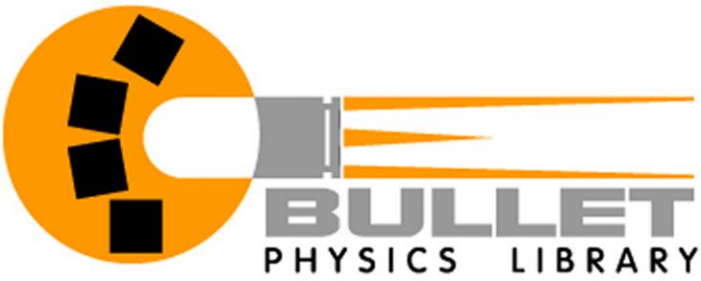

Bullet Physics Library

User Manual

Last updated by Erwin Coumans on Friday, 29 February 2008

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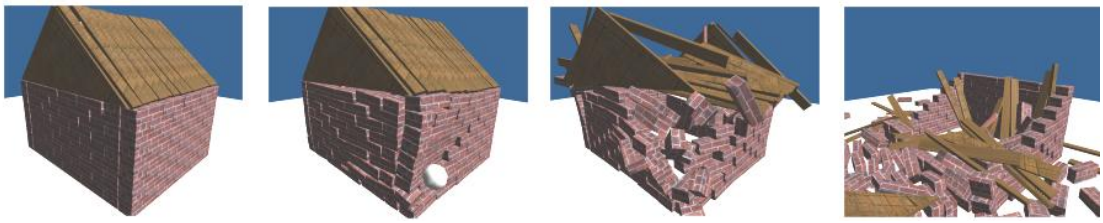
Introduction

Bullet Physics is a professional open source collision detection and physics library, related tools, demos, applications and a community forum at http://bulletphysics.com
It is free for commercial use under the ZLib license.

Bullet started in 2003 as a continuous collision detection research project by Erwin Coumans, former Havok employee. Since 2005 it has been open sourced, and many professional game developers are using, contributing and collaborating in the project. Target audience for this work are professional game developers as well as physics enthusiasts who want to play with collision detection and rigidbody dynamics.

Bullet is used in several games for Playstation 2 and 3, XBox 360, Nintendo Wii and PC, either fully or just the multi threaded collision detection parts. It is under active development and some of the recent new developments are the addition of a universal multi-threaded C++ version and a C# port that supports Windows and Xbox 360 XNA.

Authoring of physics content can be done using the COLLADA Physics specification. 3D modelers like Maya, Max, XSI, Blender and Ageia's CreateDynamics tools support COLLADA physics xml .dae files. Bullet is also integrated in the free Blender 3D modeler, http://www.blender.org. The integration allows real-time simulation and also baking the simulation into keyframes for rendering.
See the References for other integrations and links.



Main Features

- ✓ Discrete and Continuous collision detection including ray casting
- ✓ Collision shapes include concave and convex meshes and all basic primitives
- ✓ Rigid body dynamics solver with auto deactivation
- ✓ Cone-twist, hinge and generic 6 degree of freedom constraint for ragdolls etc.
- ✓ Vehicle simulation with tuning parameters
- ✓ COLLADA physics import/export with tool chain
- ✓ Compiles out-of-the-box for all platforms, including COLLADA support
- ✓ Open source C++ code under Zlib license and free for any commercial use

vidti ion

Quickstart

Step 1: Download

Windows developers should download the zipped sources from of Bullet from http://bulletphysics.com.Mac OS X, Linux and other developers should download the gzipped tar archive.

Step 2: Building

Bullet should compile out-of-the-box for all platforms, and includes all dependencies.
Visual Studio projectfiles for all versions are available in Bullet/msvc. The main Workspace/Solution is located in Bullet/msvc/8/wksbullet.sln
CMake adds support for many other build environments and platforms, including **XCode** for Mac OSX, **KDevelop** for Linux and **Unix Makefiles**. Download and install Cmake from http://www.cmake.org. Run `cmake` without arguments to see the list of build system generators for your platform. For example, run `cmake . -G Xcode` to auto-generate projectfiles for Mac OSX Xcode.
Jam: Bullet includes jam-2.5 sources from http://www.perforce.com/jam/jam.html. Install jam and run ./configure and then run jam, in the Bullet root directory.

Step 3: Testing demos

Try to run and experiment with CcdPhysicsDemo executable as a starting point. Bullet can be used in several ways, as Full Rigid Body simulation, as Collision Detector Library or Low Level / Snippets like the GJK Closest Point calculation. The Dependencies can be seen in the doxygen documentation under 'Directories'.

Step 4: Integrating Bullet Rigid Body Dynamics in your application

Check out CcdPhysicsDemo how to create a **btDynamicsWorld** , **btCollisionShape**, **btMotionState** and **btRigidBody**, Stepping the simulation and synchronizing the transform for your graphics object. Requirements:
#include "btBulletDynamicsCommon.h" in your source file
Required include path: Bullet /src folder
Required libraries: libbulletdynamics, libbulletcollision, libbulletmath

Step 5 : Integrate only the Collision Detection Library

Bullet Collision Detection can also be used without the Dynamics/Extras. Check out the low level demo Collision Interface Demo, in particular the class CollisionWorld. Requirements:
#include "btBulletCollisionCommon.h" at the top of your file
Add include path: Bullet /src folder
Add libraries: libbulletcollision, libbulletmath

Step 6 : Use snippets only, like the GJK Closest Point calculation.

Bullet has been designed in a modular way keeping dependencies to a minimum. The ConvexHullDistance demo demonstrates direct use of **GjkPairDetector**.

Integration overview

If you want to use Bullet in your own 3D application, it is best to follow the steps in the CcdPhysicsDemo. In a nutshell:

- ✓ Create a btDynamicsWorld implementation like btDiscreteDynamicsWorld

This btDynamicsWorld is a high level interface that manages your physics objects and constraints. It also implements the update of all objects each frame. A btContinuousDynamicsWorld is under development to make use of Bullet's Continuous Collision Detection. This will prevent missing collisions of small and fast moving objects, also known as tunneling. Another solution based on internal variable timesteps called btFlexibleStepDynamicsWorld will be added too.

