Engineering Graphics and Design
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Lecture No. 02
Introduction (Examples of Visualization - 1)

Welcome to the course, Engineering Graphics and Design, this is the first week's lecture and following the introduction lecture, we will now look at examples of visualization. We will continue with some more examples in the next lecture as well.

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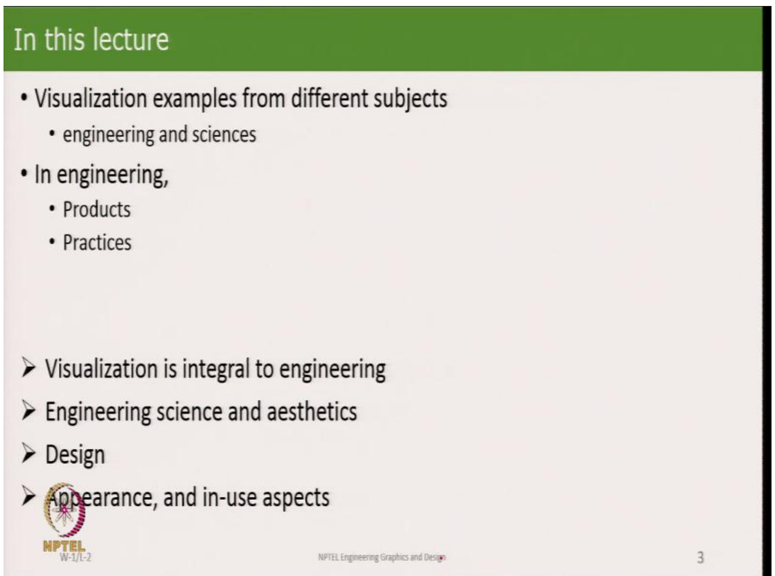

So, the question is, what is visualization, why are we doing it, and where is it applied. So, what we will see now is that we have examples of visualization that come from different subjects, in engineering, in sciences and also nowadays as a data visualization and design of GUIs. In the course, we will concentrate on the engineering applications of products and practices.

So, to recap, visualization is integral to engineering. It also augments engineering science and aesthetics. It is widely used in design, design of practically everything. And although not exactly as a part of an engineering graphics course, it does have connections to appearance, aesthetics, and it’s in use aspects. So, visualization is a tool by which we can do a lot of things in our mind first as pictures and then through pictures on paper pencil or by making it on the computer.

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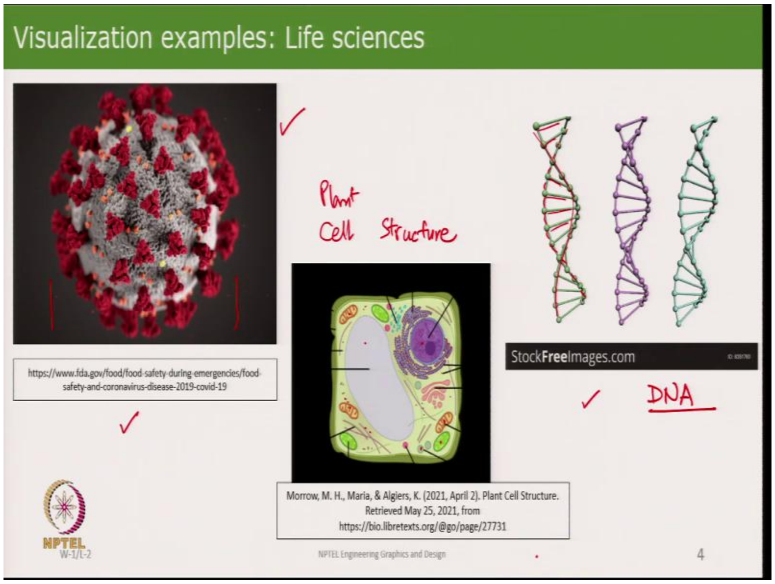

So, we now start with some examples, beginning with life sciences. The most talked about thing today is the Novel Coronavirus. And very early on we saw pictures of this virus, which as shown here on the first picture. So, this is of the order of 0.1 micrometers in size, which would be from this to this approximately spherical. And we see a lot of features on this, which have made this virus far more infectious.

So, this picture was generated not by just looking at it, but by using advanced techniques of imaging, various types of microscopy and from there, some rendering is done, colors are added, and we begin to see the external surface of this virus. There are more pictures that tell you what is inside this, you can look up the web and see what is the chemical and molecular composition of this virus.

