**VO Selected Topics in Geoinformatics-20231106\_083156-Meeting Recording**

0:09  
So with that we should be

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ready to go for today's lecture in the selected Topics in Share Informatics series

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which is organised by the school event myself. And today of course we're very happy to have Miss Kiana who Huskova Ohh with us from the Brno University of Technology Yana. You spent a couple of weeks time I think was it back in September in in Southbrook and that was within the Sibos programme, am I right? Yeah, it was action programme, action, action,

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that's that's the bilateral programme between software and the public. Yeah. Bruno is of course not very far away. It's kind of just around the corner or across the border in particular from Vienna. So there's a number of very well established universities in Bernal. So when saying someone comes to us from, we need to check which one of the. I think it's three major universities where we

1:25  
quite frequently have contact. And uh, we actually had Diana to have you with us today. May I invite you just maybe say a few more words to your own introduction, kind of the way you want to be recognised by the audience, and then just take it away with today's lecture. So the screen is yours. Let me hand it over to you. Yeah. Thank you very much Professor

1:53  
Ohh, welcome and uh great great greetings from Bruno and today I would like to introduce a topic about the lighter and about the technology and the algorithms as I was introduced. I'm from Brno University of Technology and also I could work with special help research group. So I I spent a really nice

2:25  
research month in Salzburg and uh, I will present you a few words about the lighter technologies and how to process data from lighter. So I hope it will be helpful for you. And basically, I'm a mathematician, so I prepared for you a little bit of math, so I hope you won't be afraid.

2:52  
Uh, so

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first of all is the question is if uh you are a familiar UH with the lighter technology, if you ever work with a lighter itself of with or with some lighter data. So I don't know if you know how to use the Mantic questionnaire. So you can go to menti.com and use this code and you can vote for an answer.

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So I would assume some of the audience would be familiar, some not. Yes. So I will see, I will see the response, I hope somewhere so I can, uh switch sharing to yes, yes, 11 answer, yes. First one,

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everyone can use it from the smartphone as well as from any browser. So just

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meant to dot com and you don't need to enter this complicated URL when you're prepared to enter the number code, which maybe is easier if you type on that.

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So it's always good to practise this kind of

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into actions. Hmm. So now I I can see it three Times Now, and one times. Yes, the answer. So

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try to answer so I can share you also

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the questioner like this so.

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So I don't know if the students are able to

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go to menti.com and use this code.

5:04  
Yeah, the code is on the top of the screen. So anyone who was a bit slow with switching over, I understand it's a Monday morning. So maybe takes a bit of time

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that's that's important information for me.

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So that's half to half. So I think that I,

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I can continue

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presentation.

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So

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I hope that I have, uh better also switch on, yes, so you can see the lighter in the camera. So that's the type I'm using. So that's the OSTER, OSTER OS0 the price starts at about $6000 and it uh it comes to $15,000 the most precious models and so on. So it it is not so big,

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but it's uh, it's really cool. It uh,

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uh, it, it, it is the part of the terrestrial mobile sensor. So uh, we work with the data from this sensor. So uh, sometimes UH you can use this mobile type so we are able to put it on some vehicle, on some car and make the measurement and then there is the way to use a static. So you have some tripled UH but it is not uh

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movable as in cars, but it is portable. So the aesthetic type of uh terrestrial Lidar technology is suitable for example for indoor measurements for buildings and so on. And the other type of the lighter are the urban one. So they are on aeroplanes or on drones. And you are able to prepare a lot of data from the error. But the usage of this data is different

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than the terrestrial one. For example from the era you can measure the volume of the woods, the type of the trees, um,

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the quality of the field and so on. So you have only a top view, but there is no uh that coordinate and uh the suitable data for 3D reconstruction. But in this mobile type of scanning uh you are able to see what is around with the deep information, so you know the distance of those things. So in the practise, this slider technology is

8:14  
often

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equipped with uh image camera, but in the images you are not able to reconstruct the true size through distance. Yeah, it's very it is possible but it's very difficult. So nowadays the autonomous vehicles and other sensing systems are often uh compound of the lighter technology with camera technology. And also there is a GPS system that is able to

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give you the coordinates where are you on the earth. But the depression of the GPS is around two or five metres, so it is not suitable in every application. And there is also so-called Inns, that's an inertial navigation system. So it means that your car is sending you the information about its movement. So my right vehicle, my right

9:22  
um, my right side is moving uh in the speed of 30 kilometres and I move in direction 1 metre to the left and so on. So you have also the inner information about the moving and together you are able to reconstruct the terrain, terrain and you can make the optimal path planning.

