

Internship Report

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Slovenian Forestry Institute / Department of Forest and Landscape Planning and Monitoring /
Laboratory for Geoinformatics
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Declaration and link to personal portfolio

I, Timotej Gabrijan, hereby declare that the internship itself and its report were done by me, are my original work and were not submitted anywhere else. The same applies to the screenshots and photos taken and included in the report.

- Personal portfolio: <https://timig.eu/>

1) Description of the internship scope

Overview of the projects undertaken:

During my internship, I participated in several activities related to forest inventory and forest monitoring. This included field measurements on National Forest Inventory plots as well as crown condition assessments within the ICP Forests monitoring programme, where I gained experience with the assessment of tree defoliation and other indicators of forest condition.

I also participated in remote sensing data acquisition using UAV-based LiDAR and multispectral imaging, mobile laser scanning (MLS), and terrestrial laser scanning (TLS). A substantial part of my work focused on the processing and analysis of the resulting three-dimensional point clouds, including manual processing as well as the development and testing of algorithms for point cloud analysis.

Project objectives:

The primary objective of the [ICP Forests](#) programme is to provide long-term, multi-functional monitoring of forest ecosystems and assess the effects of air pollution, climate change, and other natural or anthropogenic stressors on forests.

The main objective of the National Forest Inventory (NFI) is to provide reliable information on the state and development of forests at the national level. This includes estimates of forest area, growing stock, tree growth, biomass, forest structure, and other important forest characteristics.

Repeated measurements also make it possible to monitor changes in forests over time and to build a consistent long-term database. These data are used for national and international reporting, forest management and planning, as well as for research and the further development of forest inventory and monitoring methods.

Description of my duties:

My duties included conducting In-Situ measurements in various forest monitoring plots around Slovenia, Manual segmentation of trees from the LiDAR point clouds, which can then be used for further analysis and creating the repository of monitored trees for future comparison, doing comparisons between different LiDAR point clouds and creating Python and R algorithms that align those point clouds using various methods and also did some research on how to align MLS/TLS with UAV LiDAR to get the best result for a complete point cloud of a forest from the ground / below canopies and above them, and finally I worked on combining some datasets to create a map with all the parcels that are owned by the government and its various departments.

2) My weekly and daily activities

WEEK 1 (20. 07. 2026 -24. 07. 2026)

The first week was meant to introduce me to the forest and monitoring measurements, so I began by reading some papers and continued with field measurements to get familiar with the methods used in in situ monitoring and the research being conducted.

Monday 20.07.2026 (7.30 – 12.30)

On the first day, I read a paper published by dr. Anže Martin Pintar and some of the main researchers in forestry to familiarise myself with forestry methods. The paper was: [Diversity and occurrence of native and non-native tree and shrub species in national forest inventory plots in Slovenia](#)

Tuesday 21.07.2026 (7.00 – 16.30)

On the second day, I went to the field. Together with dr. Gal Kušar, who is the head of the Department of Forest and Landscape Planning and Monitoring, and whose laboratory for Geoinformatics is part of, I visited 3 Forest plots in southern Slovenia and conducted various measurements. The Institute maintains ICP Forests monitoring plots and National Forest Inventory (NFI) plots. During my internship, I participated in fieldwork on an ICP Forests Level I monitoring plot.

At the site, we carried out several measurements and assessments related to tree growth, stand structure, and forest condition. These included measuring tree diameter at breast height (DBH), recording and verifying tree positions, and measuring distances from reference points. We also assessed crown condition, particularly crown defoliation, which is one of the main indicators used within ICP Forests to assess tree condition.

Wednesday 22.07.2026 (6.40 – 15.40)

On the third day, I continued with fieldwork together with Nejc Lenkič and another forestry student from the Biotechnical Faculty of the University of Ljubljana. We visited two National Forest Inventory (NFI) plots near Ivančna Gorica. At the plots, we carried out standard forest inventory measurements and assessments. These included measurements of tree diameter at breast height (DBH) and tree height, assessment of regeneration, and recording of stand characteristics such as tree social position, canopy cover and vertical stand structure. We also recorded information on the overall condition of the forest and signs of damage. In addition, we collected increment cores from selected trees using an increment borer. These samples can be used to determine tree growth and analyse past growth patterns.

The National Forest Inventory is based on five systematic 4 km × 4 km sampling grids, comprising a total of 3,743 sample plots. Each grid is surveyed in a different year, so that the entire set of plots is covered over a five-year inventory cycle. Measurements are carried out within a 25 m radius around a permanently georeferenced sample point, whose location is predefined within the systematic sampling grid and remains unchanged between inventory cycles.

Thursday 23.07.2026 (6.40 – 15.10)

On the fourth day, I continued in the field with Nejc Lenkič and Aljaž. We visited 2 NFI plots near Šmarje Sap and continued the Forest inventory measurements. The Institute monitors over 3500 forest plots in Slovenia over 5 years, with around 750 plots each year. There are 4 fieldwork team leaders, each with an assistant, who is usually a part-time working student, as you need 2 people to effectively do the field monitoring, so they recruit them, while also showing them the job and getting new employees later on.

