Machine Learning for Soil and Crop Management
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Lecture 37
UAV and ML Applications in Agriculture (Contd.)

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Welcome, friends, to this second lecture of week 8 of this NPTEL online certification course of Machine Learning for Soil and Crop Management. And in this week we are talking about UAV and ML applications in agriculture. So, in our first lecture of this week, we have discussed and how these machine learning and deep learning models can be used to predict or to classify soil or plant features.

We have discussed in details about the Convolutional Neural Network method, and they had three different structures. And based on those structures, how much accuracy the researchers have got for classifying different weeds in the crop field, we have also discussed, showing some good application of machine learning and deep learning for crop image based process.

The reason we have discussed this is because the same process are being used by the UAVs for making decision using the images. So, in the later part of this week we will be seeing similar type of applications. So, things will be not, things will be more clear to us because we have already learned the basic work flow of this, how this image processing is combined with the Convolutional Neural Network.

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Now, in this lecture, we are going to focus on this 4 major aspects. We are going to talk about the UAVs or Unmanned Aerial Vehicles, and then we are talking about some of the UAV parts, then we are going to discuss about the use of UAV for agricultural operations, and finally, we are going to list some of the agricultural benefits of using these drones or UAVs. Now, these drones are basically synonymously used for UAVs in this whole week. So, whenever I am using either UAV or drone, they are basically same.

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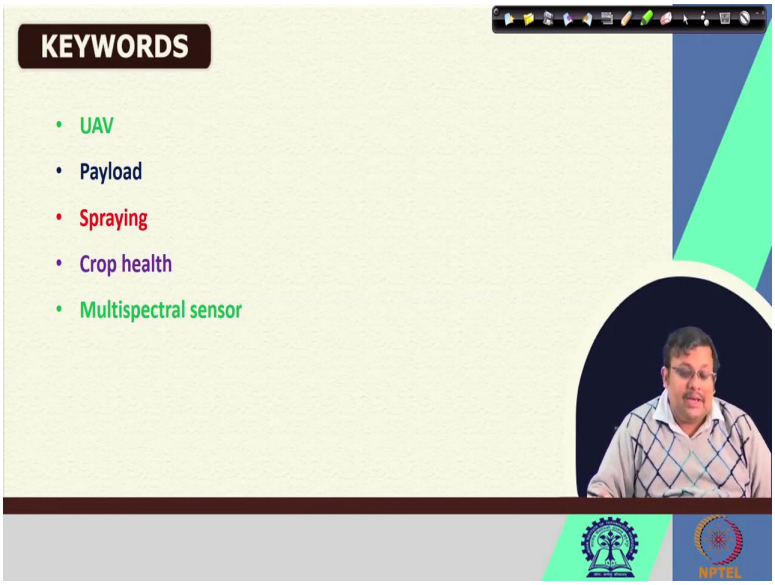

These are some of the keywords which we are going to discuss. We are going to discuss this UAV, then Payload, what is, and then Spraying, Crop health, Multispectral sensors. So, these type of things we are going to discuss in this week.

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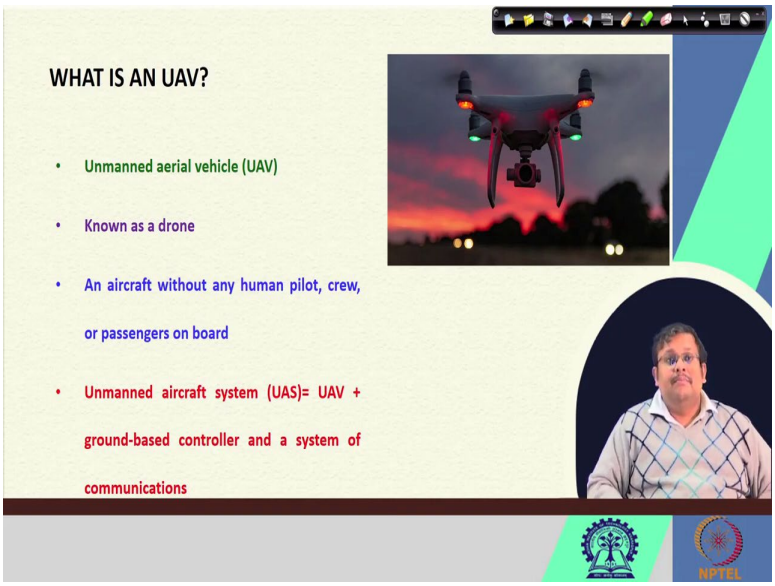

So, the first question comes to our mind, what is an UAV? Now UAV is the short form of Unmanned Aerial Vehicle, and of course, that is also known as a drone, which is basically an aircraft without any human pilot, crew or passengers on board. So, there is another term called UAS or Unmanned Aircraft System. So, this UAS is basically a combination of UAV plus ground based controller and a system of communications.

So, UAV is a component of Unmanned Aircraft System, and UAVs are very, very important nowadays for different applications. And simultaneously, in agriculture also. Although, I am going to discuss some of these applications in other field but we are going to focus mostly on the agriculture.