- ✓ Create a btRigidBody and add it to the btDynamicsWorld

To construct a btRigidBody or btCollisionObject, you need to provide:
- Mass, positive for dynamics moving objects and 0 for static objects
- CollisionShape, like a Box, Sphere, Cone, Convex Hull or Triangle Mesh
- btMotionState use to synchronize the World transform to controls the graphics
- Material properties like friction and restitution

- ✓ Update the simulation each frame: stepSimulation

Call the stepSimulation on the btDynamicsWorld. The btDiscreteDynamicsWorld automatically takes into account variable timestep by performing interpolation instead of simulation for small timesteps. It uses an internal fixed timestep of 60 Hertz. stepSimulation will perform collision detection and physics simulation. It updates the world transform for active objecs by calling the btMotionState's setWorldTransform.

There is performance functionality like auto deactivation for objects which motion is below a certain threshold.

A lot of the details are demonstrated in the Demos. If you can't find certain functionality, please use the FAQ or the physics Forum on the Bullet website.

Debugging

You can get additional debugging feedback by registering a derived class from IDebugDrawer. You just need to hook up 3d line drawing with your graphics renderer. See the CcdPhysicsDemo OpenGLDebugDrawer for an example implementation. It can visualize collision shapes, contact points and more. This can help to find problems in the setup. Also the Raytracer demo shows how to visualize a complex collision shape.

Bullet Rigid Body Dynamics

World Transforms and btMotionState

The main purpose of rigid body simulation is calculating the new world transform, position and orientation, of dynamic bodies. Usually each rigidbody is connected to a user object, like graphics object. It is a good idea to derive your own version of btMotionState class.

Each frame, Bullet dynamics will update the world transform for active bodies, by calling the btMotionState::setWorldTransform. Also, the initial center of mass worldtransform is retrieved, using btMotionState::getWorldTransform, to initialize the btRigidBody. If you want to offset the rigidbody center of mass world transform, relative to the graphics world transform, it is best to do this only in one place. You can use btDefaultMotionState as start implementation.

Static, Dynamic and Kinematic Objects using btRigidBody

There are 3 different types of objects in Bullet:

- Dynamic rigidbodies
  - positive mass
  - User should only use apply impulse, constraints or setLinearVelocity/setAngularVelocity and let the dynamics calculate the new world transform
  - every simulation frame and interpolation frame, the dynamics world will write the new world transform using btMotionState::setWorldTransform
- Static rigidbodies
  - cannot move but just collide
  - zero mass
- Kinematic rigidbodies
  - animated by the user
  - only one-way interaction: dynamic objects will be pushed away but there is no influence from dynamics objects
  - every simulation frame, dynamics world will get new world transform using btMotionState::getWorldTransform

All of them need to be added to the dynamics world. The rigid body can be assigned a collision shape. This shape can be used to calculate the distribution of mass, also called inertia tensor.

Simulation frames and interpolation frames

By default, Bullet physics simulation runs at an internal fixed framerate of 60 Hertz (0.01666). The game or application might have a different or even variable framerate. To decouple the application framerate from the simulation framerate, an automatic interpolation method is built into stepSimulation: when the application delta time, is smaller then the internal fixed timestep, Bullet will interpolate the world transform, and send the interpolated worldtransform to the btMotionState, without performing physics simulation. If the application timestep is larger then 60 hertz, more then 1 simulation step can be performed during each 'stepSimulation' call. The user can limit the maximum number of simulation steps by passing a maximum value as second argument.

When rigidbodies are created, they will retrieve the initial worldtransform from the btMotionState, using btMotionState::getWorldTransform. When the simulation is running, using stepSimulation, the new worldtransform is updated for active rigidbodies using the btMotionState::setWorldTransform.

Dynamic rigidbodies have a positive mass, and their motion is determined by the simulation. Static and kinematic rigidbodies have zero mass. Static objects should never be moved by the user.

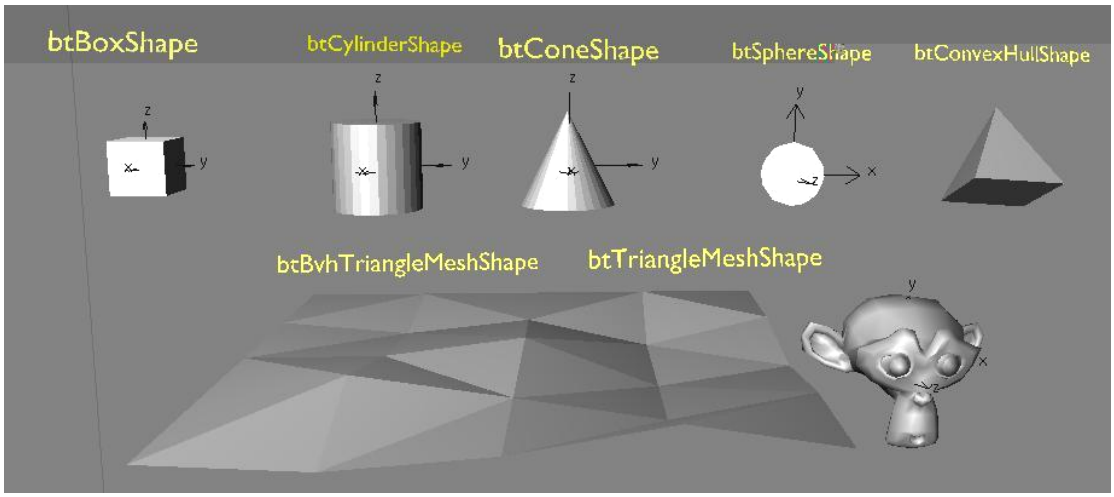
If you plan to animate or move static objects, you should flag them as kinematic. Also disable the sleeping/deactivation for them. This means Bullet dynamics world will get the new worldtransform from the btMotionState every simulation frame.

Bullet Collision Shapes

Bullet supports a large variety of different collision shapes, and it is possible to add your own.

Convex Primitives

Most primitive shapes are centerd around the origin of their local coordinate frame:



: Box defined by the half extents (half length) of its sides

: Sphere defined by its radius

: Capsule around Y axis. Also /Z.

: Cylinder around the Y axis. Also

: Cone around the Y axis. Also btConeShapeX/Z.