Friday 24.07.2026 (7.30 – 15.30)

On Friday, I read some published papers focused on Forestry inventory monitoring and various LiDAR systems that I was gonna use in the following weeks. The papers are: [Terrestrial and mobile laser scanning for national forest inventories: From theory to implementation](#) and [Forest practitioners' requirements for remote sensing-based canopy height, wood-volume, tree species, and disturbance products](#)

Week 1 Summary

Through the in situ measurements, I became familiar with the field methods used in forest inventory and monitoring and gained a better understanding of their role as reference data. I also saw how geoinformatics and remote sensing can complement these measurements by improving efficiency, spatial coverage, and repeatability. Field measurements will remain essential for validation and calibration, while new technologies can help make data collection and monitoring more systematic and consistent.

WEEK 2 (27. 07. 2026 - 31. 07. 2026)

By the start of the second week, I had mostly learned the field methods, so I joined another field team and continued with the measurements of forest inventory, biomass, tree heights and diameters, and defoliation.

Monday 27.07.2026 (6.40 – 15.40)

I started the second week early in the morning. I worked with a new team composed of Sebastjan Bambič and another forestry student from the Biotechnical faculty all week. We visited a forest site in the Kočevje region, which is known for its extensive forests and several well-preserved old-growth forest reserves.

Tuesday 28.07.2026 (6.40 – 14.40)

On the second day, we went to 2 other NFI Forest plots in southern Slovenia, around Kočevje. We again did the National Forest Inventory measurements.

Wednesday 29.07.2026 (6.40 – 15.40)

On the third day, we continued in the Kočevje forests with 2 plots. We again did the Forest inventory measurements on 1 plot. On the other plot, we also did the defoliation and canopy health estimation, which explains the health and living conditions of the forest. The daily requirement for field workers is 2 inventory monitoring sites or 1 large site with defoliation and canopy health estimation.

Thursday 30.07.2026 (6.40 – 12.40)

On the fourth day, we continued in the Kočevje forests, as it's one of Slovenia's largest forests and, as such, has many monitored plots. We again did the NFI Forest inventory measurements with defoliation and canopy health estimation like the day before, but we only visited 1 plot, as we had to be home early that day.

Friday 31.07.2026 (7.30 – 15.30)

On Friday, I read some more published papers focused on Forestry monitoring and segmentation methods from LiDAR point clouds to get familiar with them for the following weeks in the laboratory, and think of ways to improve them or automate them with remote sensing. The papers are: [Transferring instance and semantic segmentation across terrestrial laser scanning time series: towards automated forest monitoring plot measurements](#) and [Identifying Even- and Uneven-Aged Forest Stands Using Low-Resolution Nationwide Lidar Data](#)

Week 2 Summary

I did a lot of fieldwork with the new, more focused and detailed team, and got even more familiar with the methods, as well as new inputs on better methods and improvements to be done in the field, so the monitoring can be sped up by advancements in Geoinformatics. I still think we will need fieldwork in the future as well, but it'll be way faster and more systematic and objective, so the measurements become more consistent.

WEEK 3 (03. 08. 2026 - 07. 08. 2026)

Starting in the third week, I began working in the office at the Laboratory for Geoinformatics at the Forestry Institute. Located at the bottom of the hill Rožnik, at the address Večna pot 2, it's a research institution responsible for half of Slovenia's forest maintenance. The Institute is, as the name suggests, doing research on forest health, producing seeds, researching methods for better forest yield, and monitoring and planning the forests. The Laboratory for Geoinformatics is rather new and, for now, uses different types of LiDAR (TLS, UAV, MLS, and national ALS). They plan to steadily expand the Laboratory for Geoinformatics and include other methods like satellites in the near future.

Monday 03. 08. 2026 (8.10 – 15.40)

I began the third week by being introduced to the work they do in the laboratory, some of the coworkers in the office, and another forestry student, Jaka, who is very involved with remote sensing and was just finishing his Master's thesis on Forest monitoring using MLS (GeoSLAM) and a terrestrial LiDAR Scanner (TLS). By the end of my internship, he had submitted his thesis and had already applied for a PhD on another remote sensing topic focused on laser scanning and point cloud analysis. My work on the first day was to get familiar with CloudCompare and working with point clouds.

Tuesday 04. 08. 2026 (7.30 – 15.30)

On the second day, I participated in UAV-based data acquisition at a forest site near the Institute. The site is frequently used for research because of its proximity to the Institute and the structural complexity of the forest stand.

Together with my mentor, I participated in data acquisition using a DJI Matrice 300 RTK equipped with a DJI Zenmuse L2 LiDAR sensor and a DJI Mavic 3 Multispectral (M3M). The two systems provided complementary information on forest structure and vegetation characteristics, with LiDAR used to capture the three-dimensional structure of the forest and multispectral imagery used to obtain spectral information on the vegetation.

After the fieldwork, I was introduced to the processing workflow for UAV-acquired data. This included processing LiDAR data into georeferenced point clouds and processing multispectral imagery into orthomosaics and other spatial products.

Wednesday 05. 08. 2026 (7.40 – 15.40)

On the third day, I started developing algorithms to connect TLS from winter and MLS from summer, so I could automatically extract trees from the point cloud based on the reference trees. I managed to make some progress by the end of the day, as I managed to find the right method to align both point clouds in the CHM (Canopy Height Model), but as they have different focuses when scanning the area (UAV above, TLS below), the method wasn't completely suitable, so I also tried to match them by height, but I didn't manage to finish it that day.

Thursday 06. 08. 2026 (7.10 – 15.40)

On the fourth day, I continued with algorithm development. I changed my focus to something easier, so I tried to connect TLS, which has its own local coordinate system which is unknown, with national ALS (Aerial Laser Scanning). I also segmented some trees and made some progress on the algorithm.