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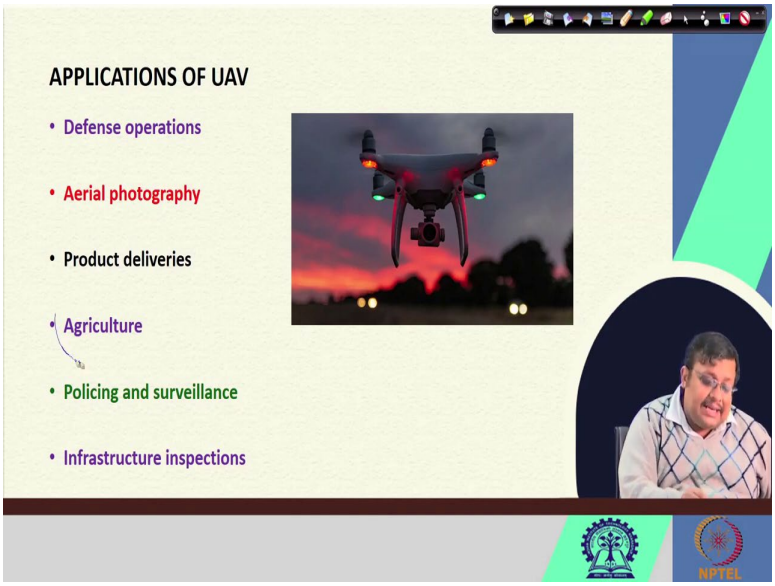

So, as you can see, the applications of the UAVs is majorly, we can see in case of defense operations, then taking the aerial photography, then product deliveries, then agriculture, policing and surveillance, and finally infrastructure inspection. So, also there are different types of variable application where drones are being used nowadays, but we are going to focus more on this agricultural aspect of using this drone or UAV.

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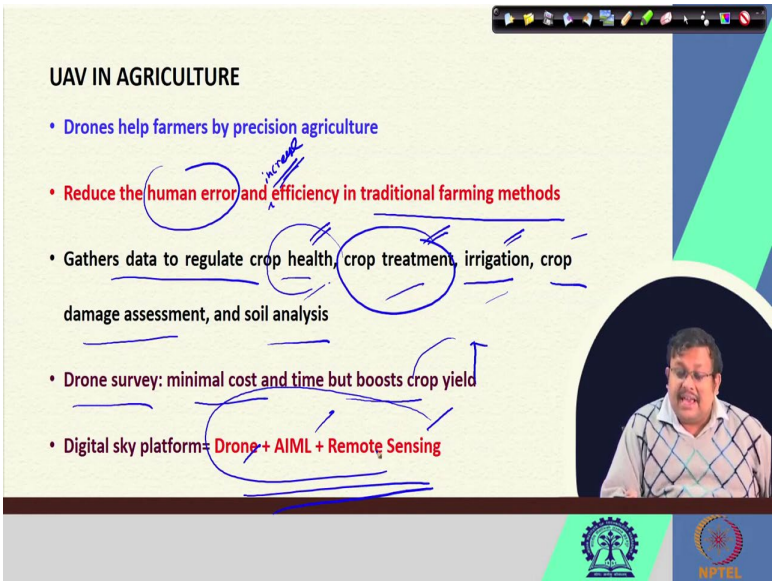

Now, so, what are we go for the UAV or drones in agriculture? Because drone can help the farmers by precision agriculture. Now, conventional agriculture where farmers grow the crops and then they apply the different types of inputs for growing the crops like fertilizers,

like pesticides, they are not very much efficient enough. So, their efficiency is diminished by manual processes.

And so, to augment their efficiency of agricultural operations it is very, very important that farmers should resort to these different precision agricultural practices. And drone is another very important concept or component of this precision agriculture. So, how? Because it can reduce the human error also it can increase the efficiency. So, here, please read it as increase the efficiency in traditional farming methods.

So, it can reduce the human error. So, whatever human error is there, it can be reduced. And it can increase the efficiency in traditional farming methods, because it generally execute that by gathering data to regulate this crop health, then crop treatment irrigation, crop damage assessment and soil analysis. We are going to discuss them in details.

So, in agriculture, you will see that most of these drone based applications are focusing on this crop health identification, then crop treatment, and then producing the irrigation or spraying, and then crop damage assessment, and finally, the soil analysis. So, it is also very much essential, because drone survey can ensure minimum cost and time, but at the same time it can boost the crop yield.

So, when you go for survey with a drone, that can ensure minimum cost, because you can cover a huge amount of land within a short period of time. And when you when you finish an operation within a short period of time, it can ensure the minimal cost and time, but at the same time due to the judicious application, due to the application based on empirical observation, it is always a fact that it can increase or boost the crop yield.

So, nowadays there is a term called digital sky platform. So, this digital sky platform becomes a buzz word where it consists of these drones, AIML based algorithms and also the remote sensing. So, in this week, later in this week, we are going to see some drone based remote sensing followed by some AIML tools to address these, one of these issues, like crop health, crop treatment, irrigation, crop damage assessment, and soil analysis.

So, so far, most of the agricultural operation using drones or UAVs are focusing on these type of aspects using these remote sensing based images as well as different types of AIML applications. Some drones are using the multispectral sensors, some drones uses the

hyperspectral sensors, and most of the common drones are using this RGB camera for getting the high resolution color photographs.

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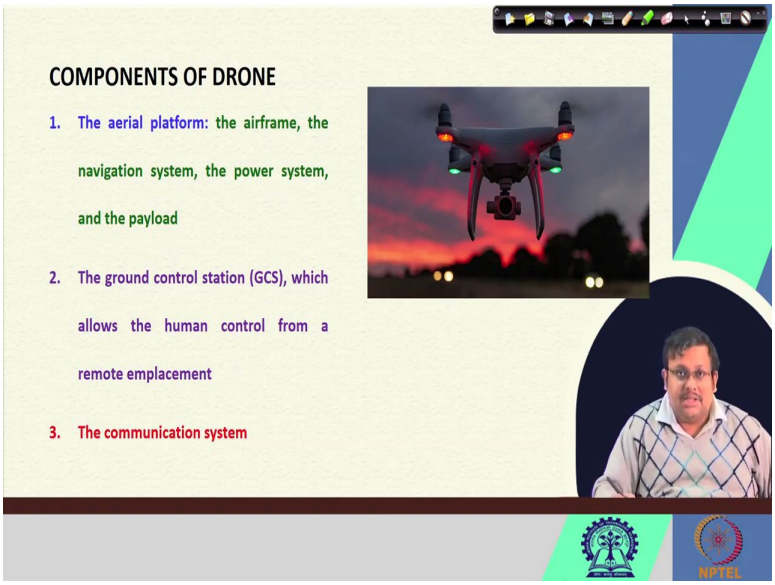

Now, what are the major components of the drone? So, in a broad sense, a drone can be composed of three major part. One is the aerial platform, second is the ground control system, and the third one is the communication system. So, the aerial platform basically composed of airframe, the navigation system and the power system, and the payload. So, these are very, very important terminologies, the airframe, the navigation system, the power system and the payload.

