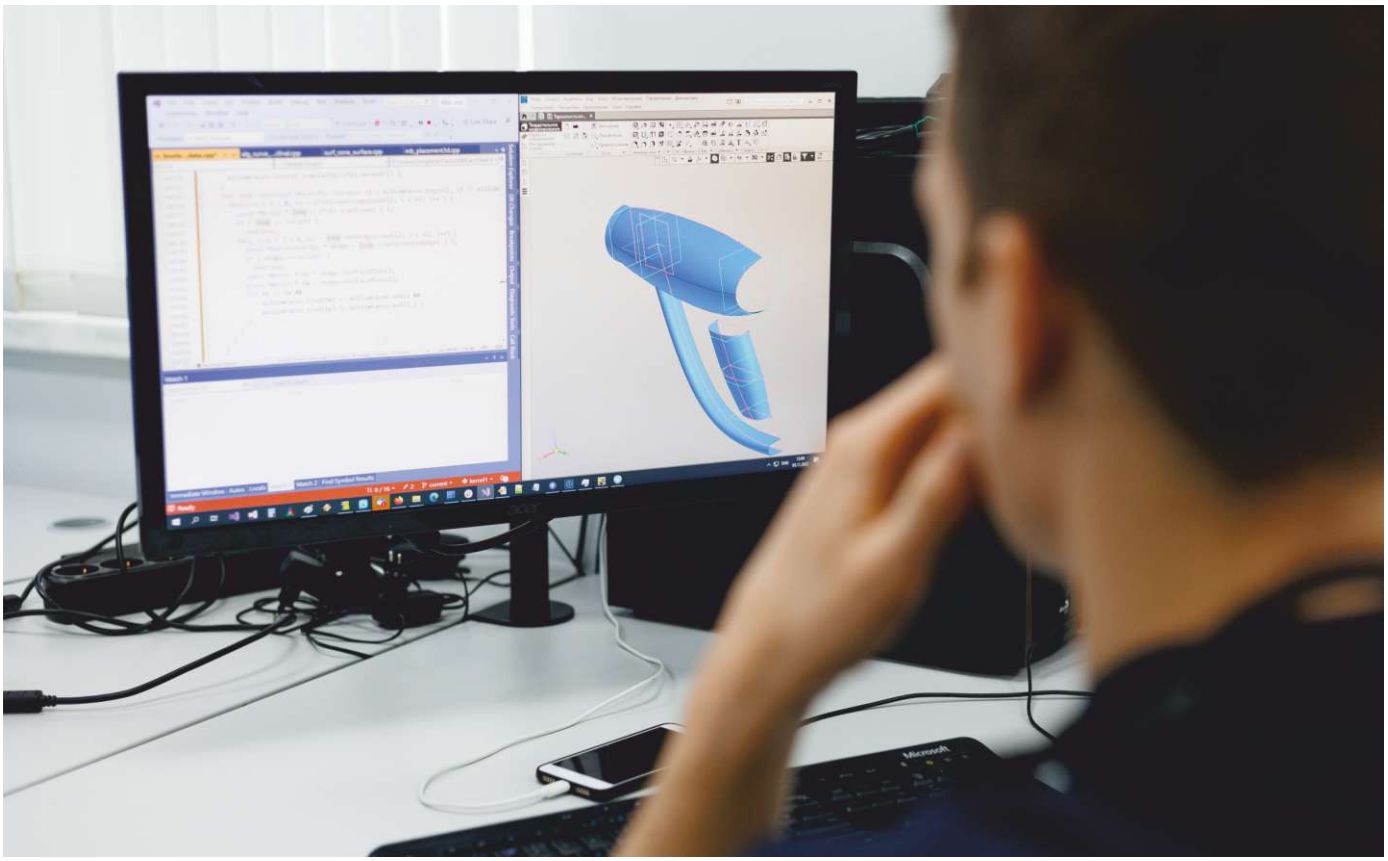
C3D Toolkit

The Most Complete Solution
for Developers Creating
Innovative 3D Software

C3D Labs

About company



The decision to write its own geometric kernel was made by ASCON in 1995. It was the beginning of creation of KOMPAS-3D three-dimensional modeling system. The commercial release of it took place in 2000. For a long time the kernel was developed as part of the KOMPAS-3D system to meet the needs of mechanical engineering and construction design.

In 2012 ASCON Group spun off its geometric modeling division as a new company - C3D Labs. Its role was to convert the 3D kernel into a software development kit (SDK), to turn it into a standalone product, and to market it internationally. The result is the "C3D Toolkit," built on renowned Russian mathematics and with nearly thirty years experience in working with advanced CAD components.

C3D Toolkit components are now used by more than 50 companies in 14 countries around the world. As customers today develop projects based on our C3D Toolkit, we work closely with them to ensure they have what they need. We are regularly praised for our wide range of functionality, reliable support, fast feedback on requests and flexible licensing terms, which we customize for each customer:

+ commercial license for vendors;
+ special license terms for startups;
+ corporate licenses for enterprises;
+ academic programs for universities.

C3D Toolkit

C3D Toolkit is a software development kit (SDK) responsible for constructing, editing, visualizing and converting geometric models

C3D Toolkit allows to construct geometric models, perform geometric calculations, and create connections between the elements of geometric models. C3D Toolkit allows to handle geometric models made in third-party applications and performs export models to other 3D systems.