Friday 07. 08. 2026 (8.10 – 15.10)

On Friday, I finally succeeded with the first alignment algorithm using the CHM (Canopy Height Model) in R instead of Python, which I was trying to do before. But then I tried to recreate it in Python as well, and managed to do it by the end of the day.

Week 3 Summary

I was introduced to the ways of UAV and other LiDAR scanning methods. I was also introduced to some of the research they do and the way the department works. For the work itself, I worked mainly in CloudCompare to segment the trees and get familiar with the software. Additionally, I started to do some research on the methods being developed for automatic segmentation of the trees from the forest.

WEEK 4 (10. 08. 2026 - 14. 08. 2026)

In the 4th week, I worked mostly on segmentation and programming the algorithms in R and Python. I also participated in fieldwork at several forest sites in Slovenia, where we carried out UAV-based LiDAR and multispectral data acquisition.

Monday 10.08.2026 (7.30 – 15.30)

I started the fourth week by trying to come up with the workflow and automation of the alignment of 2 point clouds regardless of their Coordinate Reference Systems, which is useful especially with GeoSLAM and Terrestrial LiDAR, which have their own integrated positioning system with an unknown coordinate system. It can also be useful with UAV LiDAR, as it has a different CRS than the national Aerial LiDAR scan of Slovenia and can speed up the process. I found out that dealing with point clouds can be very complicated, as different devices give different results, so finding common ground can be very complicated, as even the same trees differ.

Tuesday 11.08.2026 (7.30 – 15.00)

On the second day, I continued with research on the cloud-computing topic. I was together with Jaka, my coworker in the office, trying to come up with the ultimate combination for the creation of the digital twin of the forest, accurate enough to do all the monitoring and measurements remotely. We see the future of forest model creation in a combination of UAV LiDAR scans that are better suited for canopy estimation and creation and should be used during the time of leaf season, and, combined with it, we are trying to use TLS and GeoSLAM for the ground and bottom parts of the forest, which are a lot of times inaccessible to drone LiDAR. As mentioned previously, the process of combining is very complicated and requires extensive research to complete it. There is already some ongoing research being done, but it's still far from conclusion or getting any significant results. Also, when combining 2 point clouds from different sources, it needs to be considered what to take into account to combine them. TLS/GeoSLAM with UAV/ALS is done with a CHM – canopy height model. Other combinations can be done by identifying the trees in the point clouds and connecting them based on the trunk, but when I was programming algorithms and researching related topics, it mostly gave very bad results in combining them, as they had different point accuracies. The most convincing method was the CHM creation and comparison.

Wednesday 12.08.2026 (7.30 – 15.30)

On the third day, I took a break from the mentioned research and continued manually segmenting trees from the forest scanned by TLS in CloudCompare. The forest is the monitored area on the hill Rožnik in Ljubljana.

Thursday 13.08.2026 (7.45 – 15.45)

On the fourth day, I continued with the segmentation. It's very time-consuming work, but as I got more familiar with it, I could do it twice as fast. I still needed too much time, and because of it, I wanted to contribute to avoid this work by creating algorithms, but as it stands, it's gonna take a long time before the computer can segment individual trees. The best algorithm that currently exists is TreeLearn, and in some Pine forests and similar ones with straight trunks and not-that-dense canopies, It's already very successful, but in more coniferous forests, it has problems with trees that grow over each other and have combined canopies. The other one that sometimes gives somehow good results is the TreeISO plugin in CloudCompare.

Friday 14.08.2026 (6.10 – 15.40)

On Friday, we carried out UAV-based remote sensing at two monitored forest sites in central and eastern Slovenia, near Kum and in the Pohorje region. At each site, we acquired both multispectral and LiDAR data using the same hardware as the week before, with the same UAVs and LiDAR.

At one of the sites, low-angle sunlight interfered with the UAV's obstacle detection system, causing false obstacle warnings and requiring us to postpone the flight for approximately one hour. Conditions at the Pohorje site were more favourable, and the data acquisition there was completed without similar difficulties.

Week 4 Summary

I became more and more desperate as I found out how much there is still to research on the topic of the point clouds. Still, it also fueled my interest in the research even more, and as I continued to "play around" with algorithms, I started to think about doing a PhD more and more. I also gained more experience working with CloudCompare, the gold standard for point clouds. I also experienced where UAVs have limitations and that sometimes the most random event manages to break your plans.

WEEK 5 (17. 08. 2026 - 21. 08. 2026)

By the fifth week, I had become familiar with the main methods used at the Laboratory for Geoinformatics and continued working on tasks where I could contribute independently. Although the Laboratory for Geoinformatics was formally established in 2022/23, remote sensing has been used and developed at the Slovenian Forestry Institute for more than 30 years. The research group is well established in the field and participates in international research projects, scientific publications, and conferences such as ForestSAT. One of the main challenges is the limited number of researchers compared with the rapidly expanding range of remote sensing technologies and methods, which makes it difficult to cover all emerging approaches in equal depth.

Monday 17.08.2026 (8.30 – 15.30)

I started the 5th week by segmenting the trees in the R08 scanned area on hill Rožnik, and after I finished, I continued working on further developing algorithms for tree detection and height estimation and then comparing both point cloud measurement methods.