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So

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this UH oster that I show you it has this parameters. So you can see that the maximum range of the slider is 100 metre. This slider is 3060 degrees so it's full circle of your area. Where are you moving? Uh vertical field of view is 90 degrees so that's enough to see. A very nice background and

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the area around your vehicle and uh the maximum frame rate is 20 Hertz. This 20 Hertz means that in one second you obtain 20 images or 20 scans of the area that you are you are moving, you are moving in. Also this All Star Lidar technology is working in very hard condition so minimal operating temperature is -4

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there and maximum operating temperature is 60 degrees so that's a that's a suitable for using anywhere outdoor in the cold and so on. So that's that's fine. Also they in the past this slider technology that was based on the rotating mirrors was unstable because during some movement of in the terrain and so on they were a huge error. But nowadays they

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uh

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optimise it and you are able to use this technology also in some very rough conditions.

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So there is the image. So how does it work? So uh first you have to prepare a system that is connected to your oster wider then the lighter is sending the information. And if you plan to make your own system, you can use uh Ross Robot Operating System and prepare every data and every programme. How to how to read the data from either itself but the holster,

12:12  
Yes, it's open software, it's closed Oster Studio and you can install it on Windows or on Mac OS and then it automatically upload the data from a lighter and you are able to see a 3D scene like this. So I will try to switch to Oster Studio to show you how it looks like. So

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so I will switch to sharing now.

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So we'll start Studio.

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He's here,

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so now you are able to see the software and if you are

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moving in the terrain, so that's uh some part of the garden. So you can see here the trees, the bushes, the grass and

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you can run the window that this some frequency is adding some information here and we have 3 three different views here, so that's it.

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So that's not so difficult

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to obtain the data UH from either, but

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yeah, and then UH, in the presentation you can see the inner principle of UH, this slider technology. So it's based on time of flight. So in one moment the laser beam is going from the glider and then after it found some object it return and it measure the time between the start and the returning time and then we know the speed of the lighter. So very easily

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we are able to compute the distance of every point that will be fined by the array of these laser and it is rotating around. So you have a full view around the inner system is based on some tilting, mirroring and

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and some uh receivers and so on. So that's very difficult. So for me it's a little bit magic, but you are able to prepare your data very easily and what to do with the data. So that's the topic of my lecture. So now you obtain 1,000,000 and millions of the points and now what what we will do with them, we can watch them. Yeah, that's really nice to see. Nice scenes, but the

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data can be transferred to point clouds, Yeah, point cloud is a structure of unrecognised and ordered 3D coordinates of the points. So you can imagine it like you have 3DS coordinates XYZ and you have one million of these points that are the coordinates around the laser so that's the point cloud.

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And this point cloud can be in different data formats. So I often use the PLY for my uh we uh the oster works with PCAP. Then we have a lossless format spec files and so on. So here on the image you can see our testing car with the lighter and cameras and there is the area of

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Army Army area in Biscoff. So that's 40 kilometres from Burnell UH because in our project we cooperate if with the University of Defence and also with the Ministry of Defence on these autonomous vehicles.

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So now we have a really cool point cloud that is full of the points and umm, there are some tasks that we can make with this data. So at the input we have a lighter point cloud and then what we can do. So first task is the ground detection. So we have to find the points that are on the ground, because these ground points are

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not so important in any computation. And so on. And they will. They will.

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They will bring a huge error in some algorithms. Then other type of uh preprocessing of this input data is the clustering. So we are able for example in driving industries detect other cars to detect pedestrians and so on. Then we can recognise what is in this type of this point cloud. So there is a feature extraction and the

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classification and there is another huge area of research, so it's called point cloud registration or scene reconstruction. So we want to prepare a map of the moving of this vehicle and also to plan the optimal path of this vehicle

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and UH at the end of my presentation, that's my hobbies. So I don't know if you work with neural networks. So also for this task we are able to use UH neural networks. So nowadays we can switch from 2D so image recognition of if in this image is a cat or a dog. So we can switch to 3D and we can work with 3D convolutions, 3D pooling and make for example

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clustering or cram detection using neural networks. So I hope it will be interesting. So now I will touch in few algorithms. Uh

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this this topics SO

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so first the ground detection. So the question is why it's important? Yes, so as I said the ground is very boring in a data, so it's mostly planner shape and there is no information what we need. So many preprocessing steps consist first step as ground detection.