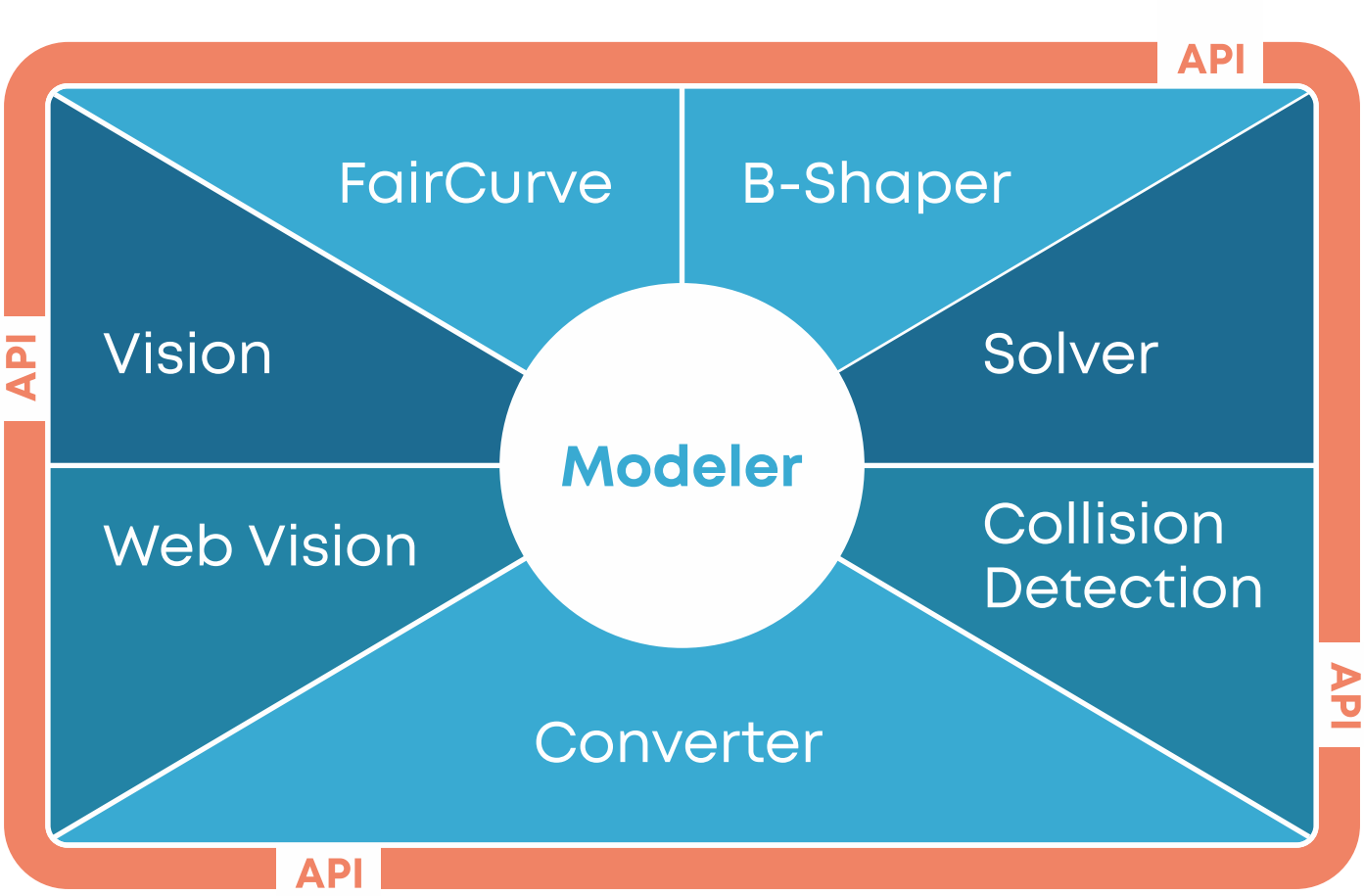
Computer-aided design (CAD) systems are the most widely known software products that require tools like C3D Toolkit for their development. Such tools are also used in computer-aided manufacturing (CAM), and engineering (CAE).

CAD/CAM/CAE systems all use the same approach to geometric modeling. A model contains:

+ describing the shapes of modeled geometric objects;
+ maintaining relations between model elements;
+ recording the history of model construction;
+ adding attributes to geometric model elements.

In addition to geometric modeling functionality, C3D Toolkit offers advanced model rendering capabilities in the graphical scene using a powerful visualization engine. These visualization capabilities can be used to develop both desktop and web applications.

C3D Toolkit comprises of a dynamic-link library, a demo application with complete source code, technical documentation, and additional support files for compatibility with many integrated development environments (IDE).



The amphibious aircraft «BOREY»

Request
C3D Toolkit trial version

C3D Modeler

The reconstruction of the aircraft «Po-2»

Implement efficient 2D and 3D geometric modeling tools in your applications

C3D Modeler performs all geometric calculations necessary for constructing 2D sketches and 3D models. It uses the boundary representation (B-rep) method in defining shapes and building geometric models based on 3D bodies. For composing 3D bodies, it uses surfaces and curves. It groups the resulting 3D bodies into building blocks in advance of creating more complex assemblies.

In addition to B-reps, C3D Modeler supports polygonal representations of geometric models. The kernel builds polygonal 3D models through triangulation. The overall structure is precisely the same for both boundary-representation and polygonal models, but polygonal models usually consist of approximated plate- and polygon-shaped items, and so are convenient for making calculations and generating visualizations.

As bodies and wireframes are constructed into geometric models, they generate individual build logs. The system records all of the methods employed, sequences taken and data inputted. The logs make it easier to edit the geometry later and then rebuild models with new parameters. Detailed information about objects' geometry (in the form of surfaces, curves and points) are kept in topological elements of model's objects such as faces, edges and vertices. Additional information for every object's item or object as whole can be kept inside them in the form of attributes.

Tested & Validated Daily

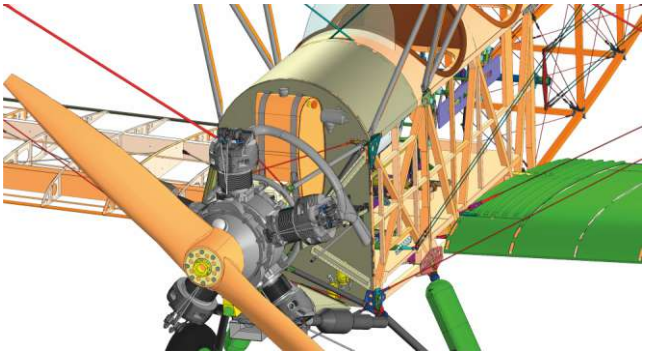
To enhance C3D Modeler quality, we employ a number of testing tools and methods. These include static code analyzers, unit testing, performance testing, automatic distribution of package assemblies and automated regression testing. To test our solid body and surface construction algorithms, we use a specially created database that contains over 500,000 of 3D models. Every day, we automatically compile the geometric kernel, as well as perform unit test checks, model rebuilding testing, flat projection construction testing and data conversion testing.

Expandable API

An essential feature of the C3D Modeler is its open architecture, which allows you to extend it beyond the standard function set. You create custom objects that are specific to your application by easily inheriting them from C3D Modeler's standard primitives. When this is combined with our safe update system (which runs independently of existing code), you are assured that version updates will not affect the functions you extended.

