Trends in Geodetic 3D Data Capture - Mobile Mapping with a Variety of Different Platforms

transcribed plenary speech of
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I am a Photogrammetrist as you heard and I try to show you lots of photos. That is my profession so showing you lots of graphs and images and hopefully I know it's late in the afternoon so hopefully I can entertain you a little bit for this. I'm going to talk about mobile mapping as you can see it's a part of geodetic data capture, geodesy or swing on mobile mapping is a topic which I just try to bring a bit closer to you. I'll give a short in the development of mobile mapping. I'll shortly look at what is the basics of what is the fundamentals of mobile mapping and of course then mainly show examples and applications in this field. Now, this graph here which you see is showing, lets say decades in the case of what happened in mobile marketing at the very beginning. In the 80s last century there was a digital cameras newly on the market the first ones appeared. We had GPS.

Everybody know what these has GPS, most if you have GPS in your mobile phone. At this time it was still fairly new and the first mobile mapper people, people who did mobile mapping they saw this opportunity. Bring the cameras, together with the GPS connect them somehow and record the imagery which has a location where you know where you are. Even in the world centered coordinate system. Then there is the phase 1990-2000 where we introduced laser scanner. So the lasers which could be used for capturing this room for example. Put the laser scanning the room and it will capture the room in 3D with point clouds. This laser scanning was developed in the 90s and it was immediately combined again with GPS for mobile mapping. 2002-2010 was that what time is the time where Airborne, ALS Airborne laser scanning be- came mature. So if you want to create, let's say a digital height model of Sri Lanka, you want to know the height with the reality of 1m everywhere in the country you use airborne laser scanning. You can use airborne laser scanning you can just capture the surface through the points clouds.

Of course you match it every streets and buildings above it. So you have to process the data to get really the ground and maybe this period now, 2010-2020is not yet decided but this might be the decade where these UAVs, unmanned aerial vehicles, or RPA's, re- motely piloted aircraft will get, will have the break- through. We have many countries worldwide now where this UAV's are recording data. I developed a note to just fly around and capture information about the scene, about the ground, about the environment. The history started probably in the US at the Ohio State University around 1990 and preceded its first stage. Basically what we see here on the graph, this one just nothing else but the camera on the right side, another one in the center, the GPS. GPS receiver on, or a GPS antenna. Receiver is a somewhere in the car that was enough to record information for example driving along the highways. So highway mapping, highway inventory was developed and of course these people in Swaine, they have not been happy just to take GPS as it is, a simple one they did it differentially that's why call it DGPS.

So differential GPS means you use the GPS receiver on your van and you use the second one, this time at least use the second one which you put into the field and then by taking the differences you get vectors in space, and they are more accurate than what you get from a, from a satellite above on to you see the accuracy level which determined to decimeter to meter rate at this time. Even though at this time, not much improved until now, the techniques became more flexible but we're still moving around in Swaine. All the other ones now in the decimeter accuracies. you can go in to centimeters but the decimeter still mostly used.

What we have today, I have not my camera, my consumer camera with me but maybe you have those also now GPS concluded in the in the camera. if you want you can load them up. I didn't know for my trouble in Sri Lanka and whenever you take a photo,

it looks like this. You get the location and the right side of the picture. You get the location where you record your photo, because in this cameras is also a com- pass, a simple one included. You know in the world in which direction you're looking at. In all your pictures that you record have this location. We call it as Geo- tagging. Its just to get some marker you know, this is the location of this is that you're looking at, if you visualize it in the map or in the Google maps forever, then it would be for example then it would look like this. You know way you have your feet, we you know very have been at which time because GPS records of all the coordinates, it also records the time.

Airborne Lasers scanning the next phase is then simply visualizing. Here we see the aircraft, we see our laser scanner, with in your GPS included and some inertial techniques. What is an inertial technique? This is basically a Gyro found accelerometers. If you have gyros, gyros give you the direction, or direction changes and accelerometers give you the accelerations and you're able to get also position and altitudes of the rotational information with high-frequency and this was necessary for the development of airborne scanning because airborne lasers even at the early stages in 1990, they had already 1000 to 10,000 measurements per second. So of course its not enough like a GPS you get one position, one measured location every second, or every 2 seconds, nowadays maybe 3,5 per second. but this is already enough that you need inertial techniques, at least the interpolation between that and of course also for the orientation. Equipment as we see it in 1998 with the German company who was operating the aircraft you see here is yellow part this again was standing on the ground, the yellow one and this tri- pod, this is the GPS antenna close by the GPS receiver of laser scanner's big boxes.

You know laser scanners are something like that, and cameras, the Photogrammetric cameras, used in Photogrammetry are also big, hundred kilograms heavy. They were used, the cameras were still film based, but this changed then after wards soon. So that was equipment at this time. And to equipment it looks like today I just give a, give you samples of those that the navigation sense of IMU's is big as a hand, this orange Boxes here, and the red one is a little bit bigger, the dark one even more big than the other one. Then this is our navigation centers and the scanners, that you see a list of those, all the cameras that will be different but at this time 10 years ago, or 15 years ago. And what is it today, these UAV's, drones. We see them flying maybe on to receive that they use the same technology, the same mobile mapping technology again that use GPS, if you use it in the geodetic field to use DGPS, the differential GPS, but IMU's with cameras all flying around, they're flying around. Of course they are so far still very limited. They kind of compete with the aircraft but you can do local areas. that they can do 2x2 km. So it was like this is some feasible sites here.

