Advanced IOT Applications
Dr. T V Prabhakar
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

Lecture – 15
Introduction to LiDAR

So let us take one more sensor for automotive applications and try to sort of expand on the capabilities of this sensor. We will talk about LiDAR's; LiDAR essentially expands to Light Detection and Ranging.

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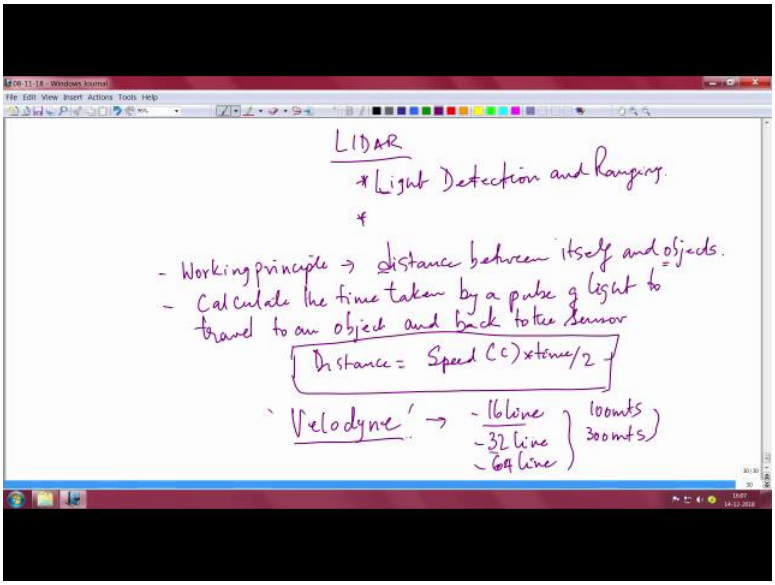

And it is based on a very simple principle quite like RADAR. If you are trying to estimate the distance between itself and some objects. You basically calculate the time taken by a pulse of light to travel to an object and back to the sensor. Very simple expression one can talk about is this distance calculation is you know the speed of light. And you know the time it takes and you know essentially if you divide by 2 assuming everything is symmetrical.

You can easily calculate the distance between LiDAR and the object that of your interest. You can see that this LiDAR has become extremely popular as a very important critical component in autonomous vehicles.

And, we will see why it is indeed the case and how can one use this simple LiDAR system? Actually LiDAR is not a simple thing, but indeed the data that you get is quite straight forward. And interpreting it and saying that how it can be used for obstacle detection for mapping purposes and all that is a very exciting area. Why it has it become popular? That is the real question. It is not that LiDARs are you know something that have appeared in the last 2 or 3 years or maybe half a decades, it is not that it is not the case.

LiDARs have been around for more than 40-50 years. So, it is not a recent technology. In fact, in several aeroplanes they installed LiDAR's and it is used for mapping purposes. Only recently it has started becoming popular for automotive applications particularly in autonomous driving scenarios and extremely good for obstacle detection and it is not based on camera please note that is the good thing about LiDAR. Because, camera if you put you know lighting becomes an issue you must have good lighting, you should be able to differentiate between shades and an obstacle.

For example, during summer you're driving on a highway and the lot of trees on either side, the shade of the tree falls on the road and that could be regarded as something like a falls alarm like an obstacle if you're using a camera.

Sometimes that same shade could have actually happened because of often because of the there is an obstacle on the road. So, in order to differentiate an obstacle from a regular shade object for a camera is extremely hard. This is something that LiDAR can actually solve and quite reliably it is able to detect obstacles so, this is the reason why it has become very popular.

And one of the companies which have pushed very hard with respect to LiDAR is indeed a company called Velodyne. If, you look up it is website you will see it's a very popular LiDAR and there are other companies, which have also started coming now. You can imagine that it is essentially a multiple layers of laser sources, this is very important. Actually in technical terms it is called multiple channels, multichannel LiDARs are what should actually be used in any autonomous or driver assisted modern technologies where sensors are used for obstacle detection.

Even, if you are doing augmented kind of driving where driver is there and several things are autonomous even in the presence of the driver, then you will need sort of a multiline.

The reason is you will have to get equivalent of a 3 D image essentially LiDAR will throw out a lot of points. And you need a 3 D view of the whole thing in order to decipher indeed if it is an obstacle or otherwise. So, which essentially means you will have multi line.

And if you look at Velodyne you will get 16 line, 32 line and 64 line also. You can imagine that if you have 64 lines of light data coming in several parts, several profiling becomes a lot more reliable, take a very simple case.

Imagine that the road is straight and you have a nice vehicle which is moving forward. You have to just do a 360 degree scan. If, you are moving straight and you are scanning you need only a single plane 2 D plane is efficient x and y is sufficient you do not need anything related to z. But, if the road is tilted and you are moving up here, you need a lot more information because obstacle maybe just down. And if there are no beams which are looking down below the road you are not going to actually catch anything.