Integration with the ODA Platform

C3D Modeler for ODA provides direct integration between the ODA Platform and C3D Modeler, allowing ODA clients to access solid modeling functionality using ODA's standard "OdDb3DSolid" API. C3D Modeler for ODA quickly extends the basic functionality of a CAD system. It achieves this through a list of ready-to-use constructing methods and functions, as well as specific guidelines on geometric modeling and technical documentation on working with the kernel. This geometric kernel provides you with basic features necessary for rapid development of 3D modeling systems, and it offers compatibility with proprietary 2D modeling systems.



C3D Modeler applications:

+ wireframe modeling;
+ surface modeling;
+ solid modeling;
+ direct modeling;
+ sheet metal modeling;
+ polygonal mesh modeling.

Key Functions Supported By C3D Modeler For Basic Surfaces And Curves:

+ bends;
+ booleans;
+ direct edits;
+ fillet and chamfers;
+ louvers;
+ reinforcing ribs;
+ sections and cuts;
+ shells with drafted faces;
+ stamping;
+ symmetry;
+ thin-walled solids.

C3D Modeler supplies the following types of geometric calculations:

+ calculating surface areas, volumes, and properties of mass inertia;
+ building planar projections;
+ generating surface triangulations.

C3D Solver

Define dimensions and constraints to create connections between geometric elements

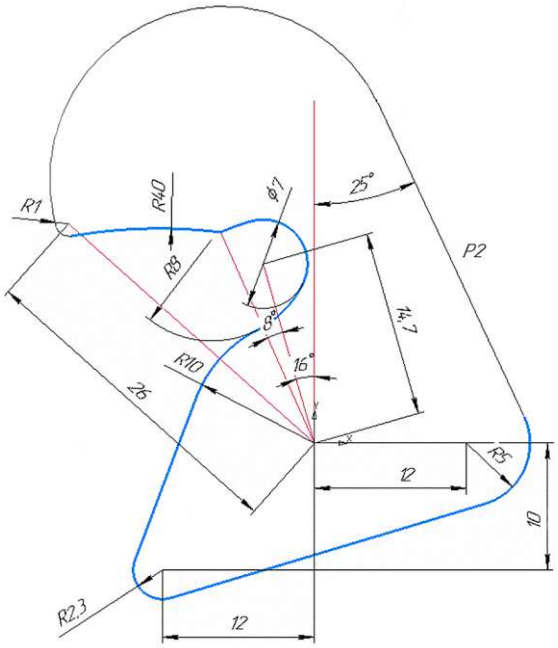
Constraints represent all relationships among geometric objects in 2D/3D applications. These include dimensions that define angles and distances and logical constraints that define concepts like a coincidence, parallelism, perpendicularity, tangency, etc.

Using C3D Solver, developers incorporate dimensions and logical constraints in their applications to create connections between geometric objects in 2D and 3D models. C3D Solver maintains constraints as users make changes to the geometry. For example, when users modify dimensions, C3D Solver instantly recalculates all depending geometric objects and maintains existing relationships.

Our C3D Solver reduces 2D/3D modeler development costs significantly, as the constraint engine is ready-made for you. You can plug the C3D Solver in at any stage of your product development cycle.

High Performance
C3D Solver was written for performance, and we are always working at finding new ways to further speed up the code by simplifying the math, dividing analysis into sub-tasks, using large sparse matrices, and so. One key productivity boost, for instance, is the Planner, which extracts from the entire set of constraints a smaller subset sufficient to do the job.

Live Constraint Verification
Splitting the initial model of constraints into sub-tasks not only improves the speed at which the solution arrives but also identifies a wide variety of situations in which the built-in diagnostics avoid contradictions in the system of constraints. This assists users in constructing high-quality parametric models without avoiding contradictions in the system of constraints.

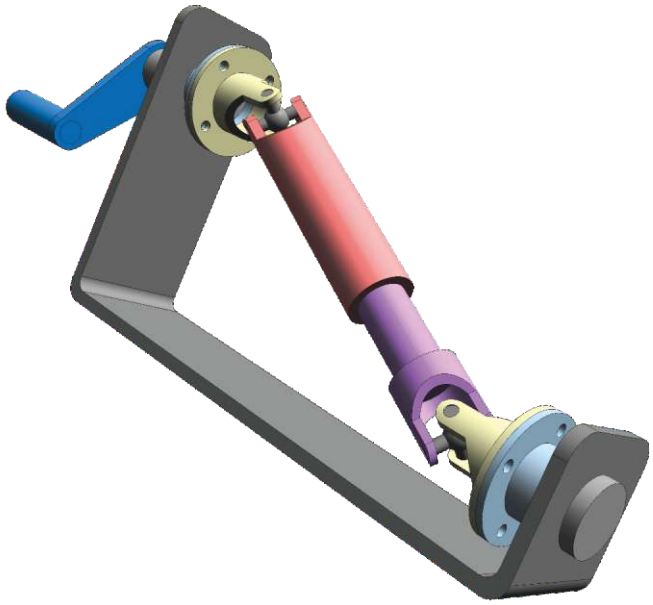


The demonstration of dragging on a sketch

Browser-Ready
Porting the 2D solver to JavaScript unveils new application possibilities for C3D Solver, such as the development of cloud solutions for doing online sketches, interior planning with driving dimensions, and so on. This makes it possible to quickly implement a 2D drawing editor in a browser complete with dimensioning and constraints. Perhaps most significantly, the 2D solver for JavaScript is a platform-independent solution.

C3D Solver Applications:

+ creating 2D parametric sketches with driving dimensions and constraints;
+ positioning bodies in assemblies using constraints and dimensions in 3D;
+ rebuilding changed models while keeping previously defined constraints intact;
+ modeling planar and spatial mechanisms;
+ creating 3D wireframes.



Cardan joint

Dimensional Constraints in C3D Solver:

+ dimensions by type of calculation: driving, interval and variable dimensions;
+ dimensions in length units: distance, radial and diameter, curve length;
+ angular dimensions.

2D and 3D Functions:

+ creating and solving parametric constraints;
+ manipulating geometry;
+ dragging geometry;
+ satisfying constraints;
+ analyzing degrees of freedom (2D only);
+ clustering rigid sets (3D only);
+ journaling API calls.

Logical Constraints in C3D Solver

General:

+ coincidence;
+ fixed geometry;
+ parallelism;
+ perpendicularity;
+ reflection symmetry;
+ tangency.