One of the basic things in life sciences is the structure, the classical structure of the double helix of DNA. So, these are the type of pictures that are drawn to show that you have one line which is going like that, the other one which is going like that and crossing it, and they are connected at different points. And analysis of this is what we get as of, as what we know as DNA analysis, genome sequencing and that is all represented in graphical form as pictures, which is what we are referring to as visualization.

The third example I put here, is of a structure of a cell. So, this is a plant cell and we may have studied some of this in school. But, this is in a very simple way in one picture, it tells us a lot of things which are there in this cell. We will not go into details of what they are that you can read up on your own, but it tells you that there is something which is here, something there, something else there, something here, something there, something there, something there and all of this is contained in this thing over here.

So, this is a slice of through the cell, the cell is actually three dimensional. And all these are actually three dimensional even the Novel Coronavirus is three dimensional, the DNA structure is highly three dimensional shape, so is the cell and what we have done is tried to represent it on a two dimensional paper or a screen you may call it and in this case, we have taken a slice through it to show what is what.

So this is, there is examples of visualization in biology, cell biology and virology. And they tell you that it is a picture that makes you think a lot and gives you a lot of information. So, that is where visualization comes in.

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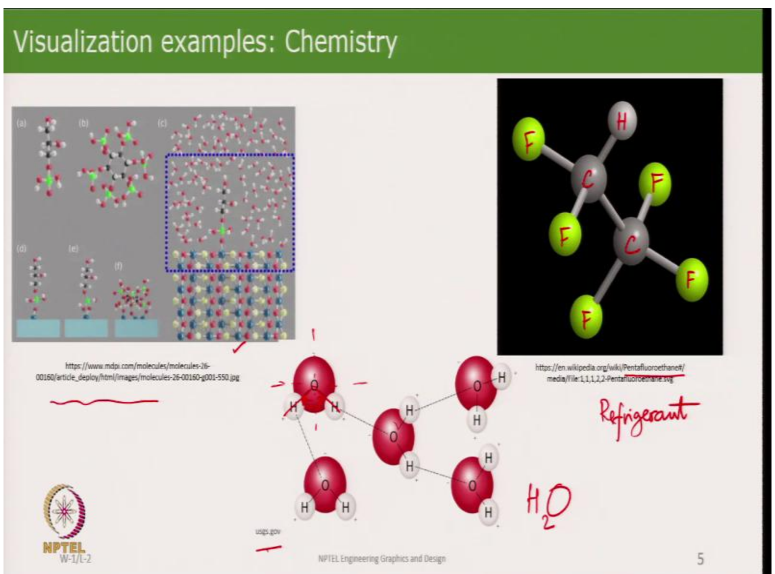

The next set of examples are from chemistry. And you may wonder you know why in engineering we are looking at visualizing chemistry and molecules. Well, an understanding of the structure of these tells us a lot about what the material does or what a product will do or what a reaction may do, or what the molecule itself will do.

So, there are three examples here. The one on the right side here is Pentafluoroethane. So, this you will know is a refrigerant. And if you are studying thermodynamics, or further courses on refrigeration and air conditioning, we require to know this substance not really at the molecular level but then we need to know its thermo physical properties and its transport properties and also its chemical properties. And one of the things one does is to look at the molecule and that gives you an idea what this could do.

So, that is a three dimensional structure. These are the 2 carbon atoms, 5 fluorine atoms, and 1 hydrogen. So, that is one example. In the picture here, there are pictures of lots of molecules. And these have been shown very nicely in different colors and they tell you what the shape of not just one atom or one molecule, but how many of them come together and then we see what type of properties they get and what use it is to us in engineering.

So, here there is a molecule which is in a straight line, here there is something which is a hexagon, around that are some more connections there. The bottom you can see a large array of molecules, which are formed the big three dimensional structure. So, that is the type of things you would like to know even when you are looking at carbon nanotubes, that is a big three dimensional structure of carbon atoms. Or we could look at this as some material which is very elastic. So, all these molecules are arranged in this way and you can pull and compress them and push them like that.

So, the structure of this if you look at it, it tells you a lot of basic idea about what is actually going to do. The third picture is what gives us our life H2O, there is a O atom in the middle a big one, 2 H atoms on the side. And this is a very unique atom, molecule, because it is asymmetric in this way. About this axis there is symmetry, but about this axis, it is not symmetric.

