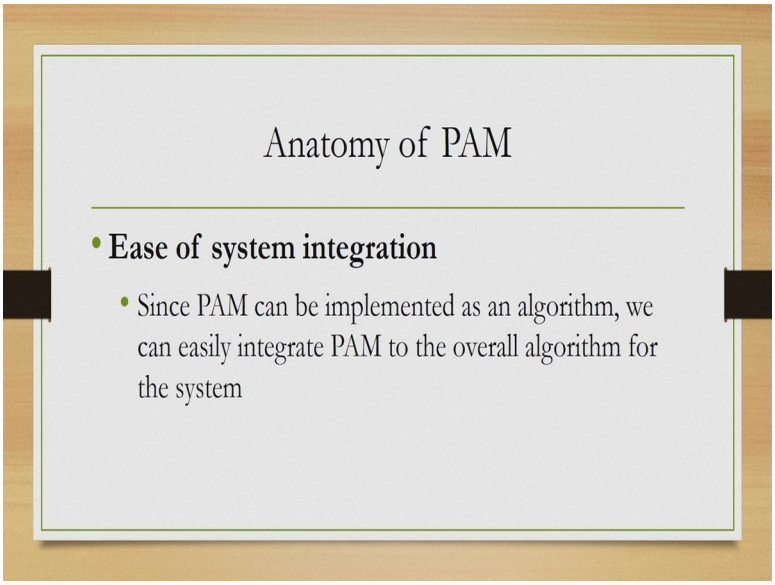

The third important thing is that the model should be such that it is easy to integrate it in the overall user centric system. Let us see how PAM satisfies that criteria.

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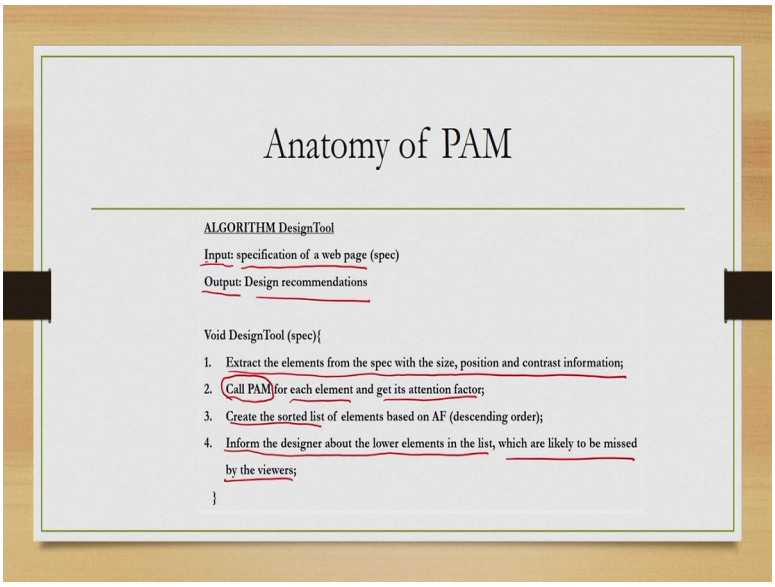

So, this is one algorithm to come up with a design tool. This tool, what it does? It takes as a input the specification of a web page and produces as a output some design recommendations in some form. Now there are four steps that this algorithm performs. It

first extracts the elements from the spec with size position and contrast information. It calls PAM for each of the element and gets the attention factor computed. Then it created creates the sorted list of the elements based on the AF and finally, based on the sorted list created it informs the designer about the lower element in the list which are likely to be missed by the viewers.

So, it flex some elements that are lower in the list. So, that the designer gets the information and decides to take corrective actions if required. So, here in this algorithm as you can see, PAM is actually part of the overall system which is a design tool that helps the designer come up with a usable product. So, then these are the things that are there in example model that we discussed the PAM. So, then from there we can generalize the characteristics that should define a user centric computing model.