Tuesday 18.08.2026 (6.10 – 15.10)

On the second day, I, together with the mentor Anže and the other student Jaka, went to the field to do UAV LiDAR and MS (Multispectral) camera scans of the forest plots on Šmihelj, Rapolje and Kamnik. We faced some problems during the acquisition in Kamnik due to it being too early in the morning, so we had to face the morning fog and postpone the scanning to the afternoon. We moved to the south of Slovenia and scanned the other 2 regions first, and then returned to Kamnik to finish the mission. After returning, we used the DJI Terra software and left it running overnight to process the scans. Photogrammetry is very computationally expensive.

Wednesday 19.08.2026 (7.00 – 16.30)

On the third day, I went to the field with dr. Gal Kušar. We visited 3 ICP Forest monitoring plots in the northwestern region (Gorenjska) of Slovenia and conducted various measurements. The locations were near the towns of Besnica, Lubnik, and Ljubno na Gorenjskem. The measurements we did were the same as on the first day of the internship, as we went to the same type of monitored plot.

Thursday 20.08.2026 (7.00 – 15.30)

On the fourth day, I again went to the field with dr. Gal Kušar, and we visited 2 ICP Forest monitoring plots. This time in the southwestern region (Primorska) of Slovenia, close to the seaside, we conducted the same measurements as the day before. The locations were near the towns of Razdrto and Padež na Primorskem.

Friday 21.08.2026 (7.40 – 15.40)

On Friday, I got a task to search for and get the database with all the parcels owned by the Slovenian government and its various departments. The task was rather complicated, as there are around 730000 parcels and the database webpage only allows queries up to 20000 at a time, and there is no API yet... So I spent 4 hours cracking the API and created code in Python with the help of AI that automatically creates 37 queries of 20000 lines to download the data in one batch and then combines the separate queries. Then I added the dataset to ArcGIS and downloaded the parcel cadastre from the JGP (Javni Geodetski Podatki) portal that offers it, thus completing the map with governmental parcels.

Week 5 Summary

I did a lot of in situ work with various coworkers and got even more familiar with their methods. In addition to the processing and field work, where I saw the progress I made in gaining forestry knowledge and methods, I finally did some work where my AGI knowledge could be exercised a bit more, as the task of creating a nationwide map with the cadastre data and government-owned parcels is something we, as Geoinformaticians, are specialised in.

WEEK 6 (24. 08. 2026 - 28. 08. 2026)

In the last week, I was mostly reviewing what I learned and continued processing point clouds and doing research by comparing the point clouds from different acquisition methods.

Monday 24.08.2026 (7.30 – 16.00)

I started the last week early in the morning by continuing the development of the point cloud combining algorithms and automation in Python. I managed to make the first step of aligning point clouds quite accurate and repeatable, but it was still far from being a complete solution.

Tuesday 25.08.2026 (7.50 – 15.20)

On the second day, I continued with the algorithm development. By the end of the day, I had managed to make the alignment more complete and sustainable by adding trunk recognition and diameter alignment to the workflow, but further development was left for the future. I'm not sure if my coworker Jaka or someone else will continue with it, but as of now, there is a lot of research on the topic in the forestry community, but there are no optimal results yet.

Wednesday 26.08.2026 (7.40 – 15.40)

On the third day, I worked on segmentation of the trees in CloudCompare again, but on a different site, R03, which is also on hill Rožnik.

Thursday 27.08.2026 (7.40 – 15.40)

On the fourth day, same as the day before, I worked on segmenting the trees in CloudCompare on R03 on Rožnik. It was my final contribution to the tree repository they were building in the final 2 days of my internship.

Friday 28.08.2026 (8.00 – 16.00)

On Friday, I was already on my way to BIP in Norway, so for the last 8 hours, I was assigned some final papers to read. As I was on the train, I had more than enough time to read through them. The papers were: [Usefulness of national airborne laser scanning and aerial survey data in forest canopy gap detection](#) and [Tree crown defoliation in Slovenia since 1991, with particular emphasis on 2024](#)

Week 6 Summary

I finalised my internship and made my last contribution to the work done at the Institute. I also used the things I learned in the Norway BIP and saw how extensive my knowledge of Forestry became after such a short amount of time at the internship, so I could apply it there. I also visited the Institute 3 weeks later, on 14 and 15th september, to see the progress they made on some projects in the meantime and share my experience in Norway. Additionally, my coworker Jaka had a master's thesis defence at that time on his MLS topic, so I listened to it to get some inspiration regarding my own thesis.

3) Description of my tasks

Methodology or process followed:

- In Situ Forest Inventory measurements on regular and intensive sites
- Algorithm programming in Python and R
- Segmentation and analysis of point clouds in CloudCompare
- UAV, MLS, and MS imagery and point cloud scanning in the field
- Photogrammetry and processing of the taken UAV images in various software (WebODM, DJI Terra, etc.)