Now, you just imagine when the road is straight and the beams are some of the beams are looking down, while there will be actually bouncing off the road when the road is straight is still ok. Because, you are the beams are actually looking down, but the very first instant when the beam can actually bend and catch an obstacle and give you back information you can quickly break, which means either going up or going down. If beams are looking all through, you have the ability to take proper corrective action something that even the humans cannot do. No camera can work, camera may even if you have multiple camera system it may be able to do.

But, this LiDAR has ability to catch an obstacle even though human eye cannot see the obstacle that is a good thing. It just not about that, the range of the LiDAR is quite amazing, you get ranges from 100 meters to about 300 meters. So, the best of something from Velodyne even can go up to 300 meters please lookup the website. So, you will have 16 line, 32 line and 64 line, just to take care of 3 D mapping, plus 3 D mapping ahead of 100 meters, ahead of 200 meters, ahead of 300 meters, which is a outstanding ability for the system to detect an obstacle and it is available x y as well as on the z plane.

So, before you actually want to go and do anything with the LiDAR you should know several important things about the LiDAR’s.

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So, let us typically look at some LiDAR, which you can say something that we regularly use in the lab. And that LiDAR's specification I will put down. Just to give you a feel of what are all the parameters you should look out for before you actually buy a LiDAR.

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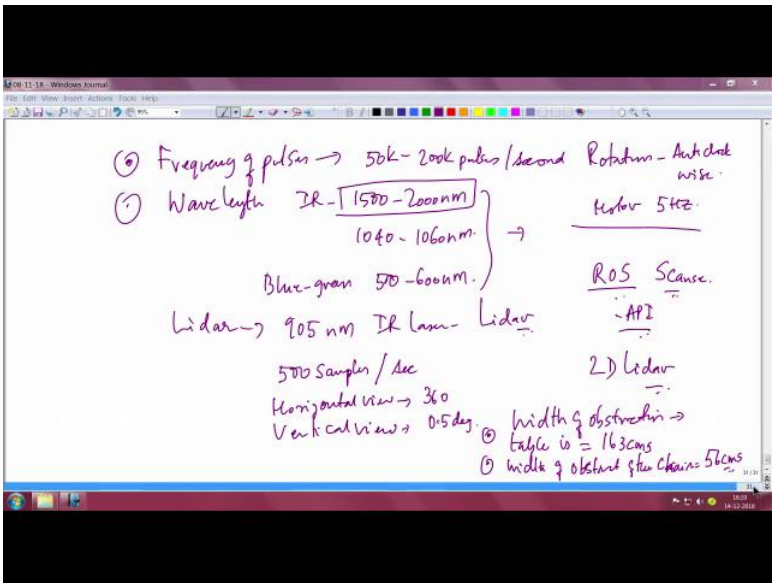

So, first thing is the frequency of pulses. So, typically you can go anywhere from 50,000 pulses to about 200,000 pulses per second.

So, you will get a humongous amount of data if, you are working with the LiDAR's. And the second parameter is wavelength. What wavelength do you want the LiDAR to work?

Typically, if it is IR range you are looking at 1500 to 200 nanometer. This is used in certain applications meteorology and all that. Then you can also have for terrestrial mapping you can have a few and so, many others. So, there are a full range of LiDAR's for different applications starting from 2000 nanometer then you have 1040 nanometer to 1060 nanometer then you will also get blue green LiDAR's, blue greens LiDAR's typically go from 500 to 600 nanometer and so on .

And you also have ultraviolet LiDAR's which are 250 nanometer and all that so, you get a range. So, you should know what range of LiDAR are you looking for your applications and most of them are scanner based so, that is very important thing. So, now, let us discuses about one LiDAR which we have in the lab, while it is really not mapping to 1500- -2000 nm range, it is indeed in the IR range, it is a 905 nanometer infrared led laser based LiDAR. This is the LiDAR that we are going to refer to it is giving not at all at any high grade samples; it is just giving out at 500 samples per second, but you can typically go from 50,000 samples to 200,000 samples.

Horizontal view is indeed 360 degrees; that means, you are covering a nice 2-D plane vertical view is very narrow just 0.5 degrees. And since it is a rotating LiDAR, it has to be rotating in some either clockwise or anti clockwise... And then there are voltage requirements and all that motor can be rotating spinning at 5 hertz. So, these are some typical settings that you may want to consider and this is essentially the kind of LiDAR that we have demonstrated to you.

In the LiDAR demonstration, it is being powered through some 5 volts. And, it is placed on the same robotic platform system, which we will be using all through in this course. Essentially a platform called Kobuki which is housing this LiDAR. And there is as you can see there is a on board computer, it is a raspberry pi hardware and it runs Ubuntu and on top of Ubuntu runs this Robot Operating System or also called the ROS, which is essentially an API for accessing several pieces of hardware, for real time communication between hardware and the OS itself.

So, there is a nice API for ROS, which you can use and the LiDAR we are using is called scanse LiDAR (scanse – company name).

So, now let us see how do this points look when you capture them at this 5 hertz range. How exactly a do this point's look and what sense can we make out from this basic LiDAR system?

