

3D Data Tools and Applications

Lecture Notes

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Learning outcomes

At the end of this lecture, the learner is expected to be able to

- Describe and choose different tools and applications for 3D data processing

Expected competences when entering the lecture

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BIRGIT – training on Building InfoRmation
models integrated with Geographical
InformaTion

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Summary

The lecture explains different tools and applications for 3D data processing. It covers commercial and free and open source.

Expected Workload

16 slides with course learning content, 2 hours



Revision History:

Revision	Date	Author(s)	Status	Description
0.1	2023-09-09	V. Cetl	Draft	Table of content
0.2	2023-09-20	V. Cetl	Draft	Main content added
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1.0	2024-01-15	V. Cetl	Final	Final after revision
2.0	2025-04-29	V. Cetl	Final	Updated EU logo and disclaimer. Edited by T. Näslund



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Introduction

CAD, BIM and GIS

There are mainly two software types used for handling spatial data. These are CAD software and GIS. CAD and GIS are two quite distinct systems in their goals, scope, and tools and standards used. The main difference between CAD and GIS is that CAD is a graphics program, used to design objects with a high level of geometrical detail (that may not exist), whereas GIS is a system using databases to model large geographic extents of the real world, such as urban, regional and (inter)national scale.

When used together, CAD and GIS can help improve the processes of the (construction) projects for which they are employed, by visualizing the designed objects in their environment, and help thus detect possible clashes with other existing elements in that location.

CAD has traditionally been used in the construction industry for the creation of two-dimensional designs, especially ones that require multiple components to fit together into a more substantial assembly, such as plant rooms.

CAD has rapidly been overtaken by BIM though, as BIM offers real-time visualisation and model-analysis that is better suited to the construction industry. The use of BIM allows architects, contractors, and engineers to work together throughout the project using the same database and building model. It goes way beyond a CAD system, as it can show critical facilities management systems such as electrical containment and mechanical cooling systems as well as roofs and windows. All of this information allows everyone involved in the project to be able to closely analyse the building at every step of the way, even before actual construction has started.

Commercial vs. Free and Open Source

Choosing a suitable software license is crucial when starting a new software project. The software license you opt for protects your software and controls the rules for collaboration on the software. Software license also ensures you adhere to restrictions of third-party components in your software.

Open source software is licensed software whose source code is publicly available for free. Open source software license allows anyone to learn, share, modify, and distribute your source code for free. Open source software is usually distributed for free. However, additional features and services may come at a cost.

Choosing an open source license has several advantages. Some of these are:

- **Community collaboration:** Choosing an open source license invites a global community of developers, designers, and users to collaborate on your project. You get to improve your software and fix bugs for free.
- **Rapid iteration:** With a larger pool of contributors, development cycles can become faster. Bugs are identified and fixed quickly, new features are proposed and implemented, and your project can evolve more rapidly than you could have imagined.



- Quality improvement: Changes to open source software are often peer-reviewed. The scrutiny of the open source community can lead to higher code quality. Contributors review the code base thoroughly to ensure best practices, identify vulnerabilities, and enhance overall reliability.
- Innovation: Open source fuels many modern-day inventions. Many technologies we rely on today are open source. Such an example is the internet. Choosing an open source license allows anyone to take your original idea and make something new from it.
- Mass adoption: According to GitHub's octoverse 2022 report, 90% of companies rely on open source software. Making your software open source means you are tapping into the population of businesses already using open source software.

Disadvantages of choosing an open source license.

- Limited support for users: Open source software often lacks dedicated support teams to help users resolve issues with the software. Contributors are usually more interested in building and shipping new features to users than in supporting users to resolve issues they encounter while using the software. Often open source software users would need to rely on discussion forums like stackoverflow to resolve an issue.
- Bad documentation: Open source software documentation often receives less attention. The software documentation is usually written by the community of developers working on the projects. Sometimes, the software documentation is adapted for users with technical knowledge and may be difficult to understand as a normal user with less technical knowledge.
- Security issues: Attackers can learn and find vulnerabilities in open software much easier compared to closed source software. Sometimes, the vulnerability might come from your software dependencies, which are exposed to attackers. In other cases, some developers might contribute bugs to your software to make it vulnerable and easy to exploit.
- Limited funds: Oftentimes, free open source projects not backed by big companies rely on crowdfunding or donations. With limited funds, it can be hard to invest in further development of your software.
- Project abandonment: Open source software contributors are more likely to abandon your software for other open source software, and it can become challenging to find new contributors for software whose core developers have stopped working on it.