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So how to make it so?

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How does it work? So in this image you can see a street, that's the part of the Bernal and we uh prepared the very easy algorithm. So first of all, if you have some data and you know XYZ and coordinates in this data, so you will say, yeah, the ground points, so the that coordinate must be the lowest one. Yeah, so that's good idea. So the primitive or very elementary algorithms.

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Works work with uh that coordinate only, so they cut off the lowest set coordinate. But what we will do if there is some hilly terrain, so does That coordinate is in the slope and it's changing very rapidly. So another more better better algorithm is to use the computation of normals. So the normal in a point show that

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the tangent plane of this of this area. So we can compute the normals in this point cloud and then make some clustering with uh planner points that can be also in a slow using for example algorithm based on RANSAC. So we can work also with the slope. But sometimes the terrain is more complicated, it can be upwards, downwards and so so many things.

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So I will show you now a very nice mathematical operation, that is uh morphological operation that is able to work with the slices of the terrain and to check where are these lowest set coordinates and to find the ground points in very complex terrain situation. So what is the morphological operation? So little bit of math

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at the start.

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So first morphological operation is called the erosion. So in the nature you can imagine how the erosion works. So you delete some information out as this rock is used due to some water and wind conditions is going out so that's the erosion. So mathematically we can write the erosion using this symbolic equation #1. So how

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how we will describe this? Yeah, for somebody there are some letters, so we have an image, so number one. It means that we have a sum points that are detected as a borders 0.

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We have the now information and then we want to preserve only some corner of this information so we can prepare it. so-called structuring element. This structuring element can be a rectangular square. It can be also some irregular shape, but you have to label the origin of the structuring element, so that's often the central central member of this metrics.

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And then you apply this structuring element by the centre position on every position in our metrics. If there is some missing information, it's 0 mathematically. So if I apply it here for example on the 2nd row and 1st column so we can see that below 111 are only three zeros so the output is 0. If

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this

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covering part is not sharing any common element so we will return one only in that case that there will be 111 in our image applying the structuring element. So only in the case that I am here on the 2nd row and 3rd and 4th column I will return one SD operation output so

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111 and I apply 111 here.

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But if you apply it here on the 1st row and certain column column so you can see that the background are 0 so I have 0111 so that the output must be zero. So the result result of the erosion are only these four elements of 1. So we put out every unnecessary information. So it can be some small waves, some

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noisy points in the data, so we are able to use this. Then the other operation is called a dilation and it's something like the opposite operation of the erosion. So we can uh fill the information. So uh, the result of the dilation is equal to 1 to true if one of these

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members behind the structuring element is equal to 1, only one. So if I apply the structuring element here so it's 000 so we have result equal to 0. But here the centre is in left corner so if I apply it on this member so we have 001. So one member here is equal to 1 so the result is equal to 1. So we can fill the small holes

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and make the final shapes move. So together the combination of erosion and dilation makes so-called opening and closing and

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for example here it is used in reconstruction of the text in image analysis. So you can see that we can add more information using structuring element and the text is more readable but in uh data of lighter and point clouds. So you are able to make a slice of this 3D data and then using erosion and closing

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together you are able to reconstruct the final shape of this slice and the lowest Z coordinate shows you the ground points and then some upper parts can be a vegetation then you can detect a buildings. So that's really nice connection between so very easy mathematical morphological operation and applying it on a lighter data.

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So that was the first task. It was it was the uh, ground removal. So remove ground points.

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Second task that I'm working with the lighter data is point cloud registration. So here on the left you can see two subsequent lighter scans, one is pink and one is green. They are very similar near they are almost same but there is a small movement in every subsequent scan and what we want to do is to reconstruct

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the final 3D scene. You can say it should be very easy to put it together, but the problem is

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that the coordinates of the point cloud they have 000 the origin in the centre of our lighter. So if I have the 00 here and then I move five centimetres, so new points, they have new coordinates in new coordinate system with moved 000 point. So that's the problem. So because of that we need point cloud registration to make

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the final 3D scene.