And one may think, what is the big deal, but it is this structure, which gives water is very different set of properties than any other substance. Why it is this particular angle, one can look at physics and solve the equations and you will know what the angle ought to be. And then you would ask how do these join up to make say snowflakes or becomes ice, then what happens if it forms a crystalline structure in ice, then what happens all those, all that information can be expressed as a picture.

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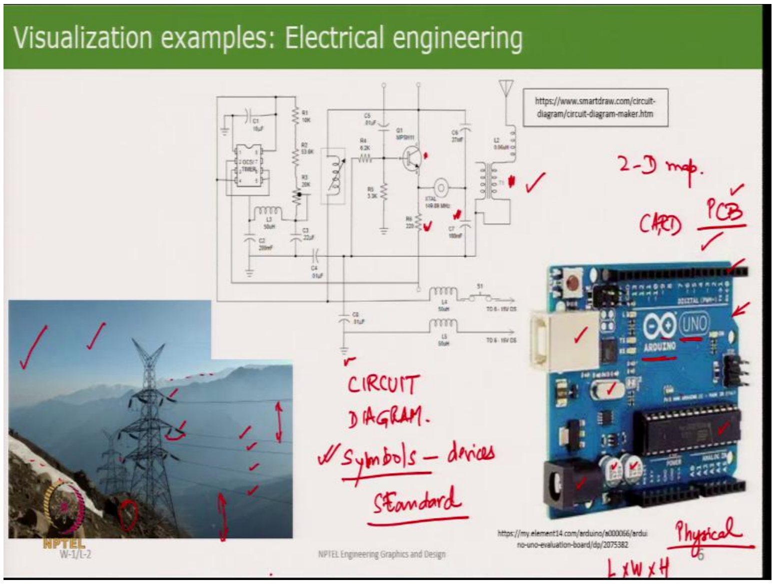

We now look at some examples from electrical engineering. And I have three pictures here. The picture here on the bottom this one is a set of power transmission towers in a mountainous region. So, you can see there is snow already there and behind that also you have these mountains with snow, but what you have with this tower, which is on the top of a mountain on a very steep incline, and this is a tall structure that has been built.

On that structure, these things which are hanging around, these are the insulators and from the insulators are these lines or wires or cables which are connected to this. So, this cable comes ends over here, another one starts here and goes to the next tower and like that on and in between they are connected here. And so, you have transmission lines that go hundreds of kilometers.

So, structure of this, the tower is dictated of course, first primarily by the electrical requirements of what should be the spacing between the lines and between ground and the lines. And then the structural design comes in which decides what should be the, the type of steel that is used, how it is fixed. And then the civil engineering part which tells you how this tower should be anchored on the mountain side.

So, what you have done is we have expressed something as a picture, which tells us a lot of things about how power transmission will take place. And all of that is a beginning, the way you look at it, the way it has been put up, it is a culmination of engineering effort. But if it is something starting from scratch, this is the beginning of first sketching and visualizing how we are going to transmit this electricity. So, that is the first example.

Another way where we visualize an electrical system is by this circuit diagram. Of course, these are all these days done using various CAD packages. And one can see here that, although it does not look like something that is physically there, but what you have seen here is we have put together various things using certain symbols, symbols for devices and the lines denote electrical connections. So, that is a transistor right there, a transformer, a capacitor, a resistor, an earthing connection and here there is a timer, induction coil, variable, resistor.

So, that is how the design of an electronic circuit happens. Even the electrical power circuit, which you have seen this first picture, it also begins with a drawing like this, where we represent the functional requirements of the electrical system as a picture. That thing here to note is that this drawing has certain symbols which here, these are standardized symbols. So, there are national and international standards, which tell you what symbol to use for what device and you cannot just create your own symbols.

And that is the importance of standards in making drawings and in this particular type of drawings, which is one form of visualization. So, you have visualized a circuit and the circuit does something which is what you wanted it to do, and that is where it came from. The third example here is an electronic card. And you can see here the name of the manufacturer, and this is a very popular card, which is used in many electronic activities also as a good thing for hobby.

So, what you see here is this thing, which is the substrate on which various devices have been mounted, so this is one, this is another one, this is another one, this is something, this is another one, this is another one, this one and so on. And the sequence in which these are connected is shown by these little lines, which are running on the card itself.