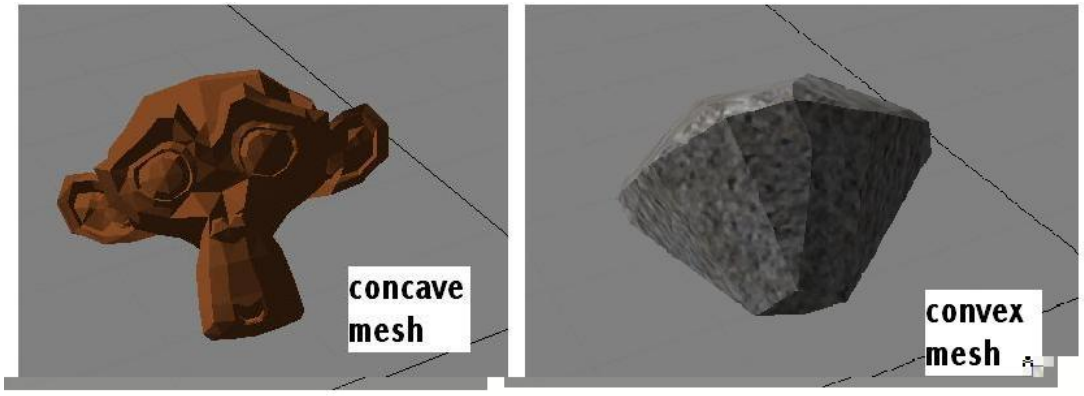
: Convex hull of multiple spheres, that can be used to create a Capsule (by passing 2 spheres) or other convex shapes.

Compound Shapes

Multiple convex shapes can be combined into a composite or compound shape, using the . This is a concave shape made out of convex sub parts, called child shapes. Each child shape has its own local offset transform, relative to the .

Convex Hull Meshes

For moving objects, concave meshes can be passed into ,.
This automatically collides with the convex hull of the mesh:



Concave triangle meshes

General triangle meshes that represent static environment can best be represented in Bullet by using the . It is possible to directly use existing graphics meshes, without duplicating the indices and vertices.
Internally, Bullet creates an acceleration structure (bounding volume hierarchy, aabb tree), and this structure supports local deformations (refitting the tree based on an bounding box that contains the local vertex deformation).

Convex Decomposition

Ideally, concave meshes should only be used for static artwork. Otherwise its convex hull should be used by passing the mesh to . If a single convex shape is not detailed enough, multiple convex parts can be combined into a composite object called . Convex decomposition can be used to decompose the concave mesh into several convex parts. See the ConvexDecompositionDemo for an automatic way of doing convex decomposition. The implementation is taken from Ageia CreateDynamics tool, which can do the same with some fancy user interface. CreateDynamics can export to COLLADA Physics, so Bullet can import that data.

An optional contribution called GIMPACT can handle moving concave meshes. See Demos/MovingConcaveDemo for its usage.

Height Field

Bullet provides support for the special case of a flat 2D concave terrain through the . See VehicleDemo for its usage.

Non-uniform local scaling of Collision Shapes

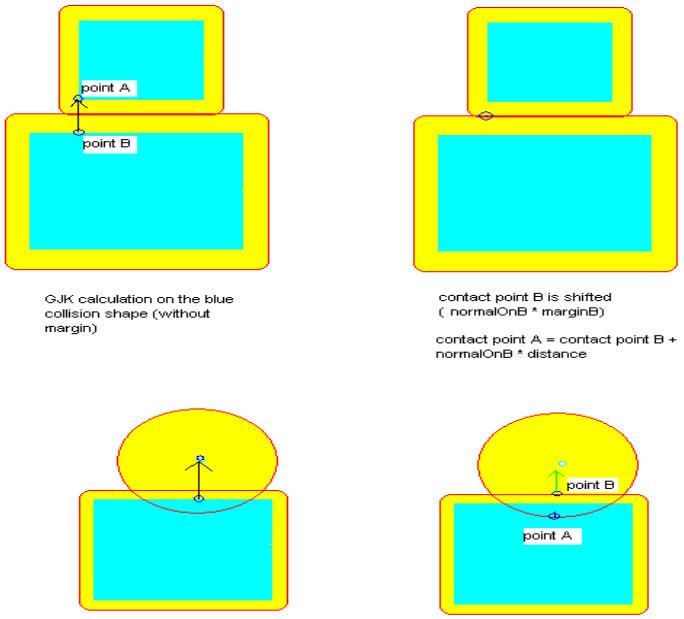
Some collision shapes can have local scaling applied. Use btCollisionShape::setScaling(vector3). Non uniform scaling with different scaling values for each axis, can be used for , , , . Note that a non-uniform scaled sphere can be created by using a with 1 sphere.

Uniform scaling of Collision Shapes

allows to re-use collision shapes with different scaling factor, to reduce memory.

Collision Margin

Bullet uses a small collision margin for collision shapes, to improve performance and reliability of the collision detection. It is best not to modify the default collision margin, and if you do use a positive value: zero margin might introduce problems. By default this collision margin is set to 0.04, which is 4 centimeter if your units are in meters (recommended).



Dependent on which collision shapes, the margin has different meaning. Generally the collision margin will expand the object. This will create a small gap. To compensate for this, some shapes will subtract the margin from the actual size. For example, the btBoxShape subtracts the collision margin from the half extents. For a btSphereShape, the entire radius is collision margin so no gap will occur. Don't override the collision margin for spheres. For convex hulls, cylinders and cones, the margin is added to the extents of the object, so a gap will occur, unless you adjust the graphics mesh or collision size. For convex hull objects, there is a method to remove the gap introduced by the margin, by shrinking the object. See the BspDemo for this advanced use.
The yellow in the following picture described the working of collision margin for internal contact generation.

Bullet Constraints

There are several constraints implemented in Bullet. See Demos/ConstraintDemo for an example of each of them. All constraints including the btRaycastVehicle are derived from btTypedConstraint. Constraint act between two rigidbodies, where at least one of them needs to be dynamic.

btPoint2PointConstraint

Point to point constraint, also known as ball socket joint limits the translation so that the local pivot points of 2 rigidbodies match in worldspace. A chain of rigidbodies can be connected using this constraint.

btHingeConstraint

Hinge constraint, or revolute joint restricts two additional angular degrees of freedom, so the body can only rotate around one axis, the hinge axis. This can be useful to represent doors or wheels rotating around one axis. The user can specify limits and motor for the hinge.