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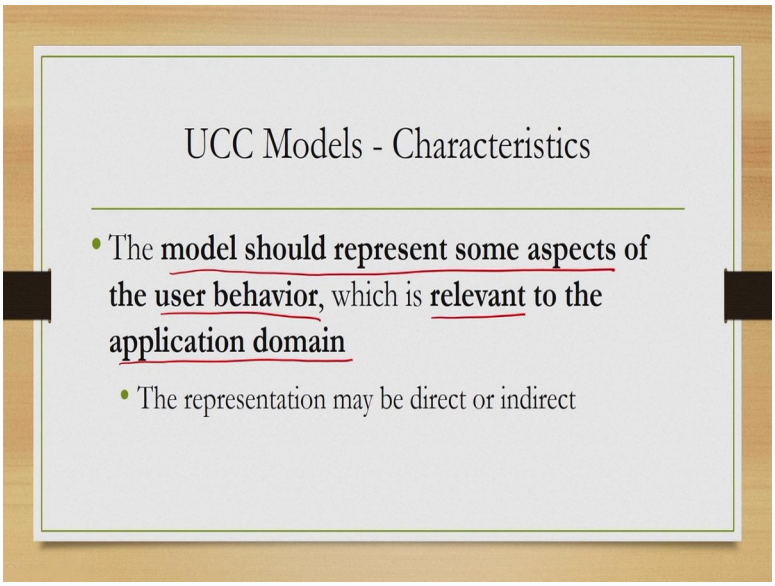

So, first of all the model should represent some aspects of the user behavior which should be relevant to the application domain. So, did not be very generic, it must be relevant to the application domain and this representation may be direct or indirect. Like in PAM, we have represented the fixation time indirectly in the form of attention factor.

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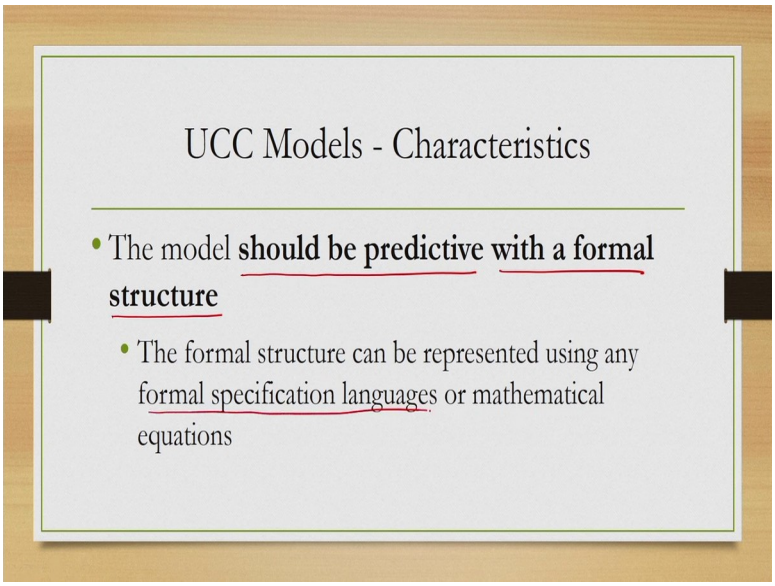

Secondly, the model should have predictive power. It should be predictive with a formal structure. So, we should be able to predict the behavior and that prediction should be done based on a model that is represented with a formal structure and this structure can be a mathematical equation or any other formal specification languages.

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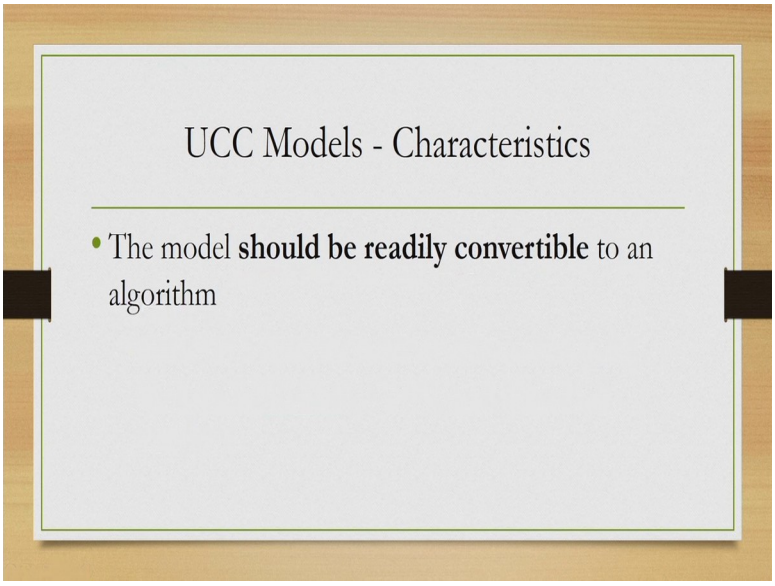

The third characteristics is that the model should be readily convertible to a algorithm which anyway follows from the formal specification.