So, what has been done is that on the card, you made a 2D map of how the devices have to be kept and how they are to be connected. So, there is a dedicated software for that, where you can take your circuit diagram and then begin to make your actual physical layout of the circuit board. So, the base of this, that is what is called the PCB, and you design the PCB according to your circuit diagram, which is reflecting your requirements, and then on that, when the card is made and ready, then we start mounting all our devices and that gives us our finished card.

So, designing the layout also involves looking at not just the electrical requirement, but also the physical requirements. For example, these two devices they have to be separated by a certain distance although their electrical connections could be much closer, physically the two devices should be somewhat away, this particular chip sitting on the top here has a certain dimension and you have to keep other things away from it.

And overall card also has a certain physical dimension in terms of what is its length, into width, into height. So, wherever else we are going to fix this card, that box should be able to accommodate this, keeping every, all the requirements in mind in that nothing on the car to touch anything else that is first and the most important requirement. So, all these devices that you see here, the PCB, the making of the PCB, putting all this, what you have seeing here, this is all printed on the circuit board.

So, the circuit board comes with all these things done including all the numbers that are written, these are all the identifiers, so everything comes out exactly the way you have wanted it. And for that you have used under customized, specialized software. And these days, there are lots of software that once you have made it you can also test whether the physical thing fits on it. And second, you can even test electronically what it is doing. That is also required. Once the card is made, everything is assembled on it then again you would like to test it.

That is the idea that you made a circuit diagram as one set of pictures, converted into a PCB layout, drawing, picked up drawings about various components and put everything together to make a circuit board.

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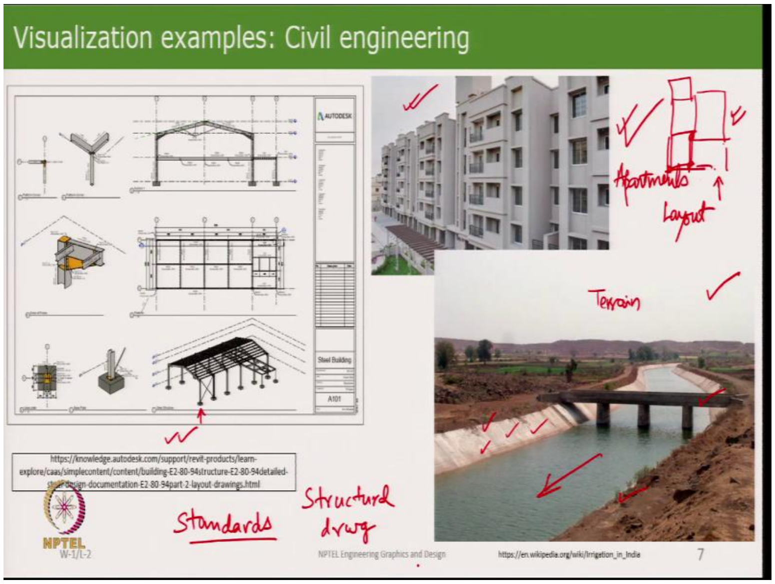

Our next example is from civil engineering. And there are many examples on that. And you can also someway add also architecture to it. I have shown you 3 drawings. This first one here is a picture of a canal, an irrigation canal. So, what we have here, a canal running tens or hundreds of kilometers over terrain, which is not necessarily flat, not running in a straight line but taking curves and ensuring the basics requirement of the irrigation canal that water should keep flowing in one direction.

So, how do you do this, for that you need to understand the terrain. And then you see where the source of water is and where do you want the water to end up. And then you start putting a line on paper to say, well, this is how I am going to route my canal. And then we go into the detail engineering to see if the soil is good enough for that or not. And how the embankments have to be designed, where you need to provide bridges for people to cross. And that is becomes the basis for them making it. Once it is made those drawings and the pictures, they are the basis for doing regular maintenance.

So, you need to look at the entire surface of the canal every so often to see if there is some crack in it or something has come off or weeds growing in it, or water seepage is happening or the embankments are weakened, all of that needs to be monitored for the entire life of the canal, which could be 30, 40, 50, 60 years. So, that is one example.

The second one is something we are all very familiar with, an apartment complex. These are dwellings of different sizes, number of rooms. And all of this design, what you see it is what comes out is done first as to how the thing may look, then you look at the layout, first which is done by just making a sketch by saying that I will make a room there, then I will have another room over there, here we will have a kitchen, on that side we will have a toilet, and the entrance to the house will be somewhere here.