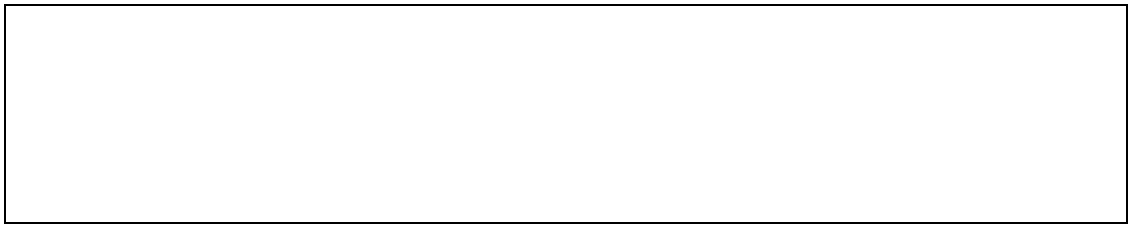
btConeTwistConstraint

To create ragdolls, the conve twist constraint is very useful for limbs like the upper arm. It is a special point to point constraint that adds cone and twist axis limits.

btGeneric6DofConstraint

The generic D6 constraint. This generic constraint can emulate a variety of standard constraints, by configuring each of the 6 degrees of freedom (dof). The first 3 dof axis are linear axis, which represent translation of rigidbodies, and the latter 3 dof axis represent the angular motion. Each axis can be either locked, free or limited. On construction of a new btGenericD6Constraint, all axis are locked. Afterwards the axis can be reconfigured. Note that several combinations that include free and/or limited angular degrees of freedom are undefined.

Following is convention:



For each axis:

- Lowerlimit == Upperlimit -> axis is locked.
- Lowerlimit > Upperlimit -> axis is free
- Lowerlimit < Upperlimit -> axis it limited in that range

Bullet Vehicle

btRaycastVehicle

For most vehicle simulations, it is recommended to use the simplified Bullet vehicle model as provided in btRaycastVehicle. Instead of simulation each wheel and chassis as separate rigid bodies, connected by constraints, it uses a simplified model. This simplified model has many benefits, and is widely used in commercial driving games.

The entire vehicle is represented as a single rigidbody, the chassis. The collision detection of the wheels is approximated by ray casts, and the tire friction is a basic anisotropic friction model.

See Demos/VehicleDemo for more details, or check the Bullet forums.

Changing the up axis of a vehicle., see #define FORCE_ZAXIS_UP in VehiceDemo.

Bullet Character Controller

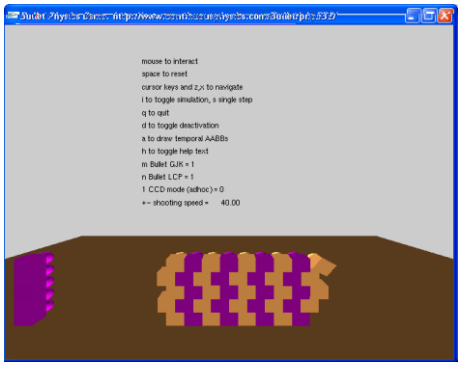
A basic player or NPC character can be constructed using a capsule shape, sphere or other shape. To avoid rotation, you can set the 'angular factor' to zero, which disables the angular rotation effect during collisions and other constraints. See **`btRigidBody::setAngularFactor`**. Other options (that are less recommended) include setting the inverse inertia tensor to zero for the up axis, or using a angular-only hinge constraint.

Basic Demos

Bullet includes several demos. They are tested on several platforms and use OpenGL graphics and glut. Some shared functionality like mouse picking and text rendering is provided in the Demos/OpenGL support folder. This is implemented in the DemoApplication class. Each demo derives a class from DemoApplication and implements its own initialization of the physics in the 'initPhysics' method.

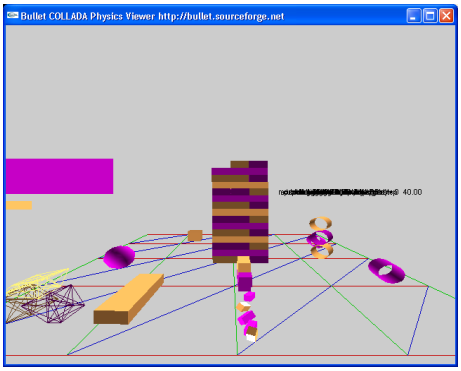
CCD Physics Demo

This is the main demo that shows how to setup a physics simulation, add some objects, and step the simulation. It shows stable stacking, and allows mouse picking and shooting boxes to collapse the wall. The shooting speed of the box can be changed, and for high velocities, the CCD feature can be enabled to avoid missing collisions. Try out advanced features using the #defines at the top of CcdPhysicsDemo.cpp



COLLADA Physics Viewer Demo

Imports and exports COLLADA Physics files. It uses the included libxml and COLLADA-DOM library.
The COLLADA-DOM imports a .dae xml file that is generated by tools and plugins for popular 3D modelers. ColladaMaya with Nima from FeelingSoftware, Blender, Ageia's free CreateDynamics tool and other software can export/import this standard physics file format. The ColladaConverter class can be used as example for other COLLADA physics integrations.

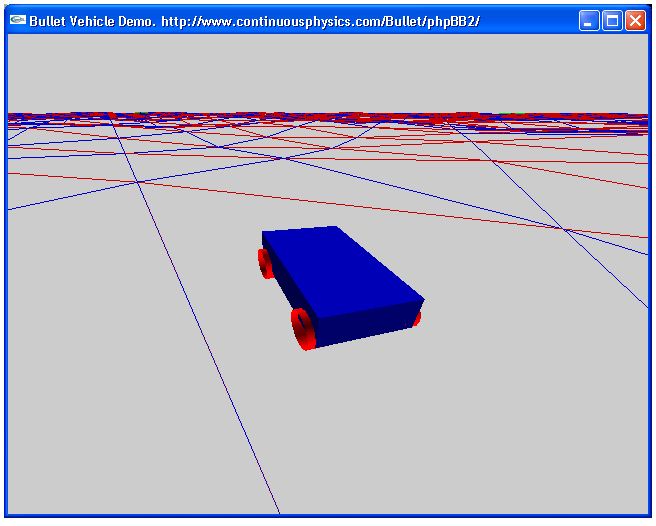


BSP Demo

Import a Quake .bsp files and convert the brushes into convex objects. This performs better then using triangles.