Commercial software refers to software distributed to make profits. Commercial software is usually proprietary. Commercial software is licensed to users at a fee under an agreement that aims to protect the business and preserve the rights of the developer.

Advantages of choosing a commercial licensing model:

- Protects interest: Choosing a commercial license for your proprietary works protects your interest in the software. As mentioned earlier, commercial software licenses protect your business and preserve your rights. These licenses may include clauses to restrict certain activities, such as reverse engineering your software and redistributing copies of your proprietary works.



- Maintains ownership: Commercial license models often do not license ownership or the rights to modify and distribute a software copy to the end user. Commercial software licenses usually restrict others from using your source code.
- Maintains competitiveness: Distributing your software under commercial licenses gives you a competitive advantage over open source software. Some users prefer licensed software over open source software for several reasons, including security and support.
- Maintains control: Licensing your software to users gives you control over your software. Simply put, you control who gets access to your source code and who can work on your software. To an extent, you can also control how the end user uses your software.
- Develops funds: Licensing your software to end users generates revenue used to fund further research and developments. Funding gives you the advantage of employing people to help develop features and improve the software.

Disadvantages of choosing a commercial licensing model.

- Impending liability: Commercial software owners or companies are often liable for any damage caused by defects in their software. They're responsible for the data protection and privacy of their users and may be subjected to litigation if any issues arise.
- Software piracy: Commercial software is often pirated by users who do not want to pay for a license. Such activities affect your ability to raise funds from your software. Piracy could also harm your brand's identity in the long run.
- Manufacturer dependence: Commercial software usually offers little customization options for users. As a result, users tend to depend on the software manufacturer to fix bugs in the released software and add features they need in further updates.
- High costs: Commercial software can be expensive to build, maintain, and scale. Commercial software owners would usually need some funds upfront to build fully functional software for their target users.
- Slower development cycle: Commercial software projects are often developed by a small number of developers. With fewer people working on the software your development cycle would be much slower compared to a similar but open source software.

In this Lecture the main focus is on software for 3D data processing of surveying data.

Commercial software

Autodesk 3D CAD software

3D CAD, or three-dimensional computer-aided design, is a technology for design and technical documentation, which replaces manual drafting with an automated process. Used by architects, engineers, and other professionals, 3D CAD software precisely represents and visualizes objects using a collection of points in three dimensions on the computer. Autodesk has a broad portfolio of 3D CAD software programs for drawing and modeling to help people explore and share ideas, visualize concepts, and simulate how designs will perform before they are made.



AutoCAD Map 3D is an Autodesk product used to create, maintain, and communicate mapping and GIS information within the AutoCAD drawing environment. It is a model-based GIS mapping software that provides access to CAD and GIS data to support planning, design, and management (Figure 1).