My Individual contributions

- Measurement of individual trees and other work on various forest monitoring sites
- Creation of a point cloud alignment workflow in R for aligning winter TLS with national ALS
- Segmentation of all the trees from a forest point cloud on plot R08 taken by TLS in winter in CloudCompare
- Segmentation of 30 trees on the forest point cloud on plot R03
- Mission planning, scanning and post-processing of the data taken by UAVs
- Development of the workflow for different point cloud alignments and automation of segmentation of individual trees (these 2 were rather unsuccessful, as they take a lot of time and my programming knowledge is not yet good enough)
- Creation of the map of Slovenia with the data on government-owned parcels

Tools, software, or equipment used

Tools:

- Tools used in the field for in situ forest inventory measurements: GNSS, Vertex, Pi-meter, a drill for taking trunk samples, and spray + hammer + stick for creating a reference point
- Tools used in the field for point cloud and photogrammetry creation: UAVs DJI Mavic3E with MS camera, DJI Matrice 300 with an individual LiDAR unit attached, remote for each drone, and many batteries for replacement of the empty ones.
- Tools used in the office: Desktop computer with 128 RAM, my personal laptop, battery chargers for UAV batteries

Software:

- Software used in the field with in situ measurements: QGIS field app created at the Institute with all the needed tools for a field survey
- Software used in the field with UAVs: DJI integrated program in remotes
- Software used in the office: DJI Terra and WebODM for post-processing, CloudCompare for point cloud cleaning, processing and analysis, Python and R for analyses, Terminal with Conda, TreeLearn and some other algorithms and dependencies, QGIS, ArcGIS

Outcomes or results

1. Field measurements and surveying
2. Segmenting trees from the R08 forest site
3. Research on point cloud segmentation automation
4. Creation of an algorithm for point cloud alignment via CHM
5. Processing of the acquired data from field surveys
6. Post-processing and cleaning in CloudCompare
- 7.1. Creation of the code for API decoding, automatic download and database creation
- 7.2. Map creation with government parcels

1. Field measurements and surveying

As mentioned in the daily work descriptions, I surveyed many different forest sites around Slovenia. I did manual measurements for Forest Inventory and also UAV scans with LiDAR and an MS camera.



Image 1 In Situ field measurements with GNSS and other tools



Image 2 UAV DJI Matrice before starting the mission at R03 plot

2. Segmenting trees from the R08 forest site

Segmenting trees from the R08 plot was the only concrete task I had to complete at the beginning (map creation came later), as the other tasks were based more on research and fieldwork, as one would expect from forestry

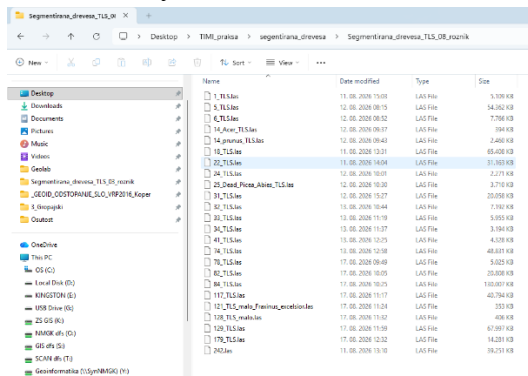


Image 4 Segmented trees from the cleaned R08 plot

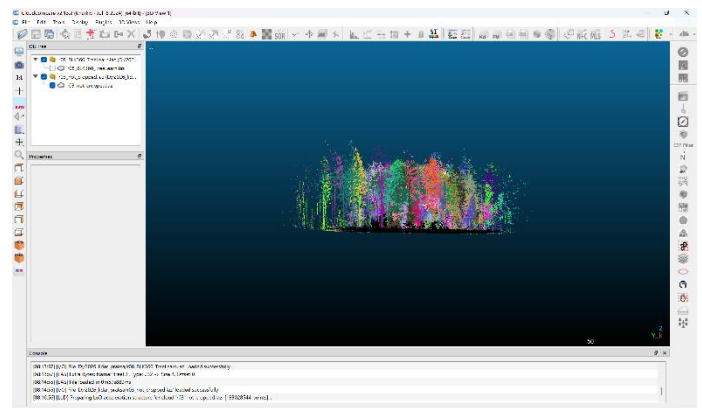


Image 3 Cleaned R08 forest plot point cloud

3. Research on point cloud segmentation automation

I did extensive research on point cloud processing and segmentation. While performing manual segmentation, I found the process to be very time-consuming and labour-intensive, which highlighted the potential value of automated approaches.

Several automated and machine-learning-based methods already exist, but their performance can still be limited in structurally complex forest stands. These methods generally perform better in stands with clearly separated trees and simpler vertical structure, while dense forests with overlapping crowns and stems remain more challenging.

Among the methods I tested and reviewed were TreeLearn and TreeISO. TreeLearn is operated through the command line, while TreeISO is available as a plugin in CloudCompare. Although TreeISO is easier to integrate into a graphical workflow, it can be computationally demanding, particularly when processing large and dense point clouds.

I learned a lot about different packages in Python and R available for point clouds, and currently, R's `lidr` package is the best for point cloud work, so I was developing it in R. I managed to complete the algorithm that combined ALS (Aerial Lidar Scan) with MLS (Mobile Lidar Scanner) or TLS (Terrestrial Lidar Scanner), but failed in other combinations. It works by creating and combining CHM patterns on top of the larger point cloud area.



Image 7 R08 site CHM

[illegible]

Image 5 Alignment code in R via CHM pattern alignment

LiDAR point cloud cleaning and stitching, and MS (multispectral camera) and RGB photo stitching and 3D model creation, photogrammetry, were done in various software, from R and Python, DJI Terra, to WebODM. I was also comparing the performance of each option, and they mainly differ in speed, quality, options for personal interference and optimisation, and how intensive they are on the Computer, though all of them are very heavy. As mentioned, photogrammetry and working with point clouds are extremely heavy even for powerful machines. Among the tested solutions, DJI Terra provided the best results, although it is commercial software and requires a paid licence. WebODM is free and very good for photogrammetry, but it's very slow and has very few ways to make it faster by reducing quality, which Pix4D allows, for example.