And the ground control station, or GCS allows the human control from a remote emplacement. And finally, the communication system. So, these three are the major three component, in a broad sense, of a drone.

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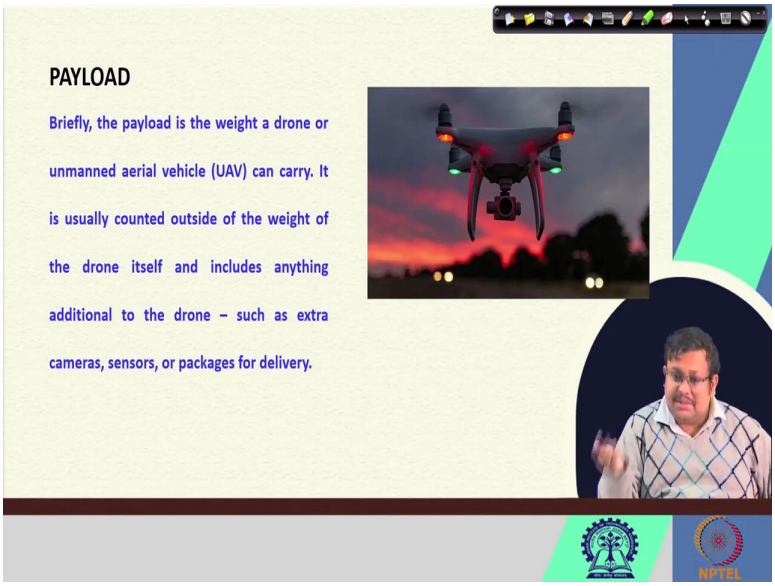

So, if we see, what is a payload? Payload is the weight of the drone, the weight a drone or unmanned aerial vehicle can carry. So, it is usually counted outside the weight of the drone itself, and it can include anything additional to the drone, such as extra cameras, sensors or packages for delivery.

In agricultural drones, which are specifically focused on agricultural operation, most of the times these payload are synonymously used for these image sensors, like RGB image, thermal image, multispectral image, hyperspectral images, image sensors, so, apart from other sensors also.

So, in case of agricultural operation, the payload is majorly encompassing these image sensors because these images will be subsequently used for different types of soil and crop applications.

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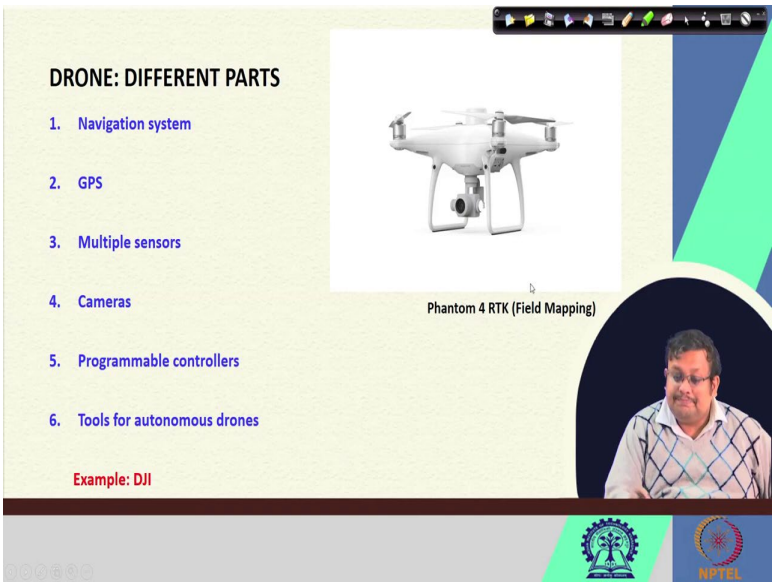

So, what are the different parts of a drone? As you can see, here this is an example of a agricultural drone Phantom 4 RTK, which is being used for field mapping. And these drones have different types of parts like navigation system, it has global positioning system, or GPS, it has different multiple sensors, they have cameras, programmable cameras, as well as tool for autonomous drones are also there.

So, this is a DJI, this Phantom 4 RTK is made by the company DJI, which has also other types of drones for different, different application. They have also sprayer drones also for agricultural spraying purpose.

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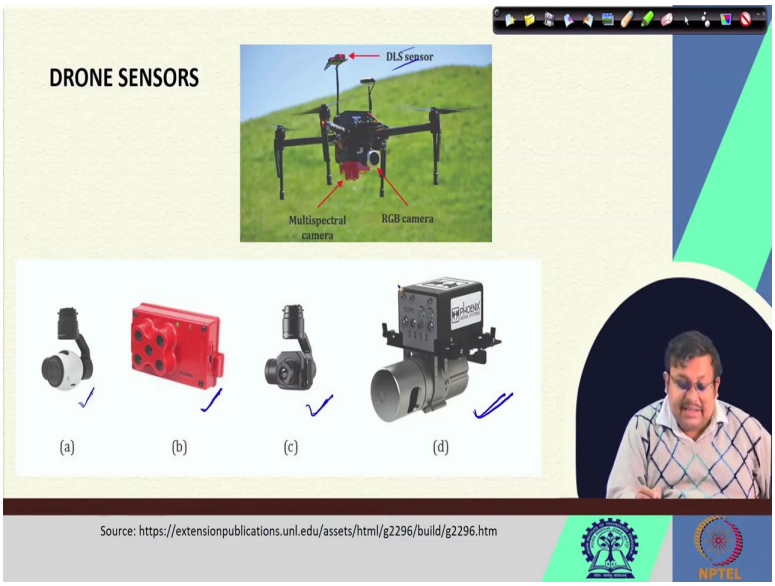

So, if we see, the different types of sensors which are there in a drone specifically for agricultural purpose, you can see that it can consist of this RGB camera, and also they have these multispectral camera, and also they have thermal camera, and they have also LIDAR camera also. So, different types of sensors are there, and these multi, as you can see these multispectral sensors, and also this RGB camera is attached to this drone, and also you can see there is a DLS sensor which is a short form, DLS is a strong short form of downwelling light sensor.