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So again a little bit of math I I hope you like it. So we have uh two point clouds A&B. So that's the set of points A, A1A, 2AN and B1 to B. And every point is given by its XY&Z coordinate. So the point cloud registration problem can be formulated as finding a rigid transformation

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Solving minimise the distance between these two point clouds. So we put them together so that the corresponding points are in at least at most. Uh

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so small distance at least. So zero is a perfect, but we want to minimise it so the summation of all these distances is the smallest one.

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So how we can make the point cloud registration?

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So I'm working with uh different type of team methods. So we can have the methods that are based on the data, so it can be principal component analysis, singular value decomposition, iterative clauses point then they uh they we know the methods that are based on statistics so that's normal distribution transform. And I'm also working with the method based on features.

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So the first one principal component analysis from the data-driven. So imagine that you will have only in 2D now two... so one is red and one is blue one and we want to put them together So what is the principle direction? So that's the vector of the greatest variance of the points. So where the change of the shape is

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he heist. So that's the

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direction of the major axis of this ellipse and minor axis of this ellipse. So these vectors are always orthogonal in the computation and they show you 2 principal directions of your data. If you move to 3D, so you have 3 vectors that are orthogonal, so one is perpendicular to other one. And then if you compute

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these two or three vectors, you can find the transformation how to switch from these two perpendicular vectors to this one. And then you can reconstruct the shape that is composed of these two input one. But there is a lot of problems, because for example if there is a noise in the data, so the direction of the excess can be a little bit different

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and then the final shape is not optimal. Also if you have symmetrical data, the major and minor axis can be switched. So this principle component analysis is suitable only for some starting of the other HMM algorithms that are more precise. So that's only for ref data and something like to compose the initial position.

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So we have another algorithm that is, uh more complex and that works. Uh uh, that works better. So again we have two point clouds

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and then the task is to find the rigid transformation. I don't know if you have some geometry, so if you know what is rigid transformation, so rigid transformation is that transformation that will preserve the size of segments of the line segments and also the size of angles. So that's very good. So you can imagine it like for example rotation around centre

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or translation of the point or symmetry.

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So this rigid transformation is given generally but rotation and translation vector. So our task is to find the metrics of rotation between these two point clouds and the translation. So if we have some input point cloud so we can translate it or of this point and then using some general rotation we are able to put this point clouds together.

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So that's the registration and how to make it

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so. First step is to compute the centre of the gravity. So we make a summation of all the points in first and the second point cloud and we divide it by the number of the points. And then there is a really cool mathematical operation. So if I moved with every point from first and the second point cloud using the centre of the gravity,

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so we make the XYZ coordinate of every point if this point cloud minus the coordinates of the this computed centre of the gravity. So if I move

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all of these point then the centre of the gravity of both \*\*\*\*

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point clouds will be in 000 coordinate so that they are translation invariant. So we can work only with the rotation now. So that's the first step

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and how to deal with the rotation. So we have shifted points here and here. So from every point from first cloud subtract the position of the centre of gravity second point cloud minus the centre of the gravity for second point cloud. And now I make the multiplication of these two vectors, so

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this size of this vector is 3 \* 1 and this is translated so the size is 1 \* 3. So the output is the metrics 3 \* 3 and it's called cross covariance metrics. So that's really easy computation and you obtain 3 \* 3 metrics that describe the connection between all the points in first and in the second point

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not.

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And then there is this SVD method, so that singular value decomposition. So that's a little bit high mathematic. So you are able from one metrics make three different matrices, the middle one contains the eigenvalues of this transformation and the U&V transformative contain the orthonormal vector or orthogonal also orthonormal.

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So it means that they are normalised and they are orthogonal 1 to each other. So we have something like the major direction of changes between these two point clouds. And then the final rotation is given only by multiplication of these two matrices together, and we can reconstruct also using the translation and the centres of gravity, the vector of the translation between 2 vectors.

38:03  
So you can imagine it like that we move

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two point clouds that they will be together in one shape, but here we have only one one try to make it so we compute it between points, computer rotation, translation and that's all. But it's not very precise. Now again

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in the first first round you are not able to prepare perfect registration. So that there is one of the most popular point cloud registration method. It's called Iterative Closest Point. Um, the authors are poor Basel and Naomi. OK, so in 1992 they presented in a AAA transactions and nowadays there article has more than

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25,000 citation. So that's really cool.