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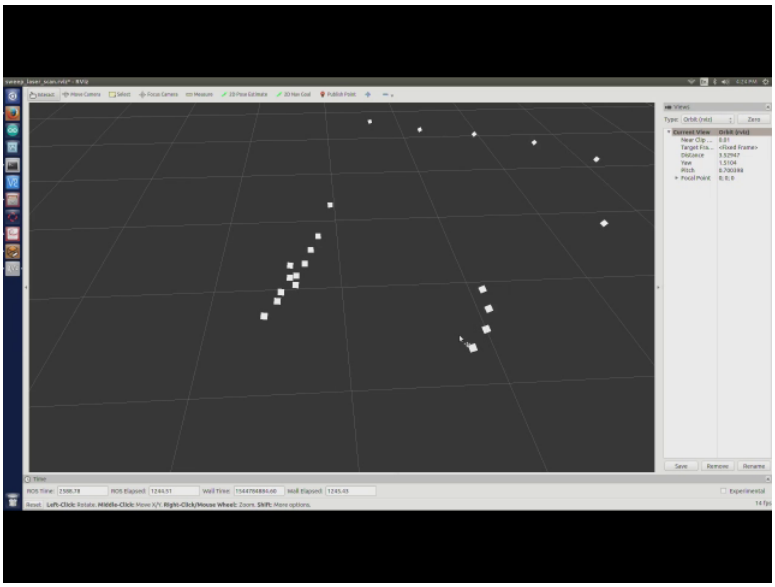

Now, you may be wondering what the set are of densely you know grouped points (shown in the above figure) and opposite to that there are a set of 3 or 4 points, and why is it in that structure right you may be wondering what it could mean? And let us see what exactly the LiDAR is viewing? To begin with I must give you a quick disclaimer that. This is a 2-D LiDAR, it is not looking at anything with respect to any height related information.

So, now you may wonder how we arrived at that. We arrived at that because we think actually we did a simple calculation to show you the width of obstruction in the table is 163 centimeters. If you take the width of obstruction of the chair is 56 centimeters.

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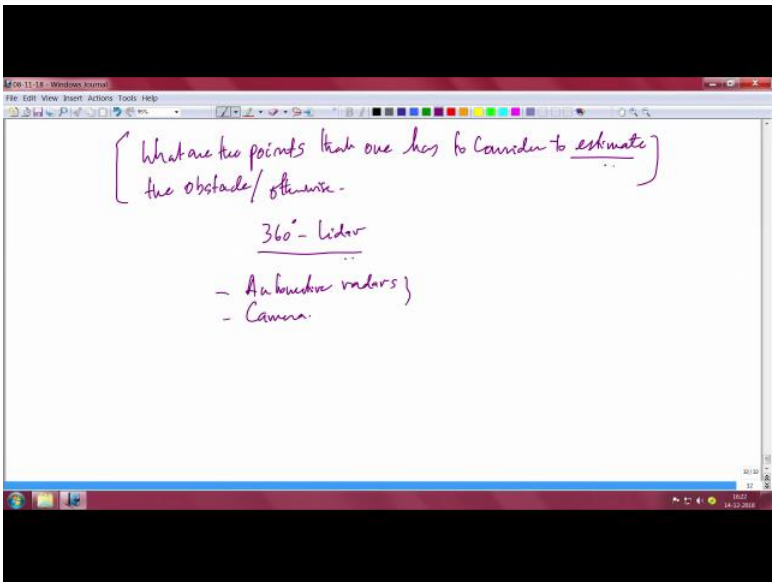

So, it is definitely possible and you can use it, but typically LiDAR is not the only one that is used to decide on an obstacle, people actually fuse this LiDAR information with other type of sensors it could be automotive RADAR's. And also sometimes camera and all of them to actually decide, if there is if it is indeed an obstacle or otherwise.

So, this is the key take away from the fact that a LiDAR has a very good capability of detecting obstacles. We can also clearly see that those point shown above comes very near to LiDAR if an object or a person comes near to it.

And this information remember will be coming to you in real time particularly when you are driving an autonomous when you are sitting inside an autonomous vehicle at extremely high speed 100 kilometre or if not more. And decisions have to be taken by computers which are on board by just looking at these points, by analysing the data from these points and taking real time actions trying to avoid obstacles are trying to go round obstacles and successfully you know navigate to the destination.

As it shown in the video lecture, when a dark colour (almost black) object is wrapped around or kept in-front of the LiDAR you can see that the points are vanished several points are vanished, And if you remove it and move away you will get back all the points and a nice good picture, which is a clear indicator that black is something that cannot reflect back. And therefore, no light can come back in any of the electromagnetic spectrum if it actually hits a black object. And therefore, one of the biggest problems

with LiDAR is if it is a black object the number of points that you get back are so, small that you cannot make out anything from the objects which are in front of the LiDARs.

Therefore, you will carry that risk of missing an obstacle if indeed this LiDAR is used. So, every sensor every technology has it is own limitations and this is one such limitation, but do not have to worry so, much about it you know that if you put 16 or 32 or 64 line at the same instant you may actually get you some data which is also good for, you can say that the height of the object the height of the obstacle is limited to so and so, then you can conclude that indeed it must be an obstacle. So, such interesting things can be done by just analysing the data that is coming from the multiline LiDAR systems.