Vehicle Demo

This demo shows the use of the build-in vehicle. The wheels are approximated by ray casts. This approximation works very well for fast moving vehicles. For slow vehicles where the interaction between wheels and environment needs to be more precise the Forklift Demo is more recommended. The landscape is either triangle mesh or a heightfield.



Character Demo

A basic character controller demo has been added with a reusable class, see Demos/CharacterDemo.

General Tips for Bullet users

Share collision shapes between rigid bodies

For better performance and reduced memory use, it is better to re-use collision shapes, among different rigid bodies.

Avoid very small and very large collision shapes

The minimum object size for moving objects is about 0.2 units. When using default gravity of 9.8, those units are in meters so don't create objects smaller then 20 centimeter. It is recommended to keep the maximum size of moving objects smaller then about 5 units/meters.

Avoid large mass ratios (differences)

Simulation becomes unstable when a heavy object is resting on a very light object. It is best to keep the mass around 1. This means accurate interaction between a tank and a very light object is not realistic.

Combine multiple static triangle meshes into one

Many small btBvhTriangleMeshShape pollute the broadphase. Better combine them.

Use the default internal fixed timestep

Bullet works best with a fixed internal timestep of at least 60 hertz (1/60 second).

For safety and stability, Bullet will automatically subdivide the variable timestep into fixed internal simulation substeps, up to a maximum number of substeps specified as second argument to stepSimulation. When the timestep is smaller then the internal substep, Bullet will interpolate the motion.

This safety mechanism can be disabled by passing 0 as maximum number of substeps (second argument to stepSimulation): the internal timestep and substeps are disabled, and the actual timestep is simulated. It is not recommended to disable this safety mechanism.

For ragdolls use btConeTwistConstraint

It is better to build a ragdoll out of btHingeConstraint and/or btConeTwistLimit for knees, elbows and arms. Alternatively, the btGenericD6Constraint can be used, see Demos/GenericJointDemo.

Don't set the collision margin to zero

Collision detection system needs some margin for performance and stability. If the gap is noticeable, please compensate the graphics representation.

Use less then 100 vertices in a convex mesh

It is best to keep the number of vertices in a btConvexHullShape limited. It is better for performance, and too many vertices might cause instability.

Avoid huge or degenerate triangles in a triangle mesh

Keep the size of triangles reasonable, say below 10 units/meters. Also degenerate triangles with large size ratios between each sides or close to zero area can better be avoided.

Advanced Topics

Per triangle friction and restitution value

By default, there is only one friction value for one rigidbody. You can achieve per shape or per triangle friction for more detail. See the Demos/ConcaveDemo how to set the friction per triangle. Basically, add CF_CUSTOM_MATERIAL_CALLBACK to the collision flags or the rigidbody, and register a global material callback function. To identify the triangle in the mesh, both triangleID and partId of the mesh is passed to the material callback. This matches the triangleId/partId of the striding mesh interface.

Custom Constraint Solver

Bullet uses its btSequentialImpulseConstraintSolver by default. You can use a different constraint solver, by passing it into the constructor of your btDynamicsWorld. For comparison you can use the Extras/quickstep solver from Open Dynamics Engine.

Custom Friction Model

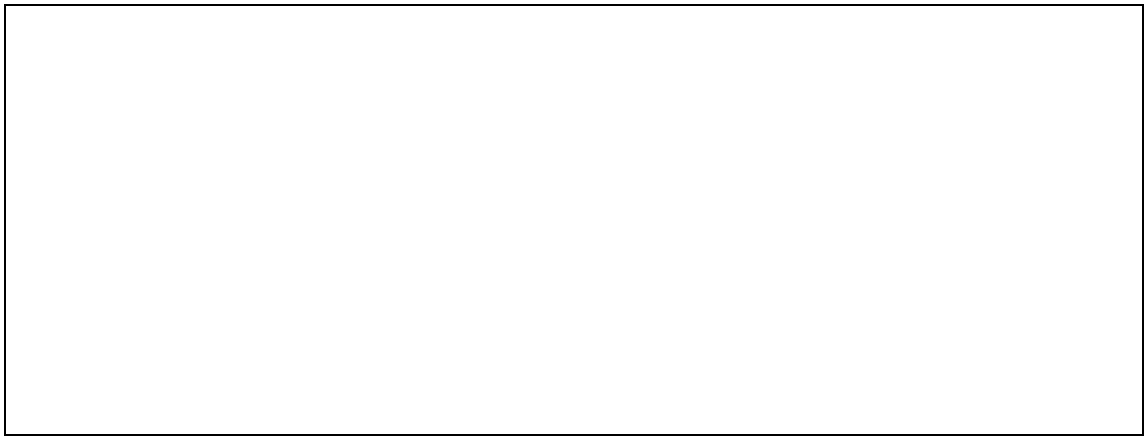
If you want to have a different friction model for certain types of objects, you can register a friction function in the constraint solver for certain body types.

See #define in Demos/CcdPhysicsDemo.cpp.

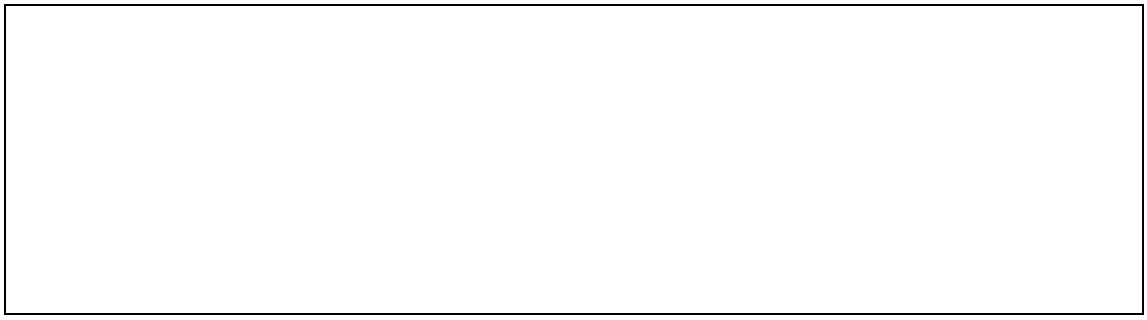
Collision Filtering (disabling collisions)

Collision groups and masks

To disable collision detection between certain shapes, collision groups and collision filter masks are used. By default, when a rigidbody is added to the btDynamicsWorld, the collision group and mask is chosen to prevent collisions between static objects at a very early stage. You can specify the group and mask in '**`btDynamicsWorld::addRigidBody`**' and '**`btCollisionWorld::addCollisionObject`**'.