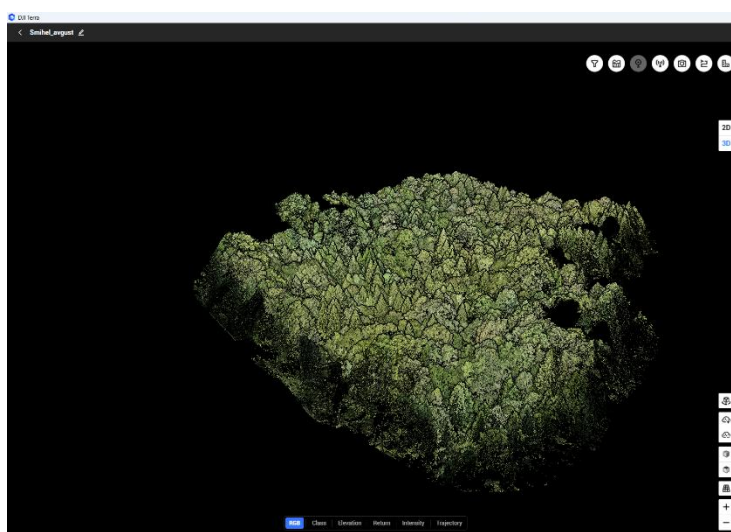


Image 8 DJI Terra forest processed from LiDAR

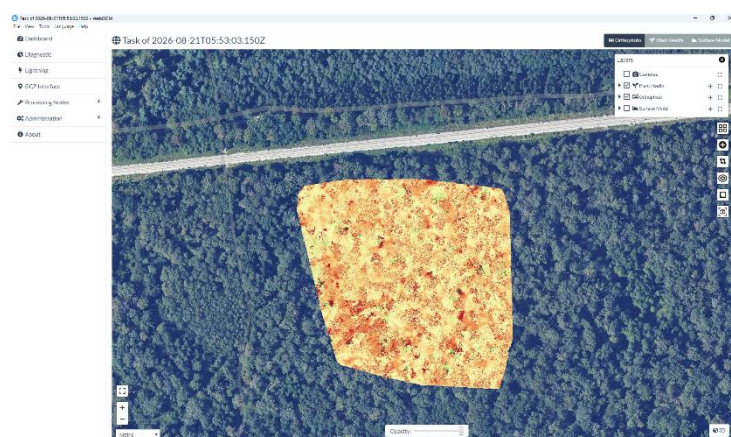


Image 9 NDVI created with MS camera in WebODM

6. Post-processing and cleaning in CloudCompare

The golden standard for point clouds in CloudCompare. Although you need another program to create a point cloud from raw data taken in the field, further processing, cleaning and also some analyses are done in it, and it works really well, especially considering that it's free software.

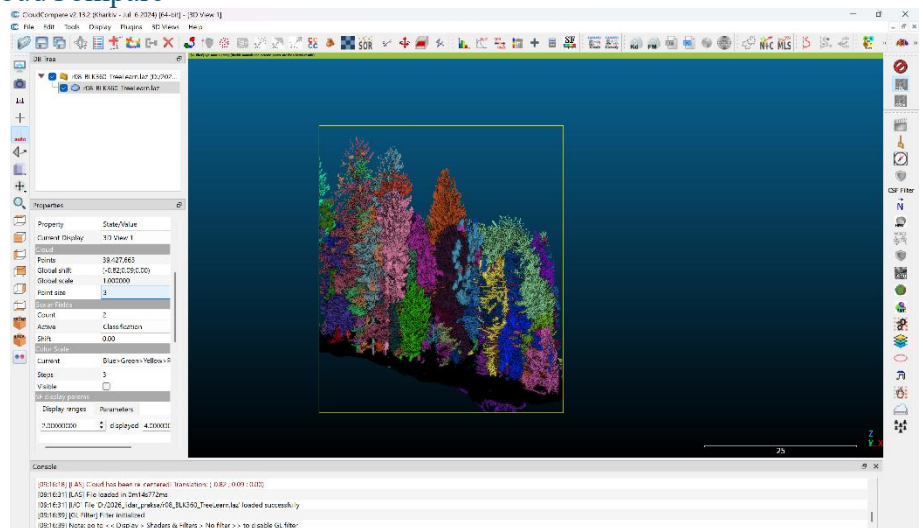


Image 10 Cleaned forest R08 site in CloudCompare

7.1. Creation of the code for API decoding, automatic download and database creation

With ChatGPT's help, I decoded the website's API with Python to download Slovenian government-owned parcels, allowing me to download all 730000 parcels in 20000-parcel batches with 1 prompt instead of manually downloading and selecting 20000 parcels each time, which was the download limit. Then I also coded a function to combine them into a 730000-parcel dataset, which I further added to the map in ArcGIS Pro for visual interpretation.