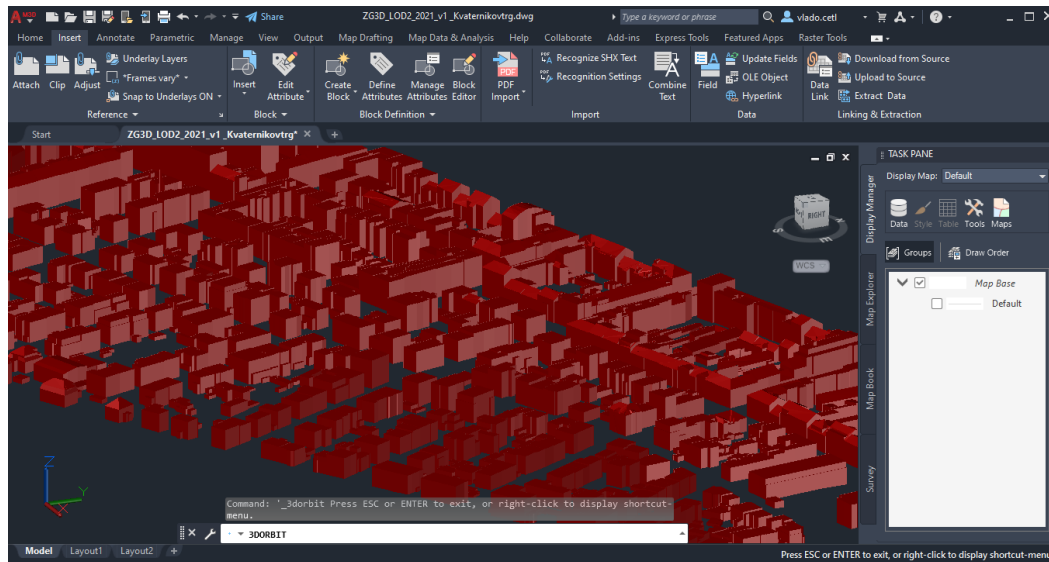


Figure 1 3D Buildings in AutoCAD Map 3D

ESRI ArcGIS Pro allows to explore, analyse, and symbolize data in 3D. ArcGIS Pro, the powerful single desktop GIS application, is a feature-packed software developed with enhancements and ideas from the ArcGIS Pro user community. ArcGIS Pro supports data visualization; advanced analysis; and authoritative data maintenance in 2D, 3D, and 4D. It supports data sharing across a suite of ArcGIS products such as ArcGIS Online and ArcGIS Enterprise, and enables users to work across the ArcGIS system through Web GIS.

Trimble RealWorks is a point cloud processing and analysis software for 3D laser scanning professionals. It includes automated tools and point cloud specific workflows allowing users to import point cloud data from virtually any source, then quickly process, analyse and create high quality customer deliverables.

Leica Cyclone MODEL is a powerful module providing a total solution for working with point clouds to create 2D and 3D deliverables. Among its advantages, Cyclone MODEL boasts powerful visualisation and point cloud navigation plus the industry's most complete tool set. These tools cover a wide range of applications in engineering, construction, asset management, heritage, forensics, and other areas.

Bentley has several products available. The most known CAD is MicroStation. It is used to model, document, access, and view architectural, engineering, mapping, construction, and operations design information with the power and flexibility needed for any size project. OpenBuildings Designer is another product used to design, analyse, document, and visualize buildings with software made for architects and engineers.



Graphisoft ARCHICAD is software used widely by architects, designers, engineers, and urban planners for a comprehensive project's design. ARCHICAD can render 3D models of everything from office park landscaping projects to entire university campuses. But one of the main advantages of ARCHICAD is that it is an open BIM. This means that BIM data can be read and written in Vendor Neutral Format (IFC). This allows seamless data exchange with other project partners regardless of other design tools.

Free and Open Source software

FreeCAD is an open-source parametric 3D modeler made primarily to design real-life objects of any size. Parametric modeling allows to easily modify design by going back into the model history and changing its parameters. It is designed to fit a wide range of uses including product design, mechanical engineering and architecture. It supports modern Finite Element Analysis (FEA) tools, experimental CFD, dedicated BIM, Geodata or CAM/CNC workbenches and a robot simulation module.

QGIS is a free and open source Geographic Information System (GIS). It allows users to create, edit, visualize, analyse, and publish geospatial information (Figure 2). It has support for raster, vector, mesh, and point cloud data in a range of industry-standard formats. QGIS supports raster, vector and mesh layers. Vector data is stored as either point, line, or polygon features. Multiple formats of raster images are supported, and the software can georeference images.