The fundamentals the theory behind it illustrated simply note this afternoon we see here is that toy in the center that this is my platform. So this is where I put all the centers which I want to route to do mapping on it on to navigation how cold is the body system so this is where the other, the moving coordinate to the navigation issue. We must know where is this van here all the time, this is our position task and he must know the rotation of the orientation of this blue coordinate system. We must know when we look at it and if you know this, then we can do mapping on to. Basically the formula is shown here. It means that if we have a tool for measuring a point, lets say its this one in this coordinate system this would be the vector which measure, and then we have to rotate it and to move it with this location and to get the results in the earth's fixed even maybe if it's GPS coordinate system.

So this is our mapping solution. if we have now more sensors, the first picture to process the navigation idea, but if you have sensors now included camera for example, this frame here is one coordinate system.

Then here is the inertial stuff. So the accelerometer and the Gyro another coordinate system, the GPS antenna another coordinate system and finally what you really want to have, this is the results, the mapping results in a mapping coordinate system. that we have a couple of coordinate systems and this is what you're learning and if you go for the KDU south campus and do the geodetic codes there all these coordinate systems you must relate to each other and you will learn it in basic courses in the formulas seem to be more complicated if you look closely at it. And the calibration is included and things like that so these are details which I don't want to go through this afternoon.

Now we go indoor outdoor GPS is helping us a lot. Indoor GPS is not available we know its not working. sometimes its little bit working but you know we don't

want to use it for mapping properly but we have other alternatives as we heard in the first lecture this after- noon and mobile networks, can be used also for positioning indoor or wireless networks can be used for positioning indoor they are to some extent used now a- days from indoor mapping so for capturing the garment indoor. Nevertheless whenever you need them they don't work. In real life it is not running PC is not running or the network is too far away you know, the stations from the telecommunications I maybe not so close and not this accurate as you want to have them but still this is research which is going on that people work on it. And it continues also here in dis part. What is it with the remaining is that the inertial navigation system again. If you see the traffic in three accelerometers and three on Gyros which are measuring accelerations and this rotational changes and be then have just the navigation task again to solve we have to integrate the rotational changes. One gives this rotation you have to integrate the accelerations twice as we learned in school to get the location. So basically this is the idea in relative to be more complicated. Where we're in now? Now we're at a stage where we see that these geodetic solutions is a colleague when we have a navigation sensor in the camera or laser scanner combined if you move around it works.

It has one problem and the problem is that to this IMU's or INS, the inertial systems have a high drift and the cheaper they are the bigger is the drift. So you can buy a Gyro four euros and dollars e50,000 and too you can buy one for one dollar and you'd match this is a very big difference. In robotics we see another development. They call it robotics or computer vision. They collect a simultaneous localization and mapping data, was basically the sensor itself, it is the camera, and to navigate around. Then we have a problem to solve, which I to try to simplify a little bit in this way that you say. Assume we know where our cameras are not the laser. Assume this is where our camera is then that this camera is observing now the scene and we have two cameras or the camera in two locations with the orientation so we can measure it 3D. We can collect 3D. This is one step and vice versa. If you assume the 3D scene is given, then we can use on the 3D scene and/or photogrammetry: spatial resection, techniques like that. We define, estimate from the 3D scenes through our image, then estimate the location and orientation. So either one or the other one is given and you can do all solve the complimentary task and slam is not just this idea to say okay do it both somehow. I don't want to go now it to all these details. How to do that there's a big robotics theory about slam it's very very interesting lots of PhD people are working there. At Wolfsburg there are working for next 10 years on this issue I'm sure.

This is not like how this the place looks nowadays or how they were looking maybe, the left one or the yellow one five years ago. We see on the roof received cameras, tried to point to them again, we see cam- eras. Hopefully you can see there is a camera, here is the camera here is the camera. There's lots of cameras on this roof. This man is just testing, is just using two laser scanners, here is one, here is one in the same thing that you see the GPS and this in not show stuff again. Put this on the roof, this is the classical mobile mapping when nowadays on in the you know the more recent developments are those ones so like the one which we see in the lower in the center of the picture. This is now all combined. There was cam- eras around. We can see them the lasers is a bit more difficult to see but here in the figure its hidden but I can show you this is the laser here. Cameras around the GPS included everything fairly compact nowadays. And the company who was selling that this one is light carpet, there is another two or three or four developed companies on the marketplace develop those. If the student is doing this, in our university it looks like this. This is our mobile mapping equipment, you see, they took something from home which you put there, that your bicycle probably but everything is included which you need for mobile mapping. It has antennas even 2 in this case. This is the laser scanner. This is the IMU even automatic counting the wheel count is included and you can do the mobile mapping what is the message behind? You can put it in nowadays on almost each platform, and even students can put this together you can mis-calibrated little bit you must measure you know the rest with respect to all the systems you must measure distances on the rest is then developed intensive software developed to be used.

Or another student project they've been event on a train in the park. And you're in this circle. We see the laser scanner and even you see antennas. It's a one for railway mapping exercise for the students the other one somewhat professional of course the laser scanner which goes along which is about here with the idea to capture here the Hubbard glacier or other, other vehicles. You can see for mining lower left, another Arial aircraft type small one, small toy

there. But you can sit there while your flight there. We call it a Gyrocopter, this aircraft or the right figure shows the equipment on top of the vehicle which is now for town for driving around here in the Golf area. It just shows it's flexible you can put it almost everywhere. Softer is avail- able to capture data interactively so you can do lots of things manually. All this yellow lines which we see in this picture, just in this two pictures this is stereo digitized, digitization results for mapping. So after that mapping results you know all your roads, you know sidewalks, you know where is the traffic lights and whatever you capture is there in your database.

Examples from some research projects which we do mostly together with the small and medium-sized companies, enterprises, SME's. We see here again how a point cloud looks like. If you resolve it a bit closer you see how much details you capture through this laser scanning. This huge, here colorize it with help of a photo. The story behind this one is that should be auto mobile industry in Europe is now starting to go towards autonomous driving. For this autonomous driving they need very accurate maps with lots of 3D details and what they want to know is the all this 3D details like all these vertical structures. So whenever there's something vertical there don't drive the car there and also automatically. So collect this all and increase the existing maps. What we in our classical navigation system today is the simple map, a little bit of 3D visualization. Next-generation of 3D maps will be full of details for sites of buildings are included, of course all this infrastructure elements along the road will be collected or easily collected. It is just a some, some filtering center image point club processing similar to image processing. Where you detect small linear structuring elements and then if you visualize lets say only the vertical ones, it looks like this. You're a bit more professional or the blue those sabbatical structures which are highlighted in blue here. These are the ones which we collected along the road.

Segmentation of states if you know, if you collect the point cloud we saw it before it looks like this, like that one which we see here just looks like a picture where we have single point. If this segmentation if you do processing for this point cloud we are interested to get the status plane just to get all the windows on to, yeah processes behind that are from laser point cloud processing. Alpha shapes but those who have an idea but that are used here to extract those windows and finally the test model the simplified by modeling in terms of rectangular areas. Another application also with the same point cloud using this point cloud just to indicate different examples. So the potential, we heard from the colleague before, we showed about the carbon dioxide and all this stuff. We see that the collecting solar information is one of the trends. Of course it's a big trend in Europe. And on the roof 's this is nowadays the trend, even Google's recently announced that they do it for all buildings. You can collect the solar potential on your roof for the Facades they have more problem because they don't see it re- ally they need the information about the Facades. Point clouds are quite nice information to do this until with a little bit of tools you can calculate solar potential in each day or per month or per months per year and calculated. This is 2 examples where we calculated the energy potential in on 22 of March. Why inventor we would like to, Germany at least to use it for solar heating or for collecting energy and to be need to heat to our buildings in Summer. In Summer we would like to collector in the same energy either for use in putting it into the power system or to do it for solar cooling of our buildings. Yeah! Going with further to another application this is our roads. We want to know about where is all that the cracks on the road. There is a quite a big one that you see on the lower left figure or the potholes or the ratsis. (thank you I'm coming to the end) on to what you want to collect systems. You know began with lots of sensors vehicles mobile mappings are available. They collect this. They can do it a little bit more simple if you just put it on the roof of a van, process it with image processing to detect the cracks on and do this along the road or this is not such laser lines, if there's a laser rotating the laser lines and to you see a lot of hidden information available can be processed and threshold to see there is now the rats.

Yeah! Finally to come to the end, the most flexible platform maybe, also something interesting for maybe you as a student at the University want to use it to take it into the hands your mobile laser, and to walk around. If you see a student who is walking around has a laser in the hand, and IMU included on, you simply go like this. Through your building walk, along collect the point cloud, process it through proper techniques and the results like this one. One level for one of our university buildings collected to you. If you see the 3D structure, the top level is your path that you see inside. One floor together with the point cloud here, visualized and this is been the 3D model which you can create

from this point cloud. At the very last picture, now if you want to collect this in buildings here is the hotel, the ground floor there's lots, of course the rooms and you walk from one room to the other, al- ways to this way. So it's a 700 g heavy this one. So whenever is okay but five hours is like a good exercise for you. On the walk around this takes maybe take like 1 hour just to go through all the rooms, collect information process it to the point clouds and you can use it for mapping more or less we receive the ground plan already, in this laser point cloud.

Summarizing slide we see in outdoor, we have a mature system with the mobile mappings with laser cam- eras and the radar is another one it is also used there. In the systems are not this much robotics has some assistance with the camera's oldest hand held laser scanner is now mature but they're still on going work here in the next 5 to 10 years will bring much more of those systems. And we see this techniques which comes from robotics and that from geodesy that navigation they are coming together more or less his hand held scanner is more or less what if this combination of both. On in that field we still have lots of things to do because I believe this is not the only hand held system which we will see you in the market in the future.

Thank you very much for your attention