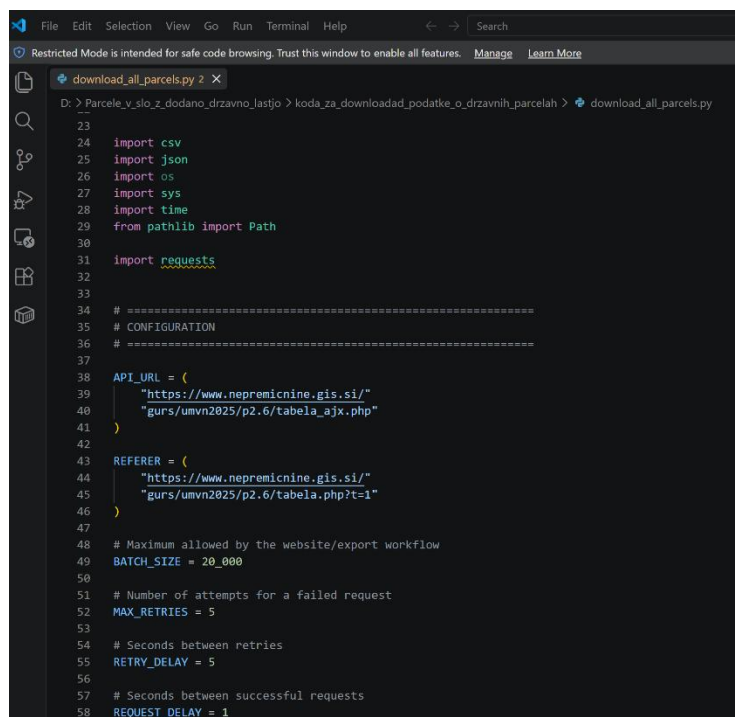


Image 11 Decoded API code for government-owned parcels database on the web

7.2. Map creation with government parcels

I created a map with parcels owned by the Slovenian government, which had attributes of ownership (Republic of Slovenia – RS, different ministries, government institutions...), type of land (Forest, Agricultural land, etc.), and some other attributes.

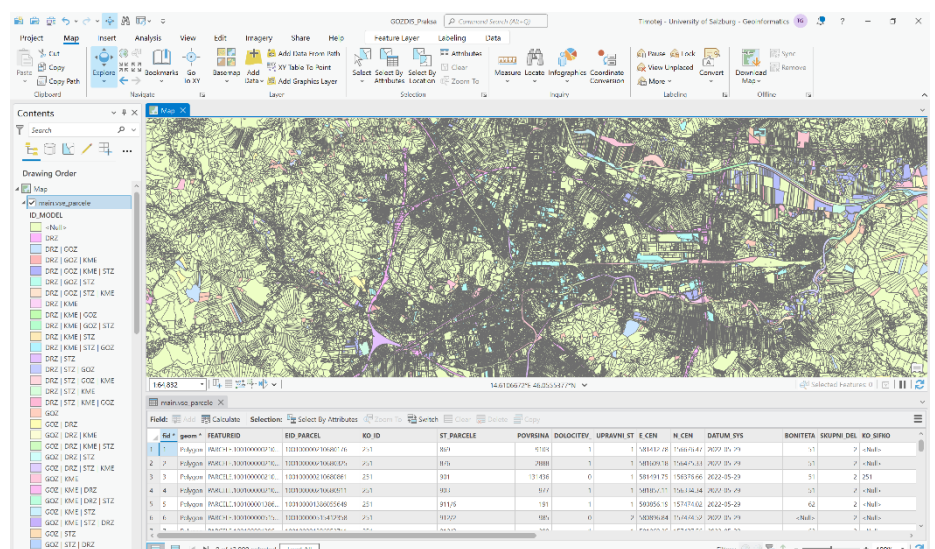


Image 12 Map with government-owned parcels in ArcGIS Pro

4) Notes regarding learning objectives

Acquired technical skills

- Knowledge of forest inventory, monitoring, and research methods, CloudCompare expertise (processing, cleaning, analyses, segmentation, etc.)
- Photogrammetry processing and softwares
- UAV mission planning and execution
- Increased familiarity with Python and R programming (with AI vibe coding)
- Knowledge of the database on Slovenian government parcels and more experience with mapping
- API decoding when possible and when not available (with AI)

Soft skills you developed

- Communication with different levels of researchers and employees at the Institute
- Researcher mindset, which gives me more motivation for doing a PhD
- Development of communication skills through interactions with forest owners and the public during fieldwork

Application of theoretical knowledge gained in MSc. AGI courses

- Basics of Python programming to understand the way it works, so I could vibecode with AI the research methods
- Basics of R (spatial statistics) for analyses and vibecoding the algorithms with AI
- API, databases, and mapping knowledge needed for creation of the map of Slovenia with government-owned parcels

Professional growth and insights

- I have grown mostly in my forestry knowledge. I did a Bachelor's in Landscape Architecture, which gave me basic knowledge of how a forest works, the species in it, and how and why it's very important to humanity. But I didn't know the methods, techniques, and research being conducted so that we can preserve and maintain it. This was the largest gain from the internship, and it was immediately shown after it when I went to BIP in Bergen on the UAV topic and had the most knowledge on the forestry topic.
- I also grew as a person by working with researchers and field measurement workers, which gave me 2 different types of communication
- I grew in software and programming knowledge and also a bit in project knowledge like Horizon Europe, ICP Forest monitoring, and other related projects
- I also grew in marketing and communications, as I had to negotiate the salary, which at first wasn't intended, but I managed to convince them of my worth and got paid.