So, that is the beginning of making a plan for a house. And that is what you are doing, you are visualizing how the house will come up. And then we add more and more details to it to say where the door is, where the windows are, then you see where the piping will go, water supply, sewage pipe, how will the electrical cables run, how will you provide the network cable inside this. So, all of that gets mapped and planned ahead of time.

After, before that, you get the structural design done as to what should be the size of the columns, where the beams will go, what is the loading it will take. So, that gives you the details of how to make it. And then when everything is done, we see a finished set of apartments as you are seeing over here. And then we need those drawings for many years so that you can check the health of the building and if someone wants to do modifications, it is the design over here which will tell you whether those modifications are safe or not. So, that is the example of apartment blocks.

The third drawing here is what you will call a structural drawing or an engineering drawing. So, this is the language in which engineers translate a desired objective into something which constructors and fabricators can follow and make it. Again, this is been made to some standards and we go into considerable amount of detail to show every little aspect of it, nothing is left to assumption and to chance or you say that okay, we will look at it later on, that is not done.

So, what is the size of the steel, sections to be used or the aluminum section if that is the case, how are they to be fitted, where is the welding to be done, where is the bolting to be done, how are the foundations going to be designed, ventilation, lighting, everything is worked out in detail. And only then, after checking and rechecking the drawings, does it go for fabrication and installation. So, that is an example of a structural drawing. And this happens to be a steel structure, where the apartment block is an example of a concrete structure.

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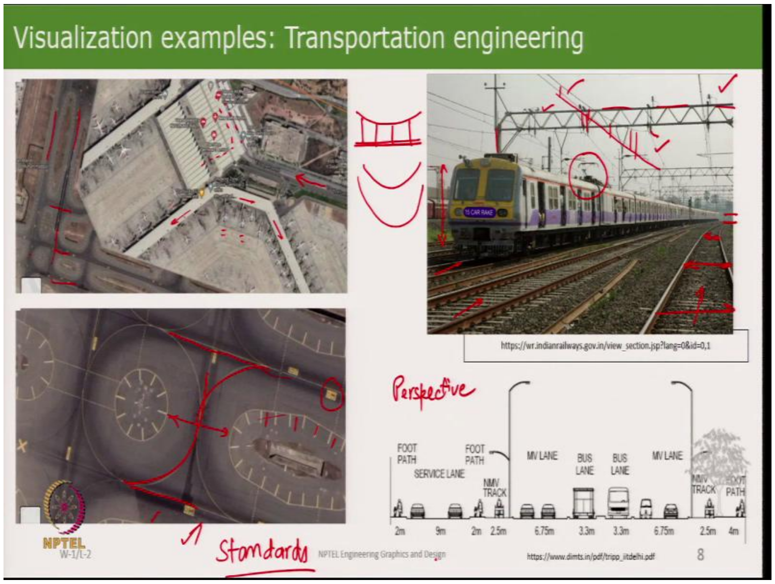

Now, we come to applications of visualization in transportation engineering. And we have some examples here from three modes of transport. The first one here on the right, you will recognize this as a train. And what you see here is of course, a railway track over here, another one here, third one there, something behind it.

And what you see in this picture very nicely is that this train, it looks this big at the front and looks that tiny little height at the back, this is what our eye sees, this is what we see, this is what we visualize a real thing. And this is called a perspective vision. You can see these tracks, here if they look this wide, here it becomes less, here it becomes less, but we know that these are two parallel lines. Same with the train, the cross section, the size of the train is same all along the length. But this is the way the human eye sees it.

This has got its own applications in visualization of how to make things look real, to how much of perspective should be provided that what causes the picture to come alive. We also see here, these things on the top, this structure, it is going on the side that is a steel structure anchored into the ground from that you can see these things hanging there. This dark thing here is the insulator, along that you see one wire has been suspended from that and then there is yet another wire which is this one which has tied to the upper wire by at different points.

And you can see that it is this lower wire which is making contact with the pantograph of the train. So, that whole arrangement serves the purpose of supplying electricity to train. These wires at the end are fed with electricity from our power grid. And this arrangement here is a moving electrical contact. And you can see here it looks quite complex. But simply put, what they have done is that this lower line which is the supply line has to be at the same horizontal level relative to the track.