The broadphase checks those filter flags to determine wether collision detection needs to be performed using the following code:



You can override this default filtering behaviour after the rigidbody has been added to the dynamics world by assigning new values to

Disable collisions between a pair of instances of objects

When two bodies share a constraint, you can optionally disable the collision detection between those instances. Pass true as optional second argument to **`btDiscreteDynamicsWorld::addConstraint`** (this bool **disableCollisionsBetweenLinkedBodies** defaults to false).

Collision Matrix

For each pair of shape types, Bullet will dispatch a certain collision algorithm, by using the dispatcher. By default, the entire matrix is filled with the following algorithms. Note that Convex represents convex polyhedron, cylinder, cone and capsule and other GJK compatible primitives. GJK stands for Gilbert Johnson Keethi, the people behind this convex distance calculation algorithm. EPA stands for Expanding Polythope Algorithm by Gino van den Bergen. Bullet has its own free implementation of GJK and EPA.

Bullet Collision Matrix (*= optional)					
Collision Shape:	**Sphere**	**Box**	**Convex**	**Compound**	**Trianglemesh**
Sphere					

Advanced Low Level Technical Demos

Collision Interfacing Demo

This demo shows how to use Bullet collision detection without the dynamics. It uses the CollisionWorld class, and fills this will CollisionObjects. performDiscreteCollisionDetection method is called and the demo shows how to gather the contact points.

Collision Demo

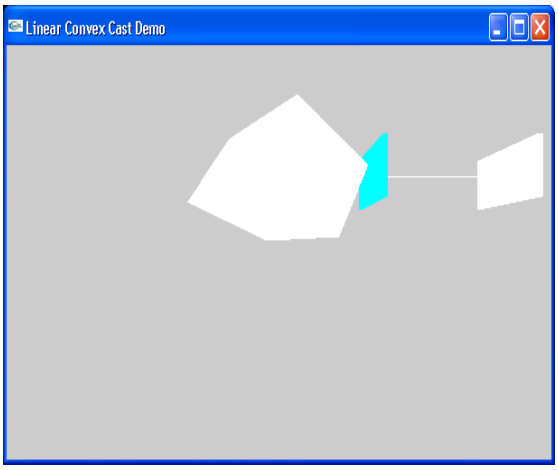
This demo is more low level then previous Collision Interfacing Demo. It directly uses the GJKPairDetector to query the closest points between two objects.

User Collision Algorithm

Shows how you can register your own collision detection algorithm that handles the collision detection for a certain pair of collision types. A simple sphere-sphere case overides the default GJK convex collision detection.

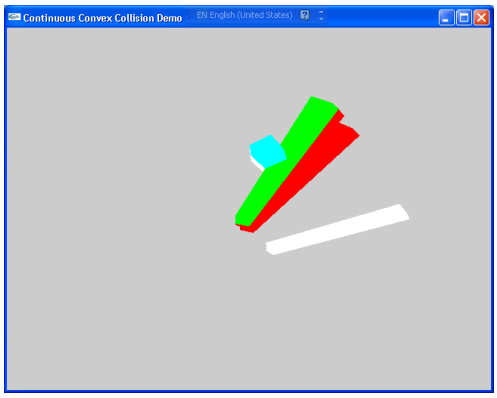
Gjk Convex Cast / Sweep Demo

This demo show how to performs a linear sweep between to collision objects and returns the time of impact. This can be useful to avoid penetrations in camera and character control.



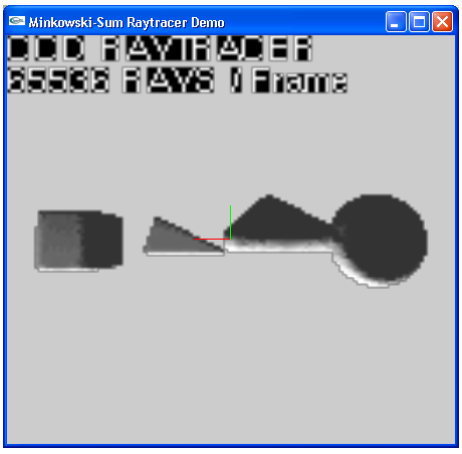
Continuous Convex Collision

Shows time of impact query using continuous collision detection, between two rotating and translating objects. It uses Bullet's implementation of Conservative Advancement.