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And this method is uh something like a stone stone base of every registration method. So everybody start with this. So what is the idea? So again we are searching for optimal rotation and vector of translation, and here I rewrite it in projective space so I can use uh more coordinates than only 3D. So I'm in four dimensional space, so we can use a translation

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vector together with the rotation in one metrics and then we want to find this um

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12 values that will make the registration of point cloud. So we want to minimise that. If we apply the rotation of one point client, we shifted using the translation and this new positions of the point cloud are subtracted from the.

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Input one. So we minimise the distance between corresponding bonds

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so we have singular value decomposition and now we will make the minimization by iterative process. So first of all we will compute the points, the pairs of points that are in the smallest distance. Then we apply singular value decomposition and we are able to find first rotation and 1st translation, so it will not be perfect. So again

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we compute the pairs of points that are connected. They are that their distance is smallest one. Then we have the double

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of coordinates and again we apply singular value decomposition and we have a new rotation and new vector of translation, so we apply them and again new positions of points that are the nearest one. So after I don't know 20 iterations you are able to find very nice registration. So that's iterative closest point.

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So these methods are very data-driven. So they were based only on data and now from these statistics one so that's I think that it's very complicated so but it looks cool I hope So there's a base that's the method that is based on statistics. So we again compute something like the coverings metrics and we compute it by the probability and the normal

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distribution. So the idea of this algorithm without any mathematic is that you divide the space of point cloud into separate cubes and for every cube you have something like a normal distribution. So that's the Gaussian distribution, normal distribution. So some shape in in 2D you know that the Gaussian curve is like this and in space that's the surface right?

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And then you can represent this cube or cubes uh cubes in point cloud by this distribution and you make it for first point cloud and for the second one. And then you are able to connect the distribution that are similar. So you can find the probability if your point is apart with the highest probability of some

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cube in the second one. So that's the idea behind. So I will let it go because it's very difficult

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and the last method, so my research uh is uh here in this feature based method. So uh I don't know if you have any idea what this feature in point cloud. So if you have any idea what can be input cloud, some feature

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so if he you are there I hope

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so. Any idea

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so

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so no. No idea what this feature in point cloud, so this is not very difficult. Feature is something that is very important. So there there is some huge change in the data. So the plain points are not definitely the features. But

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we are searching for a points with some unique properties, so we can um, detect the features based on shape of the neighbours. So we can look for the edges of the houses, curbs on the streets, the shape of the tree trunks and so on. So we need some shapes, some change in shape. Also we can work with

45:19  
uh features that are based on the colour colour. So in that case you have to connect the lighter data with the colour information. So some of the lighter technologies are able to put also RGB information of your point. So you know that the point is in coordinate XYZ and also you know that RGB is for example 200-5600,

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so that's the correct point or something like this. And another methods are for example based on curvature, so it's connected to the shape. So the high curvature of the neighbours of the point means that this point is important and you can use it as a feature point for your registration.

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So there is the description of the algorithm. So we have the point cloud of this bonnet. So there are two point cloud, source point cloud and target point cloud. And we make some preprocessing, some downsampling for example noise reduction and so on. And then we detect the key points, so the important points of the shape of our Bunny. And then for this

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points we are able to compute something called a descriptor. And this descriptor is based for example on the relationship between the points in the neighbours. It's based on the colour of the neighbours, it's based on the different type of curvatures that you have here. And then

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the registration is not made by the distance of the tuples of the points, but it is make by using this descriptors. They are often some vectors and then you compute the distance between them and then you are able to connect the models or point clouds together. So that's the idea.

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So my research I work on this uh registration method that are suitable for a natural environment. So in that case that you are in the city, so you have a lot of features, lot of different shapes. So these algorithms works very clearly, but imagine that you are moving here on this Meadow and you have only mass of the votes

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on the left side. So that's our car here with the lighter data and we are able to obtain the point cloud like this and we want to prepare

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the optimal path planning for um autonomous vehicle in this area. So I try to test a different methods, a search for a different registration algorithms that are that are able to work with the shape of the trees and the leaves that they are moving during the measurement and also the conditions of sunlight thing. They are also in different colours

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so if the IT is a cloudy so the green is dark and if the sun is shining so again I have a totally different levels of RGB so we are working on UM

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some algorithm that will be suitable for this nature environment.