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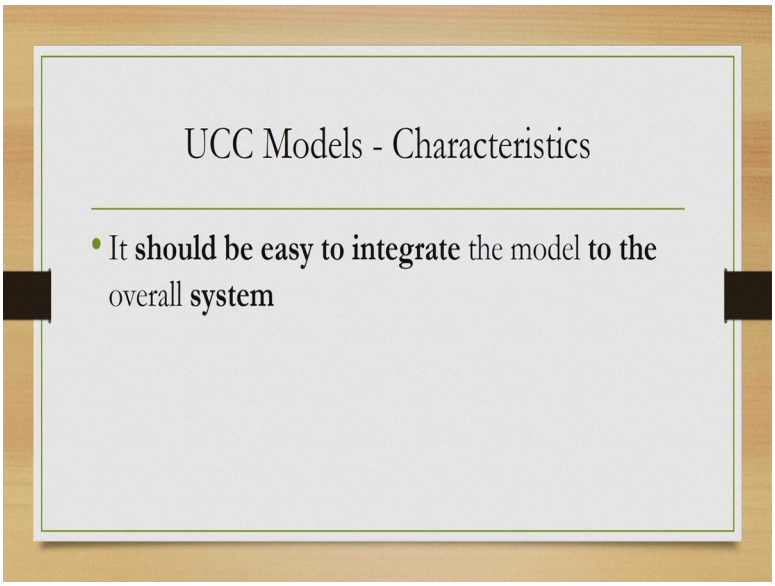

And finally, it should be easy to integrate the model to the overall system. So, because we are able to formally represented, we should be able to integrate it in the overall system. If a model of human behavior has these four characteristics that it represent some behavior, the representation is predictive and in terms of some formal specification which is amenable to algorithmic implementation and the model can be integrated to an overall system easily, then we can call that to be a user centric computing model.

So, we have explained the idea of a predictive model in terms of this hypothetical model called PAM. Then we have analyzed PAM and found out its characteristics based on those characteristics we have generalized the definition of a user centric computing model in terms of four characteristics. Now, these characteristics are found in many the of the models that are reported in the literature.

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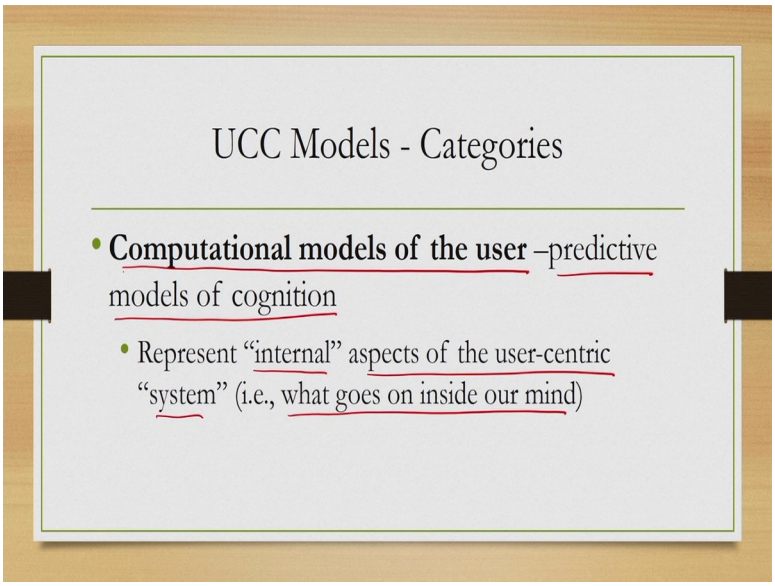

So, we can broadly divide all these models into two categories; one category is computational models of the user. These are predictive models of cognition which represent internal aspects of the user centric system. In other words, what goes on inside our mind when we are interacting with the system?

So, when we are talking of computational models, we are essentially referring to predictive models of cognition or the models that predicts our thought process what we are going to do next in our mind.