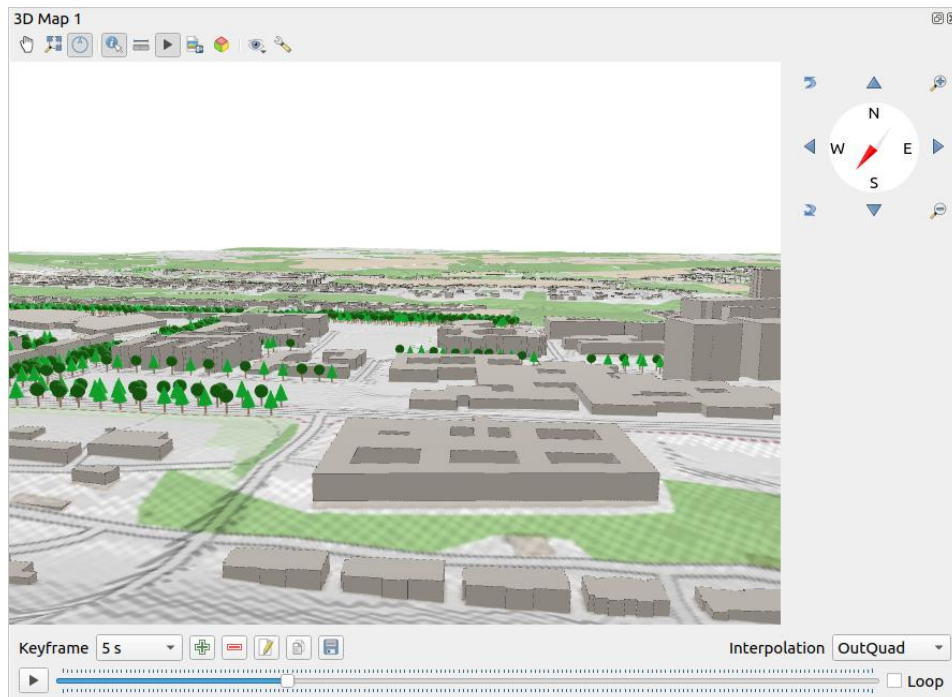


Figure 2. QGIS

Open3D is an open-source library that supports rapid development of software that deals with 3D data. The Open3D frontend exposes a set of carefully selected data structures and algorithms in both C++ and Python (Figure 3).

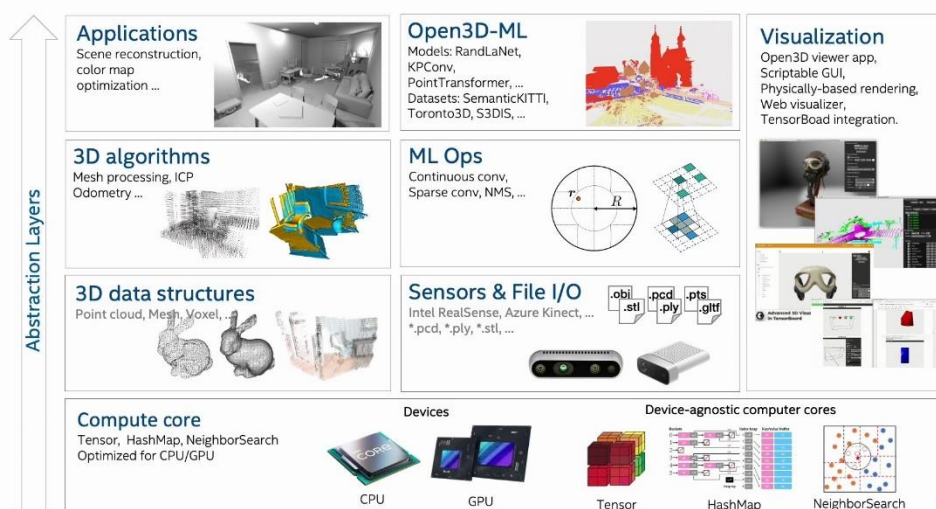


Figure 3. Components of Open3D

BIMVision is a freeware IFC model viewer. It allows to view the virtual models coming from CAD systems like Revit, Archicad, BricsCAD BIM, Advance, DDS-CAD, Tekla, Nemetschek VectorWorks, Bentley, Allplan and others without necessity of having commercial licenses of these systems or having each of particular vendor's viewer.

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