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And there is a photo of our testing card, so you can see the lighter and the camera mounted on the top. And there is also uh the battery and many computers and the measurements. So that's

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so it was the second part. So I was talking about the ground removal, my removal algorithm, so we are able to make some preprocessing. Then for a 3D reconstruction of the scene we have this registration algorithms. And now if we want to work with one scene and we want to detect for example some objects, buildings, cars, pedestrians and so on. So we need something that is called

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clustering.

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So the visualisation of clustering is very easy because here you have a four testing point clouds and then the clustering itself must make the separate object

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that uh that uh for the points that belongs together. And this is not very easy task in the case of some complex scenes. So traditionally you can use the seed algorithm and the modern approaches are based on 3D convolutional neural networks.

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So few words about the seat algorithm. So you can imagine the seat algorithm as a small seat. So you randomly choose one point in your point cloud and then you search around and you assign the point in one

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object if it is in for example distance that is smaller than some given threshold or if it's normal vector is similar to a normal vector to a seed point. So you have to set some parameters for a property that is yeah that other point also belong to my cluster.

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And then if you search your point cloud so you will label this cluster as the first one, you can remove it from your point cloud and then randomly you will again choose another seat. And then based on your rule you are able to find others and others point and make the

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clustering

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and uh at the end. So we are we are going to. The most interesting part I hope is using a convolutional neural networks. So uh working with the lighter data and neural networks you can switch to traditional 1 to convolutional 2D neural networks so you can make the layers. So in your point cloud you make something

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like a slices and you change the 3D coordinates to 2D coordinates. Ohh, so you can make some projections in different in different views and then you obtain 2D information and you are able to use a standard to the convolutional neural network.

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So in a standard 2D image convolutional neural networks, you use the operation called convolution, pulling and some activation function, and the difference is that in 3D you have to,

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uh, widen this operation to 3D. So you have 3D pooling, 3D convolution and some specific function.

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So I don't know if uh your uh you are working somewhere with the neural network. So I prepared some uh few few slides about the introduction so you will understand more clearly to this more complex 1. So

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neural networks are the base of many research nowadays and they will be more and more used in practise. Nowadays you are using them in Google search, you are using uh it in your e-mail client using for a spam. So if you are umm

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on some ish shop and there is uh some chat, so probably there is some never um ChatGPT based neural network and so on. Also you can use that ChatGPT or Barth to ask question to to

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prepare your algorithms and so on. So we have to work with with neural networks and I think that there will be more and more in a research area at universities.

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As I said, that's my home base. So I I like this theory very much and uh, it will take much more hours to explain every every task, every part. So I will make only some brief uh brief introduction and

55:43  
we can we can prepare um more more lectures about neural network if you will be interested from Salzburg. So how does it work? So there on the left side is the image of the biological neuron, So it's based on dendrites that catch some information and then the information is processed. And the important part that is same as in neural networks that there is only one output, so that's the

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excellent. So it sends the impulse in your brain or in your neural network or neural nerves neural system, um, to next to next, never on.

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So how does it work

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in a neural network? Artificial artificial neural network. So we have some inputs, so X0X1X2 are the inputs. Then we set some weights to them, so that's the label W0W1W2 and the evaluation. The body of of this neuron is similar to the evaluation function that we make a linear

57:08  
combination of the weight and of the value that is on the input. Then there is plus B. So we have some bias here. So that's because only some mathematical constraints,

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then you compute some value and then there is a task will you send the value out or it is not important this information so that there is the activation function and the activation function is applied on this linear combination and output value is sending back to the next neuron. So that's it. And what is the task of the neural network

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in programming? Is setting the weights so optimal? So if you imagine that X0X1 and X2 are some values,

58:09  
so as the output you will obtain some value. For example output will be a number one, so you have to set the optimal values so that the output will be one. Then for another input X0X1X2 the output is another number. Then you have to add more neurons and evaluate more inputs and more weights. And the major task is in our own networks

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is to set the weight. So for the given input you will obtain the output that you want.

58:52  
Yeah, the very easy example is for example if you, I don't know have uh have the problem with the heart. So the input can be the pressure, blood pressure, it can be the weight and there it can be some stress, stress level. So if you have a table of these three values, so you have some noun values, so for high

59:25  
value of stress and high value of uh of uh weight. So there is a really high number, high value of output that you will you will have heart attack for example. So that's the learning with the with the teacher, so you know the output for some inputs. Then you prepare the weights, so if somebody else will give you

59:58  
ohh my pressure is this, my weight is this, and my stress control is this one. So you will obtain the answer if the risk is high or the low by multiplication of your weights that were training on your data.