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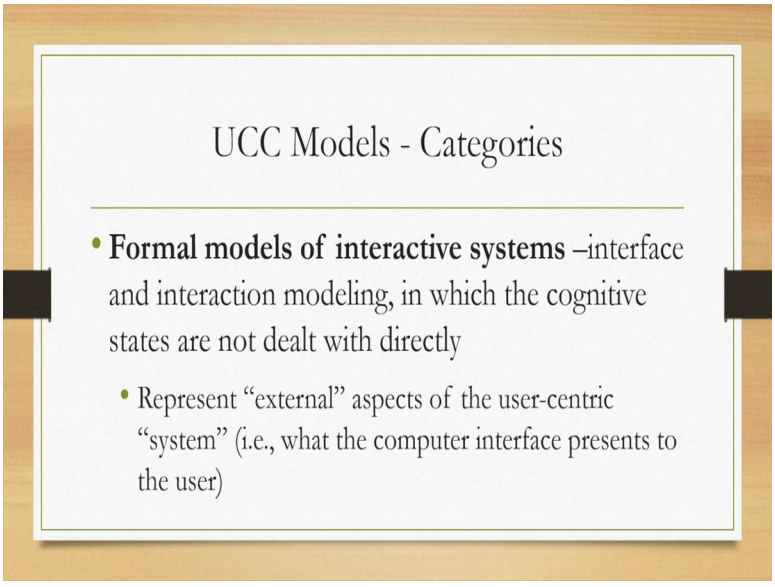

Then we have formal models of interactive systems. This is essentially the modeling of interface and interaction. However, a point to be noted here is that the cognitive states are not dealt with directly. So, if we look at it from another angle, then we can say that these formal models represent external aspects of the user centric system or what the computer interface presents to the user.

So, the cognitive model of the users are essentially models of cognitive behavior, formal models are essentially models of system behavior and together we get the overall behavior.

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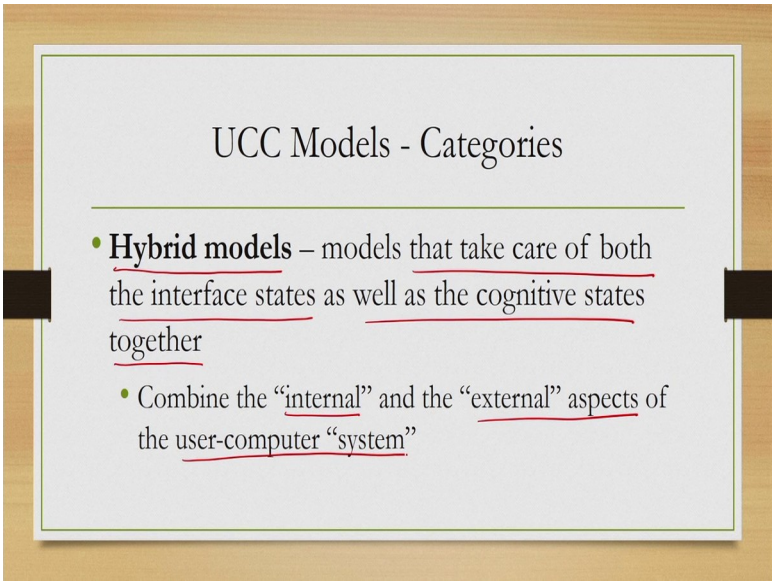

And that comes under the hybrid models where these two types of behaviors are combined. So, these are models that take care of both the interface states as well as the cognitive states together. In other words, it combined the internal and the external aspects of the user computer system. Now under computational models of the user, there are further subdivisions. So, we can have many such types of user models.