Raytracer Demo

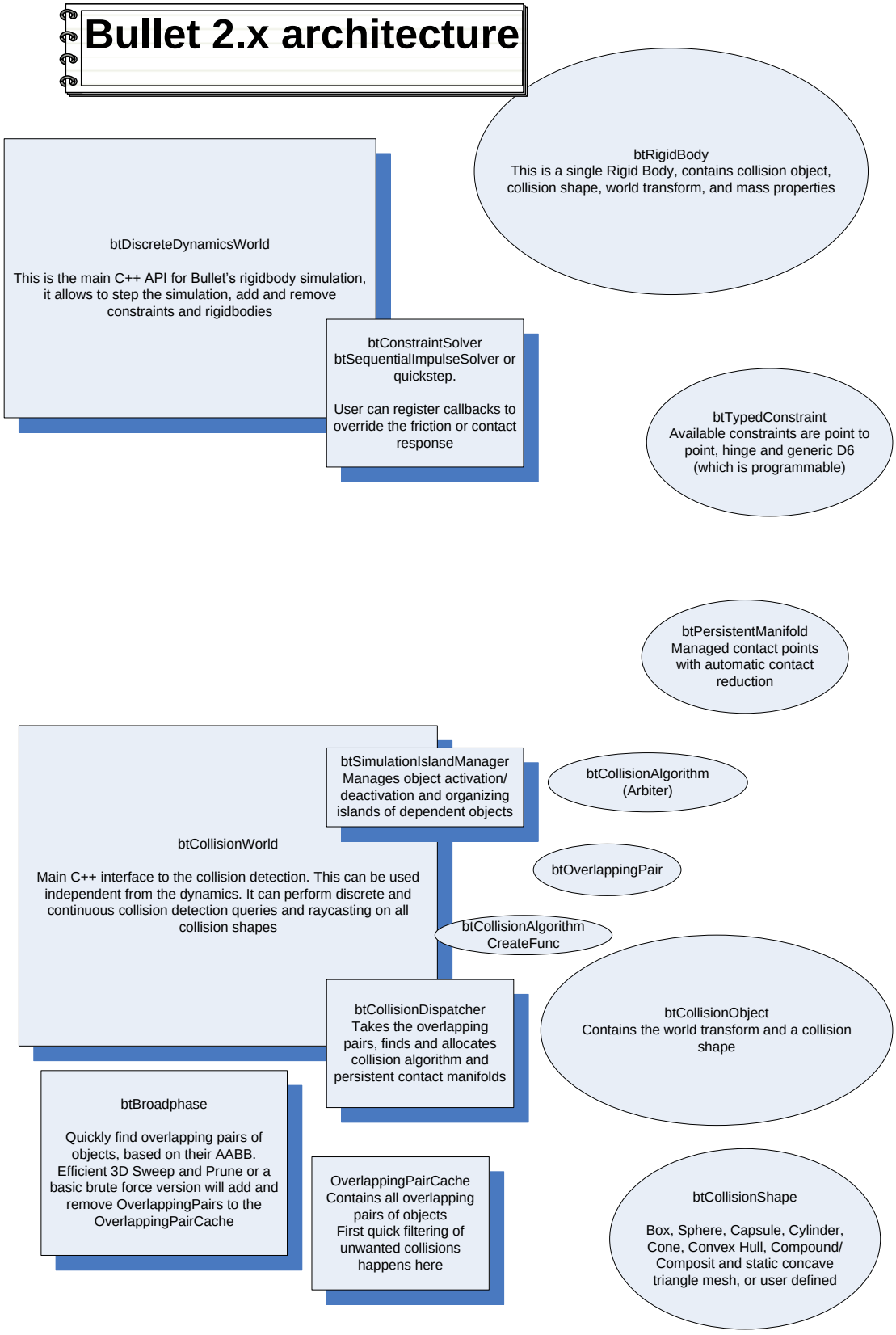
This shows the use of CCD ray casting on collision shapes. It implements a ray tracer that can accurately visualize the implicit representation of collision shapes. This includes the collision margin, convex hulls of implicit objects, minkowski sums and other shapes that are hard to visualize otherwise.



Concave Demo

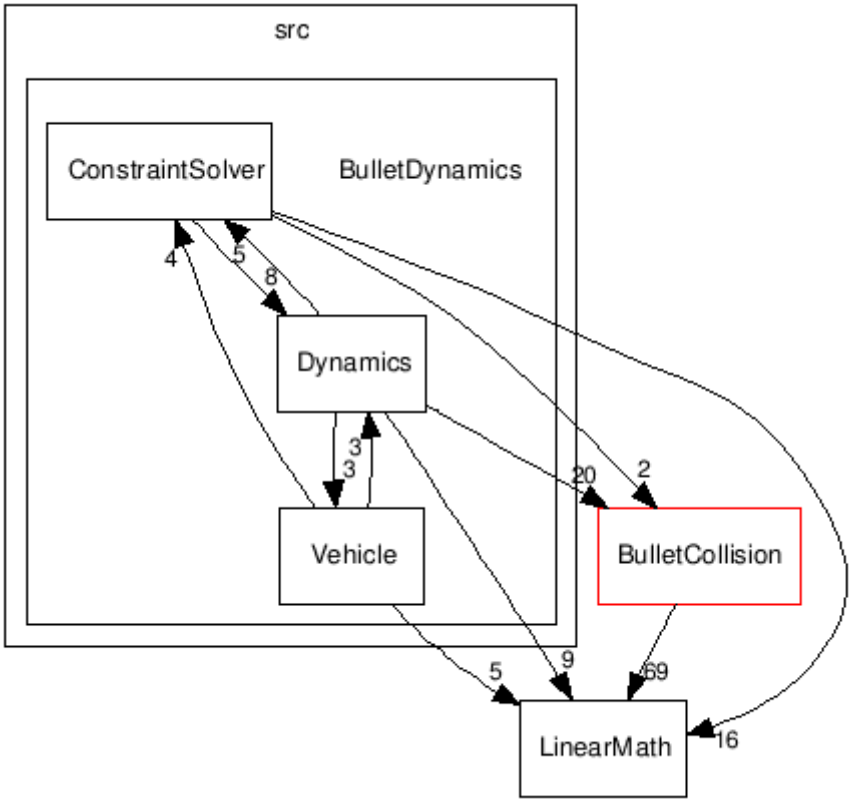
This advanced demo shows how to implement user defined per-triangle restitution and friction in a static triangle mesh. A callback can be registered and triangle identifiers can be used to modify the friction in ea02.9 (r)-6(e4(portne)5(d)]TJETBT

Bullet Collision Detection and Physics Architecture



Bullet Library Module Overview

Bullet provides Collision Detection and Rigid Body dynamics. The C++ software is divided into several sub modules with clean dependencies. The division of those modules is reflected in Bullet's directory structure, and further subdirectories are provided per module. This means that the Collision Detection module can be used without using the BulletDynamics module.