But if you have recalled mechanics to take a wire and make it straight by pulling it, it is very difficult. You need to have a lot of force or tension to make it straight. So, what is done instead is that we have an upper wire, which has the shape which goes like this between two pillars. This wire is fixed here and here we have variable length supports. So, this wire becomes horizontal.

So, here we are visualizing some more shapes. And this is a very classic shape, that you take a flexible thing and suspend it, what shape it will take, that is a catenary. So, that is an example of visualization in railways. And there are many more things one can visualize, which is say the layout of the coach, how the airflow takes place in it, and then platform, you can see how to visualize the ways by which people come in and go out of the platform, all of that can be done there.

The third example here is airport. And what you see here is the T3 terminal at Delhi airport, seen in Google Maps. And what you see here is this side, which is a road from where the vehicles come in, they drop off the passengers over there or pick them up from the lower elevation the level below from there you go through various things, and then you come into this, this or this, which connects you to the various gates, so that those are the aeroplanes standing at the gate.

So, this shows the layout that was done. And while designing it, they had to take a lot of these things into consideration, that what should be the spacing between gates, how many gates we can have, is it enough for the plane to maneuver into the space, where are you going to run the fuel supply lines which are running underground, all these things were taken up by designing this.

On the air side, what you see here is this is the tarmac. And this is connected to these things, which are your carriage base on which the planes will taxi, the taxiways. And to show the amount of geometrical design that has gone into it, I enlarged one part of it somewhere from here, and we see that in this picture.

And you can see that these are the lines on which the planes must follow. Or they can turn around and go like that. And then there is lines here, which have got these things connected, shown like this, which tells you that you are not to go out of this, you are not to cross these lines, this is your limit. It also shows you some markings, which tells the pilots which route they are on, and which is the route coming up ahead of them.

So, they can maneuver the aeroplane that the way they want to go either to the terminal or to reach the runway. So, somebody put these lines on the ground and these are not small. For instance, this width, this could easily be like about 50, 60 meters with the wings of a plane could be about 70 meters. And then to draw this line when you get to know what is the capability of the aircraft to maneuver.

And so, like that all these lines were drawn and created on the paper, and then constructed. And then as we now see it in these pictures, they have been painted. And again, all these are as per international standards. What color, what width, where to mark it, everything is the same at every airport in the world. So, that is an example of transportation engineering.

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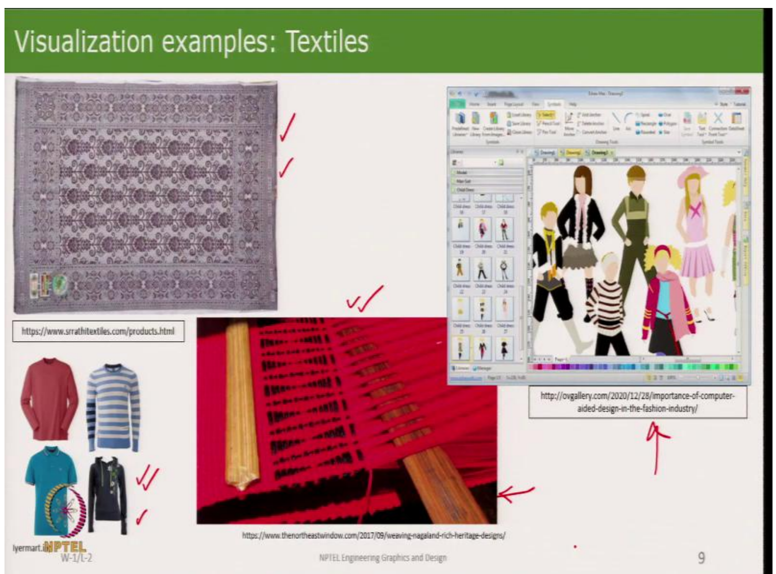

The next example I have taken is from Textiles. On the left here at the top is a chadar, which is a Solapuri chadar and these are made by weaving. And the reason for showing it is that there is a variety of intricate designs which are made by weaving, which is what we see in this picture. So, somebody actually first designed it 20, 30 years back, it was all done manually, paper pencil and the human brain and then they went about making it. These days, you can design it using some software, feed it to a machine, and it will weave out what you want. But that is one example.