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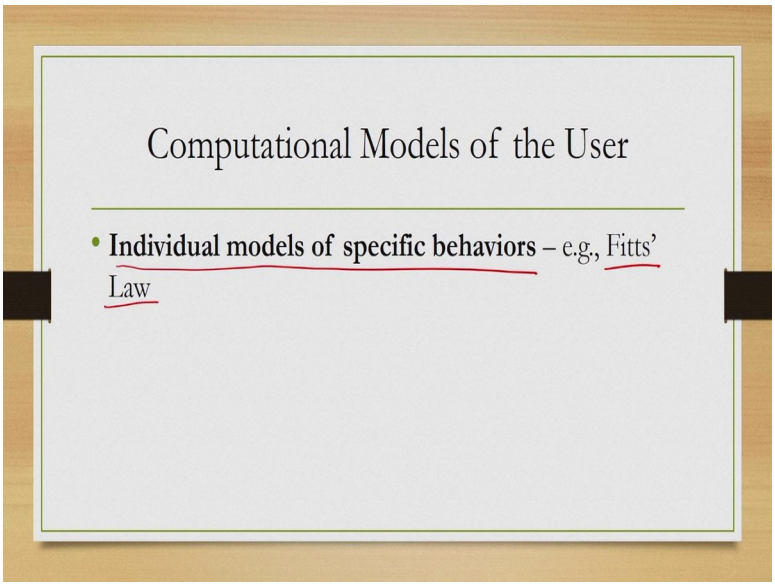

One category is individual models of specific user's behavior. This individual models of specific user behaviors essentially models the behavior of specific activities. For example, the Fitts' law it models the behavior of movement of our hand or finger. So, that is specific activity only finger or hand movement then we have simple models of human information processing.

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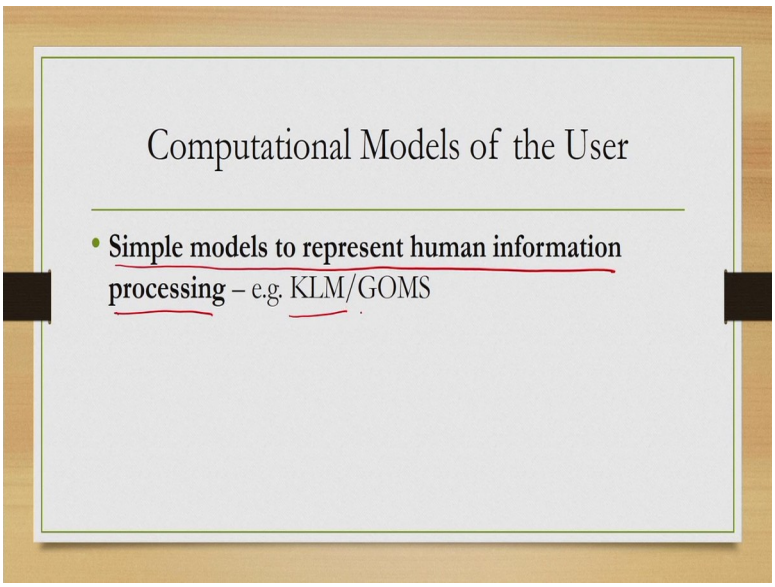

Here some simplified assumptions are made to represent the cognitive process. Examples are the keystroke level model or KLM and the GOMS models.

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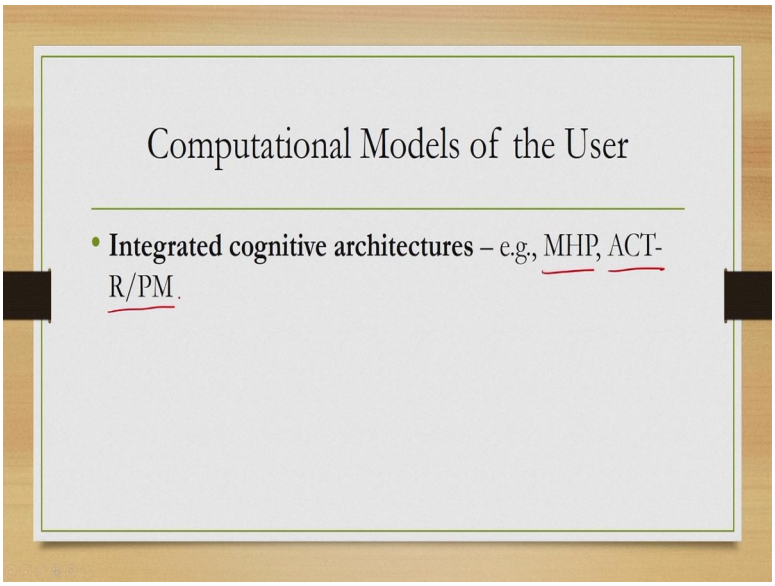

The third category is integrated cognitive architectures. These are models that tries to represent the entire human cognition. For example: the model human processor the ACT-R/PM model. There are many such models.