So, this downwelling light sensor is used for different optical based characterization. So, this DLS sensor is being used along with this multispectral camera, and RGB camera, in this drone which is being used for taking the images of the of the field. So, these are different types of sensors and image sensors are being used.

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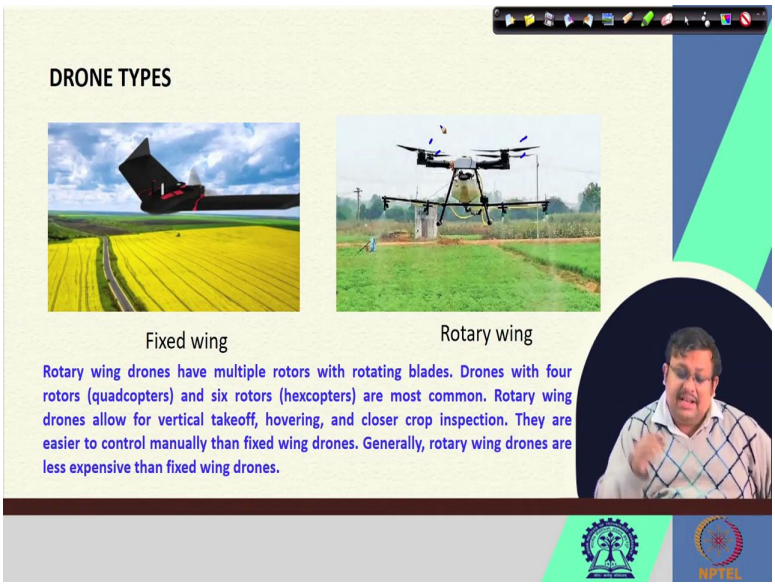

There are two broadly there are two types of drones one is called the fixed wing drones another one is the rotary drone. So, fixed wing drones are having the fixed wings and their advantage is they can cover a large area of the field within a very short period of time because of their fixed wing operations. Another type of drone is called the rotary drone, and it is the mostly, the majority of the agricultural drones are rotary drones.

So, this rotary wing drones are having multiple rotors. As you can see here, they are having this multiple rotors, 1, 2, 3, 4 here. So, they are having multiple rotors with rotating blades. So, drones with 4 rotors are known as quadcopters, and when they are having 6 rotor they call as the hexcopters. So, these quadcopters and hexcopters are made, are mostly prevalent or mostly dominated in the agricultural drone enterprise.

So, this rotary wing drones allow for vertical takeoff. So, they can take off vertically, and they can hover at a particular place, and they can be also useful for closer crop inspection. They are easier to control manually than fixed wing drones, and generally, these rotary winged drones are less expensive than the fixed swing drones.

So, there are new types of drones and they are called hybrid drones. So, the hybrid drones, you can see, these both rotary drones and rotary features and fixed wing features are there. So, those are known as the hybrid drones. But in general, most of these drones are basically either fixed wing or rotary wing drones.

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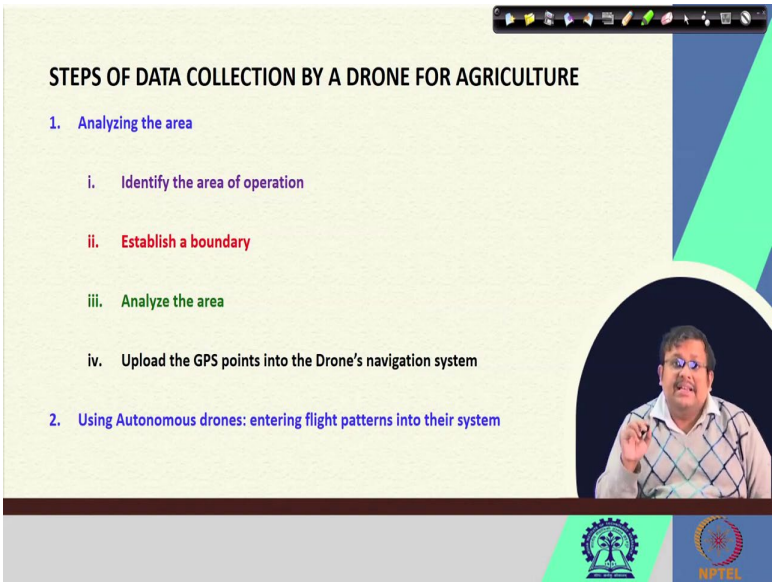

So, what are the steps of data collection by a drone for agriculture. So, the first step is of course you have to analyze the area on which you want to execute this drone operation. So, you have to identify first the area of operation, or the of the field, in case of agricultural operation you have to identify the field. And then you have to establish a boundary where you want to operate these drones. And then you have to analyze the area of this, within this boundary.

Once you analyze this area, you have to upload the GPS points into the drone's navigation system. And, so, these are the first step, that is analyzing the area. In the second step, you have to use the autonomous drones which you can use the, you can enter the flight patterns into their system, and they will fly to cover this established boundary or this area, which you have already analyzed, and you have already uploaded the GPS coordinates of that area into the drone's navigation system.