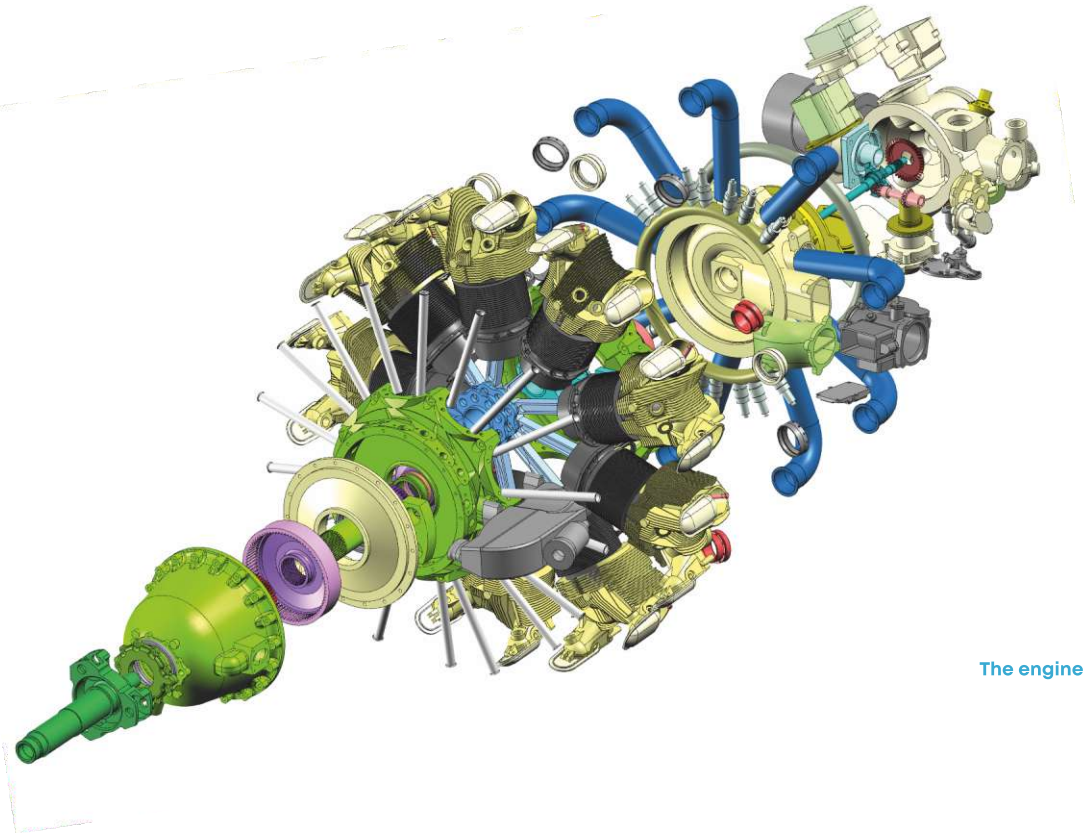
2D Constraints:

+ alignment;
+ point on a curve;
+ equal length;
+ equal radii;
+ fixed length and direction;
+ fixed spline derivatives;
+ horizontal position;
+ vertical position;
+ bisector;
+ smooth G1 and G2 transitions;
+ offset curves.

3D Constraints:

+ coaxiality;
+ user-defined dependencies;
+ linear and angular patterns;
+ mechanical transmissions;
+ cam mechanisms;
+ rack and gear mechanisms.

C3D Vision



The engine «Ai-14R»

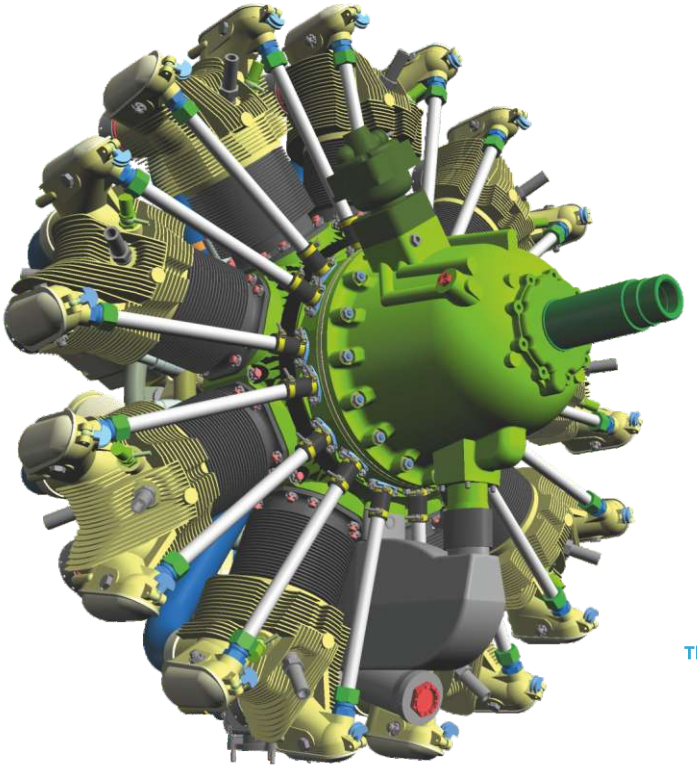
Manage visualization capabilities of 3D geometric models in your engineering software

Using C3D Vision, software developers can customize visualization parameters of displayed 3D geometric models in their applications. C3D Vision allows developers to control rendering quality of geometric models by using advanced math, software and hardware means so that It improves large-assembly performance.

C3D Vision yields new opportunities for managing 3D scenes, animations, provides ready-to-use tree for 3D models and interactive tools for scene manipulation. All of these functions became an integral part of modern design products.

C3D Vision applications:

+ parallel data processing;
+ dynamic scene rendering;
+ efficient use of video adapters architecture;
+ expert multi CPU support;
+ wide range of video cards supported.



The engine «Ai-14R»

Developed for CAD/CAM/CAE/BIM

Our visualization engine is intended for CAD and similar applications. C3D Vision includes tools essential for building new applications quickly:

+ objects and primitives searching engine;
+ mouse and other pointing device input conversions into scene coordinate systems;
+ manipulators for direct modeling;
+ visualization of linear, radial, and angular dimensions.

Integrated Environment

C3D Vision is closely integrated with the C3D Modeler geometric kernel. To automatically generate scene graphs based on mathematical models, developers now need to call just one function. There is the option to calculate polygonal models for visualization objects (based on mathematical representations of the geometry) in synchronous or multithreading mode. Searching objects and drawing is also performed in either of these two modes.