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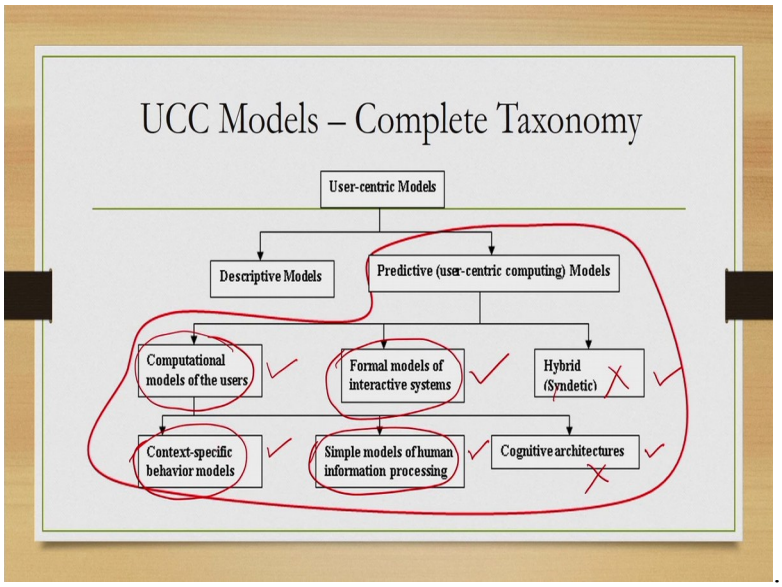

So, if you recollect in the previous lecture, we started with a very basic taxonomy of models that is descriptive model and predictive model; now today we have got introduced to many other types. So, together we can come up with a complete taxonomy of user centric models. So, we have descriptive models which we have discussed in the

last lecture, then we have predictive models today we got introduced to the idea of predictive models which are essentially the same as user centric computing models in this context.

Now this predictive models we can divide into three categories: computational models of the user, formal models of the system and hybrid models. Now these hybrid models are sometimes called syndetic model; syndetic models. Now computational models of the users have further subcategories. We have context specific behavior models simple models of human information processing and cognitive architecture.

In this course, we will focus on computational models of the users and the formal models. So, we will not talk about syndetic models further in the computational models we will talk about context specific behavior models and simple models of human information processing. We will not talk about cognitive architectures. Both of these are very complex to understand and those are outside the scope of the content of this course.

So, we will have a look at few popular models that are falling into these categories computational user models and formal models.

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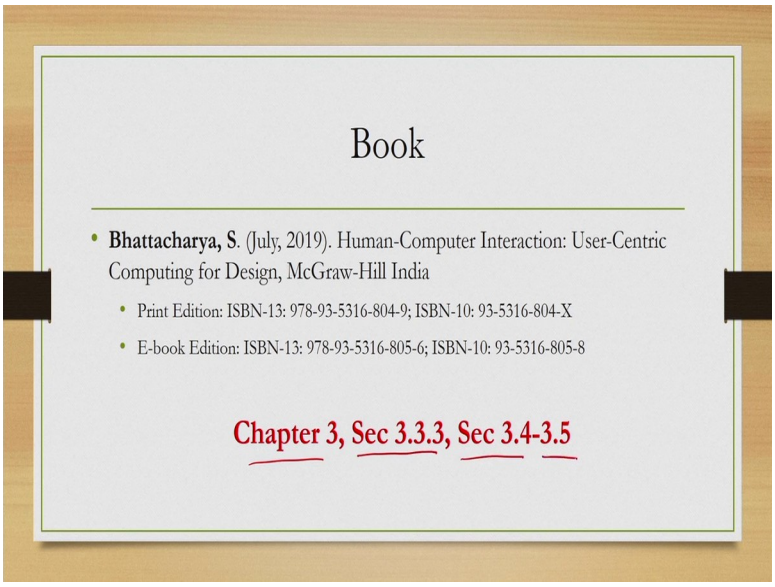

So, the material that we covered today can be found in the book and you are advised to refer to chapter 3 section 3 point 3.3 and section 3.34 to 3.5. So, all the materials can be found in these sections.

Thank you and good bye.