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So here we can see the structure of 1 neuron. So in the more complex task we need to use more layers and more evaluating criterias and more weights. So there is input of blood pressure, input of weight and input of stress control. And then you apply on these three numbers different weights and different combination

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and every line here connected. It means that you will assign number of weight

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in the first um coming through neural networks, these weights are set randomly. Then you compute some output and you compare the output with the perfect answer. So you make some mistake there. And then there is so-called learning or backpropagation of the error. So you put the error back to weights, so you change them a little bit and then

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goes through the neural network with new weights. Then you have a new output and you cooperate with the best optimal answer that you have from your training data. Then you compute new error and this error is again used to prepare a better ways in your neural connections and so on. So that's the number of epochs, number of learning parameters and so on. So you are able to prepare

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perfect weights. So then for new inputs you can say if the person is in the danger of for example heart attack or it is

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without problem and their values, uh, their values are OK.

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So with the images, the weights are not only a numbers but they are in a matrix. And uh we did do not make a linear combination with one value, but we make it with the value of the pixel and some surrounding pixels. So that's the convolution operation and the weights that are we training are here. It can be metrics. Is often

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3 \* 3, five times fives and so on. The numbers are odd and how does it work? So you make the combination of

1:03:09  
the positions that are corresponding, so there is 0 \* 4 zero times zero 0 \* 0 and you make the summation together and the result number here we have -8 is the output after application of this convolution. Kerner at the beginning of the neural networks the kernels were some specific philtres. So if you look at this

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image on the right side, so this kernel will show you the edges in the image. So you are able to find some specific detail details in the images. But nowadays the corners are chosen randomly

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and then they are training to obtain the best values. And the number of these kernels is very huge, 10 or 28 layers and so many so many parameters that you are training.

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And the second operation is a pooling, so the pooling is the operation that will reduce the size of the images. So here is a Max pooling for example. So you choose only a maximal value for some sub metrics of your image metrics, so you can obtain this data. So from the blue part here it's #4. So together the composition

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of many convolution corners

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and the values of Max cooling, you are able to prepare the optimal weights. So

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if you train the animals for example, so you have a set of cats, set of dogs set off. I don't know birds

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so that after the training, so you will use another new image of a cat and your neural network will answer you that in with the probability equal to 98% that's the cat. So that's very similar with the working in 3D. So we can use

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the UH Labeler so we can prepare the data. So for example I UH gave you here the UM MATLAB Matlab link. So if you are interested in this area you can check it the examples that they have. So the principle of 3D working with the data is that you have not only the images but you have a 3D scene and you label a 3D object in this.

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So for example here there are the boxes with the cars. Then we have we haven't got so many testing data and training data, so we make some data augmentation. So we make a little bit of transformation with this data and then using a 3D convolution and 3D pooling. So this operation are not only in 2D but we apply them in 3D space on 3D matrices.

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So you are able to prepare this 3D philtres and you can train your neural network to work with 3D data. So that was the end. So the link will be in the presentation. So I will share the presentation with Professor Strobel.

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So I think that it was enough. So thank you very much for your attention. So I hope it was helpful a little bit.

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So that was all there are any questions?

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OK. First of all, let me thank you in particular for giving everyone some indication what's behind the lighter data and lighter based models we are frequently working with. So lighter. It's a technology and the results

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in in many cases aerial, in some cases terrestrial as well, would be familiar to pretty much everyone here from the elevation terrain modelling perspective to the feature extraction. And of course whenever we go into what's sometimes called reality capture for urban modelling, yeah, maybe a little bit less in the specific application context you you have been showing

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And the belief it's good whether you dive a little bit deeper into the mathematics you have introduced or not to appreciate what's behind those lighter based data sets we we are getting. For me it was interesting that you were going to one particular technology vendor

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because we in in the Salzburg context are a little bit more familiar with with all of the reading devices because some of our graduates work in that company

1:09:00  
and the chair mythologist and our geography department, they do some surveying landslide candidate areas. So that some of the practical work with it's done around here and I'm sure you've come across some of that during your stay. So with that I'd be happy to invite everyone. I do not see any any questions in the chat, a queue and day. So please either put any questions,

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oh oh, raise your hand or just unmute your microphone.