High-Performance Code

To ensure high performance when working with large models, C3D Vision provides hardware acceleration and smart rendering algorithms. C3D Vision calculates the visibility of scene objects by specifying object sizes in pixels on the screen, as well as calculating the visibility of objects off-screen. LOD (levels of details) of scene objects can be set according to their distances from the camera.

C3D Converter

The air boat «Skat»

Import and export models and attributes into and from your applications

C3D Converter reads and writes 3D models in CAD-neutral formats. It handles geometry, authoring info, part names and IDs, and PMI (product manufacturing information).

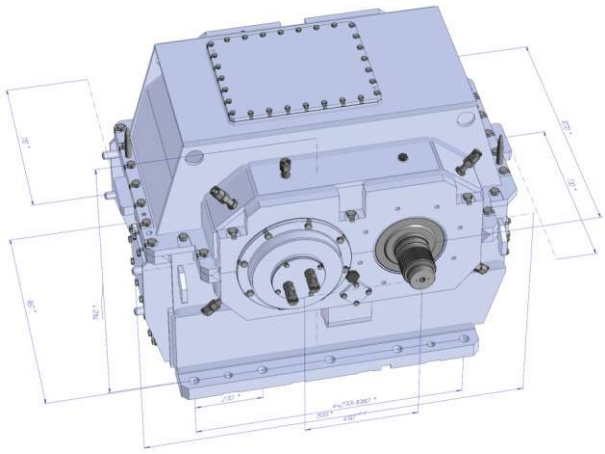
C3D Converter is eminently configurable, such as in controlling automatic stitching of surfaces into shells, and filtering entities by type. Refer to the documentation for all settings currently implemented. A built-in debug functions allow to prepare and send back problematic data to C3D Labs confidentially for analysis and further improvement of the converter; your files are not shared with anyone.

C3D Converter supports memory operations in those cases when reading and saving CAD-neutral formats would incur performance issues. For better performance, our STEP and Parasolid converters employ multithreading.

Ten Formats Supported

C3D Converter supports ten formats to export and import geometry. The choice of exchange format depends on factors such as the specific of model representation in different formats and demands by end-users. We provide an application area for each format to offer the most appropriate solution for model exchange.

Buggy, the car



The multiplier

File Import Plugins
We also support plugins, which are a fast and efficient way to import 3D models not supported directly by C3D Converter.

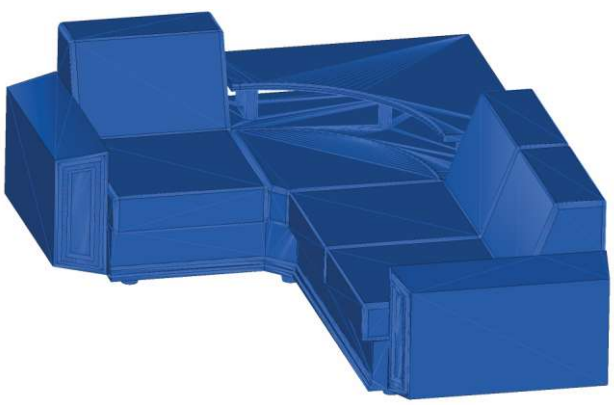
C3D Converter reads and writes file formats:

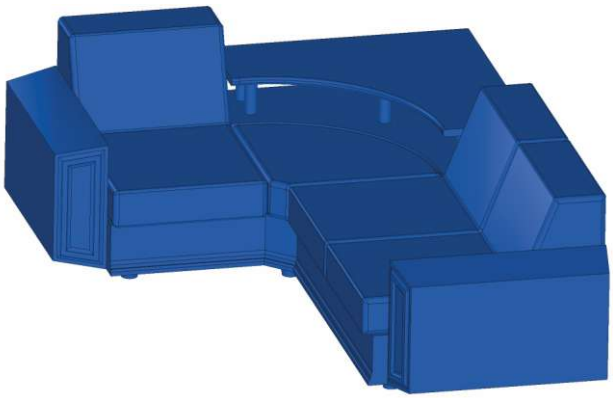
+ C3D (unified with the other formats);
+ STEP with PMI (AP203, AP214, and AP242);
+ IGES;
+ ACIS SAT;
+ Parasolid X_T, X_B;
+ JT;
+ VRML;
+ STL;
+ OBJ (reading only);
+ NX (reading only).

Depending on the capabilities of the format, the following are transmitted:

+ shape in various representations (volumetric objects, surfaces, curves, points);
+ assembly structure, including deep nesting and reference geometry;
+ technological information — annotations and numerical specifications (PMI, GD&T);
+ attributes — visual, named in name-value representation.

C3D B-Shaper





«Sofa», as a component
of the model «Dom na ostrove»

Add the capability to handle polygonal model reverse engineering to your applications

The C3D B-Shaper converts polygonal models into solids with boundary representation. Boundary representation is the basis for 3D modeling in most modern 3D engineering applications. Emergence of models in polygonal representation is promoted by the spread of 3D-scanning technologies,development of control and measuring equipment, necessity to process results of generative design

C3D B-Shaper Converts Polygonal Meshes Into B-rep Models:

+ automatic or interactive mesh segmentation: surface approximation by polygons with adjustable accuracy;
+ B-rep model generation.

Proprietary Math
C3D B-Shaper uses our unique algorithm to subdivide meshes into subsets that are then converted into faces. Subsets are recognized as either elementary surfaces (plane, cylinder, cone, sphere, torus) or free surfaces (NURBS). The module generates intersection curves between adjacent subsets, which then become body edges.

Boosted Performance
When handling multiple imported polygonal models, C3D B-Shaper accelerates the analysis and simplifies visualization which results in better overall performance.

Adjustable accuracy
The accuracy of C3D B-Shaper's results is specified by a maximum-acceptable deviation of the reconstructed surface from the vertices of the underlying polygonal mesh.

«Guitar», as a component
of the model «Dom na ostrove»

B-Shaper is built on C3D Labs' proprietary algorithms and makes polygonal models useful to many kinds of applications:

+ reverse engineering parts from 3D scanner files;
+ converting models from online product catalogs;
+ post-processing the output from CAE operations.

C3D B-Shaper's API provides the following capabilities:

+ control surface recognition accuracy through the SetTolerance method;
+ segment polygonal meshes with SegmentMesh;
+ edit segments using UniteSegments, SplitSegment, and other methods;
+ reconstruct segments in certain types of surfaces with FitSurfaceToSegment;
+ generate B-rep models using CreateBRepShell.