Out here it is something we all wear shirts, t shirts and all types of things on it. So, they are all somebody designs it, they are all various fashions come out, various styles come out, fabrics keep coming up more and more innovative fabrics, colors, designs, all of that adds an infinite amount of complexity and diversity to a very simple thing like a T shirt. You often have multiple types of fabrics put into it and it is only after you have done all of that, that you say that now let us make it.

And earlier, the tailor, they used to make only one piece at a time. Now, they will make hundreds in one go. So, that is one example of garments, there are so many more, I have just given one as an example. The picture here, this one is a weaving loom from Nagaland. And there are such looms, which have been in use for hundreds of years, it is completely a manual process. And it takes a lot of time to weave say one shawl or one carpet. But the end, their creativity also shows up as extremely beautiful aesthetic and nice-looking designs.

So, somebody thought of the design in their mind, and kept making it over and the process of making it takes many days, during which time that design stays permanent in their mind. Now you will have a computer printout in front of you, on a screen showing you what you are doing. But this was the classic thing about visualization that the picture, the process of making that was in the mind of the artist. And that is where the creativity really lies.

And this next picture here is what I have been referring to in the earlier three pictures is that these days, there are several software packages, using which one can sketch out designs, then glue the detailing of the fabrics, the stitching, the cutting, and then go into production. And we are now reaching one more step beyond it where somebody can 3D imaging cameras, one can create a complete map, the 3D structure of a person's body, create the garment that they are going to wear. And then show them how it will actually look on them.

Which includes even complex things like folds, fitting, movements, all of that we can now visualize, and those programs are still becoming more and more sophisticated. In years to come you can practically see how your garment will look on you before you even order it. And could even be custom made for you and you only. So, that is one example of visualizing garments.

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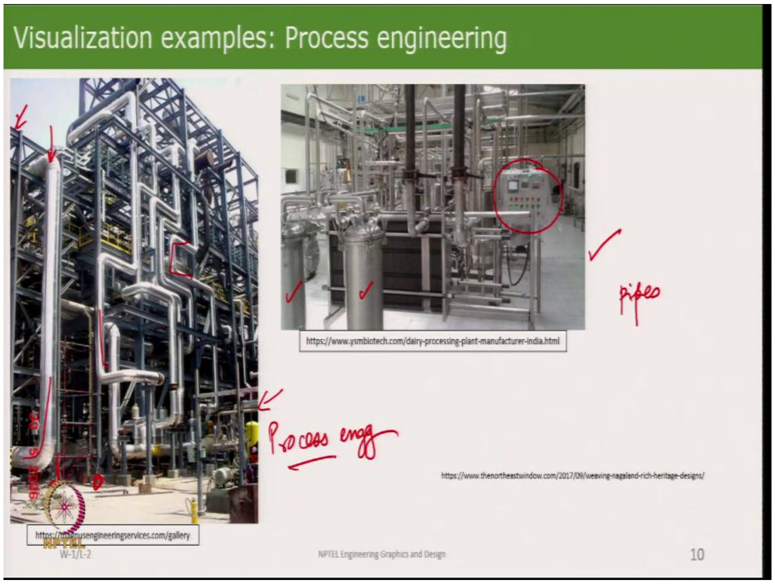

This is example of process engineering. The first one here is a milk processing plant or a dairy. To understand what is being done and why it is done, you got to understand how milk processing takes place and how the engineering works out. But simply if you look at it, what you see is that there are some things like this, then there is something like this which looks like an electrical or a control panel. And then what you are seeing is a big jungle of pipes.

So, what you have done is various fluids are moving through one another, getting hot, getting cold, mixing at times getting processed and finally, you get processed milk. That is one example. On the left is an example of a typical chemical plant, where you can see all these things, these are pipes and these other things, which you see over here, this is the structural part of the thing. So, this is a structure, this thing is a pipe.

So, one designs, what you want to do, how you are going to place it horizontally and vertically and then decide how the connections have to be made, find out how you're going to support the whole thing, work backwards and say, well that does the support interfere with the piping and the layout, iterate and freeze the design, you can walk through it in today's CAD packages. And finally, you say okay, go ahead, make it.

So, these types of things are there in chemical plants, refineries, thermal power plants, petrochemical complexes, food processing, paper making many, many places, this is what you called his process engineering.