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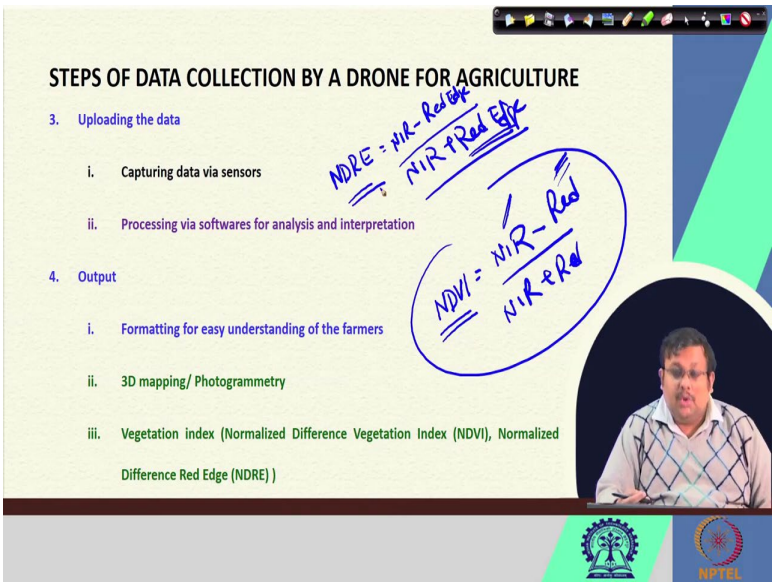

Now, once you upload the data, it can capture via, this uploading the data, it can be executed, either via capturing the data via different sensors, and then subsequently, those images will be processed by softwares for analysis and interpretation. Finally, there will be different types of outputs, like formatting for easy understanding of the farmers. These outputs can be prepared in different formats.

Either, you can produce the 3-D mappings or photogrammetry or you can also output the vegetation index based mapping. There are different types of vegetation index like Normalized Difference Vegetation Index and Normalized Difference Red Edge, or NDRE. So, this NDVI can be calculated by using this formula, that is, NIR minus Red by NIR plus Red.

So, the NIR and this Red stands for the reflectance of the near Infrared and the Red spectral bands. So, using this near infrared reflectance from this near infrared and Red spectral bands, you can predict the crop health status, because this NDVI generally is most effective for portraying the variation of the chlorophyll content, and canopy density during the early to mid growth stages of the crop.

So, this NDVI is widely used by these drones for producing different types of maps for identifying the crop health status. And another one is known as NDRE. So, NDRE is basically Normalized Difference Red Edge. So, this NDRE formula stands for NIR minus

Red Edge by NIR plus Red Edge. So, Red Edge is a band which situated, which is generally situated between Red band as well as the NIR band.

Because, when for healthy crop, the reflectance values generally increase drastically from Red to NIR, and this NIR, and this Red edge band which is situated just in between of these Red and NIR can show a drastic increase of the reflectance. So, these in Red Edge band is also used for identification of the crop health status. So, we are going to discuss this NIR and this NDRE and NDVI based maps in our upcoming lectures.

But at this point of time, you should understand these are the different types of vegetation index which shows the crop health status.

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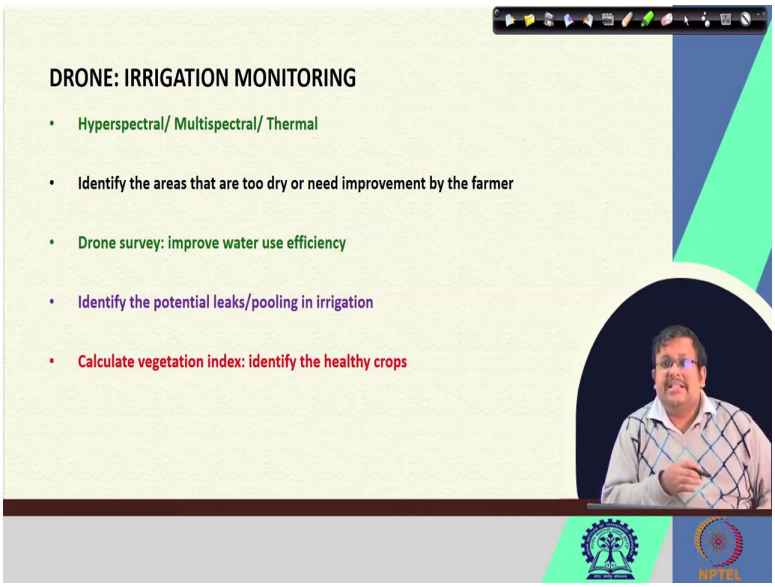

Now, what are the importance, what are the other application of NIR drone? So, for agriculture as you can see here we can use this drone for irrigation monitoring using either hyperspectral or multispectral or thermal sensor data, we can identify the areas that are too dry or needed improvement by the farmers, and using this drone survey, it is possible to improve the water use efficiency, and you can already, using this drone you can identify or recognize the leaks or pooling of in irrigation.

And also you can calculate this vegetation index to identify the healthy crops. Vegetation index like NDVI, NDRE, just like I have discussed in our previous slide.

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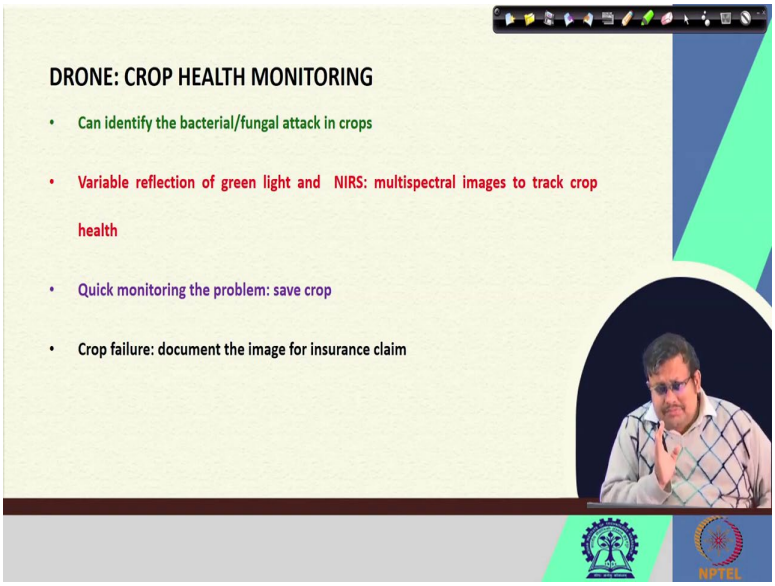

Also these drone can be used for crop health monitoring, because using this drone survey you can identify the patches which are showing the bacterial or fungal attack of the crops, you can also get the variable reflection of the green light and NIRS, and then you can, and also using that multispectral images, can track the crop health by using the reflection of the green and NIRS.