C3D FairCurveModeler

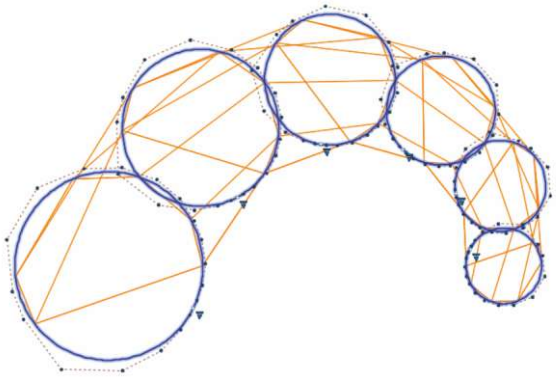
There is demand today for CAD systems advanced enough to model complex curves and surfaces, such as car bodies and high-end consumer products. Even though a CAD system could model Class A curves and surfaces, this does not mean it can provide modeling of functional curves of proper quality according to the criteria of smoothness

We took up the challenge by implementing the modeling of top-quality curves and surfaces. Our geometric modeling system offers the C3D FairCurveModeler component, which is designed to model so-called Class F curves that meet the following requirements:

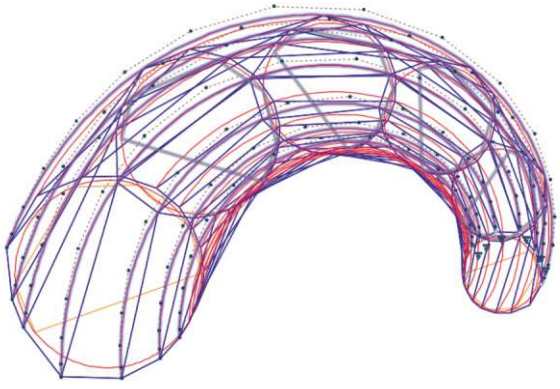
+ the minimal number of reference points of a modeled spline trajectory and a high, not lower than the 4th, order of smoothness;
+ smooth torsion of a spatial curve;
+ limiting the maximal value of the curvature and the rate of its change;
+ minimization of the potential energy functional.

Class F curves are modeled with methods provided by our C3D FairCurveModeler. The methods generate high-quality curves that meet exacting smoothness criteria, and so offer the following advantages:

+ sustainable shape generation (isogeometricity);
+ invariance to affine transformations and projections;
+ the possibility of isogeometric approximation of analytical curves that preserves their basic features;
+ flexible and various API.



A wireframe of the S-polygons of the B-curve generatrices



A wireframe of the S polygons forms an S-frame of the B-spline surface

C3D Web Vision

The maisonette

Control 3D visualization of your Web applicatiol

Web Vision Benefits

C3D Web Vision gives developers of web software a chance to break new ground. Accelerate the development of web applications, control visualization capabilities, load large assemblies.

C3D Web Vision provides powerful 3D graphics for BIM, AEC, PLM, CAM, and EDA applications. It also opens up a range of new possibilities for 3D scene management, a 3D model tree, interactive scene manipulation and more.

C3D Web Vision is used for the following tasks:

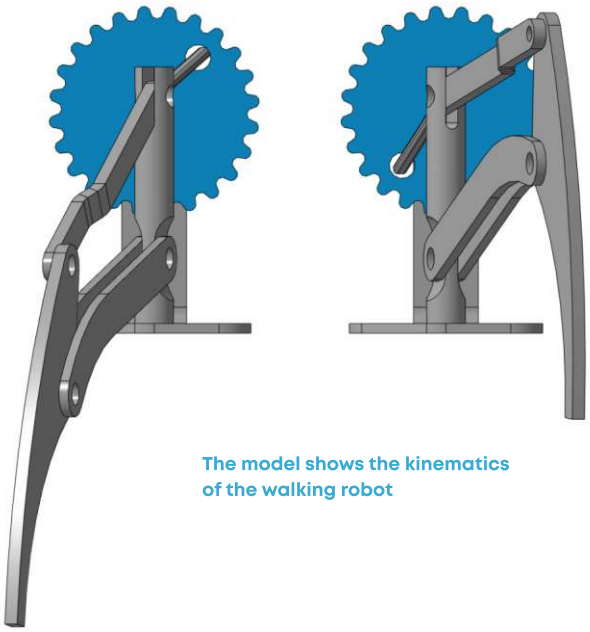
+ processing large amounts of data generated by 3D models;
+ preventing the loss of rendering quality when scaling a 3D model.

Integrated Environment

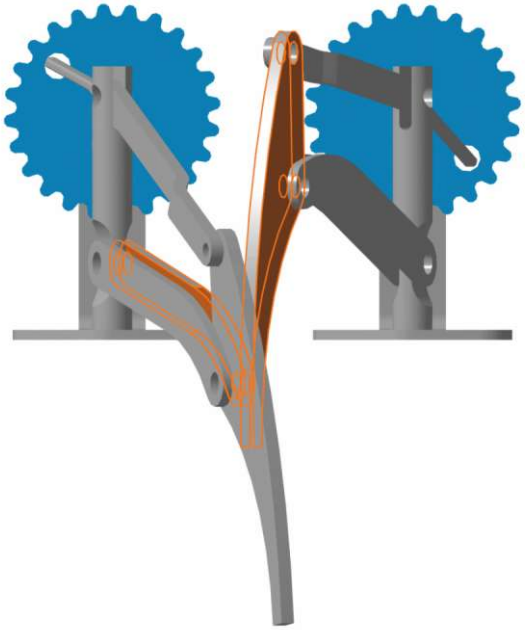
C3D Web Vision is closely integrated with our other components:

+ C3D Converter – to read third-party formats;
+ C3D Modeler – to generate model triangulation for Web Vision to render a visual representation based on it.