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Ohh, when we're doing something to to give you a little bit more time uh,

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but still think about any questions or comments you might have.

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There is one thought which was going through my mind when I was listening. Uh you talked about colour and then you made it clear this was about Co watches that RGB

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Uh sometimes the term colour in lighter context is used for the intensity of the reflection as well. Is that a metric you use in your algorithms or is it mostly kind of binary, which means reflection? Yes or no.

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Reflection we used in detection uh on the roads, on the marks of the roads. So there is a reflection, but in the natural environment I used a rough file. So uh because RGB is with more conversions. So we use another coordinate HSV model of the colours because we want the representation that is not sensitive to.

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So uh you to sun, sunlight, I think so yeah. So yeah, you're right. We connect the rough images with lighter data together and then to transform them and add a feature that is independent on lighting to the position of the features. So and the intensity of the lighter reflection as such,

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is that measured with the hardware device you're using as well

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or is that not available for this roster device? No Ulster with Ulster, no, it's I think it was Velodyne in the city that we used. So that's difficult. But umm, and I considered interesting as well.

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Umm, well, I think in the beginning when you were introducing the technology devices you were using, uh, you were stating the observational frequency in Hertz, which would be kind of complete scenes per second, right? Quite often this is stated in reflections per second. So how many beam reflections? And then we would be typically in the 100,000 up to 1,000,000 Hertz or so.

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And this be mapped together because usually I would compare UH devices with the do they have 500,000 Hertz or more or less or whatever. But your metric was for the scenes, right. So the complete scans of I guess 360 degrees that right.

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Yes, Yes, that's it. OK. So can those two metrics of scanning frequency be related to each other in any way or is it just different ways of characterising the sensors? Yeah, I'm I'm not sure, but in my opinion, I think that's different. Yeah. OK. Yeah, probably probably this this data are are not so huge with the reflectance. Yeah. So they can be in,

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uh higher frequency, but that's my opinion. I I didn't, I didn't check it. Yeah ohh post checking. Curious, being familiar with similar metric which has different approach. Yeah. And again looking to to the audience and anyone else who wants to pop in with a

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comment or question.

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So the one point as you had this vehicle mounted device, right, did you go with that form scan location to scan location or did you operate that in a dynamic way. So during movements as well both ways. So at the start we start with the full scene and then now we are working on subsequent yeah because the the

1:14:21  
task of this project is to make the autonomous vehicle for uh mine detection. So there is more more research around about the robotic arms and so on. So everything is connected there. But now they need the transformation between subsequent scans, because after small movement of the car they need to see and plan the optimal path through a tier terrain in this in this conditions

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It's good you mentioned this application use case again, because very clearly it's unfortunately a very timely and important uh application. That field

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I'm a little bit familiar, not with the details and intricacies of the kind of work. Of course for that detection

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you would use a drone base, uh sensors, light or other as well. So that would be what you are suggesting would be following the logic of having the sensor on the actual mine clearance vehicle, right?

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Yeah, I'm only on the power of the reconstruction of the scene, but uh, the other other parts in this research are working with the UH. I hope it's radar, radar data. So they are able to scan the length and also the under underland area and see the shape of of some dangerous thing and so on. So they put my information only about the rotation and translation.

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So I'm able to make this from the scans with their more specific things and also with the uh I and unit of the movement of the of the machine and so on. So that's not my part. So you are the geometry and algorithm expert. Yeah yeah I am mathematician,

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that's that's no underlying so many other things, right? Yeah, yeah, that's yeah, we can use so many libraries if you open the Matlab or Python, so you can call ICP method and you are able to make it in one step, call ICP on point cloud one, point cloud two and you have the result. But in this project, we need to see every part because they don't want to use any library, because sometimes they are not able to change some parameters

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and to see what is in the code. So we start from the from the beginning, from the points and from the connections and so on. You really do it from scratch. And yeah, if you and us the opportunity to have a little bit of a look behind the scenes of what's required for the reconstruction of surface and feature geometries. So on behalf of everyone, let me thank you. Thank you as well for making your presentation available

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again. Letting everyone know that while we work with outcomes with results from LIDAR pretty much on a daily basis that there is a lot behind that and to understand that at least a tiny little bit better. That was certainly a lot of help. So it will help you a little bit. Thank you again for your attention and have a nice day since Salzburg or everywhere around the world. Where are you?

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So bye you very much.

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Bye.

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