You can monitor any problem of the crop if you either, if you expecting there is some problem, you can monitor that problem very quickly and then you can save the crop. So, that is another advantage of using this drone for crop health monitoring. And finally, if there is a crop failure, you can take the image as a document for claiming the insurance. So, these are some of the application for crop health monitoring using drones.

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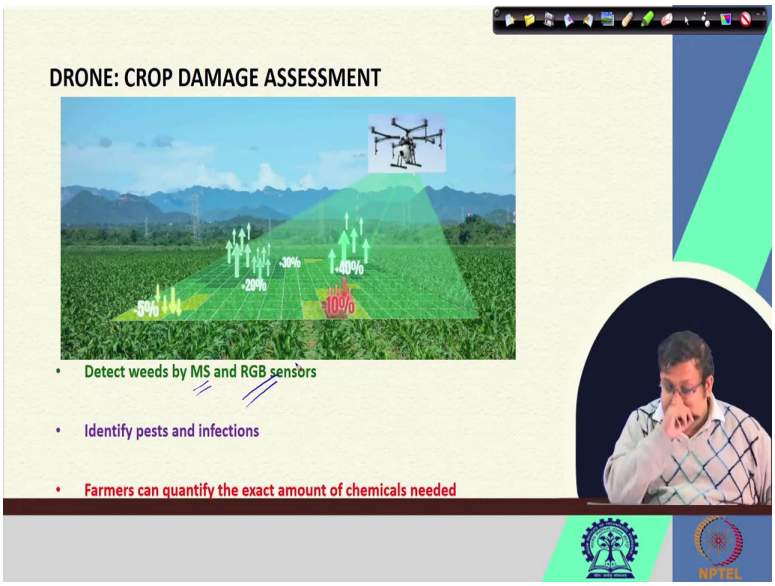

Of course, you can use, another application is crop damage assessment. So, as you can see, this image, in this image, the drone camera is capturing the reflectance from this different zones of this field, and by analyzing the reflectance values, it is now possible to identify the crop damage. So, as you can see here, it can detect the weeds by either multispectral or RGB sensors. It can identify the pests and infections, and farmers can quantify the exact amounts of chemical needed based on this type of maps.

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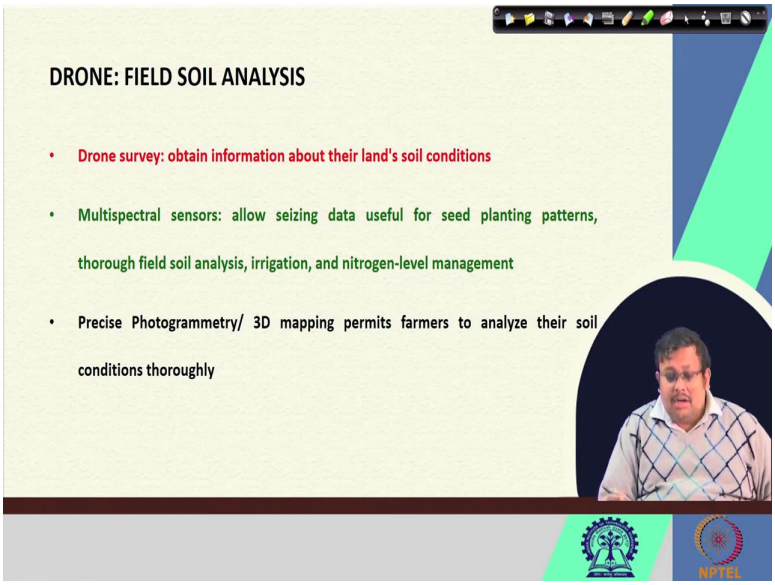

Another application for this drone is soil analysis, field soil analysis. So, you can get a huge amount of land soil information regarding the land soil conditions using the drone survey.

Generally, multispectral sensors can gather the data which is useful for planting patterns throughout the soil analysis and then irrigation and nitrogen level management and then you can also use the photogrammetry and 3D mapping for the farmers to analyze their soil condition thoroughly. So, field soil analysis is another important application for drone.

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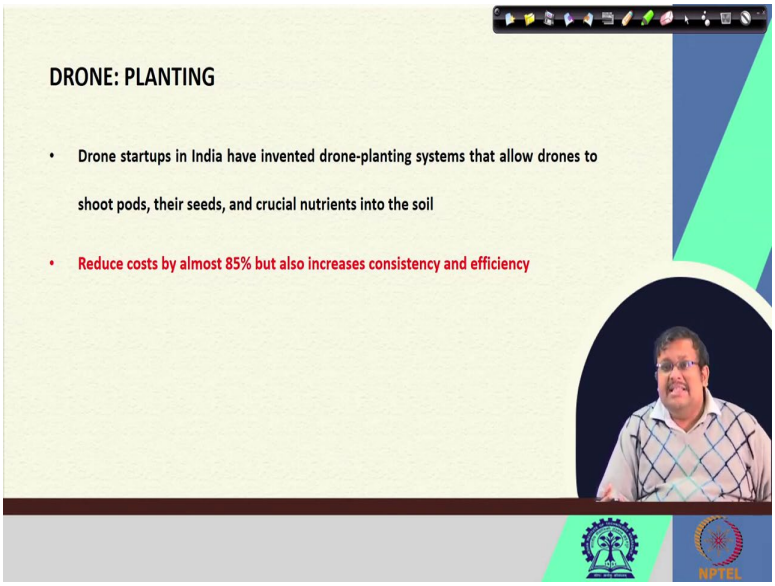

Planting is another very important application. So, nowadays, there are different type, multiple drone startups in India. They are investing in developing the agricultural drones which are focusing on agri, specific agriculture operations like spraying and the crop health monitoring. So, these drone startups in India have invented drone planting system that allows drone to shoot pods, their seeds and these important nutrients into the soil, which can reduce the cost by almost 85 percent, but also increases consistency and efficiency.