C3D Collision Detection



The model shows the kinematics of the walking robot



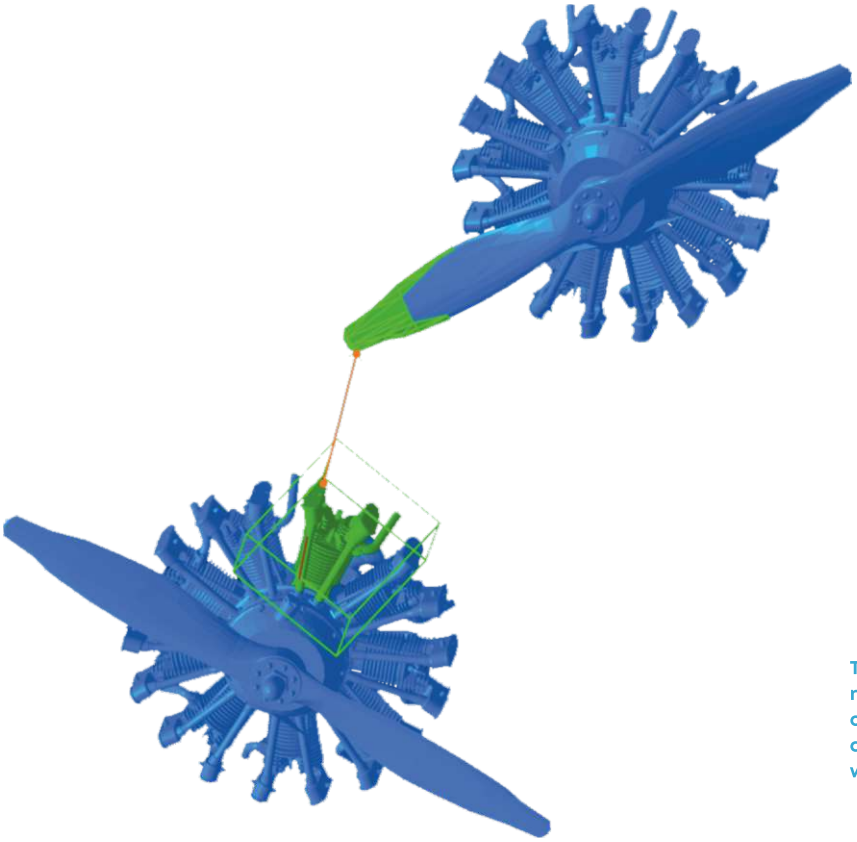
Rapid collision detection and gap measurement for solid models, supporting both exact B-rep geometry and polygonal mesh approximation

Integrity of Assemblies Guaranteed
All assemblies made of parts in CAD models should be free of collisions, a form of unwanted design error. With our Collision Detection, your CAD and BIM applications check assemblies for collisions, even at early stages, to ensure designs are free of errors. Collisions are identified as areas of contact and volumes of overlap. Early detection of collisions reduces costs during later design phases and especially when it comes to constructing physical products.

Collision Detection's distance measurement function checks user-specified gaps between parts and sub-assemblies.

Static and Dynamic Operations
Distance and clearance measurements, along with collision detection, are available for both static assemblies and dynamic sequences, in which users move parts of mechanisms interactively.

Exact and Approximate Analysis
Our Collision Detection supports both B-rep (exact geometry) representations and inexact polygonal meshes. With B-reps, Collision Detection delivers the exact results. If accuracy requirements are not high, you can use geometric objects in polygonal representation.



Two models of the aircraft piston radial engine. The algorithm applied calculates a pair of triangles and points on them with a minimum distance

Fast Performance

Our Collision Detection quickly identifies entities that collide with one another, if any. To improve performance, the detector applies bounding volume hierarchy (BVH) technology to individual solids and sub-assemblies. To further boost performance, it optimizes memory management, such as when assemblies contains multiple instances of the same components.

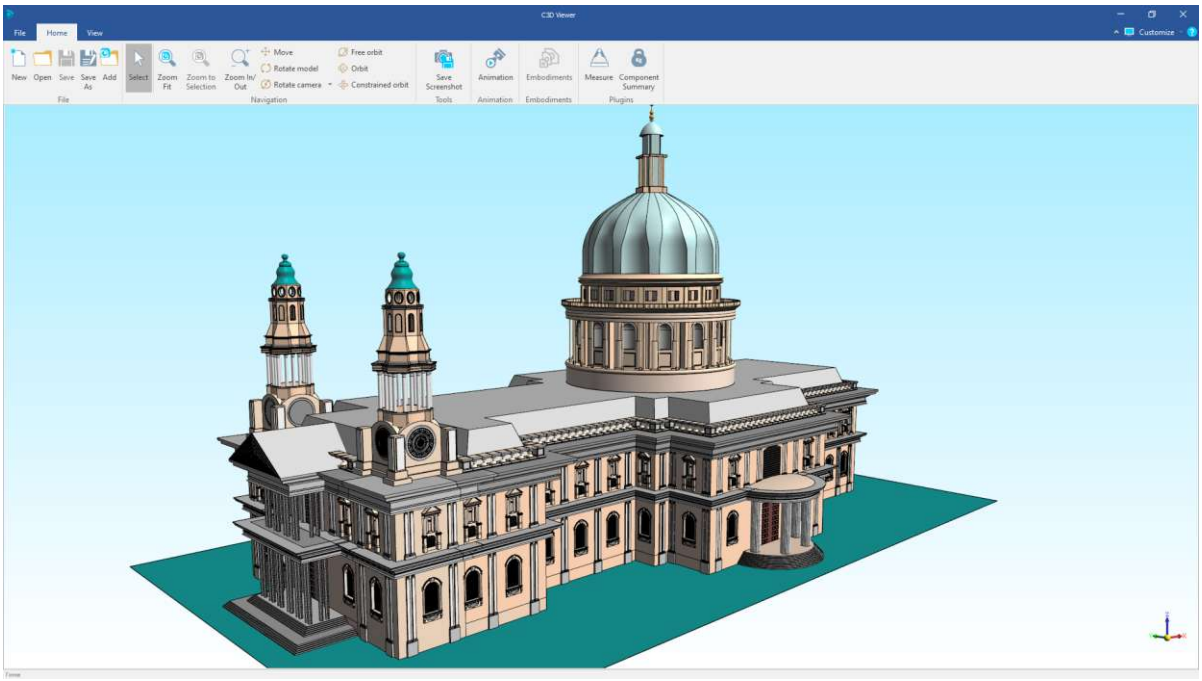
Flexible Detection Options

Collision Detection can be configured to limit the scope of detection, such as finding all collisions, or just collisions of sub-assemblies without additional details. Specific solid pairs can be excluded from collision checks. As well, users can select any of a range of available detection strategies.

Scene Structures

Scenes consist primarily of solid shells that can be arranged hierarchically. The data structure of our Collision Detection accounts for multiple shell instances. As well, it can merge bodies into groups to treat several solids as a single one, so that collisions are detected between groups and not within the groups, further saving time.