5) A self-evaluation and reflection

My personal evaluation of the internship

- It was a very interesting and educational experience, as we didn't work with UAV, TLS, and other types of remote sensing data acquisition during the Master's program, and I think in some cases, when in need of more detailed data than satellites, it would be very useful to incorporate it into the program instead of some subjects that cover the basics of analysis, which is already expected from students to know from the Bachelor's or cover from supplementary classes if not.
- I didn't know what to expect once I started working in the office, as the only concrete task I got was point cloud segmentation and later on map creation, but they gave a lot of research ideas and what challenges/problems they are generally facing, so I could feel like a researcher and try to contribute to their work, which can be problematic in case of a disinterested student, but I really liked this approach as I came to acquire the knowledge and they answered whatever curiosity I had or helped when having a dilemma or problem, so I really enjoyed the experience

Strengths and weaknesses of the experience

- The main strength of the experience was that nearly everything I did required new knowledge that I acquired during the internship, and the mentor and other coworkers were very helpful in the process, so I can now say that I'm at least familiar with forestry and the processes and methods used for monitoring
- The mentor and others were very supportive and helped in making the learning enjoyable
- The main strength is also the largest weakness, so the knowledge I gained during the AGI Master's was not used, as we are learning more general applications for remote sensing and we use satellites only, which they have yet to use, as LiDAR is currently the best method for forestry

My career goals and alignment with them

My goals are:

- To start a start-up (I already started with that by joining Bismark and helping him develop the GeoCompliance platform) or work in an international company to gain more and more knowledge
- Bring back expert knowledge to Slovenia, so we can develop more in the field of Geoinformatics
- Potentially be a researcher and go for a PhD

Alignment with the goals:

- The internship at the Institute gives me credibility and sets roots for further collaboration in forest degradation and encroachment monitoring, which are part of GeoCompliance
- We don't have any STAC development, and API development for databases is also very slow, so I familiarised the coworkers with STAC, which could later be one of the projects to participate in after studies and returning
- By working at the Institute with a lot of researchers with a PhD and those on the way to it, I found what to expect, obligations, projects, the way PhD research works, requirements for it, obligations that come with it, and other knowledge about it. The internship also increased my overall interest in doing the PhD

My overall learning impact

- As mentioned, my main gain was the expert forestry knowledge. Besides that, I gained additional experience in doing surveying with UAVs and different types of LiDARs, and working with acquired point clouds, which was confirmed on BIP, as I knew more or less the most about forestry and how to work with the data. The only thing I might change is to have a more structured plan for exact tasks in case the laboratory gets a less motivated intern, but for me, I actually liked this free-to-research and learn approach more, as it gave me freedom and a researcher-like feeling. I also began to integrate into the team, and maybe it will become my workplace in the future with my satellite knowledge contribution.

6) Recommendations to future interns

Challenges faced during the internship

- The first challenge was arranging a place to stay in Ljubljana, as it's becoming a rather expensive place to live in
- Next was the immediate start with field measurements with no prior knowledge outside of papers on the topic, but I learned on the job as I was working, and the team leaders were very helpful and patient
- Additionally, everything I worked on was more or less new to me, so it also needed some after-work studying. Though that was not required of me, as I could learn slowly on the job, I wanted to learn as much as possible to catch up, so I could work more on the actual work instead of learning in the office
- Finally, the hardest challenge came not from the internship itself but from additional tasks I had during summer, as I worked on the project for the basics of software development class, did online meetings for the EIT JumpStarter program we competed in during the summer for start-up 2-4 times a week, and also had online courses in preparation for BIP in Bergen, so my weeks were very busy

Steps taken to overcome them

- Luckily for me, I did my Bachelor's in Ljubljana, so I had a lot of friends there where I could crash for these 6 weeks. I stayed at my friend's apartment in the centre of the city and took around 30 min by walking and bus to the Institute
- Thankfully, I read and progressed through the papers assigned to me by my mentor, dr. Anže Martin Pintar, so I at least somehow knew what to expect. I also did some individual research on the web and had some prior knowledge from Landscape Architecture. The lacking knowledge on the measurement methods and other field survey needs was acquired on the job, and they are somewhat similar to civil engineering, which I worked in last year as a project manager, so I got familiar with the methods pretty fast
- I'm a quick learner, especially when interested in something, so I took whatever knowledge they gave me, or if they didn't, I tried to acquire it myself, so overall, I think I took a lot from it
- This was one of the challenges, which I wish I didn't have. It's impossible to solve, so the only way to face it is by eliminating it from the beginning. For other interns who are very active with various projects and other hobbies, if they want to have at least some of the summer vacation, recover for the next year, and enjoy their Internship, I suggest they focus only on it and don't do external activities, otherwise, they won't have time to even sleep. It was a very stressful summer, and the internship itself worked for me as a kind of stress reliever, as working in the forest tends to bring inner peace

Lessons learned from these challenges

- Better start preparing early (6 months in advance), so you can still adapt to new problems that arise in time
- No matter the preparation, always expect the unexpected. I naively planned all the meetings, project work, start-up work, and internship, thinking it'll work out somehow, as internship hours were flexible if I needed to leave early occasionally, but then it stacked up too much, so I didn't have enough time for everything
- Forest is much more complex than it seems, and there are a lot of opportunities for research and invention of new methods

For future interns, I would recommend this internship to students interested in research, remote sensing, geoinformatics, and forestry applications. The Institute is involved in numerous European and international research projects and provides opportunities to gain experience with different remote sensing methods as well as field-based forest inventory and monitoring.

I would particularly recommend the internship to students who are interested in gaining practical research experience, learning new methods, and seeing how remote sensing and geoinformatics are applied in forestry research.