So, it is quite obvious that in near future, with the advancement of these technologies, it will be possible to automate these agricultural practices, conventional agricultural practices using drone.

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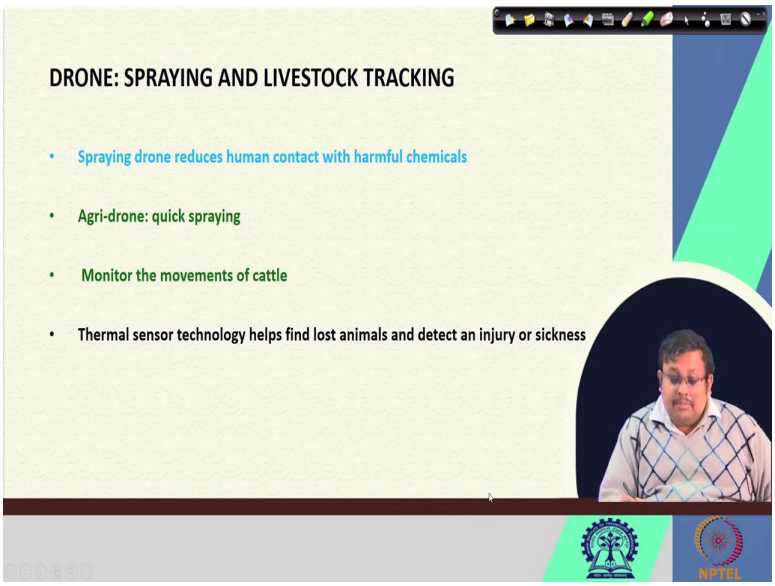

Drone, another widespread application of this drone for spraying the pesticides. So, this spraying the pesticides can reduce the human exposure or human contact for, with these harmful chemicals. And they can cover a large area relatively quickly and they can uniformly spray the liquid by flying the drone over the crop. So, this agricultural drone, spraying drone has become a very important component of the agricultural drone market.

And not only the spraying, but also using the drone, you can monitor the movement of the cattle, you can use the thermal sensor technology to find the lost animals and detect an injury or sickness. So, there are different types of sensors you can use to identify the lost animals and they can, their injury or sickness can be also identified using these drone based sensors.

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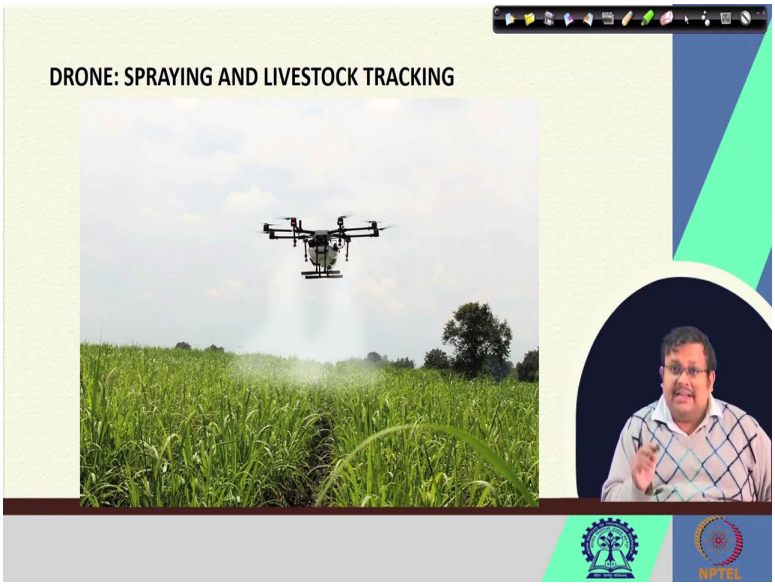

So, here, you can see the spraying drone are in operation and they can spray the droplets uniformly throughout the field within a very short period of time by flying in close contact to this crop. And in this operation, it is quite important that while doing the spraying, the human contact to these harmful chemicals are being reduced. So, that is a both way benefit, not only uniform and cost effective and rapid spraying, but also from the health as a point of view also this type of spraying drones are making a paradigm shift in Indian agriculture.

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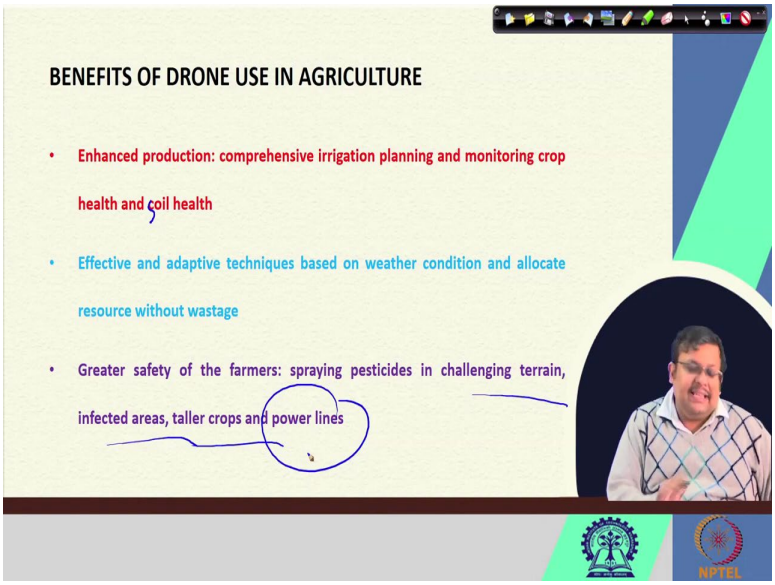

So, what are the benefits of drone use in agriculture, if we can list out some of the points. So, first of all it can ensure the enhanced production by comprehensive irrigation planning and

monitoring of crop health and soil health. Sorry, guys, so, please consider it as soil health. And then, effective and adaptive techniques based on weather conditions and allocate resource without wastage.