C3D Viewer



St Paul's Cathedral in London

C3D Viewer is an easy-to-use application for 3D geometry visualization that allows to read models from standard CAD formats and save them in C3D format. It is based on the functionality of C3D Modeler, C3D Solver, C3D Vision and C3D Converter that are components of the C3D Toolkit

Geometric Import and Export:

+ reading models from the following formats: C3D, JT, STEP, X_T, X_B, SAT, IGES, STL, VRML, OBJ;
+ loading an array of models into one session;
+ saving models to C3D format.

Navigation Functions:

+ camera rotate;
+ model rotate;
+ orbit rotate;
+ pan;
+ standard views;
+ zoom/fit.

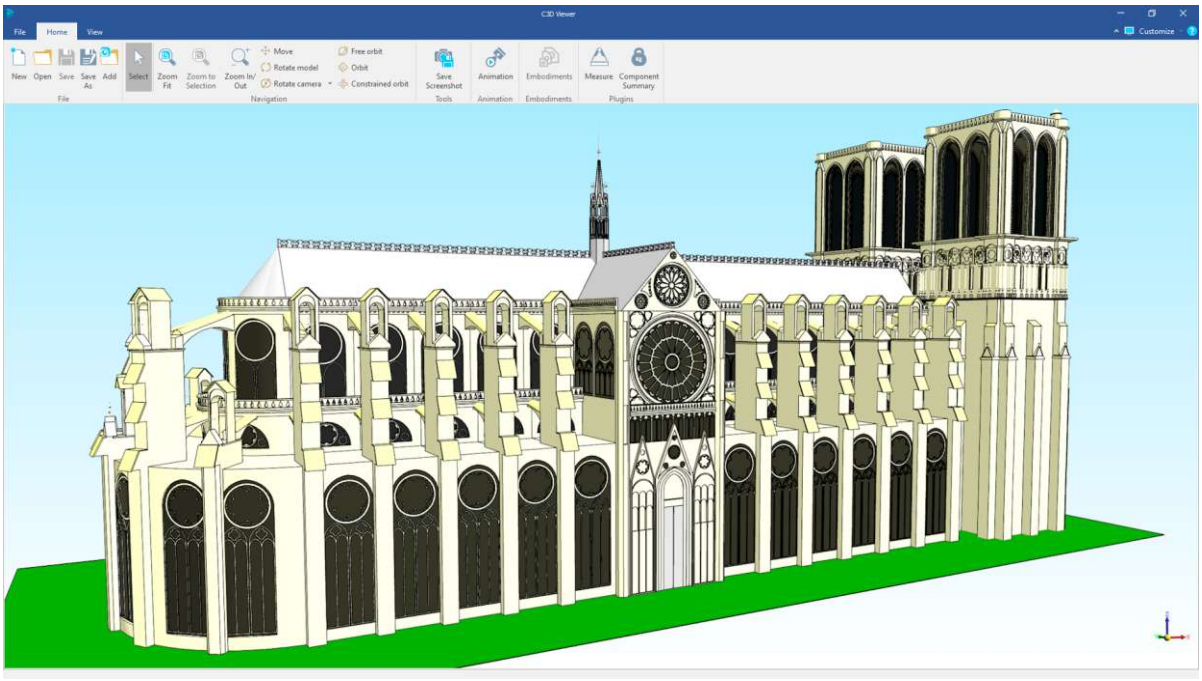
Animation Function

The viewer animates C3D models containing constraints through the driving angular dimension. The animation speed is adjustable.

Save As Raster Images:

+ JPEG;
+ TIFF;
+ BMP;
+ PNG.

Download
C3D Viewer for free



Notre-Dame de Paris

Rendering and Performance Functions:

+ parallel /perspective projections;
+ shaded / wireframe / hidden line removal modes.

Setting performance options:

+ hiding edges;
+ anti-aliasing;
+ pixel/frustum culling;
+ shaded-edge rendering.

C3D Viewer Standard Edition is a stand-alone desktop application:

+ free to use;
+ support for Windows 32/64-bit, Linux;
+ interface language: English, Russian.

Enterprise Edition

C3D Viewer is available as an embedded 3D visualization tool with a simple API. Developers can quickly add C3D Viewer to their products.

Enterprise Edition of C3D Viewer includes an additional functionality:

+ saving 3D models in JT, STEP, X_T, X_B, SAT, IGES, STL, VRML formats;
+ adding user annotations to 3D models;
+ open API for adding the functionality to other software systems;
+ measurement and calculation tools;
+ dynamic section tool.

C3D Labs

$$r = q + (vv) \times p + \cos d\,(E - vv) \times p + \sin d\, v \times p = q + A \times (rO - q)$$

$$r(u,v) = g(v) + c(u) - g(v_{min})$$

$$r(u,v) = p + r(R + \cos v)(\cos u\, i_x + \sin u\, i_y) + r \sin v\, i_z$$

$$r(u,v) = \frac{\sum_{i=0}^{n} \sum_{j=0}^{m} N_i^L}{\sum_{i=0}^{n} \sum_{j=0}^{m} N_i^L}$$

$$L_1(t_1) = (1 - t_1)\, p_1 + t_1 q_1 \qquad P_1 = [x_1, y_1]^T \qquad q_1 = [a_1, b_1]^T$$

$$L_2(t_2) = (1 - t_2)\, p_2 + t_2 q_2 \qquad P_2 = [x_2, y_2]^T \qquad q_2 = [a_2, b_2]^T$$

$$(1 - t_1)\, p_1 + t_1 q_1 = (1 - t_2)\, p_2 + t_2 q_2$$

$$(x_1 - a_1)\, t_1 - (x_2 - a_2)\, t_2 = x_1 - x_2$$

$$(y_1 - b_1)\, t_1 - (y_2 - b_2)\, t_2 = y_1 - y_2$$

$$t_1 = \frac{(x_2 - a_2)(y_1 - y_2) - (x_1 - x_2)(y_2 - b_2)}{(x_2 - a_2)(y_1 - b_1) - (x_1 - a_1)(y_2 - b_2)}$$

$$t_2 = \frac{(x_1 - a_1)(y_2 - y_1) - (x_2 - x_1)(y_1 - b_1)}{(x_1 - a_1)(y_2 - b_2) - (x_2 - a_2)(y_1 - b_1)}$$

C3D Toolkit

The most complete solution
for developers creating
innovative 3D software

C3D Labs develops tools for engineering software, including the geometric kernel (SDK), a key software component for 3D CAD.

The company was founded in 2012.

In 2023, more than 50 companies are using C3D software components.

www.c3dlabs.com

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