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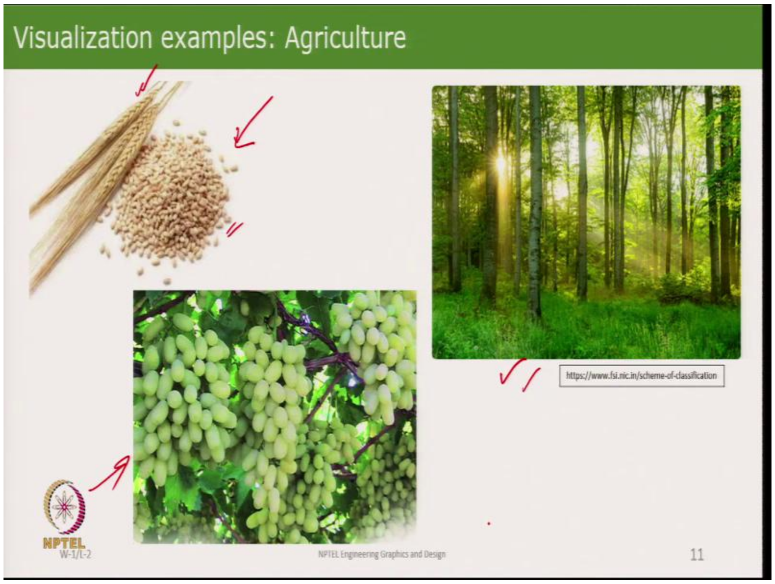

And now an example from agriculture. And what are shown here are some pictures but the pictures tell a story. The picture of a forest that you see over here when taken after year after year month after month tells you the health of the forest and these days you are doing lot of that by image processing, by satellite imaging and also tracking what the extent deforestation or even these days, is it being infected by some insect. So, that is one example here forest.

This example you can all see this is grapes and on itself it has its own beauty, how are they arranged that only nature decides but it looks nice. And then what you would like to do and is that to figure out first are the grapes ready for picking, are they being infected by some parasite, have they been damaged by hail or rain.

So, on a field which is hundreds of meters wide and long going to each and every one of them is how they do now is quite tedious and that is where now we are looking at imagery using drones or using ground moving vehicles to make quick assessment of what is required when. The third one here is you all recognize is grain, and that is how it grows and finally we pick out grains then we make flour out of it and use it for various things.

The picture itself tells a lot of stories but again the objective these days is very similar, is to look at a field and say how is the yield or look at it before the harvest it is ready for harvesting and predict that one month from now this field will; give so many quintals pf grain. That is how people are doing estimation of agricultural production worldwide using satellite images. So, that is the aspects of visualization, we are looking at something, taking a picture making sense out of it.

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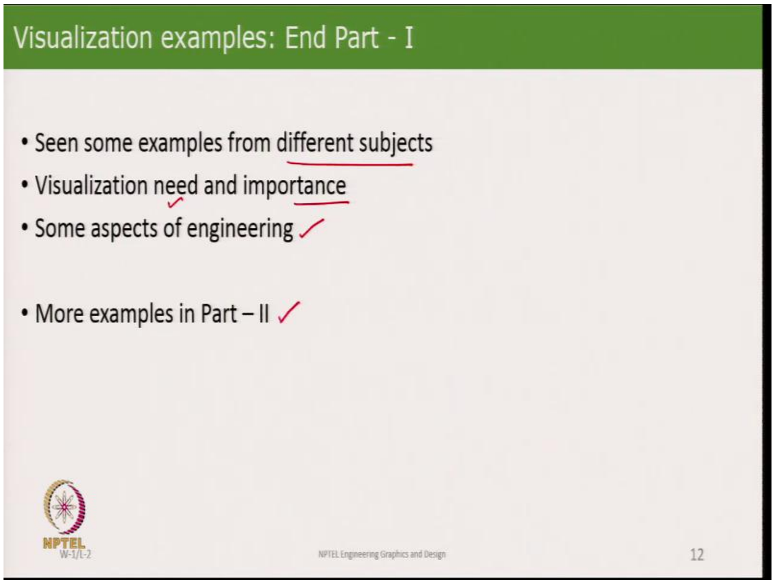

So, with that we will come to the end of this first part of examples of visualization. I have shown some examples from different topics, subjects, disciplines they all have some connection to engineering or different types of engineering. And we shave seen how in each one of those cases what is the need for looking at that picture and how it helps us in doing, achieving our objective. In all those examples we also came across some aspects of engineering not just one particular branch but across branches. We will stop here and the next class, next lecture we will look at more examples. So, we conclude there. Thank you.