The third one is greater safety for the farmers because when you are using the spraying drone for spraying the pesticides, in challenging terrains, infected areas, taller crops and power lines are there in some of the fields. So, they are the human contact is being reduced by using the spraying drone and that produced the greater safety for the farmers.

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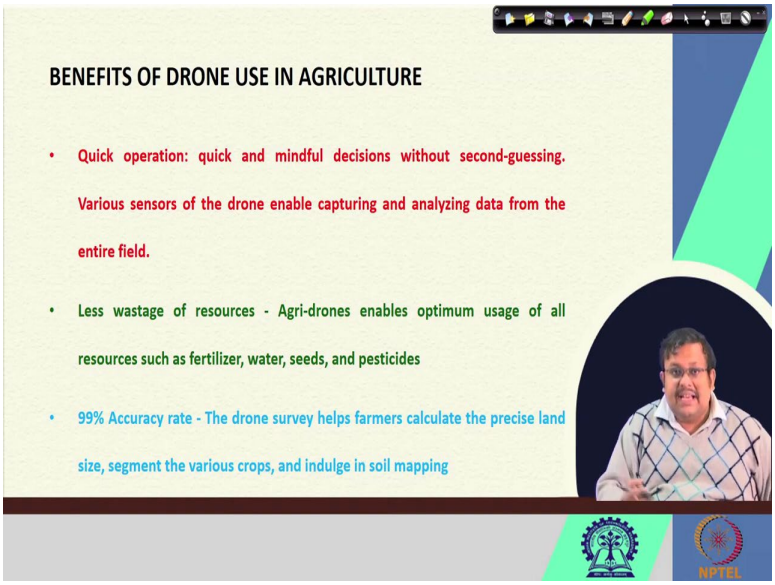

And also it ensures the quick operation, that means quick and mindful decisions can be taken without second guessing, and various sensors of the drone generally enable capturing and analyzing their data from the entire field. Less wastage of resources, of course, these agricultural drones enables optimum uses of all the resources such as fertilizer waste of water, seeds and pesticides.

And you can get that quick operation, by quick operation I mean that it can enhance the speed of operation 10 times more than the conventional operation. And simultaneously, it produces 99 percent accuracy rate. So, this drone survey helps farmers calculate the precise land size segment the various crops and indulge in soil mapping.

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Also from the point of view of insurance also this is very important, because farmers can easily capture the image of the damaged crop. If there is a failure by using the drone in a relatively easily, and they can claim the insurance benefits by producing those pictures. So, and also these drones captured images of the agricultural fields can be an evidence for the insurance companies also.

So, the agricultural insurance sectors can use agricultural drones for efficient and trustworthy data. So, they capture the photos of crop damages that have occurred for the right estimation of monetary payback to the farmers. So, you can see that there are different types of application and different types of benefits of applying the drones in agriculture sector.

Recently, couple of years ago, there was a locust swarm. So, locust, they are the insects which can feed on the crops. And when they, the swarm of locusts can invade the crop field, they damage the crop field entirely. So, to control the locust, different states of India has produced several, they have developed certain methodologies to control them using the organophosphorous chemicals. To spray these organophosphorous chemicals also they use these agricultural drones, spraying drones. So, that shows that the multi-directional uses of agricultural drones for the overall benefit of agricultural enterprise.

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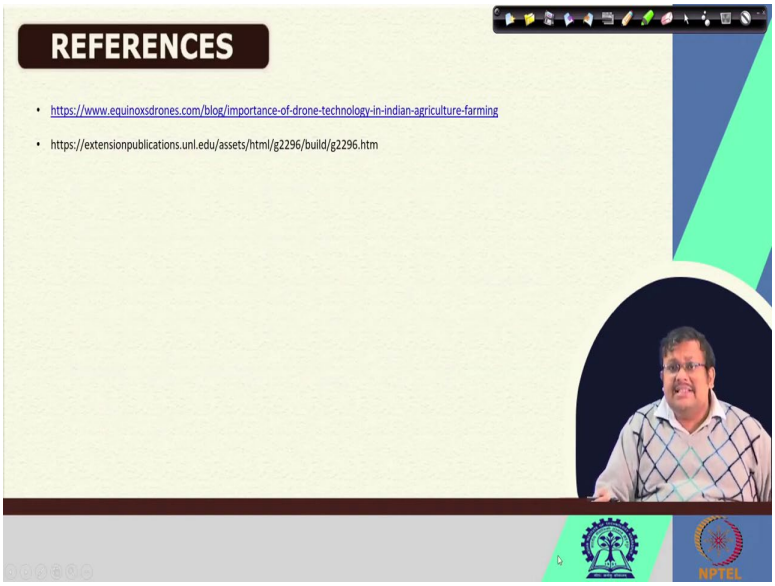

So, these are the references, guys. I hope that you have learnt something new. This is an overview class of UAVs. And in the next lecture onwards, we will be discussing more and more application of how these images are generally taken, and what are the steps of further image processing and then combine it with the machine learning and deep learning algorithms to get the desired outputs from those images.

So, thank you. Let us meet in our next lecture to discuss more about UAV based agricultural operation in combination with machine learning and deep learning algorithms. Thank you, guys.