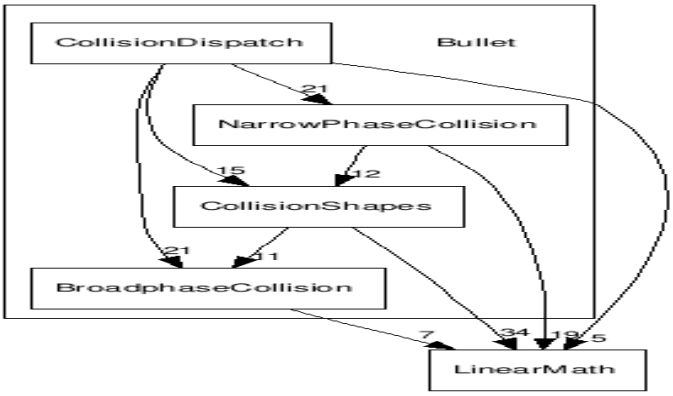


Bullet Collision Detection Library Internals

The main queries provided by the Collision Detection:

- ✓ Closest Distance and closest points
- ✓ Penetration depth calculation
- ✓ Ray cast
- ✓ Sweep API for casting shapes to find Time of Impact (TOI) along a linear path
- ✓ Time of Impact for Continuous Collision Detection including rotations

Supported Collision Shapes include Box, Sphere, Cylinder, Capsule, Minkowski Sum, Convex Hull, (Concave) Triangle Mesh and Compound Shapes and more.



Additional functionality are related to performance and to provide more detail and information useful for the usage in rigid body dynamics and for AI queries in games. The collision pipeline includes 3 stages: Broadphase, Midphase and Narrowphase.

- ✓ Broadphase

Broadphase provides all overlapping pairs based on axis aligned bounding box (AABB). It includes an efficient culling of all potential pairs using the incremental sweep and prune algorithm.

- ✓ Midphase

The midphase performs additional culling for complex collision shapes like compound shapes and static concave triangle meshes. Bullet uses an optimized Bounding Volume Hierarchy, based on a AABB tree and stackless tree traversal. This traversal provides primitives that need to be tested by the Narrowphase.

- ✓ Narrowphase

The Narrowphase perform the actual distance, penetration or time of impact query. Contact points are collected and maintained over several frames in a persistent way. This means that additional information useful for rigid body simulation can be stored in each contact point. Also this means that algorithms that only provide one contact point at a time can still be used, by gathering additional contact points and performing contact point reduction.

Multi threaded version

Cell SPU / SPURS optimized version

Bullet collision detection and other parts have been optimized for Cell SPU. This means collision code has been refactored to run on multiple parallel SPU processors. The collision detection code and data have been refactored to make it suitable for 256kb local store SPU memory. The user can activate the parallel optimizations by using a special collision dispatcher (**`SpuGatheringCollisionDispatcher`**) that dispatches the work to SPU. The shared public implementation is located in Bullet/Extras/BulletMultiThreaded.

Please contact Sony developer support on PS3 Devnet for a Playstation 3 optimized version of Bullet.

Unified multi threading

Efforts have been made to make it possible to re-use the SPU parallel version in other multi threading environments, including multi core processors.

This allows more effective debugging of SPU code under Windows, as well as utilizing multi core processors. For non-SPU multi threading, the implementation performs fake DMA transfers using a memcpy, and each thread gets its own 256kb 'local store' working memory allocated.

Win32 Threads

Basic Win32 Threads support has been implemented. Some demos show this preliminary work in action. See #define USE_PARALLEL_DISPATCHER in Demos/BasicDemo, ConcaveDemo and ConvexDecompositionDemo.

IBM Cell SDK 3.x, libspe2 SPU optimized version

IBM also provides a Cell SDK with access to SPU through libspe2 for Cell Blade and PS3 Linux platforms. Libspe2 thread support is currently under development. By providing libspe2 thread support, Bullet can run certain parts on SPU using the same **`SpuGatheringCollisionDispatcher`** . This will all be available under the ZLib license in Bullet/Extras/BulletMultiThreaded.

Future support for pthreads

If there is interest, pthreads support can be added to support multi threading on various other platforms.

Contributions / people

Thanks everyone on the Bullet forum for feedback.

Some people that contributed source code to Bullet in random order:

Erwin Coumans, SCEA: main author, project lead
John McCutchan, SCEA: core developer.
Gino van den Bergen, Dtecta: LinearMath classes, various collision detection ideas
Christer Ericson, SCEA: voronoi simplex solver
Simon Hobbs, SCEE: 3d axis sweep and prune: and Extras/SATCollision
Dirk Gregorius, Factor 5 : discussion and assistance with constraints
Erin Catto, Blizzard: accumulated impulse in sequential impulse
Nathanael Presson, NCSoft : EPA penetration depth calculation
Francisco Leon : GIMPACT Concave Concave collision
Eric Sunshine: jam + msvcgen buildsystem
Steve Baker: GPU physics and general implementation improvements
Jay Lee, TrionWorld: Double precision support
KleMiX, aka Vsevolod Klementjev, managed version, C# port to XNA
Marten Svanfeldt, Starbreeze: several improvements and optimizations
Marcus Hennix, Starbreeze: btConeTwistConstaint

Several people contributed anonymous to Bullet, thanks for that.
(please get in touch if your name should be in this list)

Contact

Use either public message or private message (PM) on the Bullet forum at
http://bulletphysics.com

Or email to bullet <at> erwincoumans.com

Further documentation and references

Bullet Physics website provides most information:
Visit http://bulletphysics.com which points to http://www.continuousphysics.com

On this website there is online doxygen documentation, a wiki with frequently asked questions and tips, and most important a discussion forum.

A paper describing the Bullet's Continuous Collision Detection method is available online at http://continuousphysics.com/BulletContinuousCollisionDetection.pdf

For physics tools and COLLADA physics visit http://www.khronos.org/collada
You can find the latest plugin versions and other information at the COLLADA forum at https://collada.org/public_forum/

Links

COLLADA-DOM included in Bullet: http://colladamaya.sourceforge.net

ColladaMaya plugin http://www.feelingsoftware.com

Blender 3D modeler includes Bullet and COLLADA physics: http://www.blender.org

Ageia CreateDynamics tool http://www.amillionpixels.us/CreateDynamics.zip

This great tool can perform automatic convex decomposition and create ragdolls from graphics skeletons. It is also available from Ageia support forums at http://devsupport.ageia.com

Books

Realtime Collision Detection, Christer Ericson
http://www.realtimecollisiondetection.net/
Bullet uses the discussed voronoi simplex solver for GJK

Collision Detection in Interactive 3D Environments, Gino van den Bergen
http://www.dtecta.com also website for Solid collision detection library
Discusses GJK and other algorithms, very useful to understand Bullet

Physics Based Animation, Kenny Erleben
http://www.diku.dk/~kenny/
Very useful to understand Bullet